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Dynamic Structural Econometric Models and High Inflation in Brazil

by

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ABSTRACT

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DYNAMIC STRUCTURAL ECONOMETRIC MODELS AND HIGH INFLATION IN BRAZIL

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The properties of the monetary system in Brazil, during the high inflation period (1980-1995) are investigated.

A literature review emphasizing empirical attempts is carried out. The evidence in the literature shows that the Cagan model is a good specification for the money demand prior to 1986. Nevertheless the results of the present doctoral thesis show that from 1986 onwards after the first stabilization plan started the empirical evidence does not support the Cagan model.

Alternatively a dynamic structural econometric model (SEM) is proposed. The sample size is divided into three distinct periods: 1) 1980 until 1986(2), 2) 1986(3) until 1994 (6) 3) 1994 until 2002 (2). A long run money demand equation is identified in the second and third periods. The results for the first period support the view that the accommodating monetary policy (M1) followed after the 1984 economic upturn in a highly indexed economy allowed the increase in the inflation rates. In period 2 the short run price dynamics depicted the presence of memory in the process reflecting indexation. The long run response to shocks in inflation is positive representing a long run increasing trend.

The influence of the administered exchange rate devaluations and nominal wage inflation on price dynamic is investigated. For the first period in the short run the impact of inflation on the industrial activity was originated in the nominal wage inflation not in price inflation. In the second period the short run model dynamics shows the growth in the industrial production and inflation rate being driven by past inflation (wage and prices) in line with the theoretical model proposed.

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Chapter 1

Introduction

Hyperinflation episodes have been studied extensively in the economic literature since Cagan's (1956) seminal paper. His theoretical model where high levels of change in price would dwarf the effect of real variables on money demand has provided a consistent basis for theoretical and empirical developments in the economic literature.

Different experiences have been analysed in the literature with great attention to the German and Austrian among other European hyperinflations that came up after the First World War. The interest on such experiences, come from the fact that hyperinflations are rare and short lived in general. The turning up of the rational expectations revolution in macroeconomics cast the basis for the model reappraisal with the original adaptive expectations being replaced by the rational expectations hypothesis in Sargent (1977) and Salemi and Sargent (1979) both dedicated to the German hyperinflation. Several researches have readdressed Cagan's model estimating it under a variety of alternative assumptions as pointed by Taylor (1991). By the end of the 1980's with the increasing attention to the presence of unit roots and cointegration property in macroeconomic time series a different stream of the literature once more dedicated attention to the Cagan's model starting with Taylor's (1991) contribution where the author formalizes Cagan's insight that nominal variables can be studied almost in isolation from the real sector of the economy in terms of time series properties of the data. In his paper, Taylor shows that stationary forecasting errors are in accordance with different assumptions concerning expectation's formation analysing the comparatively simple restrictions derived in his paper and the cross-equation restrictions underlying the vector autoregressive representation of the time series under investigation. Further developments appeared in Engsted (1993) where the author imposed stricter assumptions on rational expectations and no bubbles, deriving an extra cointegrating relationship not observed in Talyor's paper between real money balances and money growth. Engsted (1993) also criticized Taylor (1991) by arguing that using these tighter assumptions a set of cross-equation parameter restrictions is derived and can be used to evaluate the economic significance of a possible statistical rejection of the implied restrictions. Despite their initial attention to the classical hyperinflations discussed in Cagan's paper both authors extended their empirical investigations to Latin American countries almost simultaneously in Phylaktis and Taylor (1993) and Engsted (1993 a)

Among the Latin America countries examined in their papers both authors dedicated attention to the Brazilian high inflation experience. However they seem not to consider some particularities that are present in the Brazilian case and that should merit more attention. The first one is that inflation rates in Brazil only reached the same level as those in Europe during a very short period between the last quarter of 1989 and March 1990. Otherwise the annual rates appeared to be moderated. Secondly is that the Brazilian economy experienced relatively high rates of inflation without observing the explosive patterns present in the Europeans hyperinflations given of indexation widespread use.

As early as 1976 the Brazilian Central Bank started the development of open market operations as an instrument of monetary policy and their consolidation came with the creation of the SELIC (Special System of Liquidation and Custody) in 1979. After the Mexican crisis in 1982 and the restrictions imposed by the lack of external financing the Brazilian Central Government switched the main source of funding to internal savings by launching securities either indexed to the US dollar or to inflation indexes. The growing use of open market operations by the Central Government to finance itself during the 1980's[1] led then the financial sector to invest in technology aiming to offer the clients high levels of liquidity and yield without the necessity to migrate to foreign assets for protection against inflation in line, therefore, with the Central Government policy. Furthermore, the presence of a consolidated secondary market for public securities and the option of repurchase in

[1] Indeed, according to ANDIMA (1997), one of the difficulties faced by the monetary authority in this process of changing the source of financing was the control of the monetary base after 1982 given the shortness of resources. In December 1983 the total of resources fed into the system by the Central Bank was US$610 million whereas in the first two months of 1984 the amount jumped to US$ 1.6 billion. Therefore, any initial contraction in the monetary base given the open market operations was in the sequence followed by an expansion. This strategy was followed by the Central Government to avoid increases in the interest rates and consequently difficulties faced by the private financial institutions in financing their short run obligations.

some auctions guaranteed the liquidity necessary to the system. If by one hand such developments prevented the economy from undergoing an inflationary spiral leading to a hyperinflation by the other hand the economic agents were left under the impression that they would be able to avoid the costs of counter inflationary measures. The solution adopted to control the spiral was launching a set of interventionist measures through stabilization plans.

More specifically if we consider Cagan's classical definition of hyperinflation Brazil experienced a very short lived hyperinflation from December 1989 and March 1990, a period which is not even close to the shortest hyperinflations in Europe studied by Cagan (Austria, Greece and Poland) which lasted for 17 months. Nevertheless if we use the definition of high inflation as in Fisher et al (2002) namely those periods where the annual rates crosses 100% and only ends when it stays below 100% for more than one year, then the high inflation period lasted 15 years and 2 months (between April 1980 and May 1995) and the accumulated inflation rate for the period is 20,759,903,275,651% as noticed in Franco (2004).

Remarkably the literature on this subject does not seem to present a detailed analysis of such phenomenon that is comparatively even rarer than hyperinflations. In the Brazilian case Cardoso (1983), Gerlach and Simone (1985), Calomiris and Domowitz (1989), Fadil and MacDonald (1992) developed empirical models for the money demand or the monetary sector in Brazil without nevertheless mentioning or even testing the Cagan's model adequacy as well as including the high inflation period. Phylatktis and Taylor and Engsted concentrated their attention on a period where actually inflation rates were moderate with both samples ending in 1986 when the Brazilian economy experienced the first stabilization plan. As we have noted the period when the inflation actually accelerates reaching the hyperinflation levels is posterior to the period analysed by both authors. Such a pattern is present also in other papers devoted to the study of the Brazilian case e.g Juselius (2002), Durevall (1998), Feliz and Welch (1997), all of them imposing 1986 as the ceiling point in the sample length.

Phylatktis and Taylor, Engsted, and Feliz and Welch papers all share the same underlying theoretical model, namely Cagan's money demand specification under hyperinflation. But considering the length of time implied by the high inflation period in

Brazil and the presence of widespread indexation, Cagan's assumption about nominal variables being studied in isolation seems inappropriate in specifying an econometric model of inflation. Otherwise we would have to sustain the hypothesis that for more than 15 years money demand in Brazil was influenced by price expectations only. Such problem had already been noticed in the literature by Tourinho (1997) where the author suggest that nominal variables only cannot explain the complexity of high inflations that do not turn into hyperinflations.

The present thesis aims exactly to dedicate attention to this lacuna in the empirical literature specifying an econometric model for the period of high inflation in Brazil. I shall dedicate attention in chapter 2 to the complexities generated by the sequence of stabilization plans implemented in Brazil during the second half of the 1980's presenting a brief stylized analysis and exploring possible links between these plans and the economic literature available.

In chapter 3 I shall turn attention to Cagan's model following Engsted (1993). The literature review presented there calls attention to the fact that the analysis available is based on very general assumptions about the long run properties of the data. Further such analysis is not extended up to 1994 when the Real plan launching actually ended with the high inflation. The chapter also provides a benchmark to the analysis implemented in chapters 4 and 5 in the sense that in the context of Cagan's model demand shocks are interpreted as the non-explained part of the specified model. A measure of how much the specified model adheres to the data, or in other words how much the non-explained part of the model is relevant, is used to justify the rejections observed in testing the Cagan's model under the very tight restrictions implied by the rational expectations hypothesis. This procedure is criticized on the grounds of the discussion in Spanos (1990, 2005) where the author emphasizes that such sort of results are generated by the underlying hypothesis that the data generation process is the theoretical model when carrying out the empirical analysis.

Actually the results obtained in chapter 3 show that the Cagan's model is not a reasonable description of the money demand during the period that includes the hyperinflation episode. Such results led to questioning about features that were present in the Brazilian case and that possibly Cagan's model cannot account, among them merit attention the presence of indexation from prices to wages generating **inertia in inflation** and the sequence of **stabilization plans** implemented between 1986 and 1994.

The stabilization plans constituted in the Brazilian case exogenous interventions through the use of non-standard policy instruments preventing them to be modelled in the empirical models. This class of non-standard interventions imposed cannot be addressed through marginalizing variables which usually are acknowledged as policy variables like tax and interest rates demanding the use of intervention variables instead.

Considering the hypothesis that indexation was the propagating mechanism that produced inertia in price indexes during the 1980's and the first half of the 1990's, the interventions aimed to change the feedback rules present in the inflation rate generated by the widespread use of indexation what could not be obtained using standard policy variables. This sort of intervention could result in parameter instability[2] in dynamic econometric models but cannot be associated with changes in agent's expectations about how the central government would have carried the monetary and fiscal policies simply because these plans were not associated with standard policy instruments being by definition non-forecastable. In other words there are variations in the parameters with changes in the distribution of variables which are outside the direct control of the agents.

Inflation inertia on the other hand can be modelled through specifying a dynamic equation for inflation and investigating the role of nominal wage inflation in the econometric model.

In dealing with the complexities present in the high inflation process I propose the specification of a dynamic econometric model comprising a small monetary system. Introducing some notation, let $D_z(\cdot)$ denotes the joint data-density function of a vector with n observable real random variables $\mathbf{Z}_t = (z_{1t}, z_{2t}, \cdots, z_{nt})'$ for the complete sample we have:

$$D_z\left(\mathbf{Z}_t^1/\mathbf{Z}_0, \mathbf{Q}_t^1, \phi\right) \phi \in \Phi \subseteq \mathbb{R}^n \quad (1.1)$$

[2] It should be notice that this is a specific statement that can be corroborated by rejecting parameter stability in the specified econometric model.

Equation (1.1) is the Data Generation Process (DGP) where $\mathbf{Z}_0$ represents the initial conditions and $\mathbf{Q}_t^1$ the set of deterministic conditioning variables (constant, trend, seasonal dummies). The DGP is then sequentially factorized into:

$$D_z\left(\mathbf{Z}_t^1/\mathbf{Z}_0,\mathbf{Q}_t^1,\phi\right)=\prod_{t=1}^{T}D_z\left(\mathbf{z}_t/\mathbf{Z}_{t-1},\mathbf{Q}_t^1,\theta\right)\ (1.2)$$

Where $g(\phi)=(\theta_1,\theta_2,\cdots\theta_T)$ is a one to one function in such way that θ_t might not be constant over time. From the theory of reduction, see Hendry (1995) there exists a local DGP characterized by the Haavelmo's distribution derived from $D_z(\bullet)$ assuming that the following partition holds $\mathbf{Z}_t^1=\left(\mathbf{W}_t^1,\mathbf{Y}_t^1\right)$ which is given by:

$$D_Y\left(\mathbf{Y}_T^1/\mathbf{Y}_0,\Lambda_t^1,\phi\right)=\prod_{t=1}^{T}D_y\left(\mathbf{y}_t/\mathbf{Y}_{t-1}^{t-s},\mathbf{D}_t,\lambda\right)\ (1.3)$$

The econometric model $\mathbf{f}(\bullet)$ is postulated and implicitly is derived from $\mathbf{z}_t$ which is assumed to characterize the economy under analysis:

$$\mathbf{f}_y\left(\mathbf{Y}_T^1/\mathbf{Y}_0;\xi\right)=\prod_{t=1}^{T}\mathbf{f}_y\left(\mathbf{y}_t/\mathbf{Y}_{t-1}^{t-s};\xi\right)\ (1.4)$$

In general $\mathbf{f}(\bullet)\neq D_y(\bullet)$ and inferences about ξ must consider such differences. Chapter 4 discuss in details the reduction entailed from equation (1.1) to equation (1.4) following the London School of Econometrics (LSE) methodology adopted in deriving the empirical model used for modelling the high inflation period in Brazil. Following Hendry (1995) the theoretical framework is the inter-temporal optimization by rational agents in jointly modelling systems of relationships of the form:

$$E\left[\mathbf{A}(L)\zeta_t\,|I_t\right]=0\ \ (1.5)\ \text{where}\ \mathbf{A}(L)=\sum_{r=0}^{k}\mathbf{A}_r L^r$$

I assumed nevertheless that economic theory offers the initial framework but contrary to the approach in chapter 3 no empirical counterpart of a theoretical model is imposed on the data giving field to the criticism implicit in the **empirical modelling** approach exclusively based on Cagan's theoretical model and its limitations in describing inflation dynamics in Brazil. Chapter 4 also provides a discussion about this specific question relating the results obtained in chapter 3 with respect to the methodology.

Chapter 5 presents the results obtained in modelling the high inflation period in Brazil. The sample is divided into three different periods with the reasons for adopting such strategy being extensively discussed in the first section of the chapter. The other three sections, namely 5.2, 5.3 and 5.4 present the results in the econometric modelling for the three periods respectively.

In section 5.2 I analyse the first period starting in 1980 and going through February 1986 the month before the first stabilization plan casting. Despite it having been extensively studied in the literature as mentioned above some new features are explored. I explore also the impacts of the second oil prices shock plus the impacts of the balance of payments adjustment and the constant surplus in the trade balance that in conjunction with a monetary policy that only accommodated the demand pressures generated the spiral of the inflation rates as discussed in chapter 2.

Section 5.3 presents the results for the second period which starts in March 1986 and goes until June 1994 the month before the last plan starting. A long run money demand equation is identified with the same specification as that derived in the first period a remarkable result in the sense that in the 1980s a debate in the literature took place with respect the instability of the money demand in Brazil and for the period under analysis and under conditions of high inflation it seems that there is no result published in the literature that presents a money demand equation. The proposed econometric model correctly describes a negative effect reflecting the sequence of stabilization plans, whereas in the long run it shows increasing rates which dominated the period as a whole.

Finally section 5.4 presents the results for the third period starting in July 1994 and going through February 2002. A long run money demand equation is identified with a similar specification as those observed in previous periods. I explore in this section also the hypothesis that under stabilization observed in the period and with the central bank resuming a more active monetary policy control of the interest rates would have a negative impact on inflation in both the long run and in the short run. A second hypothesis addressed is the long run neutrality of money in the sense that a loose monetary policy and consequently an increase in the industrial output would lead to accelerating inflation rates only.

Chapter 6 extends the initial results obtained in chapter 5 comprising three sections and using the same structure present in chapter 5, namely one section for each period under analysis. The motivation is to test if the results obtained in chapter 5 are robust to extensions in the information set comprised in relevant theoretical hypotheses not included in the analysis previously. In particular I focus on the administered exchange rate policy followed by the Brazilian Government in the first half of the 1980's and nominal wage inflation impact on price dynamics. Such interest is justified in the first case because the Brazilian government adopted an administered policy of exchange rate devaluations and Durevall (1998) found a central role for a very close relationship in price dynamics. In the second case the generalized indexation present from prices to wages was assumed as the main force behind the inflationary spiral that started in 1986. A theoretical model based on Novaes (1991, 1993) and addressing the indexation from prices to wages is tested on the data by imposing the restrictions implied by the theoretical model on the econometric model.

Concerning the third period I test also the hypothesis that after the price stabilization reached with the Real Plan and the end of the widespread use of indexation in the economy, wage inflation should not play any role in the equation for price dynamics.

Finally chapter 7 presents the conclusions and suggestions for further developments in the empirical modelling.

Chapter 2

High Inflation and Stabilization in Brazil

The economic history has several examples of economies that experienced very high rates of inflation during relatively short periods defined in the literature as hyperinflations. In his seminal paper, Cagan (1956) defined a threshold characterizing hyperinflation as inflation rates above 50% per month. Considering the Cagan's limit the Brazilian economy only experienced a very brief hyperinflation from December 1989 to March 1990 as we can infer from figure 2.1 where we plot the first difference of the logarithm of the monthly Consumer Price Index (CPI) as defined in Juselius (2002) for the period from January 1980 until June 1994. Nevertheless, using the definition of high inflation as in Fischer et al (2002); namely those episodes when the accumulated annualized inflation crosses the 100% and only ends when it stays below this level for more than one year, the high inflation in Brazil lasted 15 years and 2 months (1980-1995) and reached 20,759,903,275,651%.

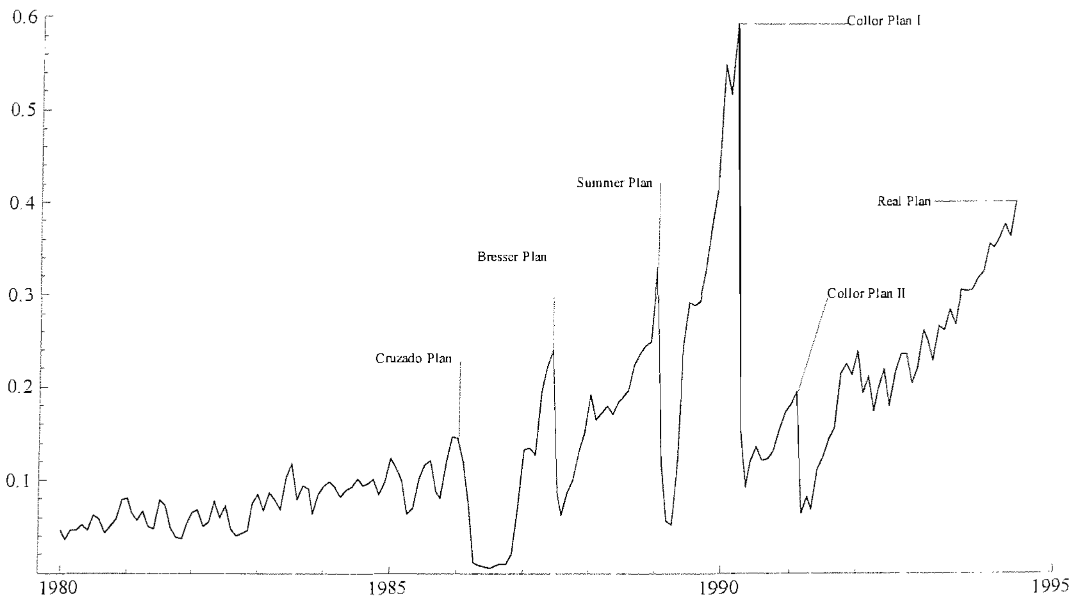
This false impression of an economy that did not face a hyperinflation was given by the sequence of stabilization plans after a period of constant increase in inflation rates during the first half of the 80's. The first of these plans, namely the Cruzado plan, started in March 1986 and was followed by the Bresser plan in July 1987, the Summer plan in February 1989, the Collor plan I in April 1990 characterizing the end of the hyperinflation period, the Collor plan II in February 1991 and finally the Real plan in July 1994. This sequence of plans accounts for the presence of valleys observed in the inflation rate, usually followed by a period of increasing inflation but without leaving the impression of a hyperinflation as in the classical episodes of the economic history.

Considering the sequence of plans implemented and their successive failures, I divided the high inflation period into two shorter periods for the purpose of the analysis presented in this chapter. The first period ranges from the beginning of the eighties up to the Cruzado plan launching in March 1986. The second period starts with the

Cruzado plan and lasts until the Real plan implementation in July 1994, which was the landmark of the end of the high inflation period as a whole.

This subdivision follows also the major monetary reforms implemented with the Cruzado plan and the Real plan. Indeed, with the Cruzado plan launching in 28 February 1986 a new currency, named Cruzado replaced the old Cruzeiro and all prices were frozen. This reform was the first attempt to fight the soaring inflation rates since 1966 and could be considered a landmark given that it was implemented by the first civil government since the military dictatorship started in 1964[1].

Figure 2.1 Brazilian Inflation Rate (CPI) 1980-1994/6



In figure 2.2 we present the inflation rate as calculated in figure 2.1 but for the immediately posterior period, namely from the first month of the Real Plan in July 1994 and the end of the sample data in February 2002. Disregarding the first month of the plan when the price index clearly carried out a residual inflation the stabilization reached is unquestionable when compared to the first two periods.

[1] Between the Cruzado plan and the Real plan, there were again three monetary reforms. The first one with the Summer plan launching which changed the currency from Cruzado to Cruzado Novo (new Cruzado). However, this in practice only meant a drop of three zeros in all prices aiming to restore the unit account function to the new currency. The core measures adopted were, nevertheless, quite similar to those implemented with the Cruzado plan do not representing a major change in the conducing of the monetary policy, as we shall discuss. We therefore opted for skipping this monetary reform. The second monetary reform took place with the Collor plan and the end of the hyperinflation from the Cruzado Novo to the Cruzeiro and finally the third one with the Collor Plan II from the Cruzeiro to the Cruzeiro Real. I skip them by arguing that the last two were merely an attempt to restore the unit of account function to the currency.

This chapter has the objective of presenting a brief stylized analysis of these major three periods. Its motivation lies in presenting the reader with a discussion about the major stabilization plans that took place and their possible links with the economic literature available in the period providing then an institutional background for the analysis of the econometric models derived in the following chapters. In doing so, it aims to link the empirical results obtained to the major facts and the conceptual analysis present in the literature for each one of the stabilization plans. The chapter is divided following the broad periods mentioned above, so in section 1 I analyse the first period, namely from 1980 until the Cruzado Plan launching in February 1986. In section 2 the second period between 1986 and the Real Plan launching in July 1994 is discussed. Finally in section 3 I discuss the Real Plan main measures and their connection to the econometric analysis pursued in chapter 5.

Figure 2.2 Brazilian Inflation Rate (CPI) 1994/7 – 2002/2

2.1) High Inflation and the External Crisis

The economic policy in Brazil in the first half of the 1980's was characterized by two phenomena that imposed drastic changes to its conduction, namely the external debt crisis and the rise in inflation rates.

The second oil price shock in 1979 hit the Brazilian economy in a moment that the policy maker's strategy was concentrated on providing a continuity solution to an ambitious plan of investment that had as the main objective the substitution of imports through fast increase in the levels of industrialization. Such strategy had its roots in the first oil shock in the 1970s when the policy followed by the dictatorship government was not to produce the necessary adjustment in the relative prices of oil and its derivatives given perhaps its large political cost. Instead of pursuing an adjustment policy, the government launched a set of long run targets for industrialization based on the import substitution model made available by the relative easy access to foreign capital. Such substitutions would accordingly lessen the pressure in the trade balance. When the oil prices doubled in 1979 and the foreign interest rates started to rise, the availability of external funding to finance the deficits in the trade balance decreased and the government was confronted by the only option of facing a costly internal adjustment since this long run plan of investments in import substitution had not yet been totally materialized. The strategy followed was then to produce a negative shock in the aggregate demand through an increase in the oil derivatives price and through credit reduction, more specifically in reducing credit ceilings for consumption. Further incentives to the export sector were implemented with special attention in developing a specific credit policy for the agricultural sector.

The expected overall result of such actions was to reverse the trade balance deficits through redirecting this reduction in the domestic absorption to exports. In terms of the reducing the trade balance deficits the strategy can be considered successful from its start in 1980. The country experienced successive surpluses from 1981, with a US$ 1 billion surplus approximately, until 1985 with a surplus of US$ 12 billion. The figures in terms of the consequent recession was a sharply decline in the industrial output of 10% and in 1981 the first decline in the real GDP since the Second World War.

When considering the capital account the lack of external funding represented the major constraint mainly after the Mexico default of its external debts in August 1982 to such extent that up to 1984 the country experienced large deficits in the balance of payments despite the fast increase in the trade balance surplus.

The followed route to deal with the soaring costs of the external debt was a policy of financing these payments through the trade surpluses whilst the purchase of necessary reserves in foreign currency was done through issuing (internal) debt and printing money as pointed out in Cardoso (1992).

In this respect, the general result of the policy adopted was a change in the main source of funding from the external debt to the internal debt. Such redirection in the source of funding of the Government's debt coincided with the deterioration in the Government savings throughout the 1970s and to some extent was the cause of that from the 1980s onwards.

Table 2.1 M1 and M2 Ratios to the GDP 1980-1993

YEAR	$^*M_1/GDP$ (%)	$^*M_2/GDP$ (%)
1980	8.51	13.53
1981	7.49	14.20
1982	6.81	15.25
1983	5.59	13.79
1984	4.28	13.18
1985	4.03	16.77
1986	8.67	20.01
1987	4.94	17.46
1988	3.14	17.30
1989	2.36	20.08
1990	3.72	9.41
1991	3.04	8.93
1992	2.15	15.31
1993	1.67	14.47

Source: Calculations from the author. *The figures are calculated as the following:

$$M_K/GDP = \left\{ \left[\left(\sum_{i=1}^{12} M_{KT}(i) \right) \Big/ 12 \right] \Big/ GDP_T \right\} * 100 \; where \; T = 1980, \ldots, 1993 \text{ and } K = 1,2.$$

The root of this deterioration is traced back to the investment policy pursued by the Government that as discussed above turned to be the only policy able to sustain the political support for a non-democratic government[2].

Indeed the deterioration of the public finances appeared as a consequence of the government objectives of inducing GDP growth rates of 10% a year following a loose fiscal policy from 1975 until 1979. (Carneiro, 1990).

The combination of lack of adjustment in the public finance and the second oil shock were possibly the main determinants of the soaring rates of inflation in an environment of widespread use of indexation.

The government incapacity to produce an adjustment in its fiscal imbalances launched the seed for the high levels of inflation observed in the future years. According to Garcia (1996) the existence of a reliable currency substitute endogenized the money supply and price increases were simply accommodated with more money supply.

With the increase in inflation observed from 1980 onwards, the economic agents started to economize in their holding of currency to such extent that the ratio M1/GDP in 1984 was half of its original value in 1980. This change in pattern in holding money is followed usually by increases in holdings of foreign currency or non-monetary assets such as historically other hyperinflationary episodes show. In the Brazilian case, differently, the issue of bonds gained momentum given the fiscal imbalances of the government and the external crisis in the beginning of the 1980s as can see in table 2.1 where I present the ratio of the annual average values of M1 and M2 stock to the GDP expressed in per cents[3]. The fast increase in the M2/GDP ratio from 1980 until 1982 contrasts with the reduction observed in the M1/GDP ratio and shows how the process of substitution took effect. Within this context of currency substitution, the Brazilian Central Bank role was to pursue an unusual target of assuring liquidity in the bonds market creating therefore the reliable currency substitute funded by public securities.

The policy focus was to avoid any losses incurred by the banks in holding securities. Such losses would come from the fact that with such low levels of money in

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[2] It is worthwhile to contextualize here that in the Brazilian case the Government investment is the main component of the gross domestic investment so the long run investment plans represented a central point in keeping the economic growth, which for instance was central for political support. In 1975, for example the public sector demand represented as a whole 20.3% of the GDP.

[3] M1 is defined as money held by the public plus cash deposits into current accounts and M2 is defined as M1 plus deposits in savings accounts, private securities, quotas of fixed income funds **and operation committed with federal securities.**

circulation the risk faced by the banks in their normal operations rose substantially. In this setting whenever an agent had written a check its bank had to sell government bonds in the market to comply with the demand for money. Such operation becomes increasingly risky in environments of high inflation given the losses imposed by the inflation rate and the uncertainty about the interest rates. To overcome this risk the Central bank followed the policy of avoiding any losses by financial institutions through continuing and massive interventions in the market injecting money in the monetary system to guarantee stability.

According to Garcia (1996) the provision of the currency substitute endogeneized the money supply and created an automatic mechanism of sanctioning to any increase in money demand. Consequently, any price shock in increasing the demand for money would be followed by an increase in supply validating the original price increases and being forwarded given the indexation. Indeed this policy had been followed since the 1970s, however the change imposed by the Mexican crises and the second oil shock switched the main sources of government from external financing to the internal debt financing only leading the central bank to lose control of the whole process and consequently of the monetary policy which became passive . It is worth noting that the root of the inflationary process is linked to the fiscal imbalances of the government being financed not through printing money but through a monetary policy that was validating the inflation expectations in an economy where indexation is present.

The argument of fiscal imbalances as the main source of inflation appeared though not to be the dominant one in the literature at that period when authors like Arida and Lara-Rezende (1985) argued that inflation in Brazil was essentially inertial since there were no fiscal imbalances in the government budget when measured by the operational deficit. In this case, inflation would follow a relatively independent process being driven by its own past and consequently insensitive to demand policies (Novaes, 1993). The widespread use of indexation had created a feedback mechanism that was responsible for the propagation of adverse shocks in the economy.

The underpinnings of this hypothesis are found in the following two features of the economy. Firstly, the institutional arrangement in readjusting wages based on past inflation (backward looking) with staggered contracts (twice a year). Secondly the empirical findings in Modiano (1983) and Lopes (1982) showed a low response of inflation to the output gap contrasting with the results obtained by Contador (1977) who states that there exists a significant trade-off between non-anticipated inflation and unused output capacity. Consequently, given a negative supply shock in the economy the immediate response would be an increase in prices (Durevall, 1999). In this case adopting tighter monetary policies accompanied by a more restrictive fiscal policy would not result in a reduction in the inflation rates because of the presence of indexation in wages and prices preventing prices from following a descending path. A change in the mechanism through which shocks in prices were transmitted to wages and in the sequence to prices again is therefore necessary to overcome the hampering mechanism represented by the indexation. Indeed, given that inflation is fuelled basically by its own past, a solution accordingly is to depart from the widespread use of indexation in the economy by changing the institutional arrangements in wages, prices and contracts that have such mechanism in their composition which are defined as non-orthodox measures.

The argument that inflation was insensitive to demand policies originated in the increase in the inflation rates despite the contraction imposed in the aggregate demand in 1983 as a result of the external constraints following the Mexican crisis. Whilst this argument is empirically verifiable, the period cannot be characterized also by a commitment of the government with reducing its fiscal imbalances. Further the monetary policy pursued in 1983 and 1984 by resorting in the internal debt led to a shortage of resources in the market and consequently increased the interest rates. Such rise in the interest rates increased the risk for the banks leading the central bank to inject money in the system with the amount jumping from US$610 million in December 1983 to US$ 1.6 billion in the first two months of 1984. Therefore, any contraction observed in the monetary base was followed immediately by an expansion to finance the debt generated as pointed out in ANDIMA (1997) and theoretically in Garcia (1996).

Nevertheless the inertial approach predominance is evident when we consider the sequence of stabilization plans implemented from 1986 onwards as discussed in the following section.

2.2) Fighting High Inflation: The Stabilization Plans 1986-1994

The alleged lack of response in the inflation rates to the demand policy measures implemented to adjust the external imbalances led some authors to question if the high inflation in Brazil would have the same causes as in the classical hyperinflation episodes. The theoretical and empirical models developed were focused in explaining inflation as a process linked not only to the trade off between output gap and inflation expressed by the Phillips curve but also to the price dynamics in conditions of external shocks and a wage policy based on periodic adjustments following past inflation.

In the political arena, an important institutional change took place in 1985 when the first civil government took power after 21 years of military dictatorship. The options to the policy makers were nevertheless limited in terms of fighting the soaring rates of inflation that reached more than 10% a month in the first months of the new government.

The political coalition that took power had its actions limited in terms of adopting the severe measures necessary to correct the fiscal imbalances with the president's death in April 1985 and in the middle of a political crisis, the vice-president took power. The sort of measures that would represent the necessary reductions in the nominal deficit was interpreted as extremely costly for a new government in a country where the democratic institutions were incipient and the political parties fragmented. The theoretical support provided by the inertial approach represented in the political context the best response to the traditional measures without incurring the costs of low rates of growth in output and higher rates of unemployment that were politically unbearable.

The economy's recovery from the recession in 1981 led by the exporting sector represented the stabilization of the balance of payments accounts with monthly surplus in the trade balance of US$ 1 billion and reverted the 1979-1983 external constraints. Under these conditions, the Cruzado plan was cast in 28 February 1986. The core measures were based on the diagnostic that inflation was inertial and that a shock in the expectations would bring down inflation. This diagnostic would indeed prevail in the following attempts, namely the Bresser and Summer plans as well, despite the sequence of failures represented by each one of them. Below a summary of the main measures adopted in each one of these plans is presented.

Cruzado Plan:

1. Price freeze at the levels in effect on 27/02/1986;
2. Monetary reform changing the currency from Cruzeiro to Cruzado;
3. Increases in wages, salaries and earnings in general followed an annual pattern and after the first collective bargain wages would be readjusted automatically whenever accumulated inflation had reached 20%;
4. Exchange rate fixed in effect on 03/03/1986;
5. Table of conversion created for converting any payment obligation expressed in Cruzeiros with no preset monetary indexing clause reducing inflation expectations built in the contracts;
6. Prohibition of monetary adjustment clauses in contracts with terms of less than one year;

Bresser Plan:

1. Ninety days price freeze as in effect on 12/06/1987;
2. Price Unit of Reference (URP) creation as reference for price and wage alterations defined as the monthly average rate of growth in prices from the immediately previous quarter in effect on each month of the subsequent quarter;
3. Exchange rate devaluation of 9.5% in effect on 16/06/1987 and implementation of a crawling peg regime;
4. Creation of a conversion table similar to the Cruzado plan for both contracts without monetary indexing clause and those with a preset monetary clause;

Summer Plan

1. Price freeze at the levels in effect on 14/01/1989;
2. Salaries, wages and earnings in general were altered by the real average for 1988 in effect on February 1989;

3. The exchange rate was devaluated on two occasions by 16.38% on 16/01/1989 and by 11.89% on 03/07/1989;
4. Creation of a conversion table similar to the Bresser plan, namely for both contracts without monetary indexing clause and those with a preset monetary clause;

As can be inferred from this brief summary the first three plans shared the reliance on non-orthodox measures for fighting inflation. The core of these plans was the price freeze and measures trying to rearrange the price adjustment periodicity in institutional terms. The diagnostic was that the government had no fiscal imbalances when measured by the operational deficit that excludes both the interest payments on government debt and the monetary correction from the nominal deficit, so the main cause of inflation was inertia. In none of these plans, the core measures were centred in dealing with the fiscal imbalances or changing the monetary policy followed by the Central Bank in minimizing risk in bank operations as discussed in the previous section.

With the Cruzado plan failure, it became clear that inflation in Brazil had a more complex pattern than the inertial hypothesis would account for and that the appeal of reducing inflation rates without incurring in the costs of tight fiscal and monetary policies was flawed. Indeed the presence of inertia in inflation caused by indexation in all sorts of contracts and prices as assumed explicitly in the Bresser plan with the URP readjusting factor was a fact – and any econometric model that attempts to model this period should reproduce the inertial pattern observed in the inflation rates. Nevertheless, the persistence in using the non-orthodox measures as described above can be explained only by the government inability in coordinating the political forces to support the necessary corrections in the fiscal imbalances and their costs. It is remarkable that from 1985 the rate of total taxation burden to the GDP has been reduced from 15% in the 1970's to less than 10% from 1985 onwards whereas nowadays when inflation is stabilized it is around 35%.

In particular, the Cruzado plan was relatively the most successful by keeping inflation under control for longer periods than the other two. The initial success led to a monetization in the economy. In numbers, the rate of growth in real money between November 1985 and November 1986 was 185% reverting temporarily the currency substitution process initiated in 1980 as shown in table 2.1 with the M1/GDP ratio in 1986 being twice that observed in 1985.

The result in terms of inflation rate was an immediate slump from rates about 14% per month, in January 1986, to rates around zero by April. However, the price freeze led to a shortage of goods in the market by July 1986 since the monetary policy coherent to the political aims of keeping high levels of output growth set the interest rate below the international level. This policy implied a redirection of resources from financial assets to real assets and by January 1987, inflation had reached the levels observed before the Plan launching. It is worth noting that the fiscal and monetary policies followed a discretionary pattern without any previous commitment by the time of the plan launching.

The Bresser plan intended not to repeat the same mistakes observed in the Cruzado Plan and this time it comprised the creation of a reference factor, namely the URP for price and wages alterations following the experience of commodities shortage of the Cruzado Plan. The plan also comprised a fiscal adjustment that never materialized and a monetary policy pursuing positive real interest rates with the objective of controlling the demand pressures observed in the previous attempt when after the price freezing agents facing negative real interest rates opted for real assets. Nevertheless, given the lack of political support for adjustments in the fiscal deficit the inflation rates soared reaching levels never observed before by the end of 1988 as we can observe from figure 2.1. Indeed the length to which the measures took effect was far shorter than in the Cruzado Plan. By October 1987, the inflation rate had already crossed 10% per month, so in practice the Bresser Plan could only control prices for three months.

With inflation rates nearby 30% per month by January 1989, the Summer plan was launched in February. A tight monetary policy was followed with interest rates raised above their historical level, however, once more the measures aiming to recover the public sector savings did not materialized due lack of political support and the impact in terms of inflation rate was even shorter than the previous two plans due the lack of credibility in the measures adopted. Further, the M1/GDP ratio decreased to only 2.36% intensifying the currency substitution process as the inflation soared.

The credibility in the monetary system as a whole was at risk with the high cost imposed by the high levels of nominal interest rates in the presence of such low levels of bank reserves. Under pressure, the Central Bank intensified the process of currency substitution and the ratio M2/GDP reached its highest value implying also the highest level of indexation observed in the economy in this period with the widespread use of indexed money represented by the government's bonds, which were negotiated in shorter and shorter periods as long as inflation soared. The inflation rate remained in control for only two months reaching 30% a month again by June 1989 and the country experienced a hyperinflation using Cagan's definition with a maximum rate of approximately 80% per month by the end of 1989. The hyperinflation episode exposed the government political fragility and passive attitude in the face of the presidential election campaign.

The new government took power and given the hyperinflation implemented the most radical of all the stabilization plans in March 1990 having as a core measure the embargo of financial assets with the imposition of ceilings in releasing these assets for a single holder of them at the same financial institution. The values above this ceiling were converted in 12 monthly instalments as of September 1991 earning monetary correction – fixed by the government – plus 6% a year interest. This measure in conjunction to the mandatory lengthening of the average terms of securities represented a considerable lengthening to the public debt apparently solving the short-term maturity of the public bonds that resulted from or caused the hyperinflation and the use of these bonds as a currency substitute.

The plan also included the classical measure of price freezing but the exchange rate regime implemented was the floating one. The wage policy adopted was discretionary with the ministry of finance in charge of setting the minimum monthly percentage growth but wage increases above this minimum being negotiated freely. The plan also innovated in implementing measures that aimed to restrict the presence of the state in the economy through deregulation and privatizations.

The diagnostic that supported the financial embargo was the excess of liquidity in the economy as the figures for the ratio M2/GDP in 1989 shows. However, to the best of my knowledge the plan had no support in any theoretical model in contrast for example to the inertial inflation hypothesis that supported the Cruzado plan and had been discussed in the literature. The immediate result was a slump in the inflation rates and the end of the hyperinflation using the Cagan's concept. Nevertheless the lack of liquidity not only implied a recession but also caused instability in the financial markets to such extent that the government was forced to readdress its liquidity contraction policy with M1 growing approximately 35% in April and 36% in May and M2 41% and 24% respectively.

However once more the central cause of inflation namely the fiscal imbalances were not addressed and despite the radical measures implemented the Collor plan failed in its attempt to reduce inflation. The monthly inflation rates reached 10% in June 1990 and by the end of the year were around 20%.

The inflation return led then the Government once more to resort to a set of non-orthodox measures trying to control the soaring rates of inflation. The Collor plan II was launched in January 1991, therefore less than one year after the Collor plan, and had as a core measure the price freeze a new wage law controlling the wages and salaries increases and the use of a table of conversion similarly to the Cruzado plan. The result as expected was a short-term decline in the inflation rates to a posterior acceleration. The reasons for another failure were the same for the other plans; no attempt was made to solve the underlying cause of inflation, namely the fiscal imbalances.

However, the Collor Plan II suffered also from lack of confidence remarkably increased after the unusual measures took in the Collor plan that proved to be completely fruitless. The political crisis that ended with the president Collor stepping down in December 1992 to avoid his impeachment after a long legal battle in Congress only contributed to reduce the agent's support to this sort of intervention that also for obvious reasons had reached a saturation point.

The economic policy followed in 1991 and 1992 was centred on keeping the real interest rates positive trying to control the pressures in the system liquidity originated in the Collor plan with the restitution of the amounts arrested in the financial embargo.

Overall the main lesson that come from this sequence of stabilization plans was that the hypothesis of inertia being the main cause of inflation in Brazil was misleading although it cannot be disregarded that it constituted one component in the inflation dynamics to such extent that any stabilization attempt must consider measures to break up indexation. In this sense, any stabilization attempt aiming to be successful in reducing inflation should then consider not only the hypothesis of breaking up indexation – the inertial component in inflation – but also fiscal imbalances and consequently a reduction in the fiscal deficit. The way to deal with the indexation nevertheless had to differentiate from the price freezing and the distortions caused in the relative prices to its implementation. The sequence of prices freezing imposed, in conjunction to the high rates of inflation, distorted largely the relative prices and proved to be innocuous in fighting inflation since their credibility was affected by the uncompromised fiscal policy.

An alternative route to follow was the introduction of a new currency using a nominal anchor that would circulate in parallel to the old currency. Once the agents had realized that the new currency was reliable, they would migrate voluntarily to the indexed one as the account unit for prices and contracts in general. This first step would then break up the indexation and, once it had been completed, the central bank could enforce legally the new currency without imposing any disruption in the contracts and without distorting the relative prices that would anyway be expressed in the new currency. Such solution to the indexation problem had already been considered in Arida and Lara Resende (1986) before the Cruzado plan launching as an alternative to the price freezing. However, the short run benefits of the price freezing seemed to be more suitable to the new civil government that took power in 1985 and the solution incorporating the two currencies circulating in parallel was delayed for 9 years until the Real plan launching in July 1994.

2.3) The Real Plan and Price Stabilization

The Real plan had the legal starting point as July 1994 when the new currency, namely Real substituted the Cruzeiro Real. However, its core measure was the introduction of a parallel indexation mechanism from March 1994, namely the Real Unit of Value (URV) fixed by the Brazilian Central Bank and that followed an estimated value based on three different price indexes performing the role of unit account in all contracts by voluntary adherence. During this period, the country followed a two-currency standard with both the URV and the Cruzeiro Real being legally acceptable.

The government initiated this process by converting the social securities benefits and contracts involving the public sector. This indexation scheme was completely opposed to past attempts in the sense that there was no attempt from the government to break up indexation by mechanisms such that price freezing that had caused large distortions in relative prices in the past. On the contrary, the new indexation scheme had as main objective to reintroduce the unit account function through a legal instrument that would be legally acceptable and carry on this function to the new currency. The difference now is its neutrality with respect to the relative prices since this unit account was launched before the new currency.

In the past plans, the new currency assumed this function by imposition on the day of the plan launching and the legislators tried to overcome the income distribution that resulted through specific legislations for the different prices. With the URV the agents had the time to rearrange the prices using the unit account before the new currency had assumed its unit account function. The hypothesis was that agents would accept the new currency, which would have a fixed parity to the URV as soon as they realized that the new currency would correspond to a reliable store of value – a result of the Gresham's law. The URV expressed the relative prices and performed a protection against the inflation and once this had been in place the following step was obviously change the monetary standard to the URV through a new currency that had the parity one URV to one Real.

The URV implementation solved then the problem of breaking up the indexation rules without imposing changes to relative prices in the sense that all agents by July 1994 had migrated to the new indexation scheme. From this point onward, the new currency could be launched provided it had the property of being a reliable substitute to the old Cruzeiro Real in the sense that the government would not repeat the Cruzado, Summer and Collor past experiences by simply changing the monetary standard. The credibility was associated in the Brazilian case with the use of the exchange rate as the nominal anchor, which had been argued as a superior alternative to the use of monetary aggregates in Arida and Lara Resende (1986) original paper.

The external scenario was favourable to its use in the sense that from 1992 the Brazilian Central Bank followed a policy of increasing the foreign reserves concentrated on a tight monetary policy with interest rates raised above the international levels and a successful plan to restructure the foreign debt allowing the return not only of foreign direct investment but also of foreign risk capital. This restructuring program also involved a privatization program and a trade liberalization program by reducing the fiscal barriers to international trade intensified after the Real plan launching.

In conjunction, such measures implied a substantial accumulation of foreign reserves that reached US$ 41 billions by May 1994 resulting, by the time the Real plan was launched in July, in an appreciation in the exchange rate with the new currency being overvalued with respect to the US dollar. With the exchange rate reaching R$ 0.85/US$ in September 1994 a shock of credibility took effect in the new currency. The opening up process exerted a downward pressure in the price index for tradable goods bringing down the final inflation index to very low rates when compared to the old currency despite the pressures posed by the non-tradable price index.

Differently from Argentine that adopted a currency board, in Brazil the monetary authorities opted to follow a crawling peg regime imposing bands to the currency devaluation/appreciation. This new regime produced the credibility shock necessary for the posterior break up indexation through legal measures that included the removal of all monetary units of account applied also to states and municipalities. These different units of account were unified in a single unit and the periodicity was settled initially in a quarterly basis for 1995 and in a half a year basis as of 1996.

In terms of the fiscal imbalances, the initial measures were taken in the immediate action program even in 1993 comprising among other measures a spending cut of US$ 6 billion, the creation of a new tax, namely the provisional tax on financial transactions and an emergency fund constituted by an act releasing some tied up expenditures to discretionary policies[4].

The diagnostic that led to these preventive measures was that the largest part of the total government expenditure was not indexed whereas the total revenue was. The indexation in the Brazilian case worked in favour of revenues with the widespread use of unit accounts similar to the URV to sustain the revenues whereas the expenditure was largely nominal, namely a decreasing function of inflation. Such difference explains why there were not high levels of operational deficits during the high inflation period whereas the nominal deficits reached levels around 40% of the GDP. The difference also explains why after each stabilization plan the fiscal imbalances were exposed and without changes in the expenditure, the inflation return was inevitable. In regimes of low levels of inflation and in the presence of tied up nominal expenditures the easiest option is to generate inflation at such levels that the indexed revenues equalize the expenditures.

The immediate action program in conjunction with the nominal anchor for the new currency produced the level of credibility to guarantee price stability in the

[4] This new tax constituted a levy on each debt transaction in any financial operation, e.g. any time one withdraws money from the cash machines or writes a cheque the debited account must pay a 0.38% levy on the total amount.

transitional phase of the plan, namely from the initial point until the new government take power in the beginning of 1995 after the political crisis that culminated with president Collor stepping down in December 1992. The new government political support to the new plan was guaranteed to the extent that the minister of finance during the immediate action program was the new elected president, so a continuity solution was found in the political arena.

The monetary policy initial goal was to accommodate the pressures imposed in the money demand with the end of high rates of inflation. A similar phenomenon had taken place during the Cruzado plan followed by an explosion in consumption, a natural result in the presence of an abrupt reduction in the nominal yields for saving accounts and fixed income bonds.

The consumption bubble represented a serious threat to the Cruzado Plan to the extent that the economy's opening up process had not taken place and the demand increase in a closed economy exerted an extra pressure on the aggregate demand generating inflation. On the contrary, with the Real plan, the opening up process had already taken place being only deepened and the tight monetary policy aiming to sustain the new currency overvalued prevented the pressures on the aggregate demand being forwarded to the consumer's price indexes but at the cost of generating trade balance deficits.

The trade balance deficits resulted in consequence of the use of foreign goods competition to balance the increase in consumption and avoid the Cruzado plan error. However, this policy represented also an extra source of pressure in the balance of payments through the successive deficits in the trade balance. The high levels of real interest rates were used to balance the pressure from the current account but resulted in an exchange rate artificially overvalued creating further pressures in the trade balance. Initially this policy had the immediate effect of reducing inflation. However, the strategy relied strongly on the availability of external funding to finance the disequilibria in the current account. Therefore the balance of payments behaviour and in particular the capital account directed from the Real plan launching the monetary policy actions with the availability of external funding to finance the successive deficits in the balance of payments imposing the limits to these actions.

The first reversal in the influx of foreign capital happened in March 1995 because of the Mexican peso fluctuation initiated in December 1994. The speculative attack represented a foreign investments withdrawal in the short run that totalled a deficit in the capital account of US$ 2.053 billions in March. An immediate raise in the basic interest rates that doubled in nominal terms and a small devaluation –around 5% – in the exchange rate took place. This first speculative attack a few months after the plan launching showed clearly the limits of the monetary policy. In the context of a small open economy like Brazil following a crawling peg regime, the exchange rate cannot be controlled without the monetary policy becoming endogenously determined. Similar speculative attacks took place in October 1997 – when the deficit in the capital account totalled US$ 4.493 billion because of the Asian crisis with the interest doubling in nominal terms again – and in January 1999 when the deficit in the capital account totalled US$ 5.379 billions. The last attack resulted in the end of the crawling peg regime with the Real fluctuating henceforth totalling on average a nominal devaluation of 24% in January and 27% in February.

The Real plan also constituted a rupture to the past main objective of avoiding the bank losses in holding securities as discussed in section 2.1. After the plan, the objective turned to sustaining the crawling peg regime exposing the financial system fragility as a consequence of the reduction in non-operational revenues. A successful program of incentives to the restructuring and strengthening of the financial system was launched in March 1995 avoiding a crisis in the system.

Following the end of the crawling peg regime and the change in the inflation targeting significant changes in the fiscal and monetary policies took place.

With respect to the fiscal policy a set of macroeconomic measures known as the macroeconomic stability program was launched aiming to reverse the trajectory of the public accounts. In particular, a set of targets to the primary deficit was proposed corresponding to 3.1% of the GDP for 1999, 3.25% in 2000 and 3.35% in 2001 giving sustainability to the new inflation targeting regime in the sense that from 1999 onwards the Real no longer had a nominal anchor. The program also contemplated the fiscal responsibility act in May 2000, which set down norms on fiscal management accountability including a ceiling limit to expenditures on personnel. With the end of the crawling peg regime and the Real fluctuation, the Central Bank regained control of the monetary policy, which became the central instrument in targeting inflation through the Selic rate[5].

The negative impact of the currency devaluation on the price indexes and a possible return in the indexation did not materialize representing therefore the final test for the stabilization program and definitely the end of the high inflation period in Brazil.

2.4) Conclusion

In this chapter, a brief review of the stabilization plans attempted to fight the chronic inflation in Brazil is presented.

The chapter highlights the role of the external crisis that took place in the beginning of the 1980's. The crisis is considered the seed for the soaring inflation rates observed from 1984 onwards on the extent that the government followed an accommodating monetary policy and avoided any adjustment in the fiscal imbalances mainly given the high political costs to a relatively fragile political coalition. Such characteristics of the period are essential in specifying the econometric model in chapters 5 and 6.

The diagnostic that the inertial component of inflation was the main force driving the price acceleration led to the Cruzado plan launching and the chapter explores the role of this diagnostic in the following stabilization plans. The main conclusion is that in specifying the econometric model this component must be addressed despite the successive failures having shown that the diagnostic that prevailed in the Cruzado plan wrongly dismissed the role of the traditional demand components in determining the price dynamics. Such long run properties are explored in chapter 5 where I identify a long run money demand and a long run relationship between the industrial output and the real interest rates. Further, in Chapter 6 I include an extra demand component, namely wage inflation in the econometric model and investigate its role.

Finally, the successful measures adopted in the Real plan are emphasized turning attention to the role of the nominal anchor in stabilizing prices and the end of

[5] The Selic rate is calculated as a weighted average rate of one-day financing operations backed by federal public securities in the form of a repurchasing agreement and therefore excluding the risk of the borrower component.

the indexation, both essential features in interpreting the results obtained in chapter 5. They also drive the analysis performed in Chapter 6 on the extent that I include an analysis based on the purchasing power parity (PPP) hypothesis through extending the econometric model derived in Chapter 5.

Chapter 3

The Cagan Model and High Inflation in Brazil[1]

In this chapter, I present a test of the adequacy of the Cagan model in its rational expectation form to the Brazilian case. The evidence given in Phylatkis and Taylor (1993) and Engsted (1993a) with respect to the Cagan model is positive when considering the period between 1980 and 1986 before the first stabilization plan when in fact inflation rates were moderated[2]. Such results suggest that the Cagan model was a good specification for the money demand even when considering that the Brazilian economy had not undergone huge rates of inflation present in hyperinflation episodes.

Nevertheless, the inflation rate pattern as discussed in chapter 2 led authors like Tourinho (1997) to argue that a valid econometric specification for the demand under high inflation should be based on the assumption that real variables do affect the demand for real money. The author argues that in the Brazilian case the economy experienced a high inflation period rather than a hyperinflation. Therefore, the classical hypothesis that the huge increases in prices and money would dwarf the real factors would not be valid in the Brazilian case.

Tourinho then specified an econometric model based on the Box-Cox transformation for the dependent variable, real money normalized by calculating the ratio of the observed values to their geometric mean of the sample period. The author argued that, using the Box-Cox transformation to the dependent variable, it is possible not only to overcome the problem faced by Cagan (1956) where the effective demand for money during the final months of the hyperinflation was greater than it was

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[1] A version of this chapter was presented in the IX Spring Meeting of Young Economists in Warsaw. The author would like to thank the comments from the discussant and participants in special from Katarina Juselius.

[2] Using the definition of extreme inflation above and considering the broad consumer price index in fact the Brazilian economy had not experienced this phenomenon until the first stabilization plan had been implemented.

explained by Cagan's equation, but also to deal with the periods of low inflation present in the sample.

I diverge from this approach by considering that because of the changes in the monetary policy represented by the Cruzado plan and the Collor plan I it would be more reasonable to think that the rule of how expectations about inflation were formed had changed in these two episodes. Consequently, the analysis could proceed by using these plans as landmarks in the monetary and fiscal policies. Therefore, instead of considering the whole period as our sample, as Tourinho did[3], I sub-divide it following their implementation.

This approach seems more in line with the original arguments exposited by Cagan (1956) where the price expectations have a fundamental role in the model and in describing relatively short periods of soaring prices, which preceded the implementation of monetary reforms. Obviously, that splitting of the whole period as I did imposes an *ad hoc* judgement on the subject. Someone could argue then that the analysis should be carried out considering all the stabilization plans and not only the three as I propose here. This however would imply even shorter periods of analysis than those proposed here limiting the inferences based on the long run properties of the data. Furthermore the measures implemented in each one of the stabilization attempts, between March 1986 and March 1990, were similar in the sense that they were based on the concept of inertial inflation as discussed in chapter 2. Consequently implementing even further sub-divisions in the sample would come with the cost of shorter samples without representing a landmark change in the economic policies, which therefore would have led agents to change their expectations.

These contrasting results lead then to the question: Can the Cagan model describe the demand for real balances for the long period of high inflation in Brazil? This question is raised having in mind that the sequence of stabilization plans could have altered the favourable evidence in the literature by changing the way that expectations were formed since some of these plans represented deep reforms in the monetary system.

The main goal is to investigate this question by testing the model following the approach implemented by Engsted (1993) that investigated the same question but for the German episode. The main contribution of this chapter is then to carry on the

[3] In fact Tourinho's sample is longer than ours since his sample starts in 1974.

empirical analysis for the Brazilian case including the period of stabilization plans. I then contrast my results with those obtained in Rossi (1994) that implemented a similar analysis for a shorter period. I argue however, that Rossi's conclusions were based on a very general assumption about the long run properties of the data and in this sense, the conclusions here are more robust than those obtained by him.

Furthermore extending the sample up to the end of the high inflation period can give us a clearer picture of how the prices evolved since by the end of the period (not included in Rossi's sample) the economy experienced again huge rates of inflation only comparable to those observed in hyperinflations. Indeed all these works have in common the fact that they do not cover the entire period of the high inflation in Brazil. In particular Phylatkis and Taylor (1993) and Engsted (1993a) are concentrated in analysing the data up to the middle of the 1980's whereas in Rossi (1994) the sample ends in 1993 and indeed the high inflation lasted until July 1994 when the Real Plan is launched.

Further Rossi (1994) has based his conclusions in very general assumptions about the long run properties of the data, which merits a reassessment. The author following Phylaktis and Taylor (1993) and Engsted (1993a) tested cointegration in two levels between nominal money and prices in first instance and secondly between real money and growth rate of money for the period between January 1980 and December 1993. His main result was that for the whole period analysed (1980-1993) the two implied hypotheses of cointegration cannot be rejected which can be interpreted as a support in favour of the Cagan model. However when the period is divided in two sub-periods 1986/1 through 1990/3 and 1990/3 through 1993/12 the author rejects the hypothesis of cointegration between real money and inflation rate, a direct implication of the Cagan's model. The author also found evidence in favour the hypothesis of cointegration between real money and growth rate of money not only for the whole period (1980-1993) but also for the following sub-periods: 1986/1 through 1990/3, 1990/3 through 1993/12 and 1980/1 through 1986/1. For this last period however the results are questionable since the unit root tests indicated that real money is I(1) whereas the growth rate of money is I(0). Rossi states: "the Cagan hyperinflationary model can not be rejected for some of the periods pursued" (Rossi, 1994 p. 91) such evidence is derived from the very general assumption of cointegration between real money and inflation.

Indeed as pointed out by Engsted (1998) the cointegration properties are general in the sense that they would prevail as much as we assume that money demand shocks are stationary and that expectations are formed either assuming rational expectations or adaptive expectations or extrapolative expectations as shown in Taylor (1991)[4]. This property of the stationary demand shocks imply a set of restrictions imposed upon a VAR under the assumption of expectations being formed rationally as much as the model can be represented as a present value model as discussed in Campbell and Shiller (1987, 1988).

Since Rossi did not test the restrictions implied by the rational expectations hypothesis as proposed in Campbell and Shiller (1987) and extended to the Cagan's model in Engsted (1993) his conclusions are restricted to the general assumption of cointegration between real money and inflation. Under these grounds, any result based on the cointegration property should not be used as evidence in favour of the Cagan model. This is due not only because the cointegration property is in accordance to different types of assumptions about how agents form their expectations, but also because the Cagan model, under the rational expectations hypothesis, can be rejected on the grounds of the restrictions imposed by the rational expectations hypothesis itself upon the VAR model. Consequently, further attempts to test the Cagan model for the Brazilian case seem justified given the lack of a consistent analysis in the literature over the period of high inflation.

The present chapter also provides a benchmark for the analysis implemented in the chapters 4 and 5 in the sense that the methodology used in the present chapter contrasts directly to the methodology implemented in those chapters. This contrast proves to be very helpful in the analysis of the data for two reasons, the first one is because with the time series used here the Cagan model apparently cannot be used to describe the money demand in the period posterior to the Cruzado plan, which ends exactly with the end of the hyperinflation in March 1990. In such context, the econometric model developed in chapter 5 covers a gap existing in the literature. Second in the context of the Cagan model the definition of demand shock is understood as the non-explained part of the

[4] It should be notice however that the rejection of the hypothesis of cointegration between real money and inflation constitutes strong evidence against the Cagan model subject to agents forming expectations rationally since the cointegration between real money and inflation is coherent to different assumptions about how expectations are formed.

model since rejections of the rational expectations hypothesis are difficult to interpret and need to be readdressed as discussed below.

In this sense, the econometric model developed in chapter 5 delivers much more interpretable results given that I start the analysis with a general model and assume that the data generation process and the theoretical model do not coincide. Such assumption is indeed responsible for the lack of interpretation of the results obtained below but is discussed in further detail in chapter 4.

The present chapter is divided into three sections. The first section formalizes the model and defines the implications of the long run properties of the data. The second section presents an analysis of these properties whereas the last section presents the test of the adequacy of the model to the Brazilian data.

3.1) The Cagan Model and the Rational Expectations Hypothesis

The demand for real money as presented by Cagan (1956) is given by the following equation:

$$m_t - p_t = \alpha - \beta\left[E_t p_{t+1} - p_t\right] + u_t \quad (3.1)$$

where m_t and p_t are the logarithms of the money stock and price index respectively, E_t is the expectations operator, β is the semi-elasticity of the real balances demand with respect to the expected inflation and finally u_t represents money demand shocks

Given its simplicity the Cagan model as represented by equation (3.1) has been the centre of an intense debate in the literature. Much of this debate has been focused on how expectations are formed and the development of the concept of rational expectations led to several attempts to test the model under this assumption. In particular one of the possible alternatives of testing the model under this hypothesis rely on conditioning inflation on real money rather than real money on inflation as in equation (3.1) which lead us to equation (3.2)[5].

[5] The causality structure here is from real money to inflation and is explored empirically in tables 3.8 and 3.9.

$$\Delta p_{t+1} = \alpha\beta^{-1} - \beta^{-1}(m_t - p_t) + \nu_{t+1} \quad \text{where } \upsilon_{t+1} = \varepsilon_{t+1} - \beta^{-1}u_t \quad (3.2)$$

One of the key features of (3.2) according to Taylor (1991) is that as long as we assume that u_t is stationary equation (3.2) is consistent with the assumptions of either rational, or adaptive or extrapolative expectations for the forecasting error $\varepsilon_{t+1} = (\Delta p_{t+1} - \Delta p^e_{t+1})$[6]. Therefore equation (3.2) can be seen as cointegration equation when both real balances and inflation are I(1).

We can consequently test for cointegration between real balances and inflation and argue that if there is cointegration the Cagan model cannot be rejected conditional on u_t being stationary. As pointed out by Taylor (1991) rejecting the hypothesis of cointegration between real balances and inflation constitutes strong evidence against the Cagan model. However, simple non-rejection of the cointegration hypothesis does not allow the identification of the underlying assumption about how expectations have been formed.

Engsted (1993) developed a test of the hypothesis of rational expectations under the assumption of stationary money demands shocks exploring the long run properties of the data through cointegration analysis. The author extended the analysis developed in Taylor (1991) and explored the time series properties of the variables deriving very interesting results from equation (3.1). He noticed that equation (3.1) admits the following solution:

$$p_t = \left(1 - \frac{\beta}{1+\beta}\right)\sum_{i=0}^{\infty}\left(\frac{\beta}{1+\beta}\right)^i E_t(m_{t+i} - u_{t+i}) - \alpha \quad (3.3)$$

when we impose the transversality condition $\underset{t\to\infty}{Lim}\left[\frac{\beta}{1+\beta}E_t p_{t+i}\right] = 0$ which rules out the presence of bubbles.

Multiplying then both sides of (3.3) by *-1* and adding m_t and letting $b = \frac{\beta}{1+\beta}$ gives:

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[6] Notice however that there will be cointegration only if the u_t 's are stationary. So testing cointegration here using the Engle and Granger procedure as Taylor did is indeed a test on the stationarity of the random errors. So instead of saying "if we assume that the u_t 's are stationary" we will be using if the random errors are stationary equations (3.7) and (3.8) would represent a cointegrating equation.

$$-p_t = E_t\left\{ \left[-m_t - bm_{t+1} - b^2 m_{t+2} - \ldots\right] + b\left[m_t + bm_{t+1} + b^2 m_{t+2} + \ldots\right] \right\} +$$
$$+(1-b)E_t\left[u_t + u_{t+1} + \ldots\right] + \alpha \qquad (3.4)$$

$$m_t - p_t = +m_t - m_t + E_t\left\{ \left[-bm_{t+1} - b^2 m_{t+2} - \ldots\right] + \left[bm_t + b^2 m_{t+1} + \ldots\right] \right\} +$$
$$+(1-b)E_t\left[u_t + u_{t+1} + \ldots\right] + \alpha \qquad (3.5)$$

$$m_t - p_t = E_t\left\{ \left[-bm_{t+1} - b^2 m_{t+2} - \ldots\right] + \left[bm_t + b^2 m_{t+1} + \ldots\right] \right\} +$$
$$+(1-b)E_t\left[u_t + u_{t+1} + \ldots\right] + \alpha \qquad (3.6)$$

$$m_t - p_t = -\Theta(1-b)\sum_{i=1}^{\infty} b^i E_t \Delta m_{t+i} + (1-b)\sum_{i=0}^{\infty} b^i E_t u_{t+i} + \alpha \qquad (3.7) \text{ where } \Theta = (1-b)^{-1}$$

At this point, it is worthwhile to notice that, if the random errors u_t are stationary, equation (3.7) implies cointegration between m and p if we also have that the rate growth of money (Δm_t) is stationary. Nevertheless even if Δm_t is not stationary it is possible to reparameterize equation (3.7) adding $\frac{b}{1+b}\Delta m_t$ [7] on both sides in such a way that equation (3.7) turns out to be:

$$\begin{aligned}
m_t - p_t + \frac{b}{1-b}\Delta m_t - \alpha &= E_t\left(-\sum_{i=1}^{\infty} b^i \Delta m_{t+i}\right) + \frac{b}{1-b}\Delta m_t + (1-b)E_t\sum_{i=0}^{\infty} u_{t+i} \\
&= -\frac{1}{1-b}E_t\left[(1-b)\sum_{i=1}^{\infty} b^i \Delta m_{t+i} + b\Delta m_t\right] + (1-b)E_t\sum_{i=0}^{\infty} u_{t+i} \\
&= -\frac{1}{1-b}E_t\left\{\left[\sum_{i=1}^{\infty} b^i \Delta m_{t+i}\right] - b\sum_{i=1}^{\infty} b^i \Delta m_{t+i} + b\Delta m_t\right\} + (1-b)E_t\sum_{i=0}^{\infty} u_{t+i} \\
&= -\frac{1}{1-b}E_t\left\{\left[\sum_{i=1}^{\infty} b^i \Delta m_{t+i}\right] - \sum_{i=1}^{\infty} b^i \Delta m_{t+i-1}\right\} + (1-b)E_t\sum_{i=0}^{\infty} u_{t+i} \\
&= -\frac{1}{1-b}\sum_{i=1}^{\infty} b^i E_t \Delta^2 m_{t+i} + (1-b)E_t\sum_{i=0}^{\infty} u_{t+i} \qquad (3.8)
\end{aligned}$$

[7] Notice that $\frac{b}{1-b} = \beta$.

In the same manner as equation (3.7) therefore, if the random errors (u_t) are stationary and m_t is **an I(2) variable**, equation (3.8) can be viewed as a cointegration equation where real money cointegrates with the first difference of m_t (growth rate of money).[8] One of the advantages of the parameterization represented by equation (3.8) over that represented by equation (3.7) is that equation (3.8) allows the estimation of the key parameter β directly from the cointegration equation $m_t - p_t + \beta\Delta m_t - \alpha$ with the well-known advantage of super-consistency of the estimator of β. Furthermore there has been evidence in the literature showing that m_t and p_t are both I(2) during hyperinflation episodes as noticed by Engsted (1993). Therefore the assumption in equation (3.8) describing a cointegration equation between real money and the rate of growth in money is supported by the empirical evidence with respect to the order of integration of m_t.

Furthermore combining equations (3.8) and (3.2) it may be possible to test for the presence of bubbles. Equation (3.8) is derived under the assumption of no bubbles represented by the transversality condition whereas equation (3.2) is valid regardless the presence of bubbles in p_t. **Therefore, if we find cointegration between real balances and both inflation and the growth rate of money then we have evidence in the data against the presence of bubbles. However if we reject the hypothesis of cointegration between real money and the growth rate of money but not between real money and inflation then there is evidence of bubbles in the data.**

Another important implication of equation (3.8) is that $S_t = m_t - p_t + \beta\Delta m_t - \alpha$ can be seen as the present value of the expected changes in the rate of growth of the money growth. This means that the error correction term of the cointegration regression, S_t, is a result of the agent's forecasts of the changes in Δm_t. This interpretation differs substantially from the usual view of an error correction model as representing a servomechanism that corrects deviations from the long run equilibrium. In the present case where S_t is an optimal forecast of future values of $\Delta^2 m_t$ as stressed by Campbell and Shiller (1988) the equilibrium error is in fact a result of the agent's

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[8] Notice that if m_t is an I(2) variable and real money cointegrates with the growth rate of money then the money demand shocks are stationary. This testable result is in evident contrast to the common assumption in the literature that u_t follows a random walk as in Salemi and Sargent (1979).

forecasts of changes in the variables of the model. In their original work, Campbell and Shiller (1987) define their error correction term S_t as the difference between the long and the short-term interest rates. This definition has a direct economic interpretation since the present value model that supports the analysis is derived from the expectation theory for interest rates.

In our case S_t has no direct economic interpretation because it is derived by adding $\frac{b}{1+b}\Delta m_t$ on both sides of (3.7) which constitute an *ad hoc* assumption since the term is added to construct equation (3.8) only and is not derived from solving equation (3.1). Nevertheless we can, following Campbell and Shiller (1987) and Engsted (1993), use the stationary property of S_t and $\Delta^2 m_t$ to generate a VAR on these two variables and calculate the optimal linear forecasts of S_t and $\Delta^2 m_t$ conditional on the information set H_t which includes past values of S_t and $\Delta^2 m_t$ only. From these forecasts, it is possible to determine then the restrictions on the parameters of the VAR model that would have implied if the Cagan model were a true representation of the data.

Therefore taking $E(\bullet/H_t)$ on both sides of equation (3.8) as the optimal forecast of S_t conditional to the information set H_t and considering $u_t = 0$[9] results:

$$E(S_t/H_t) = -\frac{1}{1-b}\sum_{i=1}^{\infty} b^i E(\Delta^2 m_{t+i}/H_t) \quad (3.9).$$

Equation (3.9) states therefore that the optimal forecast of S_t conditional on H_t is given by the present value of expected future changes in the money rate of growth ($\Delta^2 m_t$).

The VAR representation of S_t and $\Delta^2 m_t$ with the means removed can be written in the companion form as:

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[9] The reader should notice that in this case we will be testing for the **exact rational expectations Cagan model** since we are assuming that $u_t = 0$. This assumption despite being very restrictive is relaxed in the following when a measure of these money demand shocks will be discussed.

$$\begin{bmatrix} \Delta^2 m_t \\ \Delta^2 m_{t-1} \\ \vdots \\ \Delta^2 m_{t-p+1} \\ S_t \\ S_{t-1} \\ \vdots \\ S_{t-p+1} \end{bmatrix} = \begin{bmatrix} a_1 & a_2 \cdots a_p & b_1 & b_2 \cdots b_p \\ 1 & 0 \cdots 0 & 0 & 0 \cdots 0 \\ & \ddots \ \vdots & & \ddots \cdots \vdots \\ 0 \cdots & 1 & 0 \cdots & 0 \\ c_1 \cdots & c_p & d_1 \cdots & d_p \\ 0 & 0 \cdots 0 & 1 & 0 \cdots 0 \\ & \ddots \cdots \vdots & & \ddots \ \vdots \\ 0 \cdots & 0 & 0 \cdots & 1 \end{bmatrix} * \begin{bmatrix} \Delta^2 m_{t-1} \\ \Delta^2 m_{t-2} \\ \vdots \\ \Delta^2 m_{t-p} \\ S_{t-1} \\ S_{t-2} \\ \vdots \\ S_{t-p} \end{bmatrix}$$

$$\mathbf{Z_t} = \mathbf{A} * \mathbf{Z_{t-1}} \quad (3.10)$$

Now using the companion form (3.10) if equation (3.9) holds we have:

$$E(S_t/H_t) = \mathbf{g}'\mathbf{Z_t} = -\frac{1}{1-b}\sum_{i=1}^{\infty} b^i E(\Delta^2 m_{t+i}/H_t) = -\frac{1}{1-b}\sum_{i=1}^{\infty} b^i \mathbf{h} E(\mathbf{Z}_{t+i}/H_t) \quad (3.11)$$ [10]

where $\boldsymbol{g}$ is a vector that picks out S_t and $\boldsymbol{h}$ is a vector that picks out $\Delta^2 m_t$ since S_t is already in H_t. However, $E(\mathbf{Z}_{t+i}/H_t) = \mathbf{A}^i\mathbf{Z_t}$ using the companion form. Therefore (3.11) becomes in short:

$$\mathbf{g}'\mathbf{Z_t} = -\frac{1}{1-b}\sum_{i=1}^{\infty} b^i \mathbf{h}\mathbf{A}^i\mathbf{Z_t}$$

$$\mathbf{g}'\mathbf{Z_t} = -\frac{1}{1-b} b\mathbf{h}'\mathbf{A}(\mathbf{I}-b\mathbf{A})^{-1}\mathbf{Z_t} \quad (3.12)$$

because the infinite sum converges as long as the companion form is stationary and because $\Delta^2 m_t$ and S_t are already stationary variables.

[10] Following the result in Campbell and Shiller (1987) a weak implication of the present value relation for the VAR is that S_t must Granger cause $\Delta^2 m_t$. We however do not explore it further since this Granger causality is valid only for the exact rational expectations Cagan model, which we consider too restrictive for the present analysis. One possible alternative is to extend the Cagan's model dynamics since the model presented is essentially static. Such route has been addressed in the literature in Feliz and Welch (1997) but only for the period that preceded the Cruzado plan cast.

From (3.12) it is possible to derive the restrictions on the parameters of the VAR on S_t and $\Delta^2 m_t$ rewriting it as: $\mathbf{g}'(\mathbf{I}-b\mathbf{A}) = -\beta\mathbf{h}'\mathbf{A}$ which in terms of individual parameters are:

$$\begin{aligned} c_i &= (1+\beta)a_i \\ d_1 &= (1+\beta)(\beta^{-1}+b_1) \quad & i=1,\cdots p \qquad (3.13) \\ d_i &= (1+\beta)b_i \quad & i=2,\cdots p \end{aligned}$$

These restrictions represent the so-called hallmark of rational expectations models and can be implemented using a Wald test statistic. A rejection of the test would consequently imply a rejection of the hypothesis that the exact rational expectations Cagan model describes the data.

According to Campbell and Shiller (1988) however the rejection of the test are hard to interpret and a possible alternative is to construct an unrestricted forecast of S_t, S_t', and compare it with the historical (generated by the data from the cointegration equation 3.8) behaviour of S_t itself. In this case, if the two variables move closely with each other we could argue that there is some source of truth in the present value model even if we reject the restriction in equation (3.13). To see how this works notice that from equation (3.11) we can write:

$$\frac{1}{1-b}\sum_{i=1}^{\infty} b^i E\left(\Delta^2 m_{t+i}/H_t\right) = \sum_{i=1}^{\infty} b^i \mathbf{h}\, E\left(\mathbf{Z}_t/H_t\right)$$

$$S_t' = \sum_{i=1}^{\infty} b^i \mathbf{h}\mathbf{A}^i \mathbf{Z}_t$$

$$S_t' = \mathbf{h}'(-\beta)\mathbf{A}(\mathbf{I}-b\mathbf{A})^{-1}\mathbf{Z}_t \qquad (3.14)$$

The main difference between equation (3.14) and equation (3.12) is that in the former we are not imposing that the forecast should be equal to S_t. This condition was represented in equation (3.12) by the term $\mathbf{g}'\mathbf{Z}_t$ which in fact picks out S_t from the vector $\mathbf{Z}_t$ and equals to the right hand side of (3.14). Therefore we can consider S_t' in equation (3.14) as an unrestricted estimated of S_t.

Both variables, S_t and S_t', have also another two important properties as pointed out by Engsted (1998). The first property states that the difference between S_t and S_t' in the context of the Cagan model represents a measure of the noise term u_t in equation (3.1)[11]. As a consequence we can explore this difference to quantify the money demand shocks.

The second property relates to the extent to both variables S_t and S_t' move closely to each other. This measures the extent of the agent's forward-looking behaviour since in this case the error correction term is derived from agent's forecasts of future values of $\Delta^2 m_t$. In our particular case, this is an important property to be explored given the discussion in the literature that inflation in Brazil was extensively dominated by a backward looking behaviour of the agents represented by the widespread use of indexation in the economy.

Quantifiable measures of the degree of correlated movements in S_t and S_t' can be calculated following Engsted (1998) and using the correlation between S_t and S_t', the variance ratio $\frac{Var(S_t')}{Var(S_t)}$ and the ratio $\frac{Var(S_t - S_t')}{Var(S_t)}$.

The use of such measures is justified because in particular these measures have been calculated for the main hyperinflation episodes allowing them to be compared with the Brazilian case. In particular, the results in the literature have been suggesting that the money demand shocks represent more than 50% of the observed variation in the money demand during hyperinflations using the ratio $\frac{Var(S_t - S_t')}{Var(S_t)}$ to measure them.[12] However, even in the cases where money demand shocks represent 50% of the variation in the money demand the current practice in the literature has been to consider such results as favourable to the Cagan model.

The whole test procedure can be summarized in the following steps:

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[11] To see this notice that if $u_t \neq 0$ then (3.9) becomes:

$E(S_t/H_t) = S_t = -\frac{1}{1-b}\sum_{i=0}^{\infty} b^i E_t\left(\Delta^2 m_t / H_t\right) + (1-b)\sum_{i=0}^{\infty} E_t u_{t+i}$. Since $S_t' = \frac{1}{1-b}\sum_{i=0}^{\infty} b^i E_t\left(\Delta^2 m_t / H_t\right)$, then

$S_t - S_t' = (1-b)\sum_{i=0}^{\infty} E_t u_{t+i}$

[12] See for instance Engsted (2002).

1) Test the order of integration of the money stock, price index, real money and inflation.
2) Test for cointegration between Δp_{t+1} and m/p following equation (3.2) if money stock (m) and price index (p) are I(1). If these two variables are I(2) in addition test for cointegration between (m) and (p) which in first instance form the real money variable. Thus in the sequence test for cointegration between real money (m/p) and the growth rate of money (Δm) following equation (3.8).
3) Estimate then β from the cointegrating equation (3.8) and construct the variable S_t.
4) Run the VAR model using the stationary variables S_t and $\Delta^2 m_t$. Test then for Granger causality from S_t to $\Delta^2 m_t$ and for the implied restrictions represented by equation (3.13).
5) From VAR model estimation in step (4) and the estimated β in step (3) construct the companion matrix **A** and the unrestricted forecast S_t'.

3.2) Data Description and Estimation Results

The data used in this study consist of the money aggregate M1 (m for estimation purposes) at the end of the period defined as money held by the public plus cash deposits into current accounts expressed in millions of Reais (the present Brazilian currency); the Consumer Price Index (CPI for estimation purpose) as defined in Juselius (2002) and the Wholesale Price Index (IPA-DI for estimation purpose). The source of the M1 and the IPA-DI is the IPEA (Research Institute of Applied Economics)[13] and the estimations were performed using PC-GIVE version 10.0 and Ox version 3.0.

In particular, some comments are worthwhile in respect of the use of a wholesale price index in the analysis. Whilst we cannot consider a usual choice for the analysis of the Cagan Model the use of a wholesale price index, in the present case the consumer price index as given in Juselius (2002) seems to present measurement problems as source of noise in the money demand. This conclusion comes from the empirical results

[13] The author would like to thank Katarina Juselius for providing the data relative to the CPI. The remaining data is available on http://www.ipeadata.gov.br or upon request from the author.

presented in the next section that led us then to complete the analysis with the wholesale price index[14].

For estimation purposes, all the variables are in logs and the whole period of investigation between January 1980 and July 1994 was subdivided in three sub-periods as discussed above.

The first sub-period starts on January 1980 and ends on February 1986 comprising 72 observations. The guideline for the choice was the Cruzado Plan implementation on February 28th 1986.

Table 3.1 ADF Unit Root Tests CPI

Variable	Period	t- ADF	Lag	Const	Trend
p_t	1980-1986(2)	0.487	1	Yes	Yes
	1986(4)-1990(3)	0.550	1	Yes	Yes
	1990(5)-1994(6)	1.442	1	Yes	Yes
Δp_t	1980-1986(2)	-6.689**	0	Yes	Yes
	1986(4)-1990(3)	-1.597	0	Yes	Yes
	1990(5)-1994(6)	-3.701*	0	Yes	Yes
$\Delta^2 p_t$	1980-1986(2)	-7.621**	0	Yes	No
	1986(4)-1990(3)	-5.867**	0	Yes	No
	1990(5)-1994(6)	-14.21**	0	Yes	No

*and ** Represents rejection of the null hypothesis of Unit Root at 5% and 1% respectively.

Table 3.2 Unit Root Tests IPA-DI

Variable	Period	t- ADF	Lag	Const	Trend
p_t	1980-1986(2)	0.08201	2	Yes	Yes
	1986(4)-1990(3)	3.646	0	Yes	Yes
	1990(5)-1994(6)	0.5883	3	Yes	Yes
Δp_t	1980-1986(2)	-2.052	1	Yes	No
	1986(4)-1990(3)	-0.2382	0	Yes	No
	1990(5)-1994(6)	-0.9975	0	Yes	No
$\Delta^2 p_t$	1980-1986(2)	-12.39**	0	Yes	No
	1986(4)-1990(3)	-4.733**	0	Yes	No
	1990(5)-1994(6)	-7.559**	0	Yes	No

*and ** Represents rejection of the null hypothesis of Unit Root at 5% and 1% respectively.

[14] See Engsted (1996) for a discussion about the measurement and noise in the money demand shocks.

The second sub-period starts on April 1986 and ends on March 1990 comprising 42 observations. The guidelines for this sub-division were for the start date the lowest positive rate of inflation after the Cruzado plan implementation. The exclusion of one observation, March 1986 is justified in the sense that for the wholesale price index (IPA-DI) there was a deflation in this month whereas the same was not observed for the consumer price index (CPI). The final date as March 1990 is justified by the fact that this was the last month of the hyperinflation episode.

Finally, the third sub-period starts on May 1990 and ends on July 1994 when the Real plan was launched and comprises 50 observations. The exclusion of two months in the beginning of this sub-sample is justified by the fact that May 1990 had the lowest inflation rate after the Collor plan I launching and the end of the hyperinflation. The two previous months, March and April indicate in this sense that the data were most probably contaminated by residual inflation originated from the hyperinflation episode.

Tables 3.1 to 3.5 present a summary of the unit root tests for the price indexes, M1 and the two concepts of real money where M1 is deflated by the two price indexes (CPI and IPA-DI)[15]. In general the results from table 3.1 and 3.2 allow us to conclude that both price indexes are I(2) with the exception of the first period, namely 1980-1986 for the consumer price index where there is indication that Δcpi is stationary. From the results in table 3.3 it is possible to draw the conclusion that M1 is I(2).

In the sequence, we examine then the results of the unit root tests for real money. In both cases, using the consumer price index (CPI) or the wholesale price index (IPA-DI) to construct the variable and with exception of the third the period using the CPI as a deflator the results presented in tables 3.4 and 3.5 show that real money is I(1). Such result suggests therefore that money and price form the real variable since they are I(2) in levels and real money is I(1). Nevertheless, the ADF tests are considered here indicative only given the sample sizes involved rather than conclusive.

[15] The unit root tests correspond to the ADF test and the test was implemented using the PC-Give version 10.0. For all periods and all variables the maximum lag allowed in the regressions was 6 to keep the sample in a reasonable size. The lag length was selected using the F-test for the significance of the lag. The critical values for the null hypothesis of unit root were omitted for the sake of simplicity but were calculated from MacKinnon (1993).

Table 3.3 Unit Root Tests M1

Variable	Period	t- ADF	Lag	Const	Trend
m_t	1980-1986(2)	-0.2813	0	Yes	Yes
	1986(4)-1990(3)	2.013	0	Yes	Yes
	1990(5)-1994(6)	0.7133	0	Yes	Yes
Δm_t	1980-1986(2)	-2.577	4	Yes	No
	1986(4)-1990(3)	-0.844	1	Yes	No
	1990(5)-1994(6)	-0.1091	5	Yes	No
$\Delta^2 m_t$	1980-1986(2)	-7.014**	3	Yes	No
	1986(4)-1990(3)	-9.380**	0	Yes	No
	1990(5)-1994(6)	-4.431**	4	Yes	No

*and ** Represents rejection of the null hypothesis of Unit Root at 5% and 1% respectively.

Given this hypothesis about the ADF tests we investigate further the cointegration between money and prices represented by equation (3.7), and test for cointegration between money and prices considering a system analysis as described in Johansen (1995). We also test the restriction $m = 1,\ p = -1$, which would imply that money and price form the real money variable. Table 3.6 summarizes the results of testing for cointegration between M1 and the consumer price index (CPI). Table 3.7 presents the same tests as in table 3.6 but for cointegration between M1 and the wholesale price index (IPA-DI)[16].

The figures in table 3.6 support strongly the hypothesis of cointegration between M1 and the consumer price index (CPI) with cointegrating vector $(1, -1, \bullet)$ for the last two sub-periods, 1986(4)-1990(3) and 1990(5)-1994(6). In both cases, the restriction can not be rejected. However, the figures for the first sub-period are not supportive with the restriction being strongly rejected.

When we consider cointegration between M1 and the wholesale price index (IPA-DI) in table 3.7 the results appear not to support the hypothesis only for the first sub-period namely, 1980-1986(2) in accordance therefore with the results using CPI

[16] The maximum lag length used in estimating the VAR's was 6. The selection criteria for the VAR order was implemented by testing for lag exclusion sequentially and by inspecting the residuals autocorrelation function. Dummies were introduced to control for the stabilization plans where appropriate. In both tables either a trend or a constant were restricted to enter in the cointegrating space.

where the restriction imposed by the vector $(1,-1,\bullet)$ is strongly rejected for the first sub-period.

Table 3.4 Unit Root Tests Real Money m/p (deflated by the CPI)

Variable	Period	t- ADF	Lag	Const.	Trend
m/p	1980-1986(2)	-0.882	5	Yes	Yes
	1986(4)-1990(3)	-1.767	0	Yes	Yes
	1990(5)-1994(6)	4.879**	0	Yes	Yes
$\Delta m/p$	1980-1986(2)	-10.33**	0	Yes	No
	1986(4)-1990(3)	-4.791**	0	Yes	No
	1990(5)-1994(6)	-10.89**	0	Yes	No

*and ** Represents rejection of the null hypothesis of Unit Root at 5% and 1% respectively.

Table 3.5 Unit Root Tests Real Money m/p (deflated by the IPA-DI)

Variable	Period	t- ADF	Lag	Const	Season
m/p	1980-1986(2)	-1.503	2	Yes	Yes
	1986(4)-1990(3)	-2.203	0	Yes	Yes
	1990(5)-1994(6)	-1.210	0	Yes	Yes
$\Delta m/p$	1980-1986(2)	-9.826**	0	Yes	No
	1986(4)-1990(3)	-5.753**	0	Yes	No
	1990(5)-1994(6)	-2.986*	5	Yes	No

*and ** Represents rejection of the null hypothesis of Unit Root at 5% and 1% respectively.

From tables 3.6 and 3.7 it is possible to conclude that the hypothesis of cointegration between money and prices composing the real money variable[17] is reasonable except perhaps for the first period. Contrastingly, it is exactly in the first period that using the consumer price index we observe evidence in favour of the Cagan Model as presented below.

These results suggest that the unit root tests and cointegration should be interpreted with caution given the sample sizes involved. I thus proceed with my analysis arguing that equation (3.8) is a fair representation of the data. In the sequence it

[17] It should be noticed that the trend variable is included in the cointegrating vector because of the strong trending behaviour observed in both variables price and M1 in the periods under analysis as well as the real money itself when constructed. Nevertheless results shown here are just indicative.

is tested if real money, m/p, cointegrates with the growth rate of money (Δm_t) as suggested by equation (3.8).

The results for testing the cointegration hypothesis between Δm_t and m/p as suggested in equation (3.8) are presented in tables 3.8 and 3.9 for the consumer price index and the wholesale price index respectively. In conjunction the hypothesis of cointegration between m/p and Δp_{t+1} is also tested as defined by equation 2[18].

Table 3.6 Cointegrating Results M1 and CPI

	Period		
	1980-1986(2)	1986(4)-1990(3)	1990(5)-1994(6)
Trace Test [pvalue]			
$r = 0$	43.862 [0.000]	49.812 [0.000]	23.159 [0.105]
$r \leq 1$	11.308 [0.079]	10.193 [0.12]	9.237 [0.170]
Cointegrating Vector	(m, p, t)	(m, p, t)	(m, p, t)
Estimated Vector	(1,-2.35,0.082)	(1,-1.15,0.059)	(1, -1.45,-0.092)
LR test of Restrictions			
$\chi^2(1)$ [pvalue]	17.354 [0.002]	2.384 [0.125]	3.560[0.059]

Table 3.7 Cointegrating Results M1 and IPA-DI

	Period		
	1980-1986(2)	1986(4)-1990(3)	1990(5)-1994(6)
Trace Test [pvalue]			
$r = 0$	31.809 [0.001]	30.633 [0.01]	27.328 [0.004]
$r \leq 1$	6.7312 [0.146]	8.558 [0.215]	4.280 [0.384]
Cointegrating Vector	(m, p, t)	(m, p, t)	(m, p, t)
Estimated Vector	(1,-1.93,0.06)	(1,-1.33,0.09)	(1,-1.06,0.04)
LR test of Restrictions			
$\chi^2(1)$ [pvalue]	21.87 [0.000]	2.570 [0.109]	0.832 [0.660]

Overall, the figures show that the null hypothesis of no cointegration is not rejected in two cases. The first case is when testing for cointegration between m/p and

[18] The tables correspond to the implementation of the Engle and Granger two step procedure. The regressions were estimated by OLS and then the residuals were tested for the presence of a unit root. Since we have only two variables we used the ADF equation to test for the presence of a unit root in the residuals of the cointegration equation. A constant was included in all the cointegrating regressions.

Δp_{t+1} using the CPI to form the real money variable during the period between 1990(5) and 1994(6). The second case is for the same variables real money and inflation but involving the IPA-DI to form the real money variable during the period between 1986(4) and 1990(3).

Table 3.8 Cointegration Regressions (CPI)

Period	Left Hand Side	Right Hand Side	Estimate of β	R^2	ADF [lag] (MacKinnon)†
1980(1)	Δm_t	$(m_t - p_t)$	19.78	0.04	-3.692 [4]
1986(2)	Δp_{t+1}	$(m_t - p_t)$	———	0.434	-3.957 [3]
1986(4)	Δm_t	$(m_t - p_t)$	6.78	0.156	-3.821 [0]
1990(3)	Δp_{t+1}	$(m_t - p_t)$	———	0.524	-3.060 [0]
1990(5)	Δm_t	$(m_t - p_t)$	6.35	0.143	-1.351 [5]
1994(6)	Δp_{t+1}	$(m_t - p_t)$	———	0.761	-3.351 [0]

†The critical values are calculated based on MacKinnon (1991) response surfaces for N=2 and no trend. At a 5% confidence level the critical values are: 3.4379 for the first period (1980-1986), 3.4885 for the second period (1986-1990) and 3.4848 for the last period (1990-1994).

Since in both cases we reject cointegration between inflation and real money these results constitute evidence against the Cagan model for the third period using the CPI as a measure of inflation and for the second period using the IPA-DI as a measure for inflation. Our analysis is therefore restricted to the first two periods, 1980-1986(2) and 1986(4)-1990(3) using the consumer price index (CPI) and to the first and third periods, 1980-1986(2) and 1990(5)-1994(6) using the wholesale price index (IPA-DI).[19]

Given that for the periods selected above there is cointegration between real money and the growth rate of money and also cointegration between real money and inflation we can rule out the hypothesis of the presence of bubbles in the data.

[19] In a earlier version of this chapter presented at the IX Spring Meeting of Young Economists in Warsaw 2004 I also estimated the model using a different price index, namely the Broad Consumer Price Index (IPCA). The results obtained led to the same conclusions above, namely there was no evidence against the Cagan model based on the inflation regressions in the first and second period. Given this previous evidence using a different consumer price index I decided to carry on the analysis in the second period using the CPI, despite the evidence against the model in the second period given by the no cointegration result for the CPI observed in Table 3.8, where the unit root test fails to reject the null of no unit root in the residuals of the OLS equations at 5% level of confidence.

The estimates for the semi-elasticity of real balances demand with respect the expected inflation, β , given by equation (3.8) are quite close to each other regardless the price index we use nevertheless the rejection of the hypothesis of cointegration in the periods mentioned above. Such result suggests therefore that the estimator used is robust to the change in the indexes. Moreover, when considering the two final sub-periods the estimates of β around 6 are in line with the findings in the literature (see Engsted, 1993) for the German case which can be considered as a benchmark for estimates of the semi-elasticity parameter in hyperinflations. However the estimates for the first sub-period regardless the index we use appear to be too high indicating that agents were strongly economizing in their holding of real balances given the increases in expected inflation. Since in the first period indeed the inflation are moderate when compared with the following periods any interpretation of the results here deserves caution.

Table 3.9 Cointegration Regressions (IPA-DI)

Period	Left Hand Side	Right Hand Side	Estimate of β	R^2	ADF [lag] (MacKinnon)†
1980(1)	Δm_t	$(m_t - p_t)$	21.34	0.069	-3.680 [4]
1986(2)	Δp_{t+1}	$(m_t - p_t)$	——	0.275	-4.303 [1]
1986(4)	Δm_t	$(m_t - p_t)$	6.24	0.180	-4.025 [0]
1990(3)	Δp_{t+1}	$(m_t - p_t)$	——	0.530	-3.012 [0]
1990(5)	Δm_t	$(m_t - p_t)$	6.12	0.149	-4.850 [1]
1994(6)	Δp_{t+1}	$(m_t - p_t)$	——	0.745	-3.715 [0]

† The critical values are calculated based on MacKinnon (1991) response surfaces for N=2 and no trend. At a 5% confidence level the critical values are: 3.4379 for the first period (1980-1986), 3.4885 for the second period (1986-1990) and 3.4848 for the last period (1990-1994).

3.3) The Cagan Model and the Rational Expectation Hypothesis: Evidence for the Brazilian Case

Using the different estimates of β provided in tables 3.8 and 3.9 of the last section we then construct the variable $S_t = m_t - p_t + \beta \Delta m_t$[20] for the following periods:

a. 1980(1)-1986(2) with $\beta = 19.78$ using the CPI and $\beta = 21.34$ using the IPA-DI.
b. 1986(4)-1990(3) with $\beta = 6.78$ using the CPI only.
c. 1990(5)-1994(6) with $\beta = 6.12$ using the IPA-DI only.

A summary of the estimation results for the VAR model on S_t and $\Delta^2 m_t$ is presented on tables 3.10, 3.11, 3.12 and 3.13[21].

Table 3.10 Results VAR Estimation 1980(1)-1986(2) – CPI

VAR Selected Order (HQ criteria)	5
Granger Causality Test[22] $\chi^2(5)$ [p-value]	14.390 [0.013]
Rational Expectations Hypothesis $\chi^2(10)$ [p-value]	58.349 [0.000]
F-test on Regressors F(20,114) [p-value]	812.54 [0.000]

Table 3.11 Results VAR Estimation 1980(1) -1986(2) – IPA-DI

VAR Selected Order (HQ criteria)	4
Granger Causality Test $\chi^2(4)$ [p-value][23]	19.9648 [0.000]
Rational Expectations Hypothesis $\chi^2(8)$ [p-value]	237.709 [0.000]
F-test on Regressors F(16,116) [p-value]	595.688 [0.000]

[20] The constant is initially omitted from the formula, however in running the VAR on S_t and $\Delta^2 m_t$ the variables are taken as deviations from their means since in the companion form there is no constant. This also implies that in **all** VAR estimations we **do not** include constants in the regressions.

[21] In all cases the maximum lag length was 6. The Granger causality test amounts to testing the linear restriction that the coefficients of lagged S_t are zero in the equation for $\Delta^2 m_t$. The rational expectations hypothesis was tested by imposing the restrictions represented by equation 3.13 on the parameters of the VAR. Since the restrictions are non-linear a Wald test was used which follows a χ^2 distribution with degrees of freedom equal to the number of restrictions. The F-test on regressors amounts to testing the null hypothesis that all regressors in the VAR are zero.

[22] The Granger causality statistic test from $\Delta^2 m_t$ to S_t is $\chi^2(5) = 33.654\,[0.000]$

[23] The Granger causality statistic test from $\Delta^2 m_t$ to S_t is $\chi^2(4) = 8.2765\,[0.0820]$

In all periods under consideration and regardless the price index used the test for Rational Expectations Hypothesis rejects the null. Therefore indeed the exact rational expectations Cagan model is overwhelming rejected by the data regarding the Brazilian case. This result was expected in fact since the evidence in the literature has been the same, rejection of the rational expectations restrictions, for several hyperinflation episodes (Germany, Austria, Russia, Greece, Yugoslavia and China)[24]. The results of the Granger causality test where we test the weak implication that S_t Granger causes $\Delta^2 m_t$ point out that, all cases but for the second period using the consumer price index (CPI), the hypothesis of no causality is rejected.

Table 3.12 Results VAR Estimation 1986(4)-1990(3) – CPI

VAR Selected Order HQ criteria	2
Granger Causality Test[25] $\chi^2(2)$ [p-value]	6.78 [0.036]
Rational Expectations Hypothesis $\chi^2(4)$ [p-value]	95.001 [0.000]
F-test on Regressors F(8,74) [p-value]	223.61 [0.000]

Table 3.13 Results VAR Estimation 1990(5)-1994(6) – IPA-DI

VAR Selected Order HQ criteria	3
Granger Causality Test [26] $\chi^2(3)$ [p-value]	79.813 [0.000]
Rational Expectations Hypothesis $\chi^2(6)$ [p-value]	579.006 [0.000]
F-test on Regressors F(12,86) [p-value]	394.098 [0.000]

However as mentioned before this hypothesis is meaningful only under the assumption that the exact rational expectations model is a valid representation of the data which indeed is not the case here.

As discussed in section 3.1 the simple rejection of the restrictions is difficult to be interpreted. We therefore move to the comparison between the unrestricted forecast S_t' and S_t itself trying to derive a more intuitive interpretation of the deviations from the baseline model represented by equations (3.11) and (3.12).

In figures 3.1, 3.2, 3.3 and 3.4 we depict the two variables, S_t and its unrestricted forecast S_t' derived from equation (14) which in turn was generated using

[24] See Engsted (2002) for a survey about the subject.

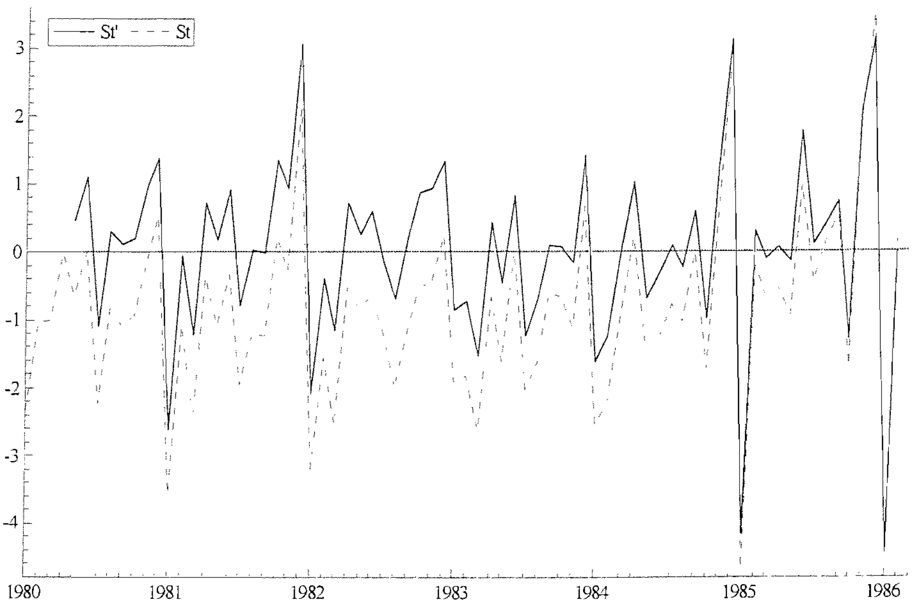
[25] Granger causality statistic test from $\Delta^2 m_t$ to S_t is $\chi^2(2) = 13.087\ [0.001]$

[26] The Granger causality statistic test from $\Delta^2 m_t$ to S_t **is** $\chi^2(3) = 34.900\ [0.000]$

the companion matrix obtained from the coefficients estimation of the VAR's summarized in tables 3.10, 3.11, 3.12 and 3.13.

The graphic comparison between the respective S_t and S_t' variables in figures 3.1, 3.2, 3.3 and 3.4 shows that both variables move very close to each other in all the periods analysed except for the second period when using the CPI where at the end of the sample S_t' looses the track with regard to S_t. Such result is unfortunate in the sense that the model looses the track exactly when the inflation rates started to soaring leading to the hyperinflation at the end of 1989 whilst indeed the reverse should be observed. If in the one hand they were expected given that table 3.8 shows evidence against the Cagan model for the period in question on the other hand it seems that considering the price indexes used here the Cagan model does not constitute a reasonable description of the demand for money in the period when it mostly should do. The correlations between S_t and S_t' presented in table 3.14 only confirm this result.

Figure 3.1 S_t and S_t' 1980-1986(2) CPI



The results for the first period using both price indexes can be interpreted as a measure of the extent of the agent's forward looking behaviour which contrasts therefore to the hypothesis alleged in the literature during the 80's that agent's backward looking behaviour was predominant in the economy when forming the expectations. In fact the equilibrium error (S_t) results from agents' forecasts of the changes in the variables of the model. The unrestricted forecasts represented by (S_t')

should be close to the equilibrium error if the model under investigation has some source of truth as a representation of the phenomena, consequently in this case the equilibrium error will be a result of the agents forecasts based on the rational expectations assumption.

Figure 3.2 S_t and S_t' 1980-1986(2) IPA-DI

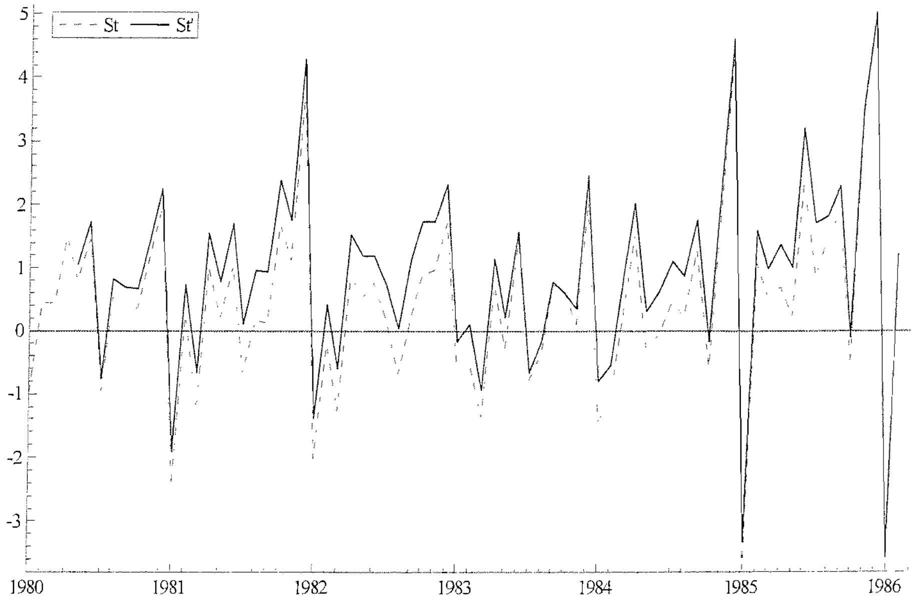


Table 3.14 Measures of Money Demand Shocks (CPI)

	1980-1986(2)	1986(4)-1990(3)
Correlation S_t, S_t'	0.9628	0.6379
Variance Ratio $\frac{Var(S_t')}{Var(S_t)}$	0.8997	47.4990
Noise Ratio $\frac{Var(S_t - S_t')}{Var(S_t)}$	0.0731	39.705

Using this information it appears from the above results that agents had a strong forward looking behaviour when forming their expectations about changes in Δm_t being incorporated into the demand for real balances in the period that preceded the Cruzado plan launching.

Table 3.15 Measures of Money Demand Shocks (IPA-DI)

	1980-1986(2)	1990(5)-1994(6)
Correlation S_t, S_t'	0.98612	0.97430
Variance Ratio $\frac{Var(S_t')}{Var(S_t)}$	0.9828	0.8578
Noise Ratio $\frac{Var(S_t - S_t')}{Var(S_t)}$	0.0276	0.0530

The high levels of correlation between S_t and S_t', have been reported in the literature for several episodes including the German hyperinflation, the China hyperinflation in the 40's and the Austrian episode in the 20's as shown in Engsted (1993, 1994 and 1998). Our findings are however substantially different from the evidence in the literature regarding the ratio of variances between S_t and S_t'. The results for the Brazilian case except for the second period using the CPI imply higher ratios and much closer to 1 than those obtained by Engsted (1998)[27]. Such results therefore imply that for the Brazilian case despite the presence of significant demand shocks in the sense that the exact model has been overwhelming rejected these are in fact much less representative than in the China and Serbian cases.

When the noise ratio $\frac{Var(S_t - S_t')}{Var(S_t)}$ is used the differences for the Brazilian case are even more pronounced. The figures for the Brazilian case not considering the second period for the CPI show that the money demand shocks account for less than 10% of the variation in the money demand. The largest number is for the firs period using the consumer price index where the demand shocks account for approximately 7.3% of the variation in the money demand. Such results are very surprising indeed when we consider that for the Germany case the noise ratio is 0.28 (Engsted, 2002). For the Serbian case the range is between 0.18 and 0.33 and for the Chinese hyperinflation the range is between 0.32 and 0.52 (Engsted, 1998).

These results led authors like Engsted to conclude that the Cagan model is an adequate description of the phenomenon. If we compare thus to the figures for the Brazilian case where the money demand shocks are much less representative we can

[27] See Engsted (1998) table 3 page 547.

therefore state that the Cagan model describes very well the demand for real balances during the first and last periods. Such conclusion reinforces the evidence in favour of the Cagan model in the literature as those in Phylaktis and Taylor (1993) and Engsted (1993 a).

Figure 3.3 S_t and S_t' 1986(4)-1990(3) CPI

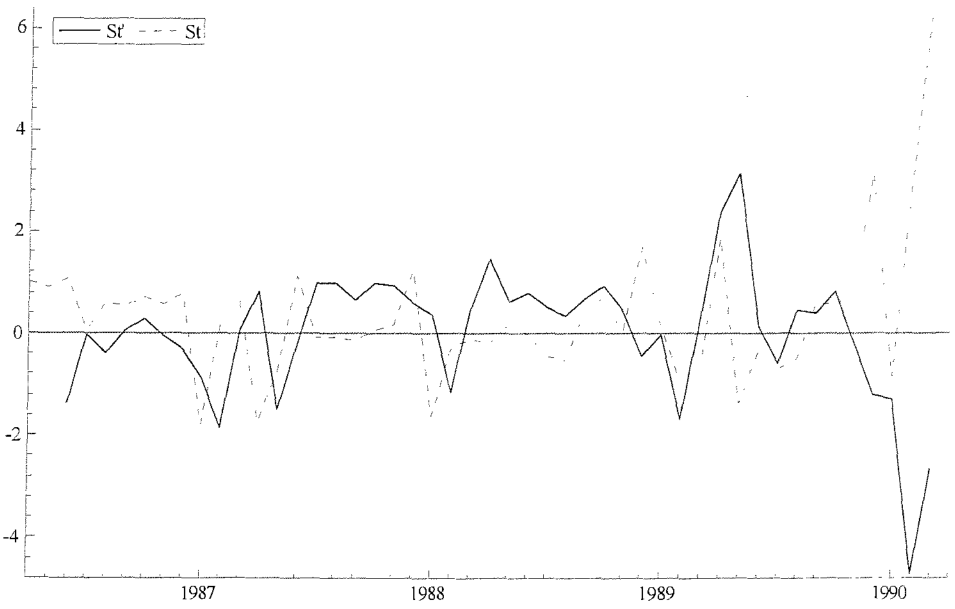
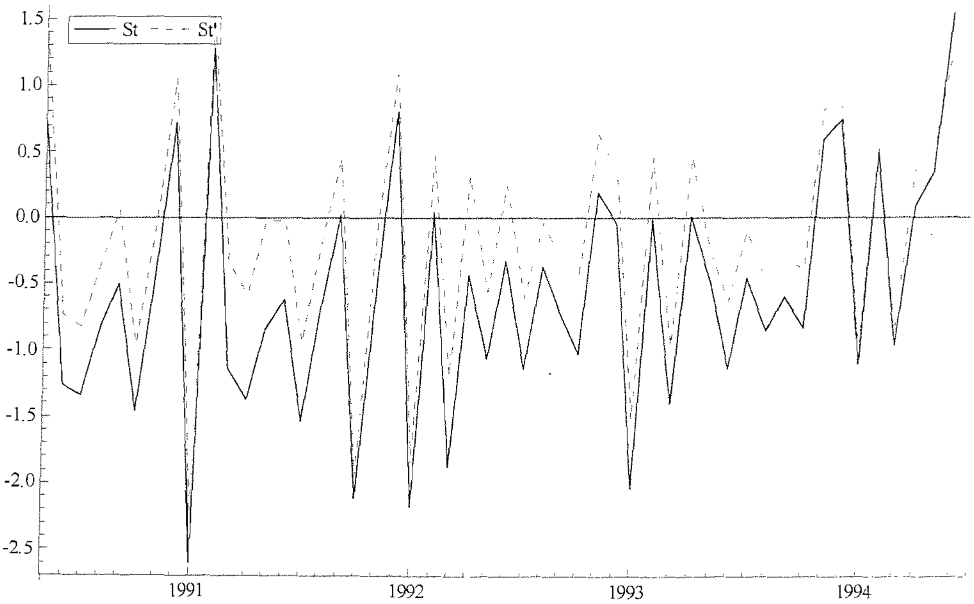


Figure 3.4 S_t and S_t' 1990(5)-1994(6) IPA-DI



Our results also are to some extent in line with those obtained by Rossi (1994) where the author concludes that the Cagan model cannot be rejected for some periods only with the advantage that the procedure adopted here is more robust than the attempted procedure in Rossi's work. Any further comparison is however prevented for two reasons, first the author did not describe which price index he used to generate his results and second because his sample ends in 1993 whereas ours goes through June 1994.

3.4) Conclusion

This chapter uses the methodology developed in Engsted (1993) to test the Cagan model under the rational expectations hypothesis. It assumes therefore that the demand for money is driven basically by forward expectations on $\Delta^2 m_t$ allegedly a rather restrictive hypothesis in the Brazilian case given the length of the high inflation period which is readdressed in the following chapters.

The chapter innovated by readdressing this model for the Brazilian case given that the previous findings in the literature were based on very general long run properties of the data. I then extend the analysis to test the rational expectation hypothesis and used the measures provided in the literature to compare the Brazilian experience to historical episodes. The chapter also innovates by assuming explicitly that the sequence of stabilization plans that took place in the 1980's and the first half of the 1990's changed the agent's expectations about inflation. I use then the information provided by these plans to sub-divide the sample into three different periods and test the Cagan model in each one of these periods. This procedure differentiates from the previous attempts by establishing three different periods using the inflation rates. So that in the first period inflation is moderated, in the second one it includes the hyperinflation period using Cagan's definition and third period starts after the hyperinflation end with soaring rates that do not cross the 50% threshold but represents potentially another period where huge rates of inflation would dwarf the changes in real variables in the money demand.

The empirical results show surprisingly that the Cagan's model does not constitute a reasonable description of the demand for money exactly in the period it was expected it should do, namely the second period that includes the hyperinflation episode measured by the consumer price index. Using the wholesale price index the result support the same conclusion than the CPI for the second period since cointegration between inflation measured by the wholesale price index and real money is rejected. Also contrary to what was expected using both price indexes, Cagan's model describes very well the money demand in the first period despite the relatively low rates of inflation and in accordance to the findings in Phylatkis and Taylor (1993) and Engsted (1993a). The results are indeed very conclusive for this period with the demand shocks accounting for 7.3% using the CPI and only 2.8% using the IPA-DI of the variation in the money demand. Such figures are for instance much lower than those observed in the German and Chinese hyperinflations are and constitute a strong support to the Cagan's model.

Interestingly the results obtained in the present chapter make room for further investigations about the money demand in the period that coincides with the stabilization plans and the hyperinflation using the Cagan's concept. Also the Brazilian high inflation have more complex features than perhaps the Cagan model can account as we can infer from the discussion in chapter 2 mainly because of the sequence of stabilization plans and the presence of an inertial component in inflation. Whilst the stabilization plans are virtually impossible to incorporate in the econometric model given their characteristic of exogenous interventions in the economy the inertial component in contrast can be modelled. Nevertheless this adds further complexities by introducing past inflation in the agents expectations that can only be addressed in an econometric model including in the analysis real variables, an extension therefore of the restrictive hypothesis implicit in the Cagan model, and a dynamic equation for prices.

Such extensions are attempted in chapters 5 and 6. In the subsequent chapter, I discuss methodological questions implicit in the use of the Cagan model and contrast the hypothesis that the data generation process is the theoretical model as assumed throughout the analysis in this chapter to the hypothesis that the DGP is unknown. The implications have been explored in more general terms in the literature but in our particular case of study, given the complexity of the analysis the last assumption is fundamental in defining how to derive the econometric model.

Chapter 4

Econometric Modelling and Structural Econometric Models

In this chapter I consider the relevant aspects of the statistical model and the modelling strategy. The main objective of the chapter is provide a discussion of the concepts that underlie the empirical analysis implemented in chapter 5 and which are relevant in our consideration. By itself it is considered a brief attempt to summarize the London School of Economics (LSE) approach in econometrics[1] providing a discussion of the fundamental concepts derived from the LSE methodological approach used to derive the empirical models for the Brazilian economy. The chapter is divided into two main sections. In the first one the main concepts for the analysis are discussed and I present the justification of carrying on the analysis using the Vector Autoregression Model (VAR). The second section presents the implications of the concept of encompassing and parsimonious encompassing in empirical modelling under the statistical background provided by the VARs. A more detailed analysis of the argument presented in the first section can be found in Hendry and Richard (1982), Hendry and Doornik (1994), Mizon (1995) and Spanos (1990). The second section is derived from Clements and Mizon (1991), Hendry and Mizon (1993), Hendry (1995), Bontemps and Mizon (2003) and Johansen (1994). Finally we draw the notation from Hendry and Mizon (1993) and Hendry (1995).

[1] The acronym LSE approach has no direct link with the institution London School of Economics in the present time. It has been used in the literature to refer to a group of econometricians, among them, David Hendry, Denis Sargan and Grayham Mizon who during the 1970's were actually conduncing research at the London School of Econometrics as an institution. In the late 1970's such group of outstanding econometricians (except Denis Sargan who retired late in the 1980's) actually left the LSE economics department and took positions in another institutions in UK but the reference to the LSE was not abandoned.

4.1) Main Concepts

The departure point of our analysis is a vector of stochastic variables which have a joint density function given by: $D_z\left(\mathbf{Z}_T^1/\mathbf{Z}_0,\theta\right)$, where the density for the vector $\mathbf{Z}_t$ comprising M variables is conditional to a set of initial values, $\mathbf{Z}_0$, with θ representing the parameters of interest. The joint density can be then rewritten as a set of sequentially conditional densities through a sequential factorization given by:

$$D_z\left(\mathbf{Z}_T^1/\mathbf{Z}_0,\theta\right)=\prod_{t=1}^{T} D_z\left(\mathbf{z}_t/\mathbf{Z}_{t-1},\theta\right) \quad (4.1)$$

Such conditioning process assumes that the joint density is a statistical representation of the economy and indeed that the vector stochastic process $\mathbf{Z}_t$ represents the Data Generation Process (DGP)[2]. It is worthwhile to notice that by mapping the economic mechanism, namely all the agents actions of each single agent in a span of time in the geographic region relevant to the analysis which can be global in open economies into a joint density of a vector of stochastic variables a considerable reduction has taken place since we are assuming that (4.1) is a statistical representation of all actions in the economy. Notice that despite this the DGP still indeed unmanageably large.

The unmanageable feature in the DGP (4.1) results from the fact that the economy is represented as a system where ultimately all the economic variables represented in the stochastic vector $\mathbf{Z}_t$ are endogenous and determined by interactions among each other. Such representation needs further reductions since usually the sample size of the macroeconomic time series do not allow the estimation of such large

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[2] Assumes that $\mathbf{Z}_t$ is a $k\times 1$ vector. The vector stochastic process $\mathbf{Z}_t$ is formed then by $\mathbf{Z}(\mathbf{t})\equiv\left[Z_1(t),Z_2(t),\ldots Z_k(t)\right]$ where each one of the $Z_k(t)$ is a stochastic process, namely, for a given probability space define the function $Z(\cdot,\cdot):S\times \mathrm{T}\rightarrow\Re$. The ordered sequence of random variables $\left\{Z(\cdot,t),t\in \mathrm{T}\right\}$ is called then a stochastic random process. In this case for each $t\in \mathrm{T}$ we have a different random variable and for each $s\in S$ we have a different realization of the process. In this sense the marginalization imposed by (4.2) and the restrictions imposed in the econometric model that is assumed to represent (4.2) either in terms of time-heterogeneity (stationarity) or in terms of the memory of the process (VAR(p)) are placed ultimately for tractability.

econometric models that would represent the DGP. Further the DGP is assumed to be unknown since the observed variables which constitute the macroeconomic time series available for modelling are in general aggregations of the original set of variables in $\mathbf{Z}_t$ across time and individuals which implies that some level of marginalization is inevitable in the sense that we do not have their correct representation. This not necessarily means that we can assume that any marginalization is an adequate representation of the DGP. Indeed it is at this point that the approach followed here has its strong point. Any final model resulted from the analysis here is subject to test and will provide therefore evidence of the adequacy of the reduction from the DGP that it assumes to be representing and theoretical hypothesis are subject to testing not simply empirical validation.

We assume then that the set of relevant variables $\mathbf{Y}_t$ with $n < M$ is derived by marginalization from equation (4.1) in such way that we have a partition of $\mathbf{Z}_T^1$ into $\mathbf{Z}_T^1 = \left(\mathbf{W}_T^1, \mathbf{Y}_T^1\right)$ and further marginalization of (4.1) into:

$$D_z\left(\mathbf{Z}_T^1/\mathbf{Z}_0,\theta\right) = D_{w/y}\left(\mathbf{W}_T^1/\mathbf{Y}_T^1,\mathbf{W}_0,\iota_t\right)D_y\left(\mathbf{Y}_T^1/\mathbf{Y}_0,\Lambda_t^1,\phi\right).$$

This marginalization defines then the Haavelmo distribution as[3]:

$$D_Y\left(\mathbf{Y}_\mathrm{T}^1/\mathbf{Y}_0,\Lambda_t^1,\phi\right) = \prod_{t=1}^{T} D_y\left(\mathbf{y}_t/\mathbf{Y}_{t-1}^{t-s},\mathbf{D}_t,\lambda\right) \quad (4.2)$$

where Λ represent a set of deterministic variables[4].

The sequence of densities in equation (4.2) is conditioned on $\mathbf{D}_t$, representing the use of contemporaneous or lagged information only in deterministic terms, on $\mathbf{Y}_{t-1}^{t-s}$

[3] Such indiscriminate use of the term Haavelmo distribution deserves a more careful definition. According to Clements and Mizon (1991) a well specified statistical model within which is possible to test competing structural hypothesis defines a Haavelmo distribution. Hendry (1995, p. 406) also defines the distribution as given by specifying the variables of interest, their status, their degree of integration, data transformations the history of the process and the sample period.

[4] This set of deterministic variables contains seasonals dummies, step dummies, constant, etc and will be exactly defined for each model used.

representing a maximum lag length imposed for tractability, and finally on $\lambda = f(\phi)$ meaning that the original set of parameters of interest ϕ might contain many transient parameters.

The Haavelmo distribution plays an important role in the sense that it comprises a set of a priori information, or knowledge about the economic events and empirical observations that defines the relevant variables in equation (4.2). It is also important to notice that its formulation comprises the assumption that it is possible to learn the parameters of interest, μ say, from ϕ alone in the sense that $\mu = f(\phi)$ only.

Furthermore equation (4.2) entails also a sequential factorization of $\mathbf{Y_t}$ in such a way that its right hand side generates a mean innovation process given by:

$$\varepsilon_t = \mathbf{y_t} - E\left[\mathbf{y_t} / \mathbf{Y}_{t-1}^{t-s}\right] \quad (4.3).$$

Nevertheless a similar sequential factorization of the DGP considering the same lag truncation in (4.1) generates:

$$D_z\left(\mathbf{Z}_{t-s}^{t-1} / \mathbf{Z}_0, \theta\right) = D_{w/y}\left(\mathbf{W}_{t-s}^{t-1} / \mathbf{Y}_{t-s}^{t-1}, \mathbf{Z}_0, \mathbf{W}_{t-s}^{t-1}, \mathbf{Y}_{t-s}^{t-1}, \theta_{a_t}\right) D_y\left(\mathbf{Y}_{t-s}^{t-1} / \mathbf{W}_{t-s}^{t-1}, \mathbf{Y}_{t-s}^{t-1}, \mathbf{Z}_{0,}\theta_{b_t}\right)$$

$$\eta_t = \mathbf{z_t} - E\left[\mathbf{z_t} / \mathbf{Z}_{t-1}^{t-s}\right] \quad (4.4).$$

Therefore given the partition of the vector $\mathbf{Z_t}$ into $\mathbf{Z}_T^1 = \left(\mathbf{W}_T^1, \mathbf{Y}_T^1\right)$ then the condition for reducing (4.1) to (4.2) without loosing information is that indeed: $E\left[\varepsilon_t / \mathbf{Z}_{t-s}^{t-1}\right] = E\left[\varepsilon_t / \mathbf{Y}_{t-1}^{t-s}, \mathbf{W}_{t-1}^{t-s}\right] = 0$, however we only know that $E\left[\varepsilon_t / \mathbf{Y}_{t-1}^{t-s}\right] = 0$.

Such condition imply that θ_a is irrelevant in the estimation and that $D_y\left(\mathbf{Y}_{t-s}^{t-1} / \mathbf{W}_{t-s}^{t-1}, \mathbf{Y}_{t-s}^{t-1}, \mathbf{Z}_{0,}\theta_{b_t}\right)$ can be written as $D_y\left(\mathbf{Y}_{t-s}^{t-1} / \mathbf{Y}_{t-s}^{t-1}, \mathbf{Z}_{0,}\theta_{b_t}\right)$ or in other words that $\mathbf{W_t}$ does not Granger cause $\mathbf{Y_t}$ being the former irrelevant in the analysis of the latter.

According to Hendry (1995) it is at the stage of marginalization that most empirical researches eliminate variables which are potentially relevant[5].

A comparative analysis to the methodological approach undertaken in chapter 2 at this point would be fruitful to explain the possible risks in not differentiating (4.3) from (4.4) when deriving empirical models through marginalization on the grounds of assuming that the theoretical model is indeed the DGP.

Comparing to the results obtained in chapter 2. The theoretical model is assumed to be the DGP and implied a set of restrictions which when they were imposed in the econometric model were undoubtedly rejected. In the sequel the rejected restrictions had to be reinterpreted in the lights of the results and under the condition that the theoretical model represents the DGP and assessments of the econometric model adequacy were not implemented to question if it would represent a reasonable description of the data and consequently of the Haavelmo distribution in (4.2). In particular this distribution was assumed to be well represented by the two variables of interest derived from the theoretical model, namely S_t representing the long run money demand equation in the Cagan model and the second difference in the rate of growth of M1 ($\Delta\Delta m_t$). Such marginalization potentially threw away relevant information as any marginalization would do. The fact that no assessment has been done to evaluate if the econometric model would represent the data correctly was unnecessary on the extent that the theoretical model represented the DGP, but even if it had been carried on and the model correctly characterized the data, it would have been innocuous in the sense that rejecting a simpler model in a specific to general modelling strategy would not allow us to derive any further information from the econometric model beyond the fact that the money demand shocks appeared to be relevant, in this case everything which is not explained by the econometric model.

Such methodological problem arises in the context that behind the modelling strategy adopted in chapter 2 is the assumption that the DGP is known a or that the

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5 Interestingly this discussion is also present in the called *semistructural* VAR approach where according to Canova (1995) the modellers are interested in identifying the behavioural shocks and in predicting the effect of a particular shock on the endogenous variables of the system. Within this approach according to the author there are situations when the observation of current and past values of endogenous variables are not sufficient to achieve the identification of behavioural shocks. Such problem is related to the fact that agents when undertaking their decisions have an information set that is larger than the one available to the econometrician. So potentially there has been some marginalization that threw away relevant variables.

sequential factorization holds at the DGP level with $D_z\left(\mathbf{Z}_T^1/\mathbf{Z}_0,\theta\right)=\prod_{t=1}^{T}D_z\left(\mathbf{z}_t/\mathbf{Z}_{t-1},\theta\right)$ where $\mathbf{Z}_t=\left(S_t,\Delta\Delta m_t\right)$.

In this case equation (3.1)[6] is assumed to be the DGP that generates the main cointegration relationship when solving it using the rational expectation hypothesis. The disturbance term in equation (3.1) is assumed to represent the money demand shocks[7]. If the test for the implied theoretical restrictions on the VAR rejects interpreting such result becomes very difficult in the sense that it is necessary to qualify if these shocks are relatively significant or not using some measure to show how stringent is the data to the theoretical model. In our case the difference between S_t and S_t' as defined in chapter 3 represents a measure of the noise term u_t in equation (3.1), so testing if this difference is significant constitutes a test of the relevance of the noise shocks in explaining the money demand behaviour. Therefore equation (3.1) is assumed to be the known DGP in such way that departures from it are considered money demand shocks but not signals of a possibly mispecified empirical representation of a given theoretical model.

This brief discussion about the methodological approach implemented in chapter 2 when compared to the Haavelmo's distribution concept lead us to conclude that any statistical model which uses this concept must be specified in terms of the random variables that ultimately compose the stochastic equation system in equation (4.2) and not as a theoretical model to which we add a disturbance assumed to follow a specific distribution and assume that the DGP is known.

In contrast to the approach taken in chapter 2 I do follow a progressive strategy, or the LSE methodology, when deriving any structure[8] from the Haavelmo distribution

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[6] Remember that equation (3.1) is: $m_t - p_t = \alpha - \beta\left[E_t p_{t+1} - p_t\right] + u_t$

[7] In Tourinho (1997) the author faces a similar problem in testing a theoretical model for money demand and supply. Despite the derived theoretical restrictions imposed on the cointegrating vectors when tested are not rejected the statistical model under which the theoretical model is assessed is clearly misspecified. In the author words: "The autocorrelation of the residuals cannot be eliminated completely for this data by taking differences, probably because of the non-stationarities which are due to the stabilization shocks" (Tourinho, 1997, p. 20). Such sort of misspecification could lead then to misleading conclusions and only reinforces the idea that the DGP and the theoretical model should be considered separately in econometric modelling and not the first being the generator process.

[8] The concept of structure is defined in Hendry and Doornik (1994, p 9) as: "... an entity (structural model) which is to be contrasted with a system having derived parameters (reduced form) and even being a synonym for the population parameter". Structure is also defined later in the same page as: "the set of basic invariant attributes of the economic mechanism". Despite the presence of these two definitions they seem to lead to the same concept which is an econometric model as described in the first definition that presents parameters which are invariant (constant across interventions) and constant (time independent).

in (4.2). The progressive strategy in the present context comprises the specification of a general linear dynamic model from which it is imposed and tested restrictions to derive the econometric model, in doing so I expect to relate the empirical model to the actual mechanism that is generating the data rather than to theory only which means then that theory and data form the DGP. The character of progression comes from the fact that when imposing and testing restrictions I am checking continuously if the proposed model (more restricted) can predict the parameters of the more general model.

In particular it is considered that the econometric model of interest imposes a set of restrictions on the statistical system represented by (4.2) which are delineated from the economic theory. The econometric model can therefore be denoted by:

$$\mathbf{f}_y\left(\mathbf{Y}_T^1/\mathbf{Y}_0;\xi\right)=\prod_{t=1}^{T}\mathbf{f}_y\left(\mathbf{y}_t/\mathbf{Y}_{t-1}^{t-s};\xi\right) \quad (4.5)$$

where $\mathbf{f}(\bullet)$ represents the postulated sequential joint densities.

In general since $\mathbf{f}(\bullet)$ is an econometric model it comprises a practical problem how to choose among the many different econometric models can be postulated to represent the joint densities in $\mathbf{f}(\bullet)$.

4.1.1) VARs and the Haavelmo's Distribution

In the present case I firstly specify a general dynamic model that represents (4.2) as the Vector Autoregressive Vector (VAR) which assumes the following representation:

$$\mathbf{y}_t=\sum_{i=1}^{p}\gamma_i\mathbf{y}_{t-i}+\omega\mathbf{D}_t+\vartheta_t \quad (4.6)$$

They may also include agent's decision rules as the econometric model used in chapter 2 represents but no assumption of these decision rules being derived from inter-temporal optimization. Within the VAR literature according to Canova (1995, p. 67): "a model is termed as structural if it is possible to give distinct behavioural interpretations to the stochastic disturbances of the model." My intention in giving these definitions is to avoid any confusion with the term structural for the model derived in the next chapter which follows the definition in Hendry and Doornik (1994) and also to satisfy at least partially a plea for linguistic stability raised by Sims (1991).

The economic theory is used to identify long run relationships among the variables and the concepts of congruence and encompassing defined in the next section to exactly tackle the problem of how to select the econometric model to represent the joint densities in equation (4.5) within the framework of an unrestricted VAR as the statistical model of interest.

Since I am considering that (4.6) represents the vector stochastic process in (4.2) and through its density the econometric model in (4.5) some considerations about the statistical assumptions underlying (4.6) become therefore necessary.

The first consideration is that the parameters of interest are the vector of coefficients (γ, ω) and the matrix of variances-covariances of ϑ which represents the statistical parameters, but they are not necessarily the theoretical parameters of interest. As discussed below a reparameterization of (4.6) in terms of a Vector Equilibrium Correction Model (VEqCM) with the identification of long run theoretical relationships between the variables allows a much more interpretable parameter structure.

A second consideration is that the sampling model behind the VAR is a stationary, asymptotically independent sample which is sequentially drawn from $D_y\left(\mathbf{Y}_t / \mathbf{Y}_{t-1}^{t-s}, \mathbf{D}_t, \lambda\right)$. The VAR stationarity assumption is discussed below with the reparameterization of (4.4) in terms of the VEqCM. The asymptotic independence is justified by the fact that in general macroeconomic time series are not temporally independent but by restricting the memory of the stochastic process they can be assumed to be asymptotically independent in such way that the initial conditions in equation (4.2) are no longer of interest. In particular here this condition is expressed by restricting the lag length of the VAR model up to order p[9].

Finally a further assumption underlying the statistical model that represents (4.2) is the linearity with respect the variables of interest in $\mathbf{y}_t$. In particular in macroeconomic time series this assumption is considered restrictive, in the sense that in general macroeconomic relationships are non-linear, and in the presence of governmental interventions as those observed in the Brazilian case under study this is even clearer given the time pattern of the data. Nevertheless it is assumed that a linear approximation can be attained by introducing dummy variables to account for the non

[9] See Spanos (1986) Chapter 8 for an excellent discussion about stochastic process.

linearity present in the data but being their use restrict to periods where I could correlate the dummy use with specific interventions carried on by the government or facts that are exogenous to the model under scrutiny[10]. However I do not assume that because the sequence of interventions observed in the Brazilian economy it is possible to ignore misspecification tests and carry on the analysis using a misspecified model as in Tourinho (1997).

Under these main assumptions therefore we are postulating a statistical model that is assumed to represent the Haavelmo's distribution (4.2) but not necessarily a theoretical model or the DGP. It is a general model that is assumed to provide a summary of the information present in the sample which can include not only a theoretical model but information about economic events of interest like oil prices rises and economic shocks such as those discussed in chapter 2. It is in this sense that the modelling process can be considered general to specific, or in other words by assuming a general statistical representation of the data that enable us to consider specific economic models of interest without restricting the DGP to be identical to the theoretical model proposed. As a consequence the model considered in (4.6) is a hypothesis about the structure of the stochastic values whose validity is assessed and indeed depends on the probabilistic structure of the observed data and not that of the theory (Spanos, 1990). In terms of the methodology used to analyse the data there is a clear separation between the DGP which it is not the theoretical model and consequently is assumed to be unknown and the statistical model of interest which allow us to test any assumption about the economic theory under a data coherent statistical model.

In this sense it is not by simple coincidence that (4.2) is assumed to be represented by a VAR as in equation (4.4). VAR models have a long tradition in macroeconomic modelling and, given their flexibility in accommodating the non-stationarity such as deterministic trends and stochastic time dependent means being modelled by integrated processes as well as non-linearity through deterministic variables, they represent a natural choice in representing the statistical model in (4.2). They also can be considered naturally as a derived model following the reduction steps as discussed in Hendry (1995, chapter 9). Further it has been established in the literature

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[10] The concept of exogenous here accounts for interventions in variables not included in $\mathbf{y}_t$ or in other words not explicitly modeled.

according to Canova (1995) that either exact or approximate solutions to many stochastic dynamic equilibrium models comes in the form of restricted VARs.

Indeed VARs can be seen as the empirical counterpart of theoretical models that assumes rational agents in a framework of inter-temporal optimization, where the relationships to be modelled are of the type:

$$E\left[\mathbf{A}(L)\zeta_t \middle| I_t\right] = 0 \quad (4.7)$$

Ignoring deterministic factors in equation (4.7), $\zeta_{n\times 1}$ represents a vector of theoretical variables of interest, I_t is the information set and $E\left[\bullet \middle| I_t\right]$ is the conditional expectations operator.

Considering that $\mathbf{y}_t$ is the vector of observable variables which adequately describes the variables in ζ_t, only finite lags are involved in (4.7) and the future expectations do not affect the outcome, the empirical counterpart of (4.7) is:

$E\left[\mathbf{y}_t \middle| \mathbf{y}_{t-1}, \mathbf{y}_{t-2}, \ldots \mathbf{y}_{t-k}\right] = \sum_{i=1}^{k} \mathbf{A}_i \mathbf{y}_{t-i}$ which is exactly the VAR described in (4.6) if we take conditional expectations and note that $\vartheta_t = \mathbf{y}_t - E\left[\mathbf{y}_t \middle| \mathbf{y}_{t-1} \cdots \mathbf{y}_{t-k}\right]$ is an innovation process to the available information.

Representing equations like (4.7) through the use of a VAR model lead us to consider that in some extent the parameters of the VAR in (4.6) are tied down to the deep parameters in the theoretical models. The degree to which the empirical modelling is treats to the restrictions imposed on the VAR basically defines the two opposite areas of research that use this modelling approach. In one extreme it can be categorized by those who derive the theoretical restriction and in the sequel impose and test their relevance in the statistical model as in Hansen and Sargent (1991). In the other extreme are those who use non-theoretical priors on all variables in a VAR to define the restrictions of interest and balance over-parameterization and oversimplification when reducing the dynamics of an unrestricted VAR as in Litterman (1980,1986 *c.f.* Canova (1995)). The approach followed by the LSE methodology as argued in Mizon (1995) can be situated in an intermediary position between these two extremes in the sense that economic theory guides the choice of the variables and identification of long run relationships but other information beyond that is used to model the vector of stochastic variables present in (4.2).

In terms of the modelling approach the LSE methodology firstly models the data temporal dependence from the unrestricted statistical model deriving a data coherent statistical basis for further inference and in the sequel uses economic theory to test and possibly to identify the structure of interest. Therefore the non-sense results of the theoretical models being rejected are avoided either because theoretical models rarely derive the extent to which temporal dependence is present or because in general the theoretical variables of interest do not find an empirical counterpart being the last ones only approximations due aggregation over time or individuals as discussed in Hendry (1995).

4.1.2) Conditional Factorization in the Context of VAR Models

In the context of the reductions implied by imposing restrictions on the econometric model a fundamental problem is the conditioning of the model on a set of weakly exogenous variables. To see this assume the following partition of $\mathbf{Y}_t$ into $\mathbf{Y}_t = (\mathbf{V}_t, \mathbf{X}_t)$ and conditioning on $\mathbf{x}_t$. When valid this conditioning allows the reduction of the system under analysis through testing its restrictions on the parameters of interest and represent an invaluable reduction in the numbers of parameters for estimation given the fact that usually the sample sizes in macroeconomics are small. Further the concept of weak exogeneity is a necessary condition to use the econometric model for policy analysis and forecasting if conditioning is to be implemented. In particular weak exogeneity allows the marginalization of variables without incurring into the cost of throwing away relevant information in estimating the parameters of interest as the definition below shows.

In this case assuming the partition in $\mathbf{Y}_t, \mathbf{x}_t$ is weakly exogenous for the parameters of interest μ if and only if there exists a reparameterization of ξ as ς, with $\varsigma = (\varsigma_1', \varsigma_2')'$ such that μ is a function of ς_1 only and ς_1 and ς_2 are variation free.

Or in other words the subset of variables $\mathbf{x}_t$ in the original vector $\mathbf{y}_t$ is weakly exogenous for the parameters of interest if inference about μ can be conduced from the conditional density alone ($\mathbf{f}_{v/x}(\bullet)$) in (4.8) without loss of information[11].

$$\mathbf{f}_y\left(\mathbf{y}_t/\mathbf{Y}_{t-1}^{t-s},\mathbf{D}_t,\xi\right)=\mathbf{f}_{v/x}\left(\mathbf{v}_t/\mathbf{x}_t,\mathbf{Y}_{t-1}^{t-s},\varsigma_1\right)\mathbf{f}_x\left(\mathbf{x}_t/\mathbf{Y}_{t-1}^{t-s},\varsigma_2\right) \quad (4.8)$$

In terms of the statistical model in (4.6) the unrestricted VAR has the number of estimated parameters increasing rapidly by extending p or increasing n what turns out the concept of weak exogeneity to be a desirable tool in carrying on valid conditioning using this class of econometric models. For instance consider the reparameterization of (4.6) into an unrestricted VEqCM which does not impose any restriction on the original VAR and where we omit the deterministic terms for simplicity such that:

$$\Delta\mathbf{y}_t=\sum_{i=1}^{p-1}\Pi_i\Delta\mathbf{y}_{t-i}+\Pi\mathbf{y}_{t-1}+\vartheta_t \quad (4.9)$$

Where: $\Pi=\alpha\beta'$, α and β are $n\times r$ matrices, Ω is the covariance matrix of ϑ_t and finally $0<r=rank(\Pi)<n$ so there are cointegration (assuming that the variables in $\mathbf{y}_t$ are I(1) which represents the case of interest in our analysis).

Following the conditioning of $\mathbf{v}_t$ into $\mathbf{v}_t/\mathbf{x}_t$, equation (4.9) can be rewritten as:

$$\Delta\mathbf{v}_t=\nu\Delta\mathbf{x}_t+\left(\alpha_y-\nu\alpha_x\right)\beta'\mathbf{v}_{t-1}+\sum_{i=1}^{p-1}(\Pi_{vi}-\nu\Pi_{xi})\Delta\mathbf{v}_{t-i}+\vartheta_{vt}-\nu\vartheta_{xt} \quad (4.10)$$

$$\Delta\mathbf{x}_t=\alpha_x\beta'\mathbf{v}_{t-1}+\sum_{i=1}^{p-1}\Pi_{xi}\Delta\mathbf{v}_{t-1}+\vartheta_{xt} \quad (4.11)$$

Where $\nu=\Omega_{vx}\Omega_{xx}^{-1}$

[11] An interesting aspect of the concept is that $\mathbf{x}_t$ can only be weakly exogenous for the set of parameters of interest μ because in fact a factorization as (4.8) can always be achieved if we define ς_1 and ς_2 adequately so we need a well defined set of parameters of interest.

The hypothesis of weak exogeneity of $\mathbf{x}_t$ with respect to β can then be tested through the hypothesis of $\alpha_x = 0$ in (4.11). Further if $\mathbf{v}_t$ does not Granger cause $\mathbf{x}_t$ in (4.9) then $\mathbf{x}_t$ is strongly exogenous to β. It should be notice that these results are of interest if the parameters of interest are the long run coefficients of the cointegrating vectors. One important result in the case of $\mathbf{x}_t$ being weakly exogenous is that for the econometric model it is no longer simultaneous in the variables $\mathbf{x}_t$ being possible to condition the system in the sense that we can concentrate the estimation on equation (4.10) without loosing information.

In proceeding with the progressive strategy postulated for deriving the structure two concepts become essential in driving the analysis from the general econometric model to the more parsimonious, congruence and encompassing. A brief review of these concepts is presented below always having in mind that VARs are a valid representation for the Haavelmo's distribution or in other words focusing the analysis on the implications that these two concepts have in context of VAR models.

4.2) Congruence

The congruence concept is related to the model coherency with the information available. Since the concept of information available is too general a more careful categorization would allow us to define more precisely coherency to the information available.

The first instance is a priori theory which is essential as the starting point of the modelling strategy but also seems to be the most controversial characteristic of an econometric modelling strategy. The controversy comes from the tension between imposing strict restrictions derived from a theoretical model or from pursuing a data basis analysis.

At this subject, Hendry (1995, p. 312) argues that "Although economic theory may offer a useful initial framework, theory is too abstract to be definitive and should not constitute a strait-jacket to empirical research: theory models should not simply be imposed on the data." We interpret the "strait-jacket" imposed by theoretical models as an allegory to the fact that there is nothing that guarantees empirical support to a theoretical model a priori no matter how stylized is the theoretical model. In other words the circumstances where the theoretical and the estimable model coincide can be thought of as particular rather than generic. Therefore simply imposing the theoretical restriction in the econometric model using a specific to general modelling strategy, can imply in non sense results. Also valuable information in macroeconomic modelling can come from different sources such as economic theory, economic history of the period studied as well as how data is defined and measured, as a consequence theoretical restrictions imposed on econometric models might limit considerably the analysis.

A second instance in congruency is sample information where the model is supposed to be congruent with the relative past information, with the relative present sample information and finally with the relative future information. The relative past demands that the model does not have errors correlated with past values of $\mathbf{y}_t$, e.g. auto-correlated errors. The relative present sample information demands that the model does not have errors correlated with present values of $\mathbf{y}_t$, e.g. heteroscedasticity. Finally the relative future sample information demands that the model does have constant parameters and does not suffer from predictive failures.

The congruency to the relative future sample entails the most complex of them in the sense that if the econometric model has its structural parameters as functions of the optimal decision rules for the economic agents and if these rules change systematically with the changes in the structure of the series which are relevant for the agents to take their decisions then inevitably any change in policy will change the structural parameters. As a consequence the parameters in the econometric model will not be invariant and forecast failure is likely. This result due to Lucas (1976) has been addressed as the Lucas' critique and pointed out as a major obstacle in the use of econometric models for deriving policy implications.

Hendry and Favero (1992) readdress the critique interpreted as a denial of invariance in the parameters of interest in some econometric models and for non-specified class of interventions affecting the economy. The authors then perform a classification of the possible classes of interventions and their relation to agent's expectations.

The first class comprises the fact that complete invariance to all possible changes in the environment is unattainable in the social sciences, so unexpected or major disruptions in the economy will generate failures in the econometric models in accounting for them.

The second class comprises the fact that changes in parameters happen when there are changes in the distribution of variable which are out of control of the economic agents but are under the control of a governmental agency or executive. Within this class expectations not necessarily are involved since the behaviour of the agents can be modelled by feedback or conditioning.

Finally in the *third class* the coefficients are not the parameters of interest as they are a mixture of behavioural and expectations parameters since the agents follow a feed-forward looking rules whereas the econometric model is based on backward looking ones. In this case the expectations parameters are the cause of parameter instability.

I do explore these levels and their implications for the statistical models used in our analysis given the changes in the policies represented by the sequence of stabilization plans. In particular we classify the changes imposed by the stabilization plans as falling in the second category above, namely, that the interventions in the economy altered the distribution of variables which were basically out of control of the agents given the type of interventions used such as prices and wages freezing, changes in the price index measurement rules among others listed in chapter 2. This would then generate forecast failure but not necessarily the changes in the parameters can be associated to changes in the expectations parameters in so far as that the model cannot be used to policy evaluation or forecasting.

In particular there are two moments when we consider that in the Brazilian case the class of interventions can be classified as falling in the second class, the Cruzado Plan and the Collor Plan cast. The solution found was then to split the sample and re-estimate the model just after the first stabilization plan cast. Interestingly we were able to derive a stable econometric model for the subsequent period despite the sequence of interventions represented by the following plans including the Collor one. Whilst such result can be considered remarkable it seems that the econometric model for the period immediately before the Cruzado plan cast, namely 1980-1986(2) suffered from parameter instability in one of the equations. Nevertheless this cannot be considered the cause of the forecast failure of this model and so we do not consider that the Lucas critique is applicable in this case, that obviously given the class of intervention to which the Cruzado plan is included. It should be noticed that I do not interpret the results found in the econometric model after the Cruzado Plan as casting evidence against the critique because in fact the second class defined above is in general not refutable in the sense that there is no amount of empirical evidence that would conclusively indicates that future interventions would not cause the parameters of the econometric model to vary with the changes in the variables which are outside the control of the economic agents.

According to Bontemps and Mizon (2003) in general we can define a model as empirically congruent if they have: ***homoskedastic*** innovation errors, weakly exogenous conditioning variables for the parameters of interest, constant and invariant parameters of interest, identifiable structures, data admissible formulations on accurate observations and are theory consistent.

4.3) Encompassing

Encompassing is related to the ability of a particular model to account for the characteristics of the rival models and new information represented by new observations. Indeed an encompassing model is defined as a model "which can account for the previous empirical findings that were thought to be relevant and adequate for the explanation of the variables and parameters of interest and can explain the features of rival models being considered currently" Mizon (1995, p 120). In comparing different models, test statistics of non-nested hypothesis can be used but since intransitivity is a property of such tests, care is necessary mainly in choosing the alternative hypotheses.

In the present case nevertheless, the analysis is confined to the use of nested models within the general framework of a VAR model representing the Haavelmo distribution, so such sort of problem is avoided.

Formally nesting can be defined as the following. Consider two parametric probabilistic models represented by the following sequential densities:

$$\mu_1 = \left\{\mathbf{f}_1\left(\mathbf{y}_t / \mathbf{Y}_{t-1}^{t-s}, \xi_1\right), \xi_1 \in \mathrm{H}_1\right\} \quad \mu_2 = \left\{\mathbf{f}_2\left(\mathbf{y}_t / \mathbf{Y}_{t-1}^{t-s}, \xi_2\right), \xi_2 \in \mathrm{H}_2\right\}$$

Then we can define that μ_1 is nested under μ_2 if and only if $\mu_1 \subseteq \mu_2$. In particular when mentioning that the models are nested within the VAR then we are using the fact that $H_1 \subseteq H_2$ so that indeed μ_1 is nested within μ_2 simply because the former is derived from restrictions in the parameter set imposed on the latter.

An important property of comparing models within a valid general framework is that if we can find a model that is a valid simplification of the general model then it parsimoniously encompasses the general model. The implication of parsimoniously encompassing is that "the relevant sample information set for the determination of a congruent model is the union of the information sets of the models implementing each competing theory" (Mizon, 1995: 121). Logically it follows therefore that instead of corroborating naively the competing models parsimonious, encompassing uses empirical evidence to evaluate and compare them. Notice that in the case of a new model based on a new a priori theory being argued as a possible contender this new model can be tested by using non-nested hypothesis if it is not nested by the general model used in the parsimonious encompassing test. But given the fact that parsimonious encompassing is based on a parsimonious model encompassing a general model irrespective of the type of encompassing (nested or non-nested) our model will be subject to a test that is pursued in an information set more general than required by its implementation. In the next section we formalize the concept of encompassing and parsimonious encompassing considering that we use a parsimonious VAR to represent the Haavelmo distribution.

4.3.1) Parsimonious Encompassing the VAR

The core of the analysis implemented in the following section is therefore consider that the Haavelmo distribution in (4.2) can be proxied by a VAR on the variables of interest represented in the vector $\mathbf{y}_t$ in line with the approach followed by Clements and Mizon (1991) and Hendry and Mizon (1993). We follow Hendry and Mizon (1993) and refer to the VAR as a system using both terms interchangeably whereas for any structural representation we term it as SEM.

The basic justification for adopting the VAR is to avoid initially any exogeneity assumption on the conditioning variables of (4.2). In this way despite deriving structural models they are not based on a priori restrictions on the variables of interest which could be considered incredible, but rather each restriction is imposed on a common basis represented by the VAR and can be tested against a well specified baseline model. Further the different structural models that evolve from the econometric modelling can be tested through encompassing avoiding therefore the presence of different well specified structural models explaining the same phenomenon.

The general system for a $n \times 1$ vector of time series variables $\mathbf{y}_t$ is given by: $\mathbf{A}(L)\mathbf{y}_t = \varpi \mathbf{D}_t + \vartheta_t$ (4.10) where $\vartheta_t \sim IN(\mathbf{0}, \Sigma)$, $\mathbf{A}(L)$ is the matrix polynomial in the lag operator such that: $\mathbf{A}(L) = \sum_{j=0}^{p} \mathbf{A}_j L^j = \mathbf{I}_n + \mathbf{A}^*(L)L$. Since the matrix has order p we have in (4.10) a p-th order system (VAR) since (4.10) can be rewritten as the following:

$$\left[\mathbf{I}_n - \mathbf{A}^*(L)\right]L\mathbf{y}_t = \varpi \mathbf{D}_t + \vartheta_t$$

$$\mathbf{y}_t - \mathbf{A}(L)^* \mathbf{y}_{t-1} = \varpi \mathbf{D}_t + \vartheta_t$$

$$\mathbf{y}_t = \mathbf{A}(L)^* \mathbf{y}_{t-1} + \varpi \mathbf{D}_t + \vartheta_t$$

Which is identical to (4.6)

Finally $\mathbf{D}_t$ is a vector that contains deterministic components as constant, trend, centred seasonal dummies etc. As it stands, the system can be classified as complete and closed. Complete in the sense that the number of equations is equal to the number of variables and closed in the sense that all n variables are modelled despite the marginalization in terms of the deterministic variables.

The system in (4.10) can be re-parameterized to account for the presence of non-stationarity generated by the presence of unit roots and beyond that modelled by $\mathbf{D}_t$ given that the presence of integrated variables in the system implies that non-optimal inference can result if we do not account for them.[12] Therefore equation (4.10) equation (4.10) is reparameterized into:

[12] There has been an intense discussion in the literature about the reasonableness of unit root tests and its implications. A strand of this literature led by Sims (1988) is very skeptical about its implications to economics as a science. He argues that the common argument that if no transformation is done to a stationary model then the inference is incorrect because the usual distribution theory does not apply is completely misplaced. We only argue here that non-optimal inference can result, but not necessarily will result if we do not reparameterize the VAR into a I(0) system. An investigation regarding this point is nevertheless far beyond the objectives of the present work. Furthermore to ignore this and proceed with

$$\Delta \mathbf{y}_t = \sum_{i=1}^{p-1} \Pi_i \Delta \mathbf{y}_{t-i} + \Pi \mathbf{y}_{t-p} + \varpi \mathbf{D}_t + \vartheta_t \quad (4.11)$$

where: $\Pi_i = -\left(\mathbf{I}_n + \sum_{j=1}^{i} \mathbf{A}_j\right)$ and $\Pi = -\left(\mathbf{I}_n + \sum_{j=1}^{p} \mathbf{A}_j\right) = -\mathbf{A}(1)$ is the matrix of long-run responses.

Notice therefore that I am considering the system as equation (4.11) to which the derived SEM is contrasted. The advantage in using (4.11) is that we can investigate the presence of cointegration between the variables in $\mathbf{y}_t$ by testing the rank (r) of Π following Johansen (1995). Apart from non-stationarity like trends or level shifts presented in $\mathbf{D}_t$, if Π has full rank then all variables in $\mathbf{y}_t$ are I(0) stationary, if Π has rank, $0<r<n$ then there exist linear combinations of variables in $\mathbf{y}_t$ which are I(0) stationary and Π can be decomposed into: $\Pi = \alpha\beta$, finally if rank of Π is zero then all variables in $\mathbf{y}_t$ are I(1) and $\Delta \mathbf{y}_t$ is I(0).

As a consequence the integrated process if existing among the variables can be expressed in terms of the difference of the variables (Δ) and as a linear combination which is stationary without incurring in loss of information. This represents a reduction in the number of parameters because it entails eliminating the linear combinations of integrated but not cointegrated variables.

It is worthwhile to notice that equation (4.11) represents a I(0) parameterization of the system in (4.10) and it is essential that the system presents a congruent representation of the available information so it can be considered as coherent statistical basis for further assessments.

The class of SEM that I consider here has the form:

$$\Theta \mathbf{f}_t = \mathbf{u}_t \quad (4.12)$$

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the analysis in levels would require a Bayesian approach rather than a classical one, which again is beyond the present objectives.

where Θ is an $n \times N^*$ matrix and $N^* = np \times r$ and $\mathbf{f_t}$ is the companion form of (4.11) given by:

$$\mathbf{f_t} = \Gamma \mathbf{f_{t-1}} + \omega_t \quad (4.13)$$

where:

$$\mathbf{f_t} = \begin{pmatrix} \Delta \mathbf{y_t} \\ \vdots \\ \Delta \mathbf{y}_{\mathbf{t}-p+1} \\ \beta \mathbf{y_{t-p}} \end{pmatrix} \text{ and } \Gamma = \begin{pmatrix} \Pi_1 \ \Pi_2 \ldots \Pi_{p-1} & -\alpha\beta' & -\alpha \\ I \ \ 0 \ \cdots \ 0 & 0 & 0 \\ \cdots \ \cdots\cdots\cdots & \cdots & \cdots \\ 0 \ \ 0 \ \cdots & \beta' & I \end{pmatrix} \text{ and } \omega_t \sim IN(0,\Omega)$$

From (4.12) and (4.13) we have:

$$\Theta \mathbf{f_t} = \Theta \mathbf{f_{t-1}} + \Theta \omega_t = \mathbf{u_t} \ (4.14).$$

If $\Theta = (\Gamma_0, \Gamma_1, \ldots \Gamma_p, \Gamma)$ then (4.11) can be rewritten as:

$$\Gamma_0 \Delta \mathbf{y_t} = -\sum_{i}^{p-1} \Gamma_i \Delta \mathbf{y_{t-i}} - \Gamma \beta' \mathbf{y}_{\mathbf{t}-p} + \Gamma \vartheta_t \quad (4.15).$$

So in the case of the rank (r) of Π being n (full rank) then Γ is free to assume any value. If $r = 0$ then $\Gamma = 0$ and if $0 < r < n$ then $\Gamma = \gamma$[13]. In this last option misspecification results if Γ excludes some cointegrating relationships. Further misspecification can result if the I(0) or $\Delta \mathbf{y}$ variables are incorrectly formulated. The possibility of misspecification reinforces therefore the necessity of a careful analysis of the econometric model. In the class of closed systems considered in this analysis the restrictions are basically restricted to the dynamic structure and the presence of the deterministic components in the final equations of the econometric model the last ones considered exogenous. Also the error covariance matrix in (4.14) will be then:

[13] Notice that, according to Johansen (1995), β is invariant to linear transformations.

$E\left[\mathbf{f}_t\mathbf{f}_t'\right] = \Theta\Pi E\left[\mathbf{f}_t\mathbf{f}_t'\right]\Pi'\Theta' + \Theta\Omega\Theta'$ so not necessarily we will have diagonal matrix of disturbances and such restriction is not imposed as we would expect if a Wold causal chain had been used to identify the econometric model.

In contrasting different SEM models we use the concept of encompassing. In the present context consider two rival SEM of the form $H_1 : \Theta_1\mathbf{f}_t = \mathbf{u}_{1t}$ and $H_2 : \Theta_2\mathbf{f}_t = \mathbf{u}_{2t}$ which are over identified relative to the congruent statistical system (4.13). Let τ_2 denote the vector of parameters in Θ_2 and let τ_p be what H_1 predicts τ_2 to be if H_1 were the DGP. Then H_1 encompasses H_2 if and only if $\tau_2 - \tau_p = 0$.

From this condition is possible to derive that the VAR, (H_1), say, encompasses H_2 once it is congruent since according to Bontemps and Mizon (2003) a general model (VAR) being congruent is a sufficient condition for it to encompass all simplifications of it, so H_1 predicts what τ_2 is to be. In the context of the general to specific modelling strategy the question of interest is that if the SEM encompasses the system since, if it does, a simpler model nested within the general model (system) is accounting for the characteristics of a more general model. The VAR provides then the framework within which we access the properties of the SEM.

A logical difficulty in establishing encompassing properties of the SEMs is that in general they rely on exogeneity assumptions to be identified and they are not in a common probability space as argued in Hendry and Mizon (1993). Nevertheless this problem is circumvented here since, by assumption, the baseline for testing different SEMs as $\Theta_1\mathbf{f}_t = \mathbf{u}_{1t}$ and $\Theta_2\mathbf{f}_t = \mathbf{u}_{2t}$ is the VAR in (4.14). So in this case the exogeneity assumptions about rival SEMs do not differ because the systems under analysis are closed so all variables are endogenously determined and the restrictions implied by Θ_1 and by Θ_2 are restrictions tested on the VAR. The closed system assumption in conjunction to the assumption of correct dynamic specification of (4.12), or more specifically that $E\left[\mathbf{u}_t\mathbf{f}_{t-1}'\right] = 0$ (4.16), are enough to circumvent the different assumptions about the exogeneity in rival SEMs[14]. To see this consider $H_1 : \Theta_1\mathbf{f}_t = \mathbf{u}_{1t}$ noticing that condition in (4.16) implies that:

[14] Notice that usually it is assumed that the errors $\mathbf{u}_t$ are serially uncorrelated, the difference here is that this condition is tested.

$$E\left[\Theta_1 \mathbf{f}_t \mathbf{f}'_{t-1}\right] = \Theta_1 \Gamma E\left[\mathbf{f}_{t-1} \mathbf{f}'_{t-1}\right] = 0 \, (4.17)$$

since: $\Theta_i \mathbf{f}_t = \Theta_i \Gamma \mathbf{f}_{t-1} + \Theta_i \omega_t = \mathbf{u}_{it} \quad i = 1, 2$.

But indeed for condition (4.17) to be valid the following condition must be true given that $E\left[\mathbf{f}_t \mathbf{f}'_t\right] \neq 0$ in (4.17), namely:

$$\Theta_1 \Gamma = 0 \ (4.18)$$

Condition (4.18) is nevertheless the condition to absence of dynamic misspecification in the VAR in the I(0) space $\left(\Theta \omega_t = \mathbf{u}_t \text{ in equation 4.14}\right)$. Consequently, if condition (4.18) holds which is originally the assumption in (4.16) it implies that the SEM represented by H_1 is congruent, which is a derivation of the restrictions represented by Θ. In this case the SEM is a valid reduction of the VAR and parsimoniously encompasses the VAR.

Therefore, parsimoniously encompassing the VAR and being congruent is a sufficient condition to the SEM to encompass rival models (Hendry and Mizon, 1993), so basically the tests are carried on in terms of the SEM being a valid reduction against the VAR, in this sense no incredible restrictions have been imposed a priori[15]. This is particularly true here because the usual order in defining the econometric model is consider the identification first through exogenous assumptions and then test the restrictions from the econometric model, whereas here we consider the VAR as representing the unrestricted reduced form, so no exogeneity assumption is imposed and then the SEM is tested against the VAR instead of a priori derived structural model. Further condition (4.18) can be tested given that it coincides with the known condition for the validity of over-identifying restrictions. The likelihood test of over-identifying restrictions is calculated as:

[15] After Sims (1980) the a priori restrictions used to identify Structural Models have been named incredible, despite some also consider incredible a valid representation of reality given by a VAR as in Kirchgässner (1991).

$$\zeta(M) = 2(l_1 - l_2) \sim \chi^2(M)$$

where M is the number of restrictions.

I assume in testing the over-identifying restrictions that the cointegrating vectors, if any, have already been identified and estimated, so in practice the system is re-estimated in equation (4.11) before imposing the restrictions and calculate the log-likelihood l_2 and after imposing the restrictions calculating the log-likelihood l_1.

Still, nevertheless to be investigated is the fact that many models could satisfy the encompassing property derived from (4.18). However as noticed in Hendry and Mizon (1993) policy regime changes will induce invariance in the parameters of the different SEM (Γ_i) which are not just reparameterizations of each other in $\Theta_i \Gamma = 0$ destroying the observational equivalence and mutual encompassing which can only be assessed in a constant parameter world, therefore only the representation that corresponds to the actual structure of behaviours will remain constant[16]. Such assertion is very interesting in our case, mainly in the second period where a sequence of policy regime changes took effect, so if we can derive a constant SEM for the period it will be unique among the class of SEM considered here and given the information set.

[16] It might nevertheless be represented by reparameterizations.

Chapter 5

Dynamic Econometric Models and the High Inflation in Brazil[1]

This chapter presents the three different econometric models for the high inflation in Brazil and the posterior stabilization periods. The analysis assumes implicitly that the Cagan's model is a rather restrictive description of the data considering the particularities of the Brazilian economy presented in chapter 2. In particular assuming that the DGP followed the Cagan model implies that the money demand was driven basically by expectations towards inflation for 15 years. In this aspect, the argument in the present chapter is similar to Tourinho (1997) one's who argues that a valid econometric specification for the demand under high inflation should be based on the assumption that real variables do affect the demand for real money.

The author argues that in the Brazilian case the economy experienced a high inflation period rather than a hyperinflation. Therefore the classical hypothesis that the huge increases in prices and money would dwarf the real factors would not be valid in the Brazilian case. A consequent question to be raised is then can we identify a long run money demand equation and how the real variables are related? In particular for the Brazilian high inflation a second question merits attention namely, does the model account for the inertial component present in the price dynamics? The motivation for the analysis comes from the fact that high inflations are even rarer than hyperinflations and despite this there have been few attempts to develop econometric models addressing this phenomenon in Brazil.

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[1] A modified version of this chapter based on section 5.3 and chapter 6 was presented at the IX ANPEC SUL conference and XXXIV ANPEC National conference held in Brazil. A further paper based on the results of section 5.2 and section 6.3.1 was accepted to presentation at the International Conference on Policy Modelling 2007. The author would like to thank the comments from the discussant and participants.

analyse the inflation behaviour. The chapter innovates by defining an econometric model following the LSE methodology for the period that includes all the stabilization plans and the hyperinflation episode what constitutes to the best of my knowledge the only attempt to carry on an econometric analysis of this particular period. Usually in the literature, the analyses concentrate on the periods that precede the first stabilization plan casting in 1986 using the Cagan model or variants of it (Feliz and Welch, 1997) as discussed in chapter 3[2]. The chapter also innovates in presenting an econometric model to analyse the period between 1980 and 1986 when the inflation started to soar after the second oil shock, a model that contrasts the analysis presented in Juselius (2002) by developing an alternative econometric model that accounts for the presence of inertia in price dynamics. The model also contrasts to the results obtained in Durevall (1998) by extending the analysis to a system rather than the one equation model representing therefore the second contribution to the literature.

Finally the chapter also develops an econometric model for the period posterior to the stabilization in the Brazilian economy, namely from the Real plan and contrasts the results obtained to those in the first period comparing the level of inertia in prices and how the long run identified money demand equation differentiates from the period of high inflation (1986-1994). Extensions of these models to include the second major theory of price formation in an economy namely the purchasing power parity (PPP) and wage inflation impacts are delayed to chapter 6 for exposition purposes.

The chapter starts with a descriptive analysis of the data in section 5.1 and evolves for the econometric models in sections 5.2, 5.3 and 5.4 where the distinct periods namely: a) From January 1980 until February 1986, b) From April 1986 until June 1996 and finally c) From October 1994 until February 2002 are analysed respectively. The reasons for splitting the sample into these three intervals are given below. Section 5.5 presents the conclusions.

5.1) Descriptive Analysis of the Sample Data

The objective of this section is present a descriptive analysis of the sample data. For purposes of estimation, I divided the sample into three sub-periods as shown above.

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[2] The exception is Pereira (1989) who develops a similar analysis to mine but using a shorter sample ending in 1987.

However, for simply describing the main features of the data I analyse the first two sub-periods together. The sub-section 5.1.2 presents then the descriptive analysis for the final period, namely from October 1994 to February 2002.

5.1.1) First Period 1980(1) - 1994(6)

The sample data are monthly seasonally unadjusted for the period 1980 (1) to 1994(6). Due to an interruption in one of the series, namely the interest rate to the payee in the bills of exchange, the period from 1992(1) to 1994(6) was used for out of sample forecast evaluation. The variables are defined as the following: M1 is the paper money held by the public plus demand deposits and measured in millions of Reais[3] at the end of the period. CPI is the consumer price index, IP is the industrial production index both as defined in Juselius (2002), BE is the bill of exchange monthly interest rate to the payee and finally CDB is the monthly interest rate paid in the certificate of deposits.

The choice of the two interest rates follows the decision of modelling M1 and the data availability criteria, which span the whole period under consideration. The CDB is a primary rate for the fixed income market in Brazil constituting a medium to short run investment depending on the period and legislation in course. This interest rate is also used to calculate nowadays the Reference Rate (TR) that can be considered a type of Brazilian Prime Rate. Since the TR is only available from 1991 onwards, I opted for using the CDB rate itself.

The BE stands for an alternative to fixed income investments. It indeed represented a potentially different investment for agent's holdings of M1 than the fixed income operations represented here by the CDB interest rate in the extent that they represent bonds that were linked to goods transactions and the real sector of the economy.

The industrial production index was used in the attempt to capture the impacts of M1 in the economic activity since ultimately M1 is the most liquid asset and even in the periods of high rates of inflation was never replaced by a foreign currency. Indeed the ability to carry on transactions using M1 was given by the existence of interest bearing accounts as discussed in chapter 2.

[3] Real is currently the currency in circulation in Brazil.

Given these definitions I construct then the real money series as: $m1-cpi$, the inflation rate as: Δcpi, where Δ stands for the first difference operator and for illustrative purposes the velocity of money v as: $cpi+ip-m1$. Figure 5.1 contains full sample time plots of the modelled variables, $m1-cpi, ip, be, cdb, \Delta cpi$ and v for illustrative purposes only. Low cases indicate the log of the variable.

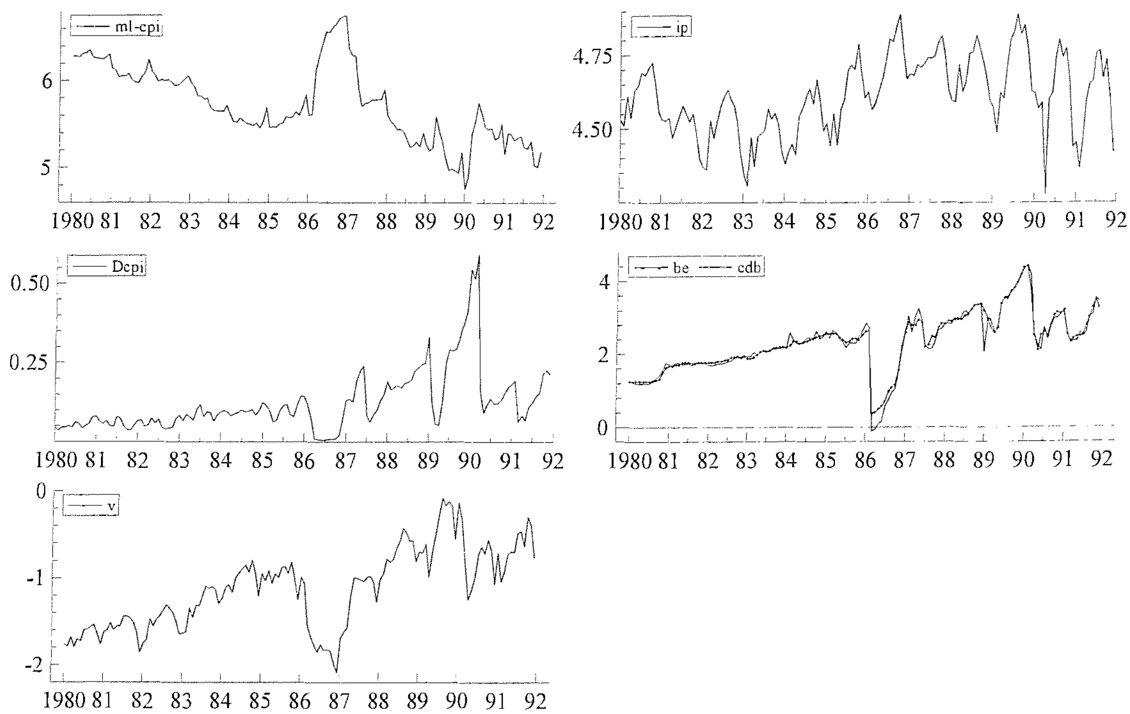
Turning our attention to the time plots in figure 5.1, a clear pattern is identifiable in the series for the period that precedes the launching of the Cruzado Plan in February 1986. The real money series presents a steady decline following the increase in the inflation rates, which however, stayed in moderated levels when compared to the posterior period and this decline is associated with an increase in the velocity of transaction as expected. The two interest rates had a similar pattern again presenting a steady increase in their nominal levels.

The decline observed in the industrial production index until 1983 reflects the deliberated recession implemented by the federal government in the first years of the decade. This picture changed drastically with the introduction of the Cruzado Plan, the first of a sequence of five stabilization plans. The result in terms of inflation rate was an immediate slump from rates about 14% per month, in January 1986, to rates around zero by April. Nevertheless, inflation reappears in the second semester and by January 1987 it had reached the levels observed before the Plan launching. In terms of the data, it can be seen in figure 5.1 the effects of the remonetization in the real money series which presented a noticeable increase along 1986 and in the velocity graphic, which declined very quickly. The "bell" shape with the subsequently slump in the real money levels is produced by the return of inflation. In numbers, the rate of growth in real money between November 1985 and November 1986 was 185% whereas by May 1987 it had already reached the same level as November 1985.

Following the loss of control in the inflation rates, a new plan was implemented in July 1987. Nevertheless, given the lack of adjustment in the fiscal deficit the inflation rates soared reaching levels never observed before by the end of 1988 as we can observe from figure 5.1. Indeed the length to which the measures took effect was far shorter than in the Cruzado Plan. By October 1987 the inflation rate had already crossed 10% per month, so in practice the Bresser Plan could only control prices for three months. At this period it is observed a stabilization in the real money series instead of a large increase with a posterior decline as the inflation increased by the end of 1987 with the velocity retaking its upward trend.

With inflation rates near 30% per month, by January 1989, a third stabilization plan (Summer Plan) was launched in February 1989. The inflation rate remained in control for only two months and by June 1989 it had reached 30% a month again and by the end of the year the country experienced a hyper inflation with rates around 80% per month.

Figure 5.1 1980(1)-1991(12) Sample Time Plots



In terms of the variables in figure 5.1, the real money series presented a fast decline along 1989 following the soaring inflation leading to an increasing velocity of circulation as the agents reduced their exposure to inflation by reducing the holdings of money. In figures, the real money level in January 1989 was reduced by 3.65-fold when compared to that observed in January 1980 and the velocity had increased by a 5-fold factor. The same figures for the period starting in 1980 and finishing in February 1986 just before the Cruzado Plan launching indicates that real money was approximately half of its observed value in January 1980 and the velocity had increased by a two-fold factor. Therefore, it seems that the succession of stabilization plans altered the dynamic in the monetary system in Brazil.

The new decade came with a new attempt to bring down inflation: The Collor Plan. The subsequent result in terms of inflation was the end of the hyperinflation and relative stability in prices for a few months. Due to lack of liquidity in the economy, a huge recession resulted. Both can be noticed visually in figure 5.1, where the inflation series shows a huge slump and the industrial production index reached the lowest level over a decade. Nevertheless, the chronic public deficit problem was not tackled once more and by December 1990 inflation went back to over 15% a month.

The real money series was affected initially by the lack of liquidity in the first month of the plan[4], which prevented the remonetization. However, this lack of liquidity soon started to cause problems in the financial system and the Government allowed the conversion of frozen assets at a discretion basis resulting in a growth of 133% in the real money from February 1990 to May 1990.

With the recrudescence of inflation by the end of 1990, the economy was, once again hit by an economic plan named Collor Plan II in January 1991. However, the political crisis that ended with President Collor's impeachment in December 1992 and lack of confidence of the society in the economic plans implied in another failure with the plan lasting for less than four months.

A general conclusion that can be draw from this analysis of the sample period with benefit of hindsight is that a distinctive pattern emerged with the Cruzado Plan. The sequence of stabilization plans implied short run cyclical movements in the real money characterized by fast increase in the first month(s) of the plan when inflation was kept low followed by a decrease in the real money after the subsequent increase in inflation. The length of the cycle has been shortened as the stabilization plans lasted less and less so the long length cycle observed in the Cruzado Plan was never repeated in the others until the Collor Plan. Given the financial embargo, this cycle was indeed interrupted in the Collor Plan, but was repeated in the Collor Plan II.

In terms of inflation, the pattern was short periods of low inflation when the plan was in effect to then it resumes its upward trend reaching usually levels never observed before the actual plan. The exception is again the Collor Plan, however in the Collor Plan II we again observed this pattern. The nominal interest rates presented a similar

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[4] Indeed the rate M4/GDP in percent fell back from 22.7% in February to 8.89% in March. Notice that M4 is the broadest concept and included at that time M1+ the remunerated special deposits + shares of short-term fixed income funds + highly liquid public securities (=M2)+savings accounts deposits (=M3)+securities issued by financial institutions.

behaviour to inflation since both rates represented the figures that were prevailing in the market. Finally the industrial production followed a pattern determined basically by the acceleration in the economy that characterizes periods of very high inflation[5].

In conjunction, this general pattern contrasts for all variables but the industrial production with the relative stability observed between January 1980 and February 1986 where inflation and the interest rates raised steady whereas the real money declined.

Given this change in pattern and the sequence of interventions I decided to split the sample into two sub periods namely, the first period from 1980(1) to 1986(2) and the second from 1986(4) to 1991(12)[6]. I justify such division given the evidence in the literature as in Rossi (1989) where the money demand equation suffered from parameter instability, which appeared to have taken place in the beginning of the 1980's. Further, the Cruzado Plan launching giving its non-orthodox profile, based on shock measures to fight inflation, produced a structural change in the level of inflation and real money that would imply predictive failure in the econometric model. Rossi had already found such result when his model failed in predicting the large movements in the M1 level after the Cruzado Plan despite using quarterly data and being perhaps smoother than our monthly data. Therefore, the evidence in the literature would suggest that instability was a major problem in the 1980's which indeed culminated with the Cruzado Plan consequently I opted to analyse the period separately for the remained of the sample.

Indeed the strategy appeared to pay dividends in the sense that in the first period, namely 1980-1986(2) the SEM presented signs of parameter instability and in the posterior period namely 1986-1991, a stable SEM could be developed showing that indeed the instability present in the econometric models in beginning of the 1980's was not carried on to the following periods[7].

Table 5.1 presents further evidence of the changes observed when considering the sample mean and standard deviation for the whole sample and the two sub-periods. The difference in the standard deviation for the two sub periods for all variables but the industrial production index is noticeable, usually approximately twice that observed in the first period for the two interest rates and real money and 4.6 times greater for inflation, which gives an idea of the instability observed in the second period.

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[5] Indeed the index reaches its highest value in August 1989.
[6] We exclude 1986(3) from the second period since the price index was likely to carry on residual inflation from February to the figures for March.
[7] Remains to be investigated in further research if it can be identified a money demand equation using and extending the same data as Rossi (1989) and Cardoso (1983) through a system approach as used here.

Finally, table 5.2 shows the unit root tests. The presence of the stabilization plans however determines a further challenge to the unit root analysis since the series present a sequence of structural changes in their levels. According to Cati et alia (1999) such changes are not of the same nature to those addressed in Perron (1989). In Perron (1989) the main argument was that the presence of structural changes would bias the conventional unit root tests towards a non-rejection of the null of unit root. When analysing inflation in Brazil, Cati et alia (1999) found exactly the opposite, namely a bias towards a rejection of the null hypothesis. Despite all the instability caused by the stabilization plans the Augmented Dickey Fuller (ADF) and the Phillips Perron (PP) tests persistently rejected the null of a unit root. Such result was not expected in the sense that in the presence of high inflation we should expect the series to be highly persistent. The authors then developed corrections to both tests mentioned above to exactly deal with this type of interventions.

Table 5.1 Sample Mean and Standard Deviation

Variable	*1980(1)*	*1991(12)*	*1980(1)*	*1986(2)*	*1986(3)*	*1991(12)*
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
$m1-cpi$	5.7328	0.4325	5.8726	0.2864	5.5851	0.5076
ip	4.6112	0.1301	4.5452	0.1001	4.6810	0.1219
be	2.3365	0.7744	1.9846	0.4126	2.7085	0.8885
cdb	2.3089	0.8260	1.9874	0.4323	2.6489	0.9941
Δcpi	0.1219	0.0983	0.0768	0.0264	0.1696	0.1217

Nevertheless when considering the second sub-period only (1986/4-1991/12), where the sequence of stabilization plans were expected to bias the test, there was no evidence against the null hypothesis of unit root that justifies the use of the corrected tests. Tables 5.2 and 5.3 present the ADF test results for the first period and second period respectively, whereas tables 5.4 and 5.5 present the PP test results for the first and second period respectively.

For the first sub-period (1980-1986/2) the null of unit root is only rejected for inflation using the ADF test and for the industrial production index using the PP test. In the second sub-period there is a congruent result with both tests rejecting the unit root hypothesis for the industrial production index. Since both tests ADF and PP are contradictory with respect to inflation in the first period I assume that the variable is indeed I(1). In general the tests results allows the conclusion that the sequence of stabilization plans that followed the Cruzado plan launching did not affect the unit root tests in the sense proposed by Cati et alia (1999), namely biasing the test towards the rejection of the null hypothesis of unit root.

Table 5.2 Augmented Dickey Fuller Test (1980/1 – 1986/2)

Variable	*Lag*	*t-value*	*Critical Value (5% / 1%*)*	*Constant*	*Trend/Seasonal*
$m1 - cpi$	0	-2.512	-3.44 / -4.02	Yes	yes / no
ip	0	-1.463	-3.44 / -4.02	Yes	yes / yes
cdb	2	-2.866	-3.44 / -4.02	Yes	yes / no
be	0	-1.963	-3.44 / -4.02	Yes	yes / no
Δcpi	3	-4.295	-3.44 / -4.02	Yes	yes / no

* The asymptotic critical values are as tabulated in Maddala and Kim (1998) for a sample size of 100 observations.

Table 5.3 Augmented Dickey Fuller Test (1986/4 – 1991/12)

Variable	*Lag*	*t-value*	*Critical Value (5% / 1%*)*	*Constant*	*Trend/Seasonal*
$m1 - cpi$	0	-1.981	-3.44 / -4.02	Yes	yes / no
ip	0	-4.388	-3.44 / -4.02	Yes	yes / yes
cdb	0	-2.656	-3.44 / -4.02	Yes	yes / no
be	0	-2.271	-3.44 / -4.02	Yes	yes / no
Δcpi	0	-2.752	-3.44 / -4.02	Yes	yes / no

* The asymptotic critical values are as tabulated in Maddala and Kim (1998) for a sample size of 100 observations.

Table 5.4 Phillips Perron Test (1980/1 – 1986/2)

Variable	*Lag*	*Z statistic*	*Critical Value (5% / 1%)‡*	*Constant*	*Trend*
$m1 - cpi$	1	-10.126	-20.7 / -27.4	yes	Yes
ip	2	-30.666	-20.7 / -27.4	yes	Yes
cdb	1	-17.063	-20.7 / -27.4	yes	Yes
be	1	-10.837	-20.7 / -27.4	yes	Yes
Δcpi	4	-14.331	-20.7 / -27.4	yes	Yes

‡ The asymptotic critical values are as tabulated in Maddala and Kim (1998) for a sample size of 100 observations.

As a general conclusion about the order of integration of the variables the evidence found using the ADF and PP tests indicates that they are non-stationary and in particular well represented as I(1)[8] and in this case it is essential that we model them using a system so we are able to accommodate more than one cointegrating vector.

Table 5.5 Phillips Perron Test (1986/4 – 1991/12)

Variable	*Lag*	*Z statistic*	*Critical Value (5% / 1%)‡*	*Constant*	*Trend*
$m1-cpi$	1	-9.232	-20.7 / -27.4	yes	Yes
ip	3	-61296.52	-20.7 / -27.4	yes	Yes
cdb	1	-11.038	-20.7 / -27.4	yes	Yes
be	1	-9.989	-20.7 / -27.4	yes	Yes
Δcpi	1	-18.948	-20.7 / -27.4	yes	Yes

‡ The asymptotic critical values are as tabulated in Maddala and Kim (1998) for a sample size of 100 observations.

5.1.2) Second Period 1994(10)-2002(2)

The sample data are monthly seasonally unadjusted for the period 1994 (10) to 2002(2)[9]. Due to an interruption in one of the series, namely the interest rate to the payee in the bills of exchange, I restrict the analysis to the following variables: *m1* which is the log of M1, defined as paper money held by the public plus demand deposits, *cpi* ,the log of the consumer price index, *ip* is the log of the industrial production index both as defined in Juselius (2002) and finally *CDB* is the monthly interest rate in percents paid in the certificate of deposits which is used in this period instead of the log values as for the former two periods. Also the lack of data for the interest rate to the payee in the bills of exchange led to the decision of restart a new modelling attempt following the Real Plan casting which represented furthermore a turning point in the recent Brazilian economic history from price instability and high levels of inflation to rates of inflation systematically under control.

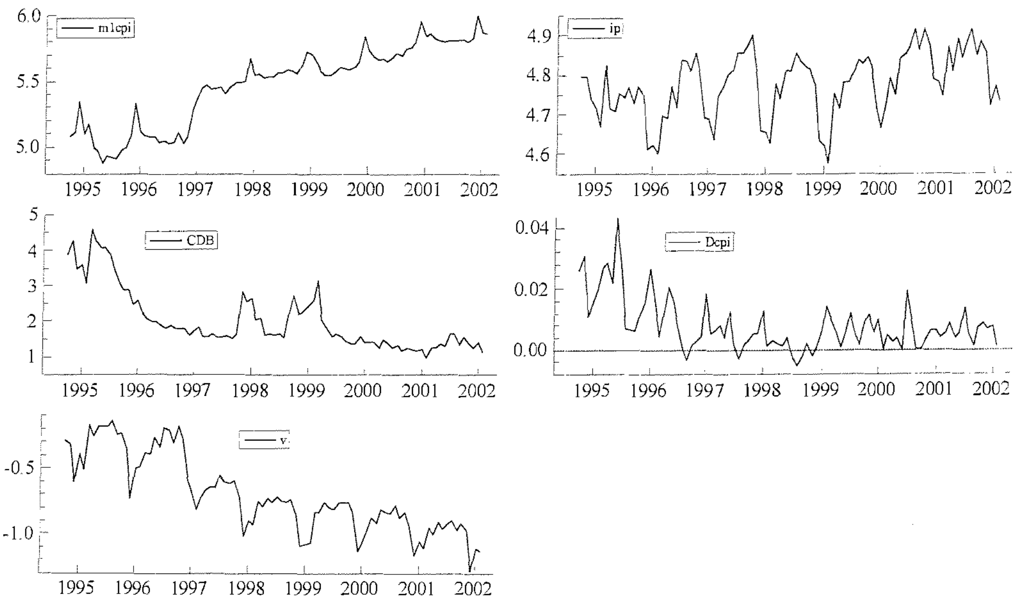
Given these definitions I constructed then the real money series as: $m1-cpi$, the inflation rate as: Δcpi, where Δ stands for the first difference operator and for illustrative purposes the velocity of money v as: $cpi+ip-m1$. Figure 5.2 contains full

[8] I do not discard the possibility of the data being well described as I(2) as well, however this hypothesis is investigated using the system estimation results rather than a univariate analysis.
[9] I excluded the initial months after the Real Plan casting because they basically represented a remonetization period when the monetary base grew from an average of 0.5% of the GDP in the first semester of 1994 to approximately 2.4% in October 1994 when the process can be considered finished.

sample time plots of the modelled variables, $m1 - cpi, ip, be, CDB, \Delta cpi$ and v for illustrative purposes.

Following the stabilization reached with the Real Plan from 1994 onwards the picture for the variables of interest changes drastically compared to that observed in the past periods. The monthly inflation rate followed a downward trend from the beginning of the sample until 1997 when then it stabilizes between 0 and 1%. With decreasing rates of inflation, the economy experienced a remonetization with real money presenting an upward trend. The real money series presents also a distinctive seasonal pattern caused by the presence in the formal labour market of the thirteenth salary paid by December as a type of mandatory bonus. Its behaviour influences the velocity that despite being characterised by a downward trend as the agents started to demand more money presents the inverse of the seasonal pattern observed for the real money series in December.

Figure 5.2 1994(10) – 2002(2) Sample Time Plots



The interest on the certificate of deposit also follows a downward trend mimicking inflation, but the difference in levels observed, even if we re-scale inflation to monthly percent rates, represents the central point of the monetary policy followed by the Brazilian Central Bank during the whole period, high levels of real interest rates. The two major increases observed in the end of 1997 with the Asian crisis and in the beginning of 1999 with the end of the crawling peg regime are the reflection of the main objective of the Central Bank in keeping inflation under control. Such pattern has then its influence on the industrial production index that does not present any distinctive pattern set aside the seasonal one characterizing therefore the period as of relative stagnation. A positive result of the central bank policy is the fact that the inflation rate remained stabilized despite the change in the exchange rate regime from crawling peg to a fluctuation one (not free of interventions).

Table 5.6 Augmented Dickey Fuller Test (1994/10 – 2002/2)

Variable	*Lag*	*t-value*	*Critical Value (5% / 1%*)*	*Constant*	*Trend/Seasonal*
$m1-cpi$	0	-1.506	-3.44 / -4.02	yes	yes / yes
ip	0	-4.818	-3.44 / -4.02	yes	yes / yes
CDB	0	-3.569	-3.44 / -4.02	yes	yes / no
Δcpi	0	-5.409	-3.44 / -4.02	yes	yes / no

* The asymptotic critical values are as tabulated in Maddala and Kim (1998) for a sample size of 100 observations.

Table 5.7 Phillips Perron Test (1994/10 – 2002/2)

Variable	*Lag*	*Z statistic*	*Critical Value (5% / 1%)‡*	*Constant*	*Trend*
$m1-cpi$	12	-1226.46	-20.7 / -27.4	yes	Yes
ip	12	-1721.60	-20.7 / -27.4	yes	Yes
CDB	1	-1272.11	-20.7 / -27.4	yes	Yes
Δcpi	1	-2316.31	-20.7 / -27.4	yes	Yes

‡ The asymptotic critical values are as tabulated in Maddala and Kim (1998) for a sample size of 100 observations.

The analysis of the unit root tests shown in table 5.6 indicates that we cannot reject the null hypothesis of a unit root in the ADF test for the real money series whilst for the rate of interest in the certificate of deposits the null is rejected only at 5% but not at 1%. The null is rejected nevertheless for the industrial production and inflation both at 1% significance level. In opposite all the results for the Phillips-Perron tests in table 5.7 are very conclusive in rejecting the null of a unit root. Despite the results presented here we analyse the presence of unit roots and cointegrating vectors using the Johansen procedure instead of simply assuming that all variables are I(0) and carry on the system analysis based on the results of the univariate tests.

5.2) Dynamic Econometric Models and the rise in inflation 1980-1986(2)

For the analysis in this sub-sample following the discussion in chapter 3 I estimate initially a VAR (2) in the following variables: $m1-cpi, ip, cdb, be\ and\ \Delta cpi$. The VAR also included centered seasonal dummies, an unrestricted constant and a restricted trend so we avoid the unlikely presence of a quadratic trend in the levels. The VAR includes also an unrestricted dummy which assumed value one for 1984 (2) and zero otherwise accounting for the exceptional growth in the first quarter of the year and a new waiver authorized by the IMF which basically signalled a new attitude of mind of the IMF towards the Brazilian external constraints in place after the Mexican external debt crisis of 1982. Table 5.8 presents the diagnostic statistics for the system.

The diagnostic tests assessed are the LM test for autocorrelation of order p in the residuals (AR 1-p), the normality test is the test proposed by Doornik and Hansen (1994), the ARCH test is the test proposed in Engle (1982) and finally the Heteroscedasticity test is based on White (1980), the system tests are the counterparts of the individual equation tests all of them as described in Doornik and Hendry (1997).

Table 5.8 Diagnostic Tests VAR (1980/1 – 1986/2)

Test\Equation	$m1-cpi$ (p-value)	ip (p-value)	cdb (p-value)	be (p-value)	Δcpi (p-value)	*System* (p-value)
AR 1-5	1.46	0.46	1.10	0.44	1.49	1.02
	(0.21)	(0.80)	(0.37)	(0.82)	(0.21)	(0.45)
Normality	2.99	1.23	1,55	3.08	2.74	14.76
	(0.22)	(0.54)	(0.46)	(0.21)	(0.25)	(0.14)
ARCH	0.38	0.45	2.19	0.73	1.64	
	(0.85)	(0.81)	(0.07)	(0.60)	(0.17)	————
Hetero	0.45	0.59	0.89	0.69	0.51	0.47
	(0.97)	(0.89)	(0.60	(0.81)	(0.94)	(1.00)

The residuals in the system have no sign of autocorrelation and heteroscedasticity, no sign of non-normality and ARCH effects in both levels, namely equation and system, so we consider the system a congruent representation of the information available in the data and proceed with the analysis of cointegration as described in Johansen (1995).

In table 5.9 we present the modulus of the five largest eigenvalues of the companion matrix[10] and table 5.10 presents the results of the trace test for testing the hypothesis of $r \leq k$ where the asymptotic values are based on the hypothesis of an unrestricted constant and restricted trend as described in Doornik (1998). In the present case since I include an unrestricted pulse dummy the results should be interpreted with caution because its presence is likely to modify the asymptotic values. Therefore, inference should be guided not only by the statistics presented, but also by other information as provided in the eigenvalues of the companion matrix and the graphic analysis of the cointegrating vectors.

From table 5.9 there are two eigenvalues which are close to unit whereas the result of the trace test indicates that we cannot reject the null of $r \leq 2$. Both results indicate that we have then two cointegrating vectors. We therefore proceed with the assumption that $r = 2$ and impose this restriction on the cointegrated VAR in equation (4). The system was re-estimated and the five largest eigenvalues of the companion matrix are reassessed again as shown on table 5.9 $(r = 2)$, since the number of unit roots is equal to 3 $(N - r = 5 - 2 = 3)$ I rule out the hypothesis of the data being I(2).

Table 5.11 shows the cointegrating vectors after imposing and testing over-identifying restrictions using the LR test[11]. The first cointegrating vector has a difficult

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[10] Notice that the VAR in equation (2) can be written alternatively as:

$$\begin{bmatrix} \mathbf{y}_t \\ \mathbf{y}_{t-1} \\ \vdots \\ \mathbf{y}_{t-p} \end{bmatrix} = \begin{bmatrix} \mathbf{A}_1 & \mathbf{A}_2 & \cdots & \mathbf{A}_{p-1} & \mathbf{A}_p \\ I_4 & 0 \cdots & 0 \cdots & & 0 \\ 0 & I_4 \cdots & 0 \cdots & & 0 \\ \vdots & \ddots & \vdots & & \vdots \\ 0 & 0 \cdots & I_4 & & 0 \end{bmatrix} \begin{bmatrix} \mathbf{y}_{t-1} \\ \mathbf{y}_{t-2} \\ \vdots \\ \vdots \\ \mathbf{y}_{t-p+1} \end{bmatrix} + \begin{bmatrix} \mathbf{D}_t \\ 0 \\ \vdots \\ \vdots \\ 0 \end{bmatrix} + \begin{bmatrix} \vartheta_t \\ \vdots \\ \vdots \\ \vdots \\ 0 \end{bmatrix}$$

$$\mathbf{Y}_t = \quad \Lambda \quad \mathbf{Y}_{t-1} + \mathrm{E}_t + \mathrm{T}_t$$

the eigenvalues of the companion matrix are exactly the eigenvalues of Λ. Notice that in total we have for the VAR(2) a total of $N \times p = 5 \times 2 = 10$ eigenvalues in the companion matrix.

[11] Following the discussion in Peasaran and Shin (2002) we impose a total of 5 restrictions on the long run components of the cointegrating vectors only, corresponding to the following:

$$\beta' = \begin{bmatrix} 0 & 1 & 1 & 0 & * & 0 \\ * & 0 & -1 & 1 & 1 & * \end{bmatrix}$$ which is tested against the data through the LR test.

The testing result is: $\chi^2(5) = 5.236\,[0.3877]$. We can conclude therefore that there is no evidence against that on the data. Since $K > r^2$, where K is the number of restrictions then the cointegrating vector is over-identified and we can propose a particular interpretation to the vector. The final form presented in interpretation,[12] but might indicate that the output measured by the industrial production index is negatively related to the real interest rate measured by the CDB interest rate[13]. With the maturity of investments in this type of certificate varying between 6 and 3 months in the period, it seems likely that they would have a significant role in the long run relationship linked to the seasonal pattern in the industrial production index. Further, they represent an alternative to consumption and M1 holding what would then reflect in the industrial output.

It is worthwhile to notice from figure 5.3 where the plots of both vectors are presented, that for the period from 1983 until the end of 1984 the deviations of the long run mean becomes smaller than it was in the other periods. It reflects a period when the open market interest rates were fixed by the Central Bank in the beginning of the daily operations and a stricter monetary policy was followed as consequence of an agreement with the IMF.

Table 5.9 Five Largest Eigenvalues Companion Matrix

Eigenvalues r *unrestricted*	*Eigenvalues* $r = 2$
0.8976	1.0000
0.8976	1.0000
0.6678	1.0000
0.6206	0.5231
0.6206	0.5231

Table 5.10 Cointegration Statistics VAR (1980/1 – 1986/2)

R	*0*	*1*	*2*	*3*	*4*	*5*
Trace Test	131.00	70.128	39.795	15.259	4.131	
p-value	0.000	0.012	0.099	0.560	0.723	
Eigenvalue[14]		0.561	0.336	0.282	0.139	0.054

table 5.11 corresponds to testing further restrictions on the dynamics of the system and zero restrictions on the components of the vectors. In particular the trend was not significant in the estimated vectors as well as the real money variable. The reader should notice nevertheless that zero restrictions imposed on components in both vectors cannot be used as (over) identifying restrictions as pointed out in Boswijk and Doornik (2004) and Greenslade *et al l*(2002).

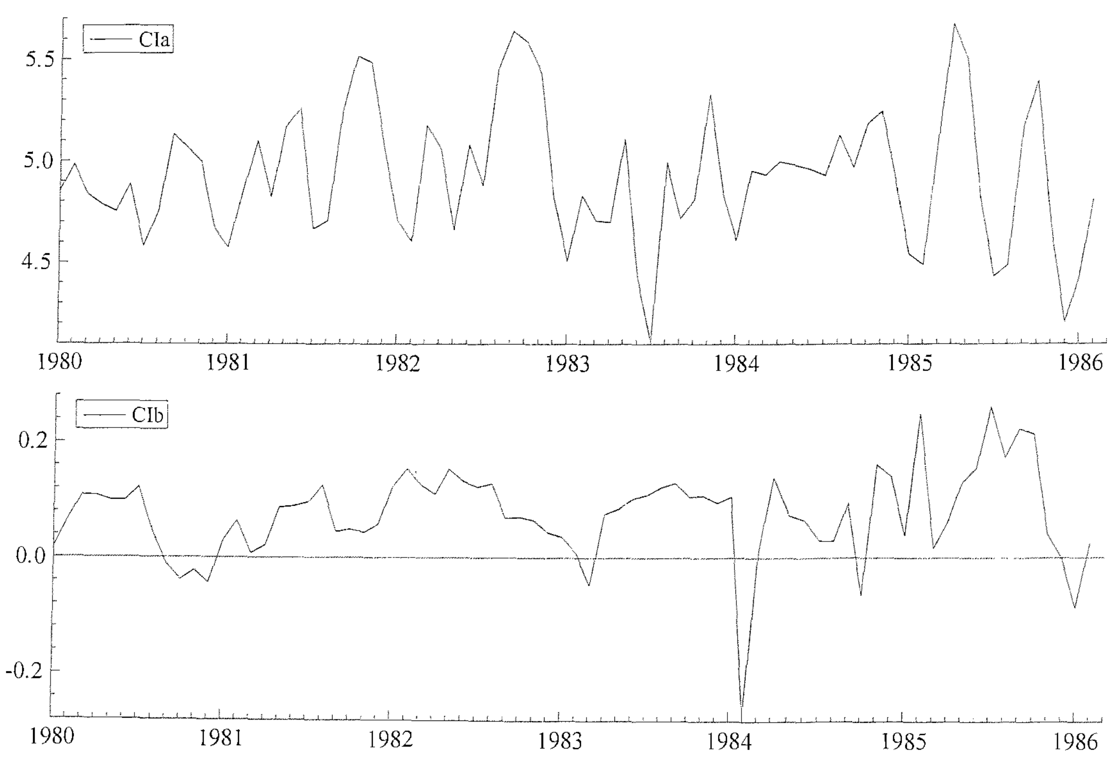
[14] Notice that the eingenvalues here are those referring to solving the eigenvalue problem generated by implementing the reduced rank regression as proposed in Johansen (1995).

In general, the first cointegrating vector appears to contradict the argument that during the period that preceded the Cruzado Plan launching the economy would not react to classical measures such as control over consumption through higher interest rates which had been implemented in the beginning of the 1980's and allegedly had been innocuous as discussed in chapter 2. Indeed it seems that the passive monetary policy followed by the Central Bank would lead to an increase in consumption and consequently in the output establishing therefore the link between inflation and output.

Table 5.11 Cointegrating Vectors and Adjustment Coefficients VAR 1980(1) – 1986(2)

Cointegrating Vectors	$\hat{\alpha}_i$ (se)	$i=1$	$i=2$
CIa: $ip + cdb - 20.908\Delta cpi_t$	$m1 - cpi$	0	0
CIb: $\Delta cpi_t - cdb_t + be_t$	ip	-0.0492 (0.015)	0
LR test of Restrictions	cdb	0	0.557 (0.127)
Equilibria and Feedback: $\chi^2(13) = 19.285$ $[0.1145]$	be	-0.030 (0.015)	0
	Δcpi	0.039 (0.006)	0

Figure 5.3 Cointegrating Vectors VAR 1980(1)-1986(2)



This seems particularly true towards the end of the period when according to Andima (1997) shortage of liquidity in the financial system led the Central Bank to inject large sums of money in the system to guarantee the solvency. This policy nevertheless imposed on the Central Bank the cost of loosing its control over the monetary aggregates starting a long period where the main goal of the Brazilian Central Bank was to avoid large portfolio losses for the banks as discussed in chapter 2[15].

The second vector indicates that the spread between the interest rates on the bill of exchanges and the certificates of deposits cointegrates with inflation, proxying a Fisher relationship between the nominal spread and inflation. The vector presented in figure 5.3 has mean close to zero and deviations of the nominal spread from inflation are not sustainable in the long run consistent therefore with the hypothesis of rational expectations.

The adjustment coefficients in table 5.11 show that real money is weakly exogenous for the parameters of both cointegrating vectors. The persistence of this result in the simultaneous equations analysis where the growth in real money appeared to be driven only by seasonal dummies reinforces the previous results and suggests that the model proposed is describing the path of inflation and its links with the real sector of the economy where money can be considered strongly exogenous. The rate of growth in the industrial production not surprisingly reacts to the first vector but does not to the second whilst *cdb* reacts to second vector only. The effect of the first cointegrating vector on the rate of growth of *be* has a possible explanation on the fact that the bills of exchange are related to goods transactions and in this case deviations from the long run equilibrium would affect the operations with this type of bond. Finally, the rate of growth in inflation reacts to the first cointegration vector only, showing that eventually disequilibria in the long run have effects on inflation.

The following vector equilibrium correction model was then estimated: $\Delta\mathbf{y}_t = \Delta\mathbf{y}_{t-1} + \alpha(\beta\mathbf{y}_{t-1}) + \varpi\mathbf{D}_t + \upsilon_t$ (4.11), where $\beta\mathbf{y}_{t-1}$[16] comprises the two cointegrating vectors. The misspecification tests presented signals of non-normality of the residuals which led us to re-estimate the system (5.11) excluding $\Delta m1 - cpi_{t-1}$ and

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[15] Indeed this has increased from US$ 610 millions in December of 1983 to US$ 1.6 billions in the first two months of 1984.

[16] It is worthwhile to notice that in both cases the trend was not significant so the variables present a long run growth given by the fact that the constant is not restricted to lay on the cointegration space.

Δcdb_{t-1} from Δy_{t-1} since both variables were not significant in the whole system according to the F-test. Testing the reduction led to the results presented in table 5.12 representing then the Parsimonious VAR against which the SEMs are tested.

The reduced system appears to be congruent to the information available with only a small sign of non-normality of residuals in the Δbe equation where the test is rejected at 5% significance level but not at 1%. Otherwise the system has no sign of serial correlation and heteroscedasticity in the residuals. The reduction constituted a valid simplification in the system[17], where the number of parameters was reduced from 100 to 90 and constitutes therefore the basis from which the SEM is tested. Although presenting no sign of misspecification there is evidence of parameter instability. The one-step residuals and Chow forecast test graphed in figure 5.4 shows that the equation for the interest in the certificates of deposits presents signals of parameter instability and as discussed in section 5.1.1 comprises evidence that a change in the monetary sector was in place during the 1980's.

Table 5.12 Diagnostic Tests Reduced VEqCM 1980/1 – 1986/2

Test\Equation	$\Delta ml - cpi$ *(p-value)*	Δip *(p-value)*	Δcdb *(p-value)*	Δbe *(p-value)*	$\Delta\Delta cpi$ *(p-value)*	*System (p-value)*
AR 1-5	1.53	0.53	1.48	0.74	1.61	0.87
	(0.19)	(0.74)	(0.21)	(0.59)	(0.17)	(0.76)
Normality	0.28	4.22	0.41	4.84	1.32	14.30
	(0.86)	(0.12)	(0.81)	(0.08)	(0.51)	(0.15)
ARCH	0.89	0.38	1.28	0.74	0.93	
	(0.49)	(0.85)	(0.28)	(0.59)	(0.46)	
Hetero	1.14	0.49	0.52	0.42	0.38	0.67
	(0.35)	(0.88)	(0.86)	(0.92)	(0.94)	(0.99)

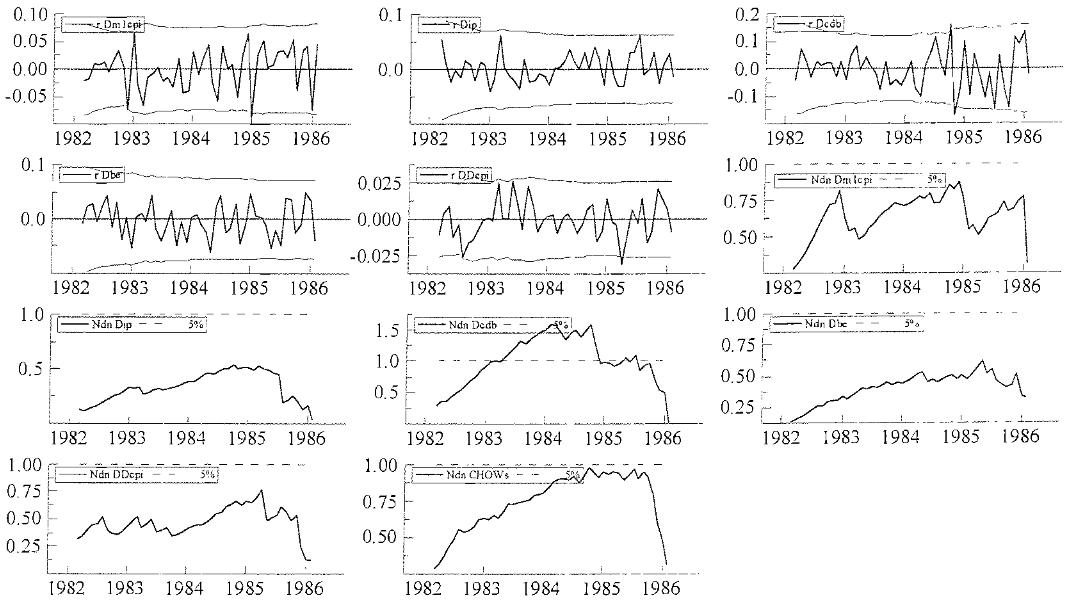
*indicates rejection at 5% level

[17] The reduction tests led to the following results:
SYS(29) --> SYS(30): F(10,100)= 0.73429 [0.6906], where SYS(29) stands for (5.11) and SYS(30) is (5.11) with Δcdb and $\Delta ml - cpi$ removed.

Interestingly parameter instability is detected before actually a change in the variables levels had taken place as a consequence of the Cruzado Plan, which usually is the easiest detectable form of parameter non-constancy[18].

The SEM[19] derived imposes a total of 15 over-identified restrictions which were not rejected based on the results of the LR test ($\chi^2(15) = 22.276$). The diagnostic tests are shown on table 5.13 whereas the final SEM is presented in table 5.14.

Figure 5.4 One Step Residuals and Forecast Chow Test VEqCM (1980/1 – 1986/2)



The SEM rejects the null of no autocorrelation in the residuals of the Δcdb equation but the vector autocorrelation test did not rejected the null hypothesis of no autocorrelation. There is also a slight signal of heterocedasticity in these residuals which, nevertheless, has no counterpart in the vector test as well. In figure 5.5 the time plots of the breakpoint Chow test are presented[20] (for each one of the equations and for the SEM as a whole) and one step residuals with ± 2 standard deviations. The SEM has

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[18] See to this respect Hendry (2000) where the author argues that using the type of test for parameter instability we use here shifts in the unconditional expectations such as those observed in our case after the Cruzado Plan (see figure 5.1) are the most easily detectable.

[19] All SEM presented in this chapter were estimated by Full Information Maximum Likelihood (FIML)

[20] This test is based on the following statistics: $\frac{(RSS_T - RSS_{t-1})(t-k-1)}{RSS_{t-1}(T-t+1)}$ which under the null of constant parameters has a F distribution as $F(T-t+1, t-k-1)$ for $t = M, \ldots, T$. The sequence of forecasts run from $T-M+1$ to 1 where M here is 1982/10.

no sign of break points and individually there is signal of parameter instability in the equation for Δcdb only. The plot of the one step residuals does not indicate also signals of outliers so I consider that the SEM is a congruent representation of the data and parsimoniously encompasses the VAR.

The equation for $\Delta m1 - cpi$ shows the growth of real money being driven basically by the centered seasonal dummies with Δbe_{t-1} appearing to be marginally significant, nevertheless excluding it from the equation led to a non-congruent representation of the data. Such result does not match exactly the weakly exogeneity observed in the cointegration analysis in the sense that we cannot condition on $\Delta m1 - cpi$, but Δbe_{t-1} being only marginally significant in some extent shows that the model is likely to be capturing the long run relationship among industrial output, represented by the industrial production index, interest rates and inflation.

Table 5.13 Diagnostic Tests SEM 1980/1 – 1986/2

Test\Equation	$\Delta m1 - cpi$ *(p-value)*	Δip *(p-value)*	Δcdb *(p-value)*	Δbe *(p-value)*	$\Delta\Delta cpi$ *(p-value)*	*System* *(p-value)*
AR 1-5	1.80	1.66	4.50**	1.36	2.05	0.86
	(0.12)	(0.16)	(0.001)	(0.25)	(0.08)	(0.79)
Normality	0.95	4.59	1.37	0.01	1.33	11.45
	(0.62)	(0.10)	(0.50)	(0.99)	(0.51)	(0.32)
ARCH	0.84	0.44	1.05	0.67	0.99	
	(0.52)	(0.81)	(0.39)	(0.63)	(0.42)	———
Hetero	0.97	0.47	2.12	1.32	0.39	0.81
	(0.48)	(0.90)	(0.03)*	(0.24)	(0.95)	(0.93)

Interestingly the results obtained by Cardoso (1983) who investigated the money demand in Brazil using quarterly data spanning the period between 1966 and 1979 showed that indeed the bill of exchange monthly interest rate was relevant in the estimated money demand equation whereas inflation was not, a result that seems to persist in the SEM model for the subsequent period and has a difficult interpretation[21].

[21] Cardoso's estimations were severely criticized by Gerlach and Nadal de Simone (1985) given the econometric techniques used by Cardoso. This discussion given the elapse of time has lost its appeal and will not be reproduced here but the main fact here is that accounting for the problems of simultaneity and non stationarity not discussed in the previous two works a similar result has been found.

Under this assumption, given the increasing use of indexation which gave the impression to the agents that they would be able to cope with inflation without facing the cost, it could have been that they were only adjusting their cash holds according to inflation to keep real money balances constants through financial operations.

In the Δip equation the rate of growth in the industrial production index is a negative function of its lagged value most likely being influenced by the 1982-1983 recession and the rate of growth in inflation in a such way that increases in the rate of growth in inflation would lead to reductions in Δip. The relation shows that the level of indexation in the economy did not allow increases in inflation to have a positive impact in the industrial sector and consequently on the real sector of the economy. If we consider the cumulating impulse response functions to a one standard deviation shock in figure 5.6 the long run effect is negligible and in the context of the Brazilian economy indicates that the indexation has removed any impact of inflation on the economy except perhaps in its level. Such conclusion contrasts with the findings for the first cointegrating vector and exposes the risk of interpreting cointegrating vectors without considering the short run properties of the system as discussed in Lütkepohl (1994).

Table 5.14 SEM 1980/1 – 1986/2

$$\underset{SE}{\Delta m1 - cpi} = -\underset{0.005}{0.003} - \underset{0.101}{0.172}\,\Delta be_{t-1} + \hat{\varpi}\mathbf{D}_t \quad \hat{\sigma} = 0.040$$

$$\underset{SE}{\Delta ip} = \underset{0.075}{0.242} - \underset{0.108}{0.286}\,\Delta ip_{t-1} - \underset{0.294}{0.835}\,\Delta\Delta cpi_{t-1} + \underset{0.015}{0.048}\,CIa_{t-1} + \hat{\varpi}\mathbf{D}_t \quad \hat{\sigma} = 0.031$$

$$\underset{SE}{\Delta cdb} = \underset{0.013}{0.019} - \underset{0.571}{0.304}\,\Delta\Delta cpi_{t-1} + \underset{0.125}{0.452}\,CIb_{t-1} + \hat{\varpi}\mathbf{D}_t \quad \hat{\sigma} = 0.084$$

$$\underset{SE}{\Delta be} = \underset{0.059}{0.230} + \underset{0.093}{0.276}\,\Delta ip_{t-1} + \underset{0.075}{0.237}\,\Delta be_{t-1} - \underset{0.011}{0.041}\,CIa_{t-1} - \underset{0.052}{0.159}\,CIb_{t-1}$$
$$+\hat{\varpi}\mathbf{D}_t \quad \hat{\sigma} = 0.031$$

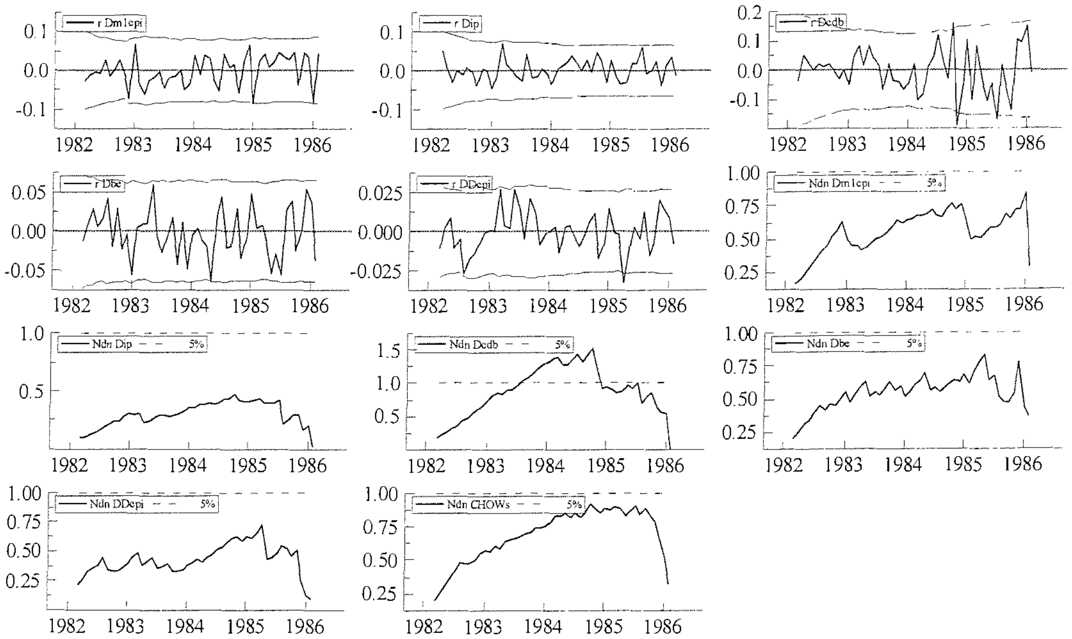
$$\underset{SE}{\Delta\Delta cpi} = -\underset{0.028}{0.205} + \underset{0.041}{0.100}\,\Delta ip_{t-1} + \underset{0.123}{0.330}\,\Delta\Delta cpi_{t-1} + \underset{0.005}{0.040}\,CIa_{t-1} + \underset{0.020}{0.046}\,CIb_{t-1} + \hat{\varpi}\mathbf{D}_t$$
$$\hat{\sigma} = 0.013$$

$\mathbf{D}_t$ stands for a vector with centered seasonals a pulse dummy for 1984/2 and in the equation for Δbe also a pulse dummy for 1980/11 which represented the end of pre-fixed monetary correction policy. This measure implied that the monetary correction would follow the consumer price index and the exchange rate devaluations would cover the difference between the internal and external inflation rates.

When we consider the equation for $\Delta\Delta cpi$ this variable is positively influenced by Δip_{t-1} and $\Delta\Delta cpi_{t-1}$. Such pattern explains why inflation rate gained momentum and why inflation assumed a pattern of persistence in a period where the Government followed a loose monetary policy by simply accommodating the inflation pressures.

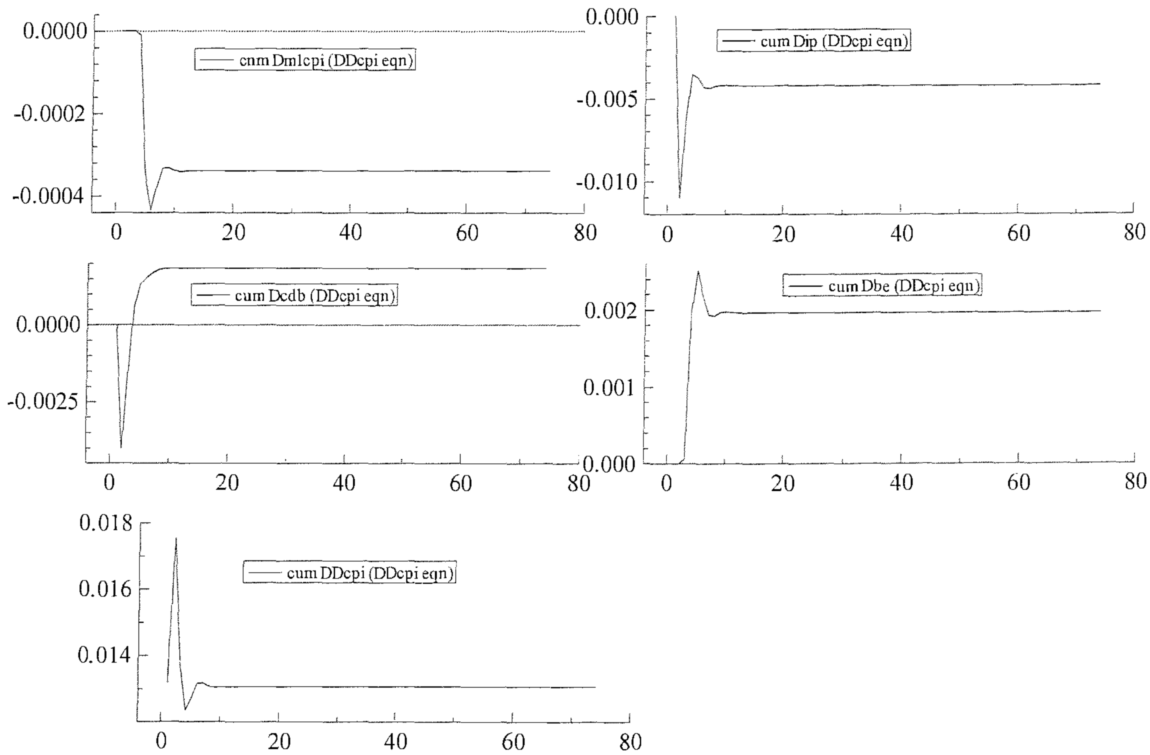
Indeed when we consider the impulse response functions to a one standard deviation shock to $\Delta\Delta cpi$ in figure 5.6 the effect is basically concentrated on the $\Delta\Delta cpi$ equation with an initial high level of impact on the rate of growth of inflation. In the long run the shock shows some degree of inertia in the inflation rate in the $\Delta\Delta cpi$ equation. This conclusion follows because the shock leads to increasing *rates of growth in inflation* for five periods approximately and considering that we are modeling the rate of growth in the inflation rate and the accumulated shocks have the magnitude of one standard deviation they represent accelerating inflation rates.

Figure 5.5 One Step Residuals and Chow Breakpoint Tests (SEM 1980/1 – 1986/2)



Juselius (2002, p.30) traces the following scenario to explain the inflation growth in Brazil: *"The expansion of money stock need to finance recession and devaluations in the first case increased inflationary expectations in the black market, which then gradually spread to the whole domestic economy"*. She derives this conclusion after using the exchange rate in a trend liquidity ratio, namely given by $\beta x_t = m_{t-1} - s^b_{t-1} - y^r_{t-1} - 0.005t$ where m is the log of M3 stock, s^b is the log of the black market exchange rate and y^r is the log of the industrial production index. In her comments she stresses that the inflationary expectations were strongly affected by the expansion of money stock and that explains why the exchange rate has been used instead of the consumer price index. Nevertheless M3 in Brazil as defined in footnote 3 includes the public securities, which after the currency devaluation in 1983 started to be issued indexed to the US dollar explaining therefore the role of the exchange rate in the trend liquidity ratio as a parameterization to the expected inflation. The expansion of money observed by Juselius is indeed the growth in non-monetary but indexed assets observed following the increases in inflation and after expectations of a currency devaluation being materialized in 1983. They were representing an increasing demand for indexed money in an environment of soaring rates of inflation.

Figure 5.6 Cumulative One Standard Deviation Impulse Response Functions
Shock To (From) SEM 1980/1 – 1986/02



A more plausible scenario given the results found here is that the accommodating monetary policy (M1) followed in the period after the 1984 economic upturn and represented here by the growth in the industrial production index in a highly indexed economy allowed the increase in the inflation rates as shown by the equation for $\Delta\Delta cpi$. Given the model's dynamic presented in figure 5.6 any negative shock to the economy as an increase in the oil prices would magnify the inflation rate and represent in the short run a change in its level as we can infer from the blip in figure 5.6 for the

$\Delta\Delta cpi$ equation. The economy recovery observed from 1984 onwards seems to have represented this negative role with its associated perverse connotation. The balance of payments adjustment and the constant surplus in the trade balance were followed by a monetary policy that only accommodated the demand pressures generating then a spiral on the inflation rates[22].

Such pattern in the dynamic properties of the estimated model is clearly in accordance with a highly indexed economy and with the hypothesis that inflation had an inertial component as defended by Resende and Lopes (1981 and 1982), Lopes (1983) and Modiano (1983) but I do not derive the policy implication that its path was following an independent process. Rather the SEM is showing that we cannot ignore the links between the real variables and inflation in the period. The results of the empirical modeling throw light on the debate about the level of inertia present in the Brazilian inflation for the period. According to Novaes (1993) the notion that inflation in Brazil was largely dominated by its past values and by inertia being further insensitive to demand policies had became widespread. Nevertheless she found using a univariate approach that indeed the persistence of a one percent shock to the inflation rate was only 35% after 30 months. The author then argues to a reassessment of the importance of the inertial component in the Brazilian inflation in line therefore to the conclusions found here despite the different approaches implemented.

As a final remark the equations for the interest rates seems to describe their conceptual difference with Δcdb being influenced by $\Delta\Delta cpi_{t-1}$ and the second cointegration vector only, whereas Δbe is influenced by Δip its own lag appearing to be linked to operations in the real sector.

[22] The impact of the 1984.2 dummy in both equations, Δip and $\Delta\Delta cpi$ despite being marginal is positive. $\underset{(0.034)}{0.071}$ and $\underset{(0.014)}{0.016}$ respectively.

5.3) The Stabilization Plans and the Dynamic Econometric Models: 1986(4) – 1991(12)

For the analysis in the second period following the discussion in section 3 we estimate initially a VAR (2) with the following variables: $m1 - cpi, ip, cdb, be$ and Δcpi. The VAR also included centered seasonal dummies, an unrestricted constant and a restricted trend so we avoid the unlikely presence of a quadratic trend in the levels. The following unrestricted dummies were also included:

$$D3 = \begin{cases} 1 & t = 1989(1) \; to \; 1989(4) \\ 0 & otherwise \end{cases}$$

corresponding to period when the Summer plan actually took place,

$$dfma4 = \begin{cases} 1990(6) \\ 0 \quad otherwise \end{cases}$$

corresponding to the first month after the end of the Collor plan (fourth plan),

$$dfm4 = \begin{cases} 1990(3) \\ 0 \quad otherwise \end{cases}$$

corresponding to the first month of which the Collor plan actually took place

$$dfm(3) = \begin{cases} 1989(1) \\ 0 \quad otherwise \end{cases}$$

corresponding to first month of which the Summer actually took place[23].

[23] The precise dates observed for the plans are the same as the in Cati et ali (1999) paper, namely:

Plan	*Begins*	*Ends*
Cruzado	March, 1986	October, 1986
Bresser	July, 1987	September, 1987
Summer	February, 1989	April, 1989
Collor	March, 1990	May, 1990
Collor II	February, 1991	June, 1991

In table 5.15 we present the diagnostic statistics for the system. The individual diagnostic tests for the system show the presence of autocorrelation and non normality in the residuals for the Δcpi equation and autocorrelation in the residuals of the equation for the industrial production index. In contrast, at the system level the tests suggest that there is no departure from the null hypothesis of no autocorrelation, normality and homocedasticity. Having in mind that Pc-Give does the individual tests using the system residuals as they were the residuals for each one of the individual equations the interpretation of the individual tests is compromised. At best according to Doornik and Hendry (1997) the individual tests are usually valid only when the remaining equations are problem free, so we decided to carry on the analysis based on the results of the system test.

Table 5.15 Diagnostic Tests VAR 1986(4)-1991(12)

Test\Equation	$m1-cpi$ (p-value)	ip (p-value)	cdb (p-value)	be (p-value)	Δcpi (p-value)	*System* (p-value)
AR 1-5	1.15	2.91*	0.53	1.09	5.53**	1.18
	(0.35)	(0.02)	(0.75)	(0.38)	(0.00)	(0.23)
Normality	0.56	2.91	2.91	6.75	6.48*	13.79
	(0.75)	(0.23)	(0.23)	(0.03)	(0.03)	(0.18)
ARCH	0.25	0.47	0.10	0.47	0.72	
	(0.93)	(0.79)	(0.99)	(0.80)	(0.60)	——
Hetero	0.52	0.34	0.23	0.21	0.66	0.25
	(0.93)	(0.99)	(0.99)	(0.99)	(0.83)	(1.00)

*indicates rejection at 5% level and **at 1% level.

The results of the cointegration statistics based on the trace test presented in table 5.17 and the eigenvalues of the companion matrix (unrestricted) presented in table 5.16 admit an opposite interpretation. The trace test suggests that there are three cointegrating vectors whereas the third eigenvalue of the companion matrix seems to be a bit far from one which would suggest that we have only two unit roots and possibly only two cointegrating vectors. However since the hypothesis of rank 2 being the last

The result obtained here was derived from initially setting these dummies as defined $D(i)$, $dfm(i)$ and $dfma(i)$ for each one of the plans (Cruzado, Bresser, Summer, Collor and Collor I) but only those presented here were significant.

significant statistics is strongly rejected I carry on the analysis based on the hypothesis of 3 cointegrating vectors. Imposing the rank condition on the model and re-estimating generates the eigenvalues of the companion matrix presented in the second column in table 5.16, which shows that the number of unit roots is equal to two with the third eigenvalue being far from the unit, so we rule out the hypothesis of the data being I(2).

Table 5.18 shows the cointegrating vectors after imposing and testing over-identifying restrictions using the LR test.

The first cointegrating vector is similar to the second vector found in the analysis of the first period, where both interest rates cointegrated with inflation admitting the interpretation of a Fisher relationship between nominal interest rates and inflation. The difference now is that only the interest rate for the bill of exchange is present and there is a small but significant trend.

A possible explanation for the rate of interest of the certificate of deposit absence is that in several occasions the Brazilian Central Bank changed the scope of the operations with CDBs and BEs[24]. Nevertheless, the operations with CDBs seem to have been more affected than those with the bill of exchange.

Table 5.16 Five Largest Eigenvalues Companion Matrix

Eigenvalues r *unrestricted*	*Eigenvalues* $r = 3$
0.8898	1.0000
0.8898	1.0000
0.6519	0.7154
0.6519	0.5299
0.4425	0.5299

[24] Indeed several interventions took place during this period and all were valid for both CDB and BE. The first one in January 1986 fixing the minimum period for investment in 90 days at market determined rates or market rates plus monetary correction. Then in February 1986 the period was reduced to 60 days but only for those investments with ex-ante interest rates. In December 1986 the period was extended to 90 days again but the investment could have the same nominal yield as the Brazilian Central Bank Bills plus negotiable interest rates. These bills were negotiated in the open market and should give a closer nominal correction to the rates of CDB and BE. In November 1987 nevertheless the CDB and BE rates were again linked to official indexation rates. Finally in May 1989 the minimum period of investment was reduced to 30 days.

Table 5.17 Cointegration Statistics VAR (1986/4 – 1991/12)

R	*0*	*1*	*2*	*3*	*4*	*5*
Trace Test	200.29	124.26	68.73	23.91	4.74	
p-value	0.000	0.000	0.000	0.085	0.639	
Eigenvalue		0.668	0.552	0.477	0.242	0.006

Table 5.18: Cointegrating Vectors and Adjustment Coefficients VAR 1986(4) – 1991(12)

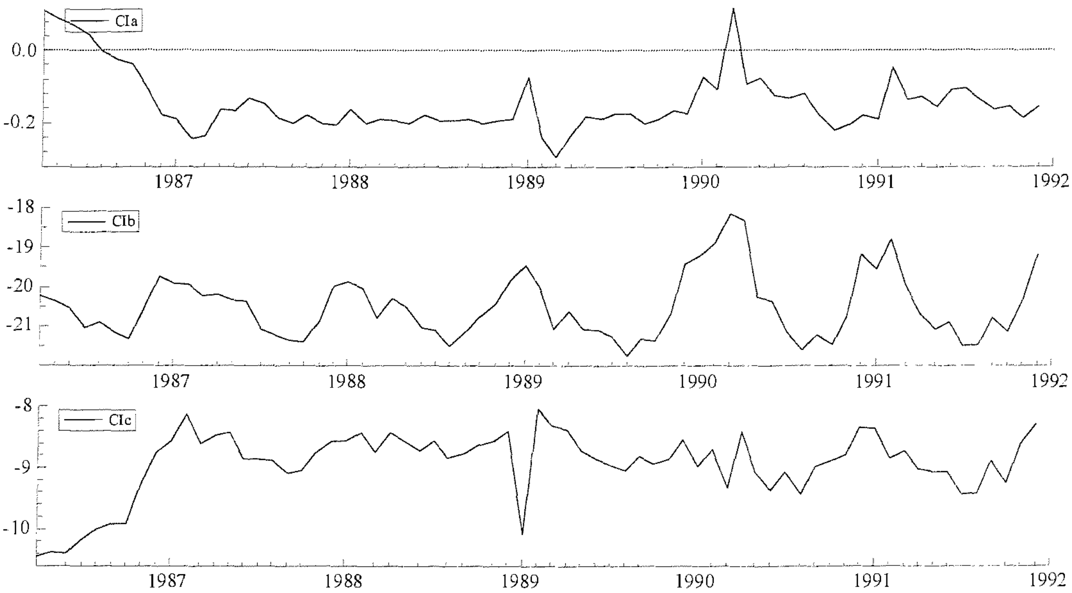
Cointegrating Vectors	$\hat{\alpha}_i$ (se)	$i=1$	$i=2$	$i=3$
CIa: $-0.197be+\Delta cpi_t+0.001t$	$m1-cpi$	3.937 (0.737)	-0.179 (0.057)	0.550 (0.108)
CIb: $m1-cpi-5.747ip_t+4.799\Delta cpi_t$	ip	0	0	0
CIc: $0.518cdb-2.335\Delta cpi-ip_t-0.012t$				
	cdb	-7.035 (0.781)	0	-1.321 (0.133)
LR test of Restrictions				
Equilibria and Feedback: $\chi^2(9)=5.205\quad[0.8160]$	be	0	-0.376 (0.522)	-0.221 (0.049)
Equilibria only: $\chi^2(2)=0.005\quad[0.997]$	Δcpi	0	-0.110 (0.014)	0

As observed in Andima (1997) in 1989 the market share for the CDB underwent a significant reduction since this type of investment could not follow the high real interest rates offered by the overnight operations after the change in the monetary correction index in November 1987 and possibly was no longer reflecting the real inflation rates.

The second cointegrating vector represents a long run demand for real money being positively influenced by increases in the economic activity represented by the industrial production and negatively affected by increases in inflation. Both coefficients have therefore the correct sign. Despite all the instability of the period the long run relationship appears to be remarkably stable as can be noticed in figure 5.7 where we depicts the time plot of the three cointegrating vectors.

I consider the identification of this vector that assumes the interpretation of a money demand equation a remarkable result in the sense that in the 1980s a debate in the literature took place with respect the money demand in Brazil. The focus was the instability in the parameters of the estimated money demand equations as found by Rossi (1989). Indeed the results presented in section 5.2 suggest that real money is weakly exogenous for the long run parameters of interest, the equation for real money in the initial VAR (not shown) presented signals of parameter instability and further no identification was obtained.

Figure 5.7 Cointegrating Vectors VAR 1986(4)-1991(12)



In contrast, for the period posterior to the Cruzado Plan the attempts in the literature were very restricted to a Cagan specification as we did in chapter 3 given the high levels of inflation. Nevertheless, using a different approach in this chapter, it was possible identify a long run money demand equation leading to a much richer analysis than that allowed by the Cagan model in the sense that the real money demand equation is linked to the level of activity in the economy and not only to inflation or the rate of growth in M1 as in chapter 3. Further, the dynamic properties of the SEM investigated below allow a much more detailed analysis of the monetary system in Brazil in that period. Such results point out that the approach adopted here is more adequate than the Cagan model in describing empirically the phenomenon observed in Brazil.

Finally, the third vector is the same as that found in the analysis of the first period but with the sign for industrial production reversed and being detrended which add extra difficulties to the interpretation. Therefore, in the present case the interpretation of increases in the CDB interest rate leading to a reduction in the economic activity reflected in the industrial production index has no meaning since indeed in the present case it would lead to an increase in the economic activity.

Nevertheless, a similar specification is found in the third period with identical signals to those observed in the first period suggesting that these variables represent a long run relationship present in the Brazilian economy and that this intermediate period can be considered an exception rather than the rule given the stabilization plans. Interestingly with the change in the signal in the industrial production index the inflation rate admits an opposite interpretation when compared to first period with a negative impact on the industrial production.

The adjustment coefficients show that the industrial production index is weakly exogenous for the parameters of the cointegrating vectors whereas the real money equation reacts to the three vectors. Finally the equation for Δcpi reacts only to the identified money demand.

In the equation for the bill of exchange, surprisingly there is no reaction to the first vector whereas in the equation for the interest rates in the certificate of deposits it reacts to the first and third vectors. The latter result is difficult to interpret since this vector links be and Δcpi only. It might be related to the fact that in the previous period the long run relationship between the interest rate and inflation included cdb as well, a result that did not persisted in the long run in the second period but can be represented by the equation for cdb reacting to the first vector.

The following vector equilibrium correction model was then estimated: $\Delta \mathbf{y}_t = \Delta \mathbf{y}_{t-1} + \alpha(\beta \mathbf{y}_{t-1} + \kappa t) + \varpi \mathbf{D}_t + \upsilon_t$, where $\beta \mathbf{y}_{t-1}$[25] comprises the three cointegrating vectors. The misspecification tests presented signals of autocorrelation in the residuals of the equation for $\Delta\Delta cpi$ which led us to re-estimate the system excluding Δip_{t-1} from $\Delta \mathbf{y}_{t-1}$ since this variable was not significant in the whole system according to the F-test.

Testing the reduction led to the results presented in table 5.19. The diagnostic tests show that there are signs of autocorrelation and heteroscedasticity in the equation for $\Delta\Delta cpi$ and non-normality in the equation for Δbe. In contrast in the system level the VEqCM appears to be congruent with the information available with normal residuals, no sign of autocorrelation and heteroscedasticity. Figure 5.8 depicts the one step ahead residuals with the two standard deviations band and the Chow's forecast test from

[25] It is worthwhile to notice that in both cases the trend was not significant so the variables present a long run growth given by the fact that the constant is not restricted to lie on the cointegration space.

where we can infer that the system does not present any signal of instability in the parameters. But at the equation level there are signals of instability for the Δip equation in the beginning of 1990 which coincides with the end of the hyperinflation and the severe recession imposed by the Collor Plan financial embargo. Despite this and given the magnitude of the changes imposed in the main variables I consider that the system has stable parameters.

Table 5.19 Diagnostic Tests Reduced VEqCM 1986/4 – 1991/12

Test\Equation	$\Delta m1 - cpi$ *(p-value)*	Δip *(p-value)*	Δcdb *(p-value)*	Δbe *(p-value)*	$\Delta\Delta cpi$ *(p-value)*	*System* *(p-value)*
AR 1-5	0.37	1.44	0.38	0.56	2.46	1.23
	(0.86)	(0.23)	(0.86)	(0.72)	(0.048)*	(0.14)
Normality	1.98	1.98	3.83	7.96	4.24	11.89
	(0.37)	(0.37)	(0.15)	(0.018)*	(0.12)	(0.23)
ARCH	0.40	0.24	0.54	0.36	0.84	
	(0.85)	(0.93)	(0.74)	(0.87)	(0.53)	—
Hetero	0.49	1.17	0.24	0.35	2.24*	0.53
	(0.92)	(0.35)	(0.99)	(0.98)	(0.03)	(1.00)

*indicates rejection at 5% level

The reduction constituted a valid simplification in the system[26], where the number of parameters was reduced from 120 to 115 and constitutes therefore the basis from which the SEM is tested.

The SEM derived imposes a total of 19 restrictions which were not rejected based on the results of the LR test ($\chi^2(19) = 8.90$) and a total reduction of 19 parameters. The diagnostic tests are shown on table 5.20 whereas the final SEM is presented in table 5.21.

The results shown on table 5.20 indicate that the SEM has no sign of autocorrelation, non-normality and heteroscedasticity at the system level. The results at individual equations level in contrast to the system, show signs of misspecification in the equation for $\Delta\Delta cpi$ which are restricted to the presence of heteroscedasticity and autocorrelation with this last test being rejected at a 5% confidence level. I nevertheless

[26] The reduction test led to the following result:
SYS(29) --> SYS(32): F(5,41) = 1.7221 [0.1512]

opted to carry on the analysis using the specified SEM on the basis of the system level tests.

Figure 5.8 One Step Residuals and Breakpoint Chow Test VEqCM 1986/4 – 1991/12

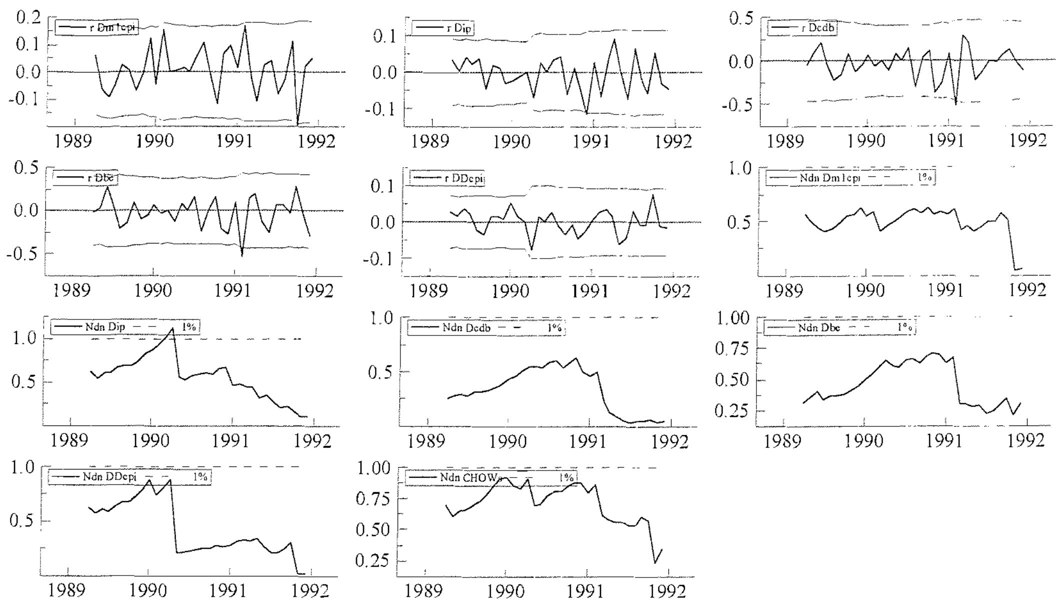


Table 5.20 Diagnostic Tests SEM 1986/4 – 1991/12

Test\Equation	$\Delta ml - cpi$ (p-value)	Δip (p-value)	Δcdb (p-value)	Δbe (p-value)	$\Delta\Delta cpi$ (p-value)	*System* (p-value)
AR 1-5	0.89	2.07	1.00	1.45	2.63*	1.28
	(0.49)	(0.08)	(0.42)	(0.22)	(0.037)	(0.09)
Normality	2.63	1.98	3.64	4.63	4.18	11.37
	(0.26)	(0.37)	(0.16)	(0.09)	(0.12)	(0.32)
ARCH	0.28	0.09	0.76	0.47	0.86	
	(0.91)	(0.99)	(0.57)	(0.79)	(0.51)	——
Hetero	0.54	1.48	0.42	0.53	2.62**	0.61
	(0.91)	(0.16)	(0.96)	(0.91)	(0.0089)	(0.99)

*indicates rejection at 5% level and ** at 1% level.

In figure 5.9 we present the test for parameter instability based on the Chow break point test and one step residuals. Remarkably there is no sign of instability in the parameters over the period under consideration. Again I qualify this result as remarkable given that in the period analyzed in the test the economy underwent three stabilization plans, one short lived hyperinflation plus the financial embargo enforced in the Collor Plan. The SEM track to the variables is presented in figure 5.10 which shows that the model describes relatively well the growth in the variables considering that they are in first differences.

Figure 5.9 One Step Residuals and Breakpoint Chow Test SEM 1986/4 – 1991/12

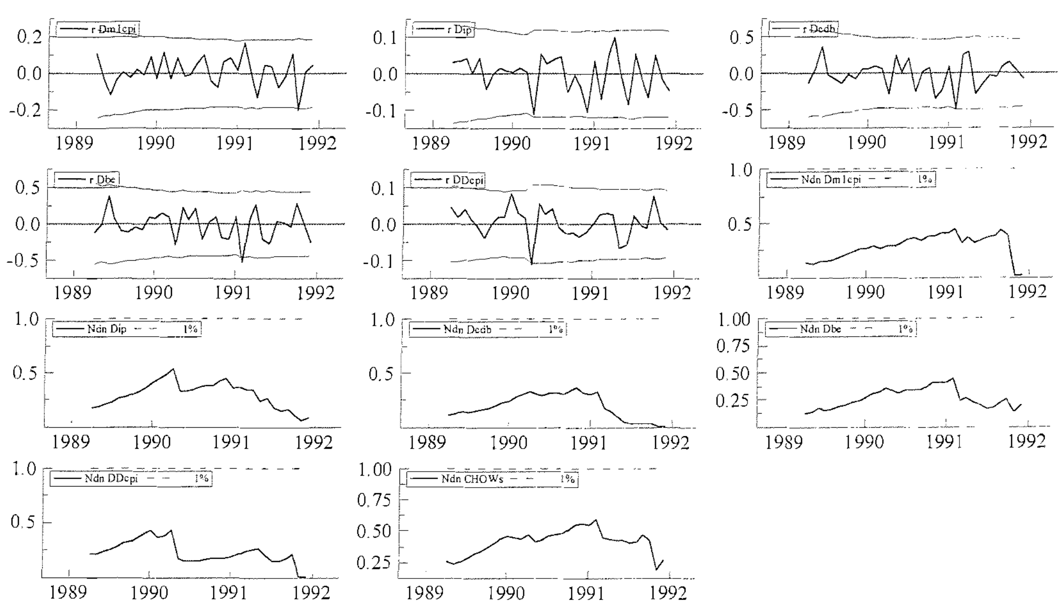
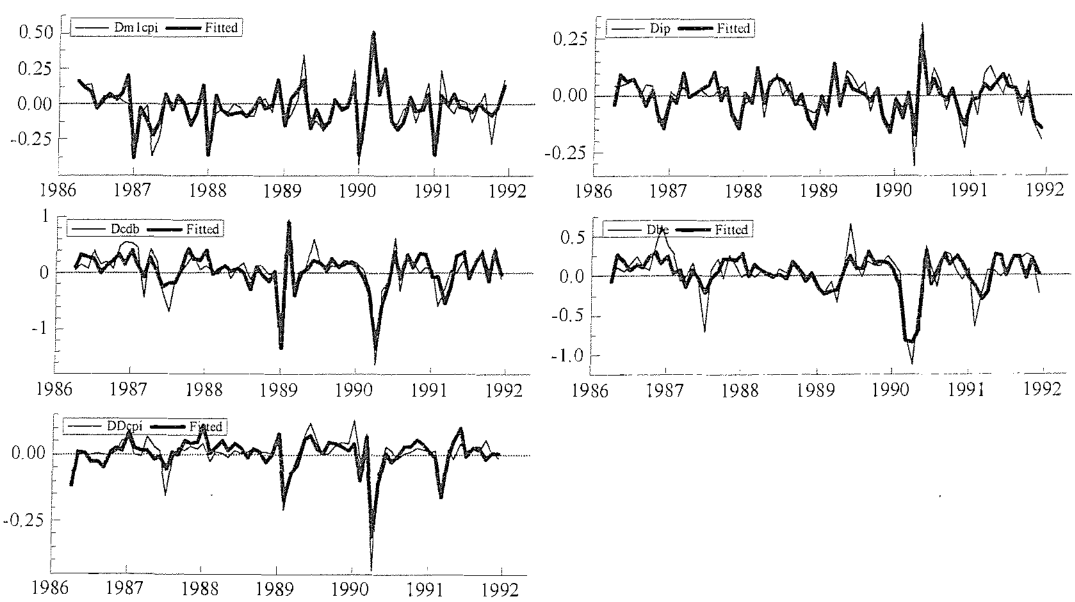
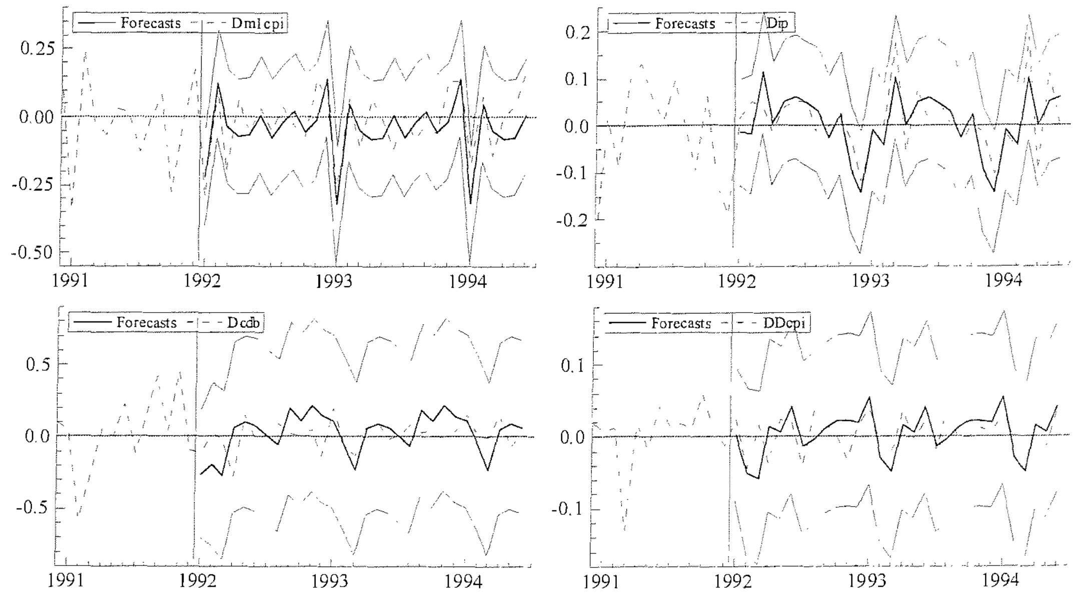


Figure 5.10 Actual and Fitted Values SEM 1986/4 – 1991/12



The *ex ante* dynamic forecasts from January 1992 to July 1994 are shown in graph 511 plus $\pm 2se$. The SEM tracks well the growth in real money and industrial production index but not so well the rate of growth in the interest rate for certificate of deposit and in inflation the latter most likely because it is the second difference of the price index. Despite the instability in the period when the president stepped down in the middle of a political crisis and the upcoming of a new stabilization plan in 1994 there is no sign of forecast failure. So in general we consider that the SEM is congruent with the information available and parsimoniously encompass the VAR.

Figure 5.11 Out of Sample Forecasts SEM 1986/4 – 1991/12



The SEM short-run dynamic in table 5.21 shows a richer structure than the model in the previous period. The equation for $\Delta m1 - cpi$ is affected positively by changes in the bill of exchange interest rate, a sign that has a difficult interpretation. A possible interpretation lies in the fact that this interest rate is catching the effects of growth in the economy in the presence of low levels of M1 holdings in such way that agents would need more money in their demand accounts to apply in a different asset which would be otherwise protected from inflation in interest bearing accounts.

The sign for the rate of growth in inflation is as expected negative. The sign for the rate of growth in the interest rates for the certificate of deposits seems to reflect simply the substitution between M1 and a fixed income investment which had its maturity period reduced in relation to the previous period in line with inflation rates growth.

Table 5.21 SEM 1986/4 – 1991/12[27]

$$\underset{(SE)}{\Delta ml - cpi} = \underset{0.57}{0.94} - \underset{0.06}{0.22}\,\Delta cdb_{t-1} + \underset{0.08}{0.29}\,\Delta be_{t-1} - \underset{0.15}{0.63}\,\Delta\Delta cpi_{t-1} +$$

$$+\underset{0.70}{3.97}\,CIa_{t-1} - \underset{0.05}{0.21}\,CIb_{t-1} + \underset{0.10}{0.52}\,CIc_{t-1} + \hat{\varpi}\mathbf{D}_t \quad \hat{\sigma} = 0.090$$

$$\underset{(SE)}{\Delta ip} = -\underset{0.29}{0.69} - \underset{0.09}{0.59}\,\Delta\Delta cpi_{t-1} - \underset{0.18}{0.49}\,CIa_{t-1} - \underset{0.03}{0.07}\,CIc_{t-1} + \hat{\varpi}\mathbf{D}_t \quad \hat{\sigma} = 0.056$$

$$\underset{(SE)}{\Delta cdb} = -\underset{0.83}{11.50} - \underset{0.19}{0.43}\,\Delta ml - cpi_{t-1} - \underset{0.04}{0.13}\,\Delta be_{t-1} - \underset{0.47}{6.62}\,CIa_{t-1} -$$

$$-\underset{0.09}{1.19}\,CIc_{t-1} + \hat{\varpi}\mathbf{D}_t \quad \hat{\sigma} = 0.22$$

$$\underset{(SE)}{\Delta be} = -\underset{0.87}{8.32} - \underset{0.16}{0.19}\,\Delta ml - cpi_{t-1} - \underset{0.03}{0.34}\,CIb_{t-1} - \underset{0.05}{0.14}\,CIc_{t-1} +$$

$$+\hat{\varpi}\mathbf{D}_t \quad \hat{\sigma} = 0.21$$

$$\underset{(SE)}{\Delta\Delta cpi} = -\underset{0.26}{2.37} - \underset{0.010}{0.017}\,\Delta cdb_{t-1} - \underset{0.07}{0.29}\,\Delta\Delta cpi_{t-1} - \underset{0.21}{0.50}\,CIa_{t-1}$$

$$-\underset{0.01}{0.09}\,CIb_{t-1} - \underset{0.03}{0.06}\,CIc_{t-1} + \hat{\varpi}\mathbf{D}_t \quad \hat{\sigma} = 0.045$$

Overall the impact of shocks in $\Delta ml - cpi$ appears to be restricted to $\Delta ml - cpi$ only as we can infer from the accumulated impulse response functions in figure 5.12

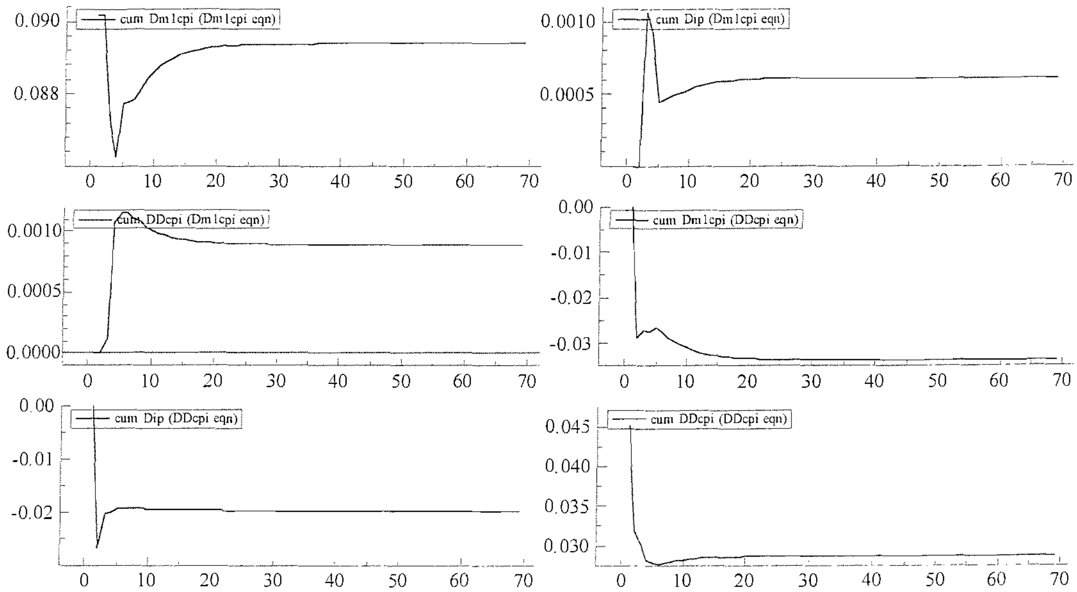
The equation for Δip shows a negative relationship with the growth rate in inflation. Such relationship has a similar interpretation to that observed in the previous period (SEM 1980-1986(2)) and is certainly expressing the nominal impacts of inflation only. It is also represented in the impulse response functions where the dynamic properties of the estimated model indicate a negative fast response and posterior stabilization to a shock in $\Delta\Delta cpi$ with the impact reaching approximately half of the standard deviation for the equation to Δip. The findings of the cointegrating VAR were not reproduced with the equation for Δip since it reacts to the first cointegrating vector and not surprisingly to the third one.

The equation for Δcdb basically depicts this variable as negatively related to the rate of growth in real money reinforcing the interpretation that investing in fixed income would represent an alternative to holding money. The negative sign in the interest rates

[27] The reader should notice that the vector $\mathbf{D}_t$ comprises a different set of variables for each equation. We use the same notation only to save space. Indeed for all equations it comprises the centered seasonal dummies but for the first equation it includes also all dummies. For the second equation it comprises the *dfm4, dfma4* and *D3* dummies. For the third equation it includes only *dfm3* and *D3*. For the fourth equation the vector comprises all dummies, and finally in the last equation *dfm4,* and *D3* only.

for the bill of exchange coefficient represents the substituting effect between the two interest rates and finally the negative sign in Δip has no clear interpretation.

Figure 5.12 Accumulated One Standard Deviation Impulse Responses Functions Shock To (From) SEM 1986/4 – 1991/12



The equation for Δbe has a difficult interpretation since it is not clear why the coefficient for $\Delta ml - cpi$ should have a negative sign, nevertheless this variable is only marginally significant implying therefore that Δbe is basically driven by the second and third cointegrating vectors and the deterministic variables.

Finally in the equation for $\Delta\Delta cpi$ the negative sign in $\Delta\Delta cpi_{t-1}$ depicts the presence of memory in the process but possibly reflecting the sequence of attempts for bringing down inflation. Nevertheless when we consider the impulse response function the picture is reversed and shocks on $\Delta\Delta cpi$ present a positive impact which shows the contrasting short-run impacts of the stabilization plans and a long run effect of increasing inflation rates given their successive failures. The coefficient for Δcdb_{t-1} despite having a difficult interpretation is only marginally significant which led us to conclude that the equation for $\Delta\Delta cpi$ is basically driven by its past values and the cointegrating vectors. This result seems to be describing the presence of inertia in inflation despite all the attempts to break down this component with the stabilization plans. As in the previous analysis the cumulating impulse response functions show a similar pattern to a one standard deviation shock, initial impact stabilizing after less than ten periods in values close to the standard deviation of the $\Delta\Delta cpi$ equation.

Overall the SEM main strengths are the correct characterization of the growth in real money as a negative function of $\Delta\Delta cpi$ and the negative sign of Δcdb_{t-1} in this equation showing the trade off between fixed income and cash holding. The SEM also is able to disentangle the short and long-run effects in $\Delta\Delta cpi$ of a shock in $\Delta\Delta cpi$. In the short run the SEM correctly describes a negative effect reflecting the sequence of stabilization plans, whereas in the long run it shows increasing rates which dominated the period. When contrasting these main properties and results of the SEM to those implied by the econometric model used in chapter 3, where the basic cointegration vector is $m1 - cpi + \beta\Delta m1_t - \alpha$, they are much more interpretative even disregarding the rejection in the rational expectations hypothesis.

5.4) Stability and Low Inflation: 1994(10) – 2002(2)

In the analysis for the third period a VAR(3) was estimated on the following variables: $m1 - cpi, ip, CDB \text{ and } \Delta cpi$. The VAR also included centered seasonal dummies, an unrestricted constant, a restricted trend so we avoid the unlikely presence of a quadratic trend in the levels and the following unrestricted dummies assuming value 1 in the specified dates and zero otherwise: 1995.3; 1996.1; 1997.1; 1997.11; 1998.9-10; 1999.2-3; 2000.7. The dummy for 1995.3 accounts for the reaction of the Brazilian monetary authorities to the Mexican crises which started in December 1994 with the peso fluctuation. It comprised a small adjustment in the exchange rate in March 1995. Another similar adjustment took place in January 1996 and explains the dummy for this month. The dummy for 1997.11 accounts for the Asian financial markets crisis whereas the dummy for 1998.9-10 accounts for the Russian crisis and their impacts on the Brazilian crawling peg regime. The dummy for 1999.2-3 accounts for the end of this regime and implementation of the floating regime for the exchange rate.

The diagnostic tests are in table 5.22. The system presents only marginal signs of non-normality in the residuals for the Δcpi equation and at the system level. Otherwise there is no sign of misspecification.

The results for the cointegration analysis in table 5.23 based on the trace test statistic suggest that there are 2 cointegrating vectors with the hypothesis of $r \leq 1$ being rejected only marginally at 5% level of confidence. However since the test rejection is only marginal I opted for carrying on the analysis with the hypothesis of just one cointegrating vector. Re-estimating the system with the restriction of $r = 1$ gives the roots of the companion matrix presented in the second column of table 5.23 from where we can rule out the hypothesis of the data being I(2) on the same grounds of the last two sections.

Table 5.22 Diagnostic Tests VAR 1995(1)-2002(2)

Test\Equation	$m1-cpi$ (p-value)	ip (p-value)	CDB (p-value)	Δcpi (p-value)	*System* (p-value)
AR 1-6	1.383	1.545	0.557	0.546	1.248
	(0.240)	(0.183)	(0.762)	(0.770)	(0.131)
Normality	5.990	1.189	1.281	7.736*	16.089*
	(0.05)	(0.552)	(0.527)	(0.021)	(0.041)
ARCH	0.614	0.516	0.406	0.056	
	(0.718)	(0.793)	(0.871)	(0.999)	—
Hetero	0.491	0.374	0.606	0.566	0.440
	(0.963)	(0.993)	(0.897)	(0.924)	(1.000)

*indicates rejection at 5% level and **at 1% level.

Table 5.23 Five Largest Eigenvalues Companion Matrix

Eigenvalues r *unrestricted*	*Eigenvalues* $r = 1$
0.8953	1.0000
0.8953	1.0000
0.8679	1.0000
0.6614	0.8354
0.6614	0.6137

Table 5.25 presents the cointegrating vector after imposing and testing two over-identifying restrictions on the long run vector and two extra restrictions on the dynamic

terms[28]. The vector admits the interpretation of a money demand equation with real money being positively influenced by the detrended industrial production, which proxies the output gap, and negatively by the real interest rate. The difference presented to the money demand identified in the previous period is that now the real interest rate has a role to play in the monetary system reflecting the tighter monetary police imposed after the Real plan cast in 1994.

Table 5.24 Cointegration Statistics VAR (1986/4 – 1991/12)

R	*0*	*1*	*2*	*3*	*4*
Trace Test	104.03	43.078	18.329	2.231	
p-value	0.000	0.0496	0.329	0.938	
Eigenvalue		0.508	0.250	0.171	0.026

Table 5.25 Cointegrating Vectors and Adjustment Coefficients VAR 1995(1) – 2002(2)

Cointegrating Vector	$\hat{\alpha}_i$ (se)	$i=1$
CIa: $m1 - cpi - 16.194ip + CDB - \Delta cpi_t + 0.021t$	$m1 - cpi$	0
LR test of Restrictions	ip	0
Equilibrium and Feedback: $\chi^2(4) = 3.017[0.5550]$	CDB	-0.166 (0.022)
	Δcpi	-0.0017 (0.0007)

The diagnostic tests for the VECqM are presented in table 5.26. The system presents signs of autocorrelation, non-normality and heterocedasticity in the residuals for the real money equation. The vector tests however do not present any sign of misspecification. Nevertheless the positive results obtained in the vector tests, including a dummy variable for January 1995 led to a more congruent system with no signs of misspecification in the equations. Further from figure 5.13 the one step residuals and breakpoint Chow tests indicate that there is no evidence against the hypothesis of stable parameters. I considered therefore that the resulting system is a congruent representation of the data and constitutes the base from which the SEM is tested.

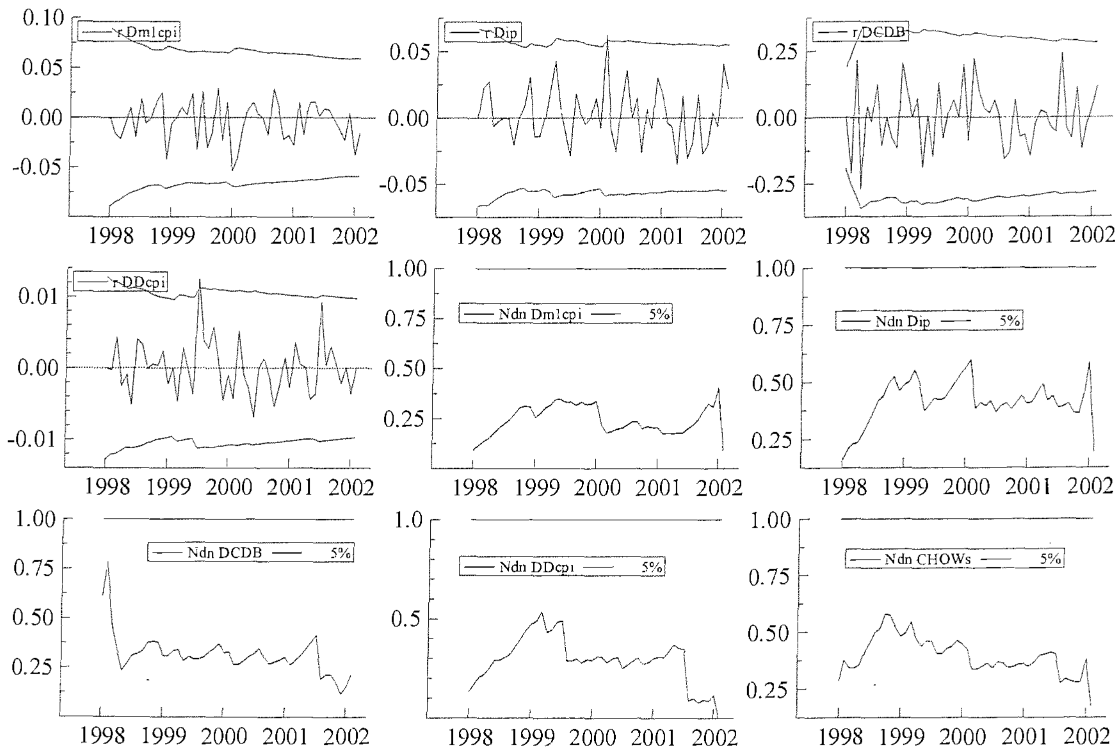
[28] The hypothesis tested through general restrictions on the cointegrating vector is: $\beta' = [1 \quad * \quad 1 \quad -1 \quad *]$. The test statistic is: $\chi(2) = 0.331[0.8474]$ which shows that there is no evidence against the restrictions on the data.

Table 5.26 Diagnostic Tests VECqM 1995(1)-2002(2)

Test\Equation	$m1-cpi$ (p-value)	ip (p-value)	CDB (p-value)	Δcpi (p-value)	*System* (p-value)
AR 1-6	2.332*	0.972	0.561	0.946	1.246
	(0.045)	(0.453)	(0.758)	(0.470)	(0.123)
Normality	7.802*	4.061	1.412	1.983	15.215
	(0.020)	(0.131)	(0.493)	(0.370)	(0.055)
ARCH	0.623	0.429	0.311	0.254	———
	(0.710)	(0.855)	(0.927)	(0.954)	
Hetero	1.923*	0.899	0.977	0.792	0.971
	(0.043)	(0.582)	(0.502)	(0.696)	(0.580)

*indicates rejection at 5% level and **at 1% level.

Figure 5.13 One Step Residuals and Breakpoint Chow Test VEqCM 1994/10 – 2002/2



The SEM imposed a total of 36 restrictions which were not rejected based on the results of the LR test $\left(\chi^2(36)=40.600\right)$ and a total reduction of 36 parameters when compared to the Parsimonious VAR.

The diagnostic tests results presented in table 5.26 show that the model has signs of autocorrelation in the residuals for the $\Delta m1 - cpi$ equation and marginally in the $\Delta\Delta cpi$ equation, but such result has no counterpart in the system tests. Further the parameter instability tests show no-sign of instability in the equations which led us to conclude that the SEM is congruent and represents a valid reduction parsimoniously encompassing the VAR. The SEM dynamic structure is shown on table 5.27.

Table 5.27 SEM 1995/1 – 2002/2*

$$\underset{(SE)}{\Delta m1 - cpi} = \underset{0.003}{0.010} + \underset{0.106}{0.291}\,\Delta ip_{t-2} - \underset{0.010}{0.041}\,\Delta CDB_{t-2} + \hat{\varpi}\mathbf{D}_t \quad \hat{\sigma} = 0.029$$

$$\underset{(SE)}{\Delta ip} = -\underset{0.002}{0.000004} - \underset{0.102}{0.519}\,\Delta ip_{t-1} - \underset{0.105}{0.203}\,\Delta ip_{t-2} - \underset{0.009}{0.034}\,\Delta CDB_{t-1}$$

$$-\underset{0.009}{0.024}\,\Delta CDB_{t-2} + \hat{\varpi}\mathbf{D}_t \quad \hat{\sigma} = 0.026$$

$$\underset{(SE)}{\Delta CDB} = -\underset{1.349}{11.492} - \underset{0.641}{3.843}\,\Delta ip_{t-1} - \underset{0.593}{2.850}\,\Delta ip_{t-2} - \underset{0.053}{0.230}\,\Delta CDB_{t-1}$$

$$-\underset{0.051}{0.093}\,\Delta CDB_{t-2} - \underset{0.019}{0.165}\,CIa_{t-1} + \hat{\varpi}\mathbf{D}_t \quad \hat{\sigma} = 0.134$$

$$\underset{(SE)}{\Delta\Delta cpi} = -\underset{0.048}{0.133} - \underset{0.021}{0.069}\,\Delta ip_{t-1} - \underset{0.020}{0.061}\,\Delta ip_{t-2} - \underset{0.087}{0.321}\,\Delta\Delta cpi_{t-2}$$

$$-\underset{0.0006}{0.001}\,CIa_{t-1} + \hat{\varpi}\mathbf{D}_t \quad \hat{\sigma} = 0.004$$

*The dummies specification varies among the equations. In the first equation the following dummies were included, 1995.1; 1995.3; 1996.1; 1997.1; 1997.11 and 1999.2.3. In contrast in the equation for Δip only the 1997.11 dummy is actually included. The equation for ΔCDB has the following dummies included: 1995.1; 1995.3; 1997.1; 1997.11; 1998.9.10; 1999.2.3. Finally in the last equation the dummies included are: 1996.1; 1999.2.3; 2000.7.

An interesting feature of the SEM final dynamic specification is that the lagged variables $\Delta(m1 - cpi)_{t-1}$, $\Delta(m1 - cpi)_{t-2}$ are not present which is somewhat expected since the economic policy implemented with the Real Plan is based on the control of interest rates and its impacts on the economic activity and further in inflation.

The objectives of the policy makers since the Real plan cast have not been to pursue a fixed target policy for M1 as an instrument. From 1999 onwards with the end of the crawling peg regime the Central Bank adopted a successful inflation control strategy by using an inflation target regime whose main instrument is a baseline interest rate[29]. What we should expect from the SEM therefore is that it reflects the impact of

[29] The baseline interest rate is the SELIC created in 1990 which is currently fixed by the Monetary Committee in a quarterly base with an indicative bias allowing the Central Bank Governor to change the rate within this time span according to the pre-established bias. It is constituted by weighted average rates of the daily operations carried on by the financial institutions backed by the public securities with a repurchase commitment implying that it excludes any risk component from the rate calculations.

the interest rate on the economic activity measured by the industrial production index and on inflation and this is exactly what it does.

The growth in real money is impacted negatively by ΔCDB as we observed in the previous period, namely 1986-1991(12) and positively as expected by Δip. The equation for Δip is impacted negatively for its past two lags, much likely to be reflecting the distinctive seasonal pattern and also negatively by ΔCDB. The latter result seems to represent basically a consumption and investment reaction to increases in the baseline interest rate[30].

The equation for ΔCDB, nevertheless, has a difficult interpretation, in particular the negative signs for Δip_{t-1} and Δip_{t-2} for which there is no clear interpretation. The negative signs in the lagged ΔCDB might be capturing the downward sloped long run trend.

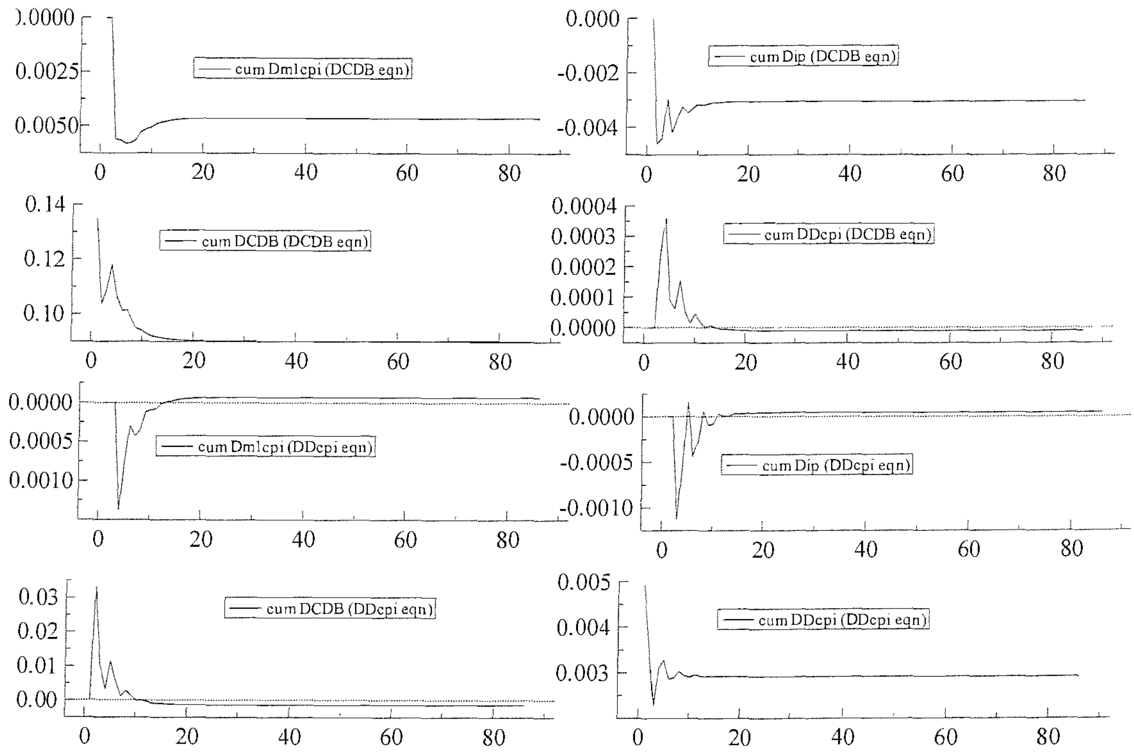
Finally in the equation for $\Delta\Delta cpi$ both lags of Δip have a negative impact on the rate of growth of inflation, which implies that growth in the industrial activity has no longer the accelerating impact on the inflation rate; a contrast to the positive impact observed for the first period (1980-1986), when the economy was indexed and the monetary authorities had lost their control on the monetary policy by following an accommodating policy when facing the growth in the industrial activity observed at that time. The contrast is even more highlighted if we consider that in the present SEM the signal for lagged $\Delta\Delta cpi$ is negative showing possibly the downward trend observed in the inflation rates and the end of indexation. The impact of the monetary policy in the short run seems to be concentrated in the economic activity not in the inflation rate dynamics itself but still a contrasting result with the first period where the CDB interest rate had been excluded from the system given its lack of significance, once more reinforcing our hypothesis that the monetary policy followed was accommodating towards the increase in the economic activity mainly from 1984 onwards. As in the present system also $\Delta m1 - cpi$ was not significant in the system for the first period, but conversely to the SEM in the first period when conditioning to this variable was a possible route to follow, in the present one the rate of growth in money is influenced significantly by the rate of growth in the industrial production index and in the CDB

[30] Indeed the in sample estimated correlation between the CDB interest rate and the SELIC base rate is 0.98793 a expected result considering that the CDB is used to form the "Brazilian prime rate" TR.

interest rate, most likely to be representing the remonetization in the economy that has taken place after the stabilization in the inflation rates observed from 1994 onwards.

The dynamic properties of the estimated model nevertheless show that indeed the accumulated impact of one standard deviation shock in the ΔCDB equation shown in figure 5.14 is concentrated basically on the variable having negligible negative effects on $\Delta m1 - cpi$, $\Delta\Delta cpi$, and Δip.

Figure 5.14 Accumulated One Standard Deviation Impulse Responses Functions Shock To (From) SEM 1995/1 – 2002/2



The positive impact in the long run on the equation for ΔCDB from a shock in $\Delta\Delta cpi$ shows clearly the reaction of the monetary policy to increases in the inflation rate. Interestingly there is no counterpart effect in the short-run since the interest rate equation does not react to inflation dynamics and the effect on the equation for inflation dynamics itself is negligible. The result of the short run and long run analysis of the inflation dynamics seems to demonstrate therefore that we have a negative impact in the short run for the process reinforcing the end of indexation and an immediate reaction in the interest rates to any increase in inflation rates in the long run highlighting the use of the interest rate as the main instrument in carrying on the monetary policy operations.

5.5) Conclusion

This chapter presents an analysis of the main results obtained by deriving SEMs following the LSE's methodology. The main assumption in deriving the econometric models is that valuable information in specifying them can come from numerous different sources beyond economic theory, including information from the observable sample of relevant variables and economic history in such way that we expect to relate the empirical model to the actual mechanism that is generating the data rather than to theory only which means then that theory and data form the DGP. The analysis follows the main discussion in chapter 4 in assuming that modeling joint densities is essential in pursuing an empirical analysis of economic time series and that knowledge acquisitions are progressive and partial. Under this methodological framework the chapter presents three contributions to the literature about the Brazilian high inflation period.

In section 5.2 the SEM derived demonstrates the role of economic activity measured by the industrial production in the long run identified cointegrating vector and how it relates to the real interest rates. Also the short run price dynamics is influenced by the first difference of the industrial production index. Such result contrasts to the usual findings in the literature that the demand variables had no role in the accelerating inflation period as discussed in chapter 2 and stressed in Durevall (1998) where the author using the same methodological approach derived a one equation model for inflation in Brazil including the period I analyzed here and could not find any influence from demand variables in the econometric model. The results found also contrasts to those obtained by Juselius (2002) where the author concentrated on the demand for M3 and explains the accelerating inflation using a trend liquidity ratio. Whilst her model explains how inflation expectations played a significant role on the demand for M3 through the black market exchange rate it does not show any link between the economic recovery observed from 1984 onwards that had strong links with the acceleration in prices observed.

Such links had been emphasized in chapter 2 and the SEM allows us to emphasize its role with the dummy 1984.2 having a positive effect on $\Delta\Delta cpi$ and on the industrial production index. Further the equation for the rate of growth in inflation shows how inflation rate gained momentum and why inflation assumed a pattern of persistence. The impulse response function of a shock to $\Delta\Delta cpi$ from itself shows a short accelerating impact lasting only 5 periods a result that emphasizes the role of the inertia in inflation but constitutes strong evidence against the hypothesis of inflation being driven only by its past. In chapter 6 I extend the analysis to discuss the role of the administered nominal exchange rate devaluations as a complementing theory explaining the price formation in the period as well as the role of wage inflation in the model following Durevall (1998).

Section 5.3 presents the model for the period 1986-1994 where a stable long run money demand equation is identified being negatively related to inflation and positively related to the growth in the industrial production index, both consistent with the economic theory. A remarkable result not only because to the best of my knowledge this is the first econometric model developed for this period in Brazil to identify a money demand equation but also because the long run money demand equation shows that the hypothesis of inflation being insensitive to demand policies was mislead. Further a similar specification for the money demand was found for the subsequent period where then the real interest rate rather than the inflation rate only started to have a significant role in the long run money demand after inflation stabilization. Such result demonstrates that the estimated vector is in some extent robust to the class of interventions observed and that indeed the monetary policy would have had a central role in both periods. This last conclusion comes from the fact that the main argument in the period of high inflation and plans was that the monetary policy was ineffective given the particularities of the Brazilian economy as discussed in chapter 2 whereas from 1994 onwards it has been used as one of the core policies of the stabilization as in any other country.

The SEM short run dynamics show the demand for real money being negatively related to inflation and the interest rate on the CDB both in accordance to the economic theory. In the equation for $\Delta\Delta cpi$ the negative sign in $\Delta\Delta cpi_{t-1}$ depicts the presence of memory in the process but possibly reflecting the sequence of attempts for bringing down inflation. Nevertheless when we consider the impulse response function the picture is reversed and shocks on $\Delta\Delta cpi$ present a positive impact which shows the contrasting short-run impacts of the stabilization plans and a long run effect of increasing inflation rates given their successive failures. This result shows the ability of the econometric model in describing the results of the successive stabilization attempts, namely short periods of low inflation and accelerating rates in the sequence. It is worth noticing that the shocks to $\Delta\Delta cpi$ from $\Delta\Delta cpi$ die out after less than 10 periods what shows some degree of inertia in the process but not that inflation had been only determined by its past.

The second cointegrating vector found in this second period, namely1986-1994 has a similar specification to those found in the first period, namely 1980-1986. In particular for the first and second periods it suggests that there is a link between the real interest rates measured by the CDB and the economic activity reinforcing the role played by the monetary policy in controlling the industrial output levels in the long run. Nevertheless for the second period there is a change in the signal for the industrial production index leading to an opposite interpretation with a positive impact on the industrial production which might be due to the sequence of interventions that took place.

In chapter 6, I also assess the impact of wage inflation on the model and the differences between the two models, namely with and without wage inflation.

Finally, in section 5.4 a SEM is derived for the third period. Similarly, to the second period a long run money demand was identified with the same signal for the industrial production but being negatively related to the real interest rate rather than inflation only in accordance with the new monetary policy implemented which has been using the interest rate as the main instrument. In the equation for $\Delta\Delta cpi$ both lags of Δip have a negative impact on the rate of growth of inflation, which implies that growth in the industrial activity has no longer the accelerating impact on the inflation rate which presented also a negative autoregressive pattern highlighting the end of indexation and the downward trend present in the Brazilian inflation rate.

Chapter 6:

The Role of Nominal Wage Inflation and the Administered Exchange Rate during High Inflation in Brazil

The econometric models derived in chapter 5 despite their originality in modelling the Brazilian high inflation period comprise in fact a set of baseline models representing a summary of the information present in the sample based on the central assumption that a standard money demand equation drives price formation in the long run, but not necessarily in the DGP in such way that the theoretical model is not imposed on the econometric model through testing restrictions derived from theoretical formulations.

In particular the empirical model's dynamic properties describe clearly the pattern of relative persistence in inflation and the long run cointegrating vectors allow the identification of a money demand equation whereas the main theoretical models for the Brazilian inflationary process postulate different variables and dynamic processes as the main cause of persistence in inflation. Such theoretical hypotheses were not addressed in the analysis pursued in chapter 5 and one implication is that the encompassing analysis was carried by concentrating on finding empirical reductions of the VAR and did not consider empirical versions of these theoretical models on aiming to specify parsimonious encompassing models to each period analysed, namely the SEMs compared to the VAR termed as the system. Therefore each SEM (the empirical reduction of the VAR) was in turn derived from eliminating non significant variables from the system following a general to specific modelling strategy as postulated in Hendry and Richard (1982), Hendry and Doornik (1994) and Hendry (1995). Therefore, we can conclude from the theoretical discussion in chapter 4 and from the results of the over-identifying test statistics that the

SEMs derived in chapter 5 consisted of congruent models that parsimoniously encompassed the VAR.

Although this can be considered a central property for any econometric model an interesting question in this framework is if the results obtained in chapter 5 are robust to extensions in the information set comprised in relevant theoretical hypotheses not included in the analysis previously. One could argue that it would have been preferable to have initiated the general to specific modelling strategy including this extended information set embracing the theoretical framework not considered in the analysis performed in chapter 5.

However the sample size in the present case prevents an extensive analysis through including more endogenous variables in the system. In particular I focus on the Administered Exchange Rate policy (AER) followed by the Brazilian central government implemented in the first half of the 1980's and nominal wage inflation impact on price dynamics. I justify such interest in the second case because the generalized indexation present in prices and wages more specifically was assumed as the main force behind the inflationary spiral that started in 1986 with the Cruzado plan and culminated into the 1989 short lived hyperinflation.

Given the restricted sample size the strategy that I follow is to perform the extended analysis of the econometric models developed in chapter 5 through testing for the presence of omitted variables in these models in the case of the AER. The constraint imposed by the sample size is therefore the reason for not including the relevant variables implied by the AER hypothesis in a VAR framework comprising the estimation of a full system to re-assess the model derived in chapter 5 in a comparative analysis through the use of the over-identifying restrictions test as an encompassing test as suggested in Hendry and Mizon (1993).

Alternatively, for the nominal wage hypothesis I carry out a test of weak exogeneity of this variable by the parameters of interest. In this case if the variable is weakly exogenous there is no loss of information in estimating the marginal system only instead of carrying on the full system analysis[1]. The weak exogeneity test in a VAR framework and its implications for the present analysis is discussed in section 1.

The strategy pursued of testing if the SEM is robust to extensions in the information set raises the following subtle question beyond the exogeneity assumption: can the test for over-identifying restrictions be used on the same grounds as it was in chapter 5? This question is relevant exactly because in the presence of exogenous variables the SEM is no longer a closed model and the results shown in chapter 4 are valid only for closed systems. Put in another way using the test for over-identifying restrictions in an encompassing analysis on the grounds of the discussion in section 4.2 is in principle only valid if the VAR in a closed form works as a catalyst model for testing the reductions. This question in particular is also addressed in the first section.

Therefore the objective of this chapter turns out to be different from the past one to the extent that the analysis performed draws on specific theoretical models not addressed in chapter 5 to derive the SEMs.

The motivation behind extending the empirical analysis comes from two theoretical underpinnings, namely the AER and the hypothesis that wage inflation dynamics made an effective impact on price formation in Brazil during the high inflation period.

From November 1980 onwards the central government adopted a policy for the monetary correction where it would follow the consumer price index, and the exchange rate devaluations would cover the difference between the internal and external inflation rates. Such policy can be thought of as a return to the policy of devaluations in the nominal exchange rate in line with the difference between the internal and external inflation rates initiated in 1968 and interrupted in 1979/1980 when a new scheme for the monetary correction – including the exchange rate – based on pre-fixed values had been implemented by the new government.

Interestingly the policy enforced by the government is likely to produce an effect on the grounds of the Purchasing Power Parity theory (PPP)[2] and Durevall (1998) shows that

[1] It should be noticed that the AER hypothesis include in the estimation the variable *DDcpi*, so testing the hypothesis of weak exogeneity to the system in chapter 5 is not a feasible option.
[2] Blejer and Liederman (1981, p.138) make a similar assumption in implementing their empirical model, namely: " With a view to the empirical implementation of the model for Brazil, we postulate here that the

the PPP holds well until 1979 when then it breaks down. This result is not expected given the explicit policy followed from 1980 onwards[3]. Since the result is not expected I hypothesize that Durevall's result may have been influenced by his interest in developing specifically a PPP hypothesis test whilst the more reasonable hypothesis is that there was a close link between inflation and foreign and internal price index through administered prices but not necessarily that the PPP held during the period. This alternative hypothesis therefore merits assessment.

The hypothesis that wage inflation influences inflation dynamics comes directly from the theoretical models developed to account for inflation inertia as in Novaes (1991). Such models are derived from the seminal paper Taylor (1979) and include a wage equation where the wages follow periodically the past inflation rates. The model is completed with two more equations one determining the aggregate demand and a final one defining a monetary rule. Whilst the hypothesis of pure inertial inflation has been rejected in most of the empirical developments, some degree of inertia has been assumed to be present in the inflation process in Brazil as pointed out in empirical studies by Barbosa and McNelis (1990) and by Novaes (1991, 1993). Barbosa and McNelis found evidence in favor of wage inflation being linked to increasing inertia in the Brazilian inflationary process, whereas Novaes (1991) found that the degree of inertia in the inflationary process was far less than that implied by the theoretical model, a conclusion similar to that obtained by Durevall (1998) when modelling persistence in inflation. However the findings in Durevall (1998) with respect to the role played by wage inflation in particular, show that there is no evidence of this variable being significant in his econometric model. This contrasts with Barbosa and McNelis and leaves open the hypothesis that indeed wage policy was not a strong inflation-propagating mechanism as argued by Durevall (1998) quoting Baer (1989). Given these contrasting results in the literature for empirical models and the wage inflation central role in the theoretical models to explain indexation I considered that it is essential that the role played by wage inflation dynamics be assessed in any empirical model

policy objective is to avoid long run changes in the real exchange rate and that the nominal rate is therefore altered to maintain purchasing power parity."

[3] Such result does not arise in my analysis because I start the estimation in 1980 whereas Durevall starts modelling inflation from 1968 onwards. So in fact I am avoiding the changes that took place during 1979. However a closer look at Durevall's conclusions is necessary because he extends his analysis up to 1985 a period when the administered exchange rate was in place.

developed for this period. Section 2 briefly summarizes these two theoretical models and their main implications.

Further the own dynamics of the SEM developed in chapter 5 has shown some degree of persistence in the model through the analysis of the impulse response functions. This provides an extra argument for performing a deeper analysis of the inertia's dynamic through developing a new SEM and testing if it encompasses the SEM derived to the same period in chapter 5. For comparative purposes I perform the test to the three periods under analysis. The main objective in performing the test to all periods is to compare the results for the third period with the other two in the sense that we can expect that after the price stabilization reached with the Real Plan and the end of the widespread use of indexation in the economy, wage inflation should not play any role in the equation for price dynamics. Section 3 presents the estimation results and comparative analysis.

6.1) Encompassing the VAR in Open Systems

The encompassing analysis pursued in chapter 5 used the VAR as a catalyst for testing the different SEMs. The testing procedure works by specifying a congruent VAR and comparing the different SEMs using the over-identified restrictions test. In chapter 4, section 4.2, it is shown that a sufficient condition for the SEM to encompass its competitors in the same class is that it parsimoniously encompasses the VAR and be congruent. Such condition is valid on the assumption that the VAR is closed, or more specifically, that all variables are modelled. In particular following the notation introduced in chapter 4 we have for a closed system:

$$\Delta \mathbf{y}_t = \Pi \mathbf{y}_{t-1} + \sum_{i=1}^{p-1} \Pi_i \Delta \mathbf{y}_{t-i} + \kappa + \upsilon_t \quad (6.1)$$

where: $\Pi = \alpha\beta'$, α and β are $n \times r$ matrices, Ω is the covariance matrix of υ_t and finally $0<r=rank(\Pi)<n$ so there is cointegration (assuming that the variables in $\mathbf{y}_t$ are I(1) which represents the case of interest in our analysis).

It is worth noticing that testing the theoretical hypothesis represented by the nominal wage inflation poses an extra difficulty in our case regarding the encompassing test based on the over-identifying restrictions test. In particular, including an extra variable in the SEM and testing encompassing implies an assumption about the variable's status, or more specifically that it is exogenous for the parameters of interest in the system, namely the cointegrating vector's parameters (not exogenous for the parameters of interest in the SEM). This is because the system (VAR) provides the framework within which we can assess the properties of the SEM. In chapter 5 I test the hypothesis that the SEM encompasses the VAR considering that the VAR is the unrestricted model on which restrictions are imposed by the SEM. Alternatively, in the present chapter I test first the hypothesis that nominal wage inflation is weakly exogenous to the system (the VAR not the SEM). Doing that I can test the weak exogeneity of the relevant variable to the VAR and at the same time, construct an open VAR that corresponds to the unrestricted model.

Johansen (1994) shows that by partitioning the vector $\mathbf{y}_t$ in (6.1) such that we have $\mathbf{y}_t = (\mathbf{s}_t, \mathbf{v}_t)$ and conditioning $\mathbf{s}_t$ on $\mathbf{v}_t$ there is a very special case where estimating the conditional model only is efficient so that there is no loss of information. This case arises when $\alpha_v = 0$ in (6.3)

$$\Delta\mathbf{s}_t = \lambda\Delta\mathbf{v}_t + (\alpha_s - \lambda\alpha_v)\beta'\mathbf{y}_{t-1} + \sum_{i=1}^{p-1}(\Pi_{si} - \lambda\Pi_{vi})\Delta\mathbf{y}_{t-i} + \kappa_s - \lambda\kappa_v + \upsilon_{st} - \lambda\upsilon_{vt} \quad (6.2)$$

where $\lambda = \Omega_{sv}\Omega_{ss}^{-1}$

$$\Delta\mathbf{v}_t = \alpha_v\beta'\mathbf{y}_{t-1} + \sum_{i=1}^{p-1}\Pi_{vi}\Delta\mathbf{y}_{t-i} + \kappa_v + \upsilon_{vt} \quad (6.3)$$

Testing the hypothesis that $\alpha_v = 0$ constitutes therefore the test of weak exogeneity of $\mathbf{v}_t$ for β whereas testing the additional hypothesis that the coefficients of $\Delta\mathbf{s}_t$ are zero in equation (6.3) constitutes the test of strong exogeneity of $\mathbf{v}_t$ for β[4].

Johansen (1994) suggests an alternative weak exogeneity test for the case when there are many variables or the sample size is short. He argues that an alternative test involves evaluating (6.2) by the reduced rank procedure determining the cointegrating

[4] In the present case I focus on testing weak exogeneity since I am interested in statistical inference.

vectors, and then testing if their coefficients are different from zero using a F-test in the marginal model given in (6.4), or more specifically that $\varphi = 0$ in (6.4).

$$\Delta \mathbf{v}_t = \varphi \hat{\beta} \mathbf{y}_{t-1} + \sum_{i=1}^{p-1} \Pi_{vi} \Delta \mathbf{y}_{t-i} + \kappa_v + \upsilon_{vt} \quad (6.4)$$

I follow this alternative test when testing if nominal wage inflation is weakly exogenous for the $\beta's$ instead of re-estimating the VECM's including the nominal wage inflation and carrying out the reduced rank analysis that equations (6.2) and (6.3) would suggest. The justification is the reduced sample size in the first and second periods mainly, where the VAR's in chapter 5 were estimated with 5 equations each whereas the test proposed in equations (6.2) and (6.3) would imply re-estimating the VAR's with 6 equations.[5]

Hendry and Mizon (1993) suggest a two-step encompassing test in the open systems case, namely, firstly test each closed model against the VAR using the over-identifying restriction test, and then as a second step test the validity of the weak exogeneity reduction of each closed model. Such encompassing analysis is nevertheless unfeasible in the present case because I am not formulating a closed model including Δnw in $\mathbf{y}_t$ in equation (6.1), where nw is a measure for nominal wage inflation. If nominal wage inflation is weakly exogenous for the parameters of the cointegrating vectors we can rewrite (6.1) as (6.2) and without loss of information concentrate our analysis on (6.2) which will act as the catalyst VAR relative to which we can test restrictions using the over-identified restrictions test. According to Hendry and Mizon (1993) if the variable is validly weakly exogenous, the relevant underlying congruent statistical system is a VAR, even if it is open, as conditioning implies. In this case we preserve the specification order pursued in chapter 5

[5] The other theoretical hypothesis of interest in the present chapter, namely the AER hypothesis, does not allow a test of weak exogeneity because the Brazilian consumer price index enters in both cointegrating vectors, the AER VAR analysis and in the system analysis carried on in chapter 5 so I can not decompose equation 6.1 as equations 6.2 and 6.3. Further alternatively testing $\varphi = 0$ in equation 6.4 does not ensure that $\mathbf{v}_t$ is weakly exogenous for β. Consequently, in the cases where the model incorporates the cointegrating vector derived from the AER VAR analysis I test encompassing through a forecast encompassing test.

where the SEM arises as a valid reduction of the system rather than the reduced form being derived from the SEM. If this were the case the reduced form would have been identified on incredible restrictions which are in other words assumptions on the exogeneity of the variables of interest.

The approach followed in the present chapter consists in running the extended VAR and test if nominal wage inflation is weakly exogenous. If this variable is not exogenous it is advisable to restart modelling by including the variable in the system. On the contrary if the variable is weakly exogenous we define an unrestricted model which is an extended system to that used in chapter 5 and assess the congruence of the system relative to the data. This analysis is nevertheless restricted in such way I cannot compare among different econometric models. Given this sort of restriction that prevents the use of the over-identifying restriction test as an encompassing test, I carry on the encompassing analysis based on the forecast encompassing tests.

6.1.1) Forecasting Encompassing Tests: Encompassing the SEM

Forecast encompassing tests have a widespread use in applied econometrics given their simplicity. The basic hypothesis states that model 1 forecast encompasses model 2 if model 2 forecasts provide no further useful information for the prediction made by model 1. Let ϕ_1 and ϕ_2 be two forecasts from two different SEM's of interest for the variable of interest $y_t \in \mathbf{y}_t$ in (6.1) and let e_1 and e_2 be the corresponding forecast errors. According to Newbold and Harvey (2002) a natural test for model 1 forecast encompassing model 2 is a test for $\theta = 0$ in (6.5).

$$e_{1t} = \theta(e_{1t} - e_{2t}) + v_t \quad (6.5)$$

Chong and Hendry (1986) propose a slightly different test given by (6.6) where the rationale is to test if the information provided by the forecast in model 2 is of no value to the forecast error in model 1. Alternatively, tests based on (6.7) have also been used in applied work such as testing the hypothesis $(\alpha, \beta_1, \beta_2) = (0,1,0)$ in Diebold and Lopez (1996) and $\beta_2 = 0$ in Fair and Shiller (1989).

$$e_{1t} = \alpha\phi_{2t} + v_t \quad (6.6)$$
$$y_t = \alpha + \beta_1\phi_{1t} + \beta_2\phi_{2t} + v_t \quad (6.7)$$

I do use the three different ways of testing forecast encompassing, namely Hendry and Chong (HC), Diebold and Lopes (DL) and Fair and Shiller (FS) when comparing the SEM's. A particular comment of interest here is that if the variables involved in (6.6) and (6.7) are integrated it is likely that the time series represented by ϕ_{it} will be integrated. Nevertheless this is not of particular concern here since all models were mapped into an I(0) representation before the forecasts had been generated.

6.2) Theoretical Models

6.2.1) The Administered Exchange Rate Policy (AER)

The AER hypothesis establishes that from November 1980 onwards the central government adopted a policy for the monetary correction where it would follow the consumer price index, and the exchange rate devaluations would cover the difference between the internal and external inflation rates. Considering the real exchange rate definition we would have:

$$E = \frac{\kappa P^*}{P} \quad (6.8)$$ where κ is a proportionality factor.

In equation (6.8) if κ is a constant we can take log on both sides and differentiate to obtain:

$$\ln e = \ln \kappa + \ln P - \ln P^*$$
$$\frac{de/dt}{e} = \frac{d\kappa/dt}{\kappa} + \frac{dP/dt}{P} - \frac{dP^*/dt}{P^*}$$ where low cases represent the natural
$$\Delta\% e = \Delta\% p - \Delta\% p^* \quad (6.9)$$

logarithm of the variable

Equation (6.9) states that the exchange rate devaluation equals the excess of the internal inflation to the external one and is particularly useful in investigating the Brazilian inflation in the first period. One of the goals of the AER analysis proposed here is exactly to identify a long run equation like (6.9) in the first period and test its relevance in the SEM developed in chapter 5.

The test implemented here is specifically intended to account for such measures and their implications for the price formation in the econometric model in accordance to the LSE methodology which exactly assumes that economic theory guides the choice of the variables and identification of long run relationships, but other information beyond the theoretical model is used in deriving the SEM.

6.2.2) Nominal Wage Inflation

The role played by nominal wage inflation in the Brazilian high inflation is captured in a theoretical perspective by readdressing the Taylor's (1979) model as proposed in Novaes (1991).

The model is composed of a wage rule, a mark-up price rule for prices, a monetary rule and an aggregate demand equation. The key assumption in modifying the original model is to assume that the wage rule follows a backward adjustment as well as the monetary rule which accommodates immediate past inflation. Following Novaes (1991) we write:

$$\Delta w_t = \Delta p_{t-1} + \gamma \Delta y_t \quad (6.10)$$

$$\Delta p_t = \left(\frac{\Delta w_t + \Delta w_{t-1}}{2} \right) \quad (6.11)$$

$$\Delta m_t = \Delta p_{t-1} + \varphi \left(\Delta p_t - \Delta p_{t-1} \right) \quad (6.12)$$

$$\Delta m_t = \Delta p_t + \Delta y_t + \varepsilon_t^d \quad (6.13)$$

In equations (6.10) through (6.13) low cases indicates variables in log so that they are expressed in their variation rates given the $\Delta = (1 - L)$ operator. w is the nominal wage, y is a measure of demand excess, p is the price index, m is money and ε is a random shock in the demand equation. Equation (6.10) represents the wage rule, (6.11) the price rule, (6.12) the monetary rule and finally equation (6.13) the aggregate demand equation.

The main features of the model are the monetary rule that simply accommodates in the totality the previous inflation rate but with some discretionary power in such way that the growth in money is adjusted by the acceleration in the inflation rate in the current period. Further given this hypothesis the model differently from the original one does not assume that the agents have rational expectations. Novaes in her paper solves the model defining a reduced form equation for inflation as a function of its own past since her objective was test persistence in inflation. I follow though an alternative route finding a reduced equation form for inflation as a function of w and y in solving the model. The justification is that originally Novaes carry out a univariate analysis of the time series data whereas I am interested in the equation for p derived from the SEM in a multivariate context. Solving the model yields then:

$$\Delta p_t = \left(\frac{1-\varphi}{2}\right)\Delta w_t - \left(\frac{\varphi}{2}\right)\Delta w_{t-1} + (\varphi\gamma - \gamma - 1)\Delta y_t + \vartheta_t^d \quad (6.14)$$ where

$\vartheta_t^d = -\varepsilon_t^d$

Equation (6.14) relates inflation to the nominal wage growth rate and the excess in the aggregate demand. I use the modified model of Taylor to interpret the results obtained in deriving the SEM.

6.3) Empirical Results

In this section I present the empirical results considering the theoretical implications of the AER hypothesis and the nominal wage inflation in each one of the periods, so the section is subdivided into three subsections. I consider each one of the periods separately corresponding to each one of the subsections.

6.3.1) The Rising Inflation Period: 1980-1986(2)

For the analysis in this sub-sample following equation (6.4) I estimate initially a VAR (2) in the following variables: $m1 - cpi, ip, cdb, be\ and\ \Delta cpi$ plus Δnw which represents the first difference of the nominal wage index calculated to the São Paulo manufacturing industry by the FIESP[6]. The VAR includes also a restricted trend and an unrestricted dummy which assumed value one for 1984 (2) and zero otherwise accounting for the exceptional growth in the first quarter of the year and a new waiver authorized by the IMF. Table 6.1 presents the diagnostic statistics for the system.

The residuals in the system have no sign of autocorrelation and heteroscedasticity, no sign of non-normality and ARCH effects in both levels, namely equation and system, so we consider the system a congruent representation of the information available in the data and proceed with the analysis of cointegration as described in Johansen (1995).

In table 6.2 we present the modulus of the five largest eigenvalues of the companion matrix and table 6.3 presents the results of the trace test for testing the hypothesis of $r \leq k$. Despite the clear rejection of the hypothesis of the number of cointegrating vectors being less than two in table 6.3, the moduli of the eingenvalues in table 6.2 suggest that we have only one unit root with the remaining values being far lower than the first largest modulus which led us to assume that we have just one cointegrating vector in the system. The over-identifying restrictions were not rejected and led to the following estimated vector:

[6] Sao Paulo Industry Union, data available from IPEA at www.ipeadata.gov.br.

Table 6.1 Diagnostic Tests VAR Exogeneity Test (1980/1 – 1986/2)

Test\Equation	$m1-cpi$ *(p-value)*	ip *(p-value)*	cdb *(p-value)*	be *(p-value)*	Δcpi *(p-value)*	Δnw	*System* *(p-value)*
AR 1-5	1.17	0.47	1.12	0.41	1.22	0.40	1.36
	(0.33)	(0.79)	(0.36)	(0.83)	(0.31)	(0.84)	(0.0524)
Normality	1.42	1.48	2.09	2.93	1.58	0.42	10.10
	(0.49)	(0.47)	(0.35)	(0.23)	(0.45)	(0.80)	(0.60)
ARCH	0.39	0.42	1.64	0.65	1.25	0.97	———
	(0.85)	(0.82)	(0.17)	(0.65)	(0.30)	(0.44)	
Hetero	0.46	0.52	0.69	0.50	0.27	0.69	0.20
	(0.96)	(0.94)	(0.81)	(0.95)	(0.99)	(0.81)	(1.00)

$$\frac{m_1}{cpi} - ip - cdb + (41.64\Delta cpi - 6.56\Delta nw) \quad \chi(5) = 3.52 \qquad (6.15)$$

Table 6.2 Five Largest Eigenvalues Companion Matrix

Eigenvalues r *unrestricted*
0.9351
0.7484
0.7484
0.6369
0.5965

Table 6.4 presents the results of estimating equation (6.4) including the over-identified cointegrating vector in (6.15). Since the F-test does not reject the null we cannot find evidence in the data against excluding the cointegrating vector and therefore it is possible to conclude that nominal wage inflation is weakly exogenous to the system.

After concluding that the nominal wage inflation is weakly exogenous, the VAR in the I(0) space represented by equation (6.16) is estimated The estimation results are presented in table 6.5 where we focus on the diagnostic tests only.

Table 6.3 Cointegration Statistics VAR Exogeneity Test (1980/1 – 1986/2)

R	*0*	*1*	*2*	*3*	*4*	*5*	*6*
Trace Test	185.99	123.95	74.510	37.320	14.308	3.56	
p-value	0.000	0.000	0.004	0.163	0.637	0.799	
Eigenvalue		0.567	0.487	0.395	0.267	0.135	0.046

Table 6.4 Nominal Wage Weak Exogeneity Test[7]

$$\Delta nw = -\underset{0.008}{0.016}CIa + \sum_{i=1}^{3}\hat{\Pi}_i \Delta nw_{t-i} + \sum_{i=1}^{3}\hat{\Theta}_i \Delta \mathbf{y}_{t-i} + \hat{\upsilon}_t \quad \bar{\sigma} = 0.03403$$

$$F(1,55) = 3.7668[0.057]$$

$$\Delta \mathbf{s}_t = \lambda \sum_{i=0}^{1} \Delta v_{t-i} + \alpha_s \beta' \mathbf{y}_{t-1} + \Theta \Delta \mathbf{s}_{t-1} + \omega_t \quad (6.16)$$

$$\text{where } \mathbf{y}_t = \frac{m_1}{cpi} - ip - cdb + (41.64\Delta cpi - 6.56\Delta nw)$$

Table 6.5 Diagnostic Tests Open VAR (1980/1 – 1986/2)

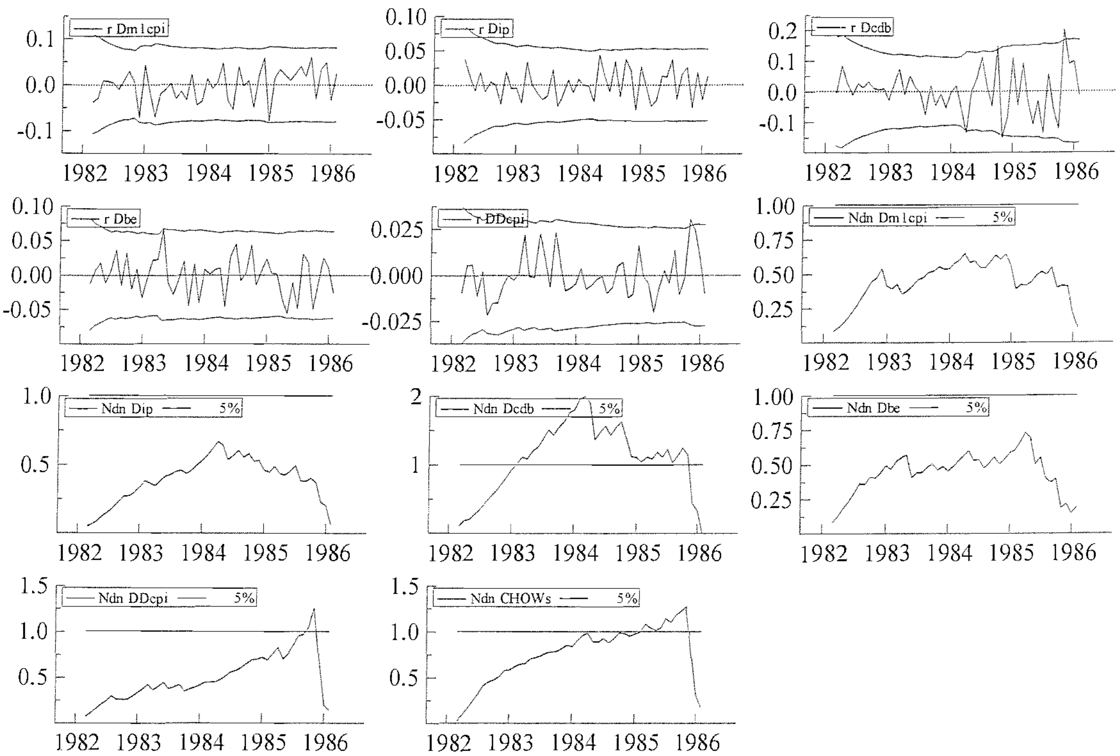
Test\Equation	$m1 - cpi$ (p-value)	ip (p-value)	cdb (p-value)	be (p-value)	Δcpi (p-value)	*System* (p-value)
AR 1-5	1.08	1.21	1.34	0.30	0.96	0.92
	(0.37)	(0.31)	(0.26)	(0.90)	(0.45)	(0.66)
Normality	0.02	1.94	2.78	0.55	4.54	11.09
	(0.98)	(0.37)	(0.24)	(0.75)	(0.10)	(0.35)
ARCH	0.42	0.54	2.65*	0.61	0.96	
	(0.83)	(0.74)	(0.035)	(0.69)	(0.45)	—
Hetero	0.55	0.69	0.73	0.92	0.17	0.55
	(0.90)	(0.78)	(0.75)	(0.55)	(0.99)	(1.00)

The long run cointegrating vector admits the interpretation of a long run money demand equation which is positively related to the output and real interest rate where inflation is measured as a weighted average between consumer and wage inflation. The positive signal on the real interest rate might be reflecting the agent's reactions to the loose

[7] Figures below coefficients are standard deviations and inside square brackets are p-values

of control observed in the monetary policy in such way that increases in the interest rate would sign for a tighter monetary police more in line with fighting the soaring inflation rates. Such conclusion is related to the use of M1 as the money stock of analysis and the reduction observed in the holdings of M1 as a proportion of the GDP during the first half of the 1980's as discussed in chapter 2.

Figure 6.1 One Step Residuals and Breakpoint Chow Tests Extended System (1980/1-1986/2)



The diagnostic tests show only a small sign of conditional heteroskedasticity in the residuals of the CDB equation, otherwise there is no sign that the system is not congruent with the data. The one-step residual and break point Chow tests shown in figure 6.1 have a similar pattern in the certificate of deposit equation to the observed in chapter 5 where there was sign of instability. The system also presents some sign of instability at the end of period only in the inflation equation and in the system test as a whole most likely reflecting the accelerating inflation rates that preceded the Cruzado plan cast in February 1986.

6.3.1.1) The AER hypothesis: Empirical Results

The AER hypothesis test for the first period was focused on equation (6.9) and included the nominal exchange rate in Reais to U.S dollar (e)[8], the consumer price index (cpi) as defined before and the U.S. wholesale price index (p^*)[9]. Initially I ran a fourth order VAR on the first difference of the variables including two dummies, the first one assuming the value one for 1983-2 and 1983-3 and zero otherwise and the second dummy assuming the value one for 1984-3 and zero otherwise. Table 6.6 presents the diagnostic test results.

Table 6.6 Diagnostic Tests VAR (1980/1 – 1986/2)

Test\Equation	Δcpi	Δp^*	Δe	*System*
	(p-value)	*(p-value)*	*(p-value)*	*(p-value)*
AR 1-5	2.63*	1.99	0.94	1.02
	(0.036)	(0.09)	(0.46)	(0.44)
Normality	0.46	0.11	1.54	3.78
	(0.79)	(0.95)	(0.46)	(0.71)
ARCH	0.82	0.08	0.79	——
	(0.54)	(0.99)	(0.56)	
Hetero	0.39	0.68	0.40	0.47
	(0.98)	(0.81)	(0.98)	(1.00)

In general there is no sign of non-congruence of the model with the data except in the equation for Δcpi where there is a sign of autocorrelation in the equation residuals with the autocorrelation test rejecting the null of no autocorrelation at a 5% significance level but not at 1% level. Such result nevertheless, is not reproduced in the system test for autocorrelation which led us to conclude that the system is a congruent representation of the

[8] This series is measured as the monthly average of daily asking price and corresponds to the official exchange rate for international trading.
[9] All series are available from request to the author or from the IPEADATA at www.ipeadata.gov.br

information available in the data and to proceed with the analysis of cointegration as described in Johansen (1995).

In table 6.7, we present the modulus of the five largest eigenvalues of the companion matrix and in table 6.8 we present the results of the trace test for testing the hypothesis of $r \leq k$ where the asymptotic values are based on the hypothesis of an unrestricted constant and restricted trend as described in Doornik (1998).

Table 6.7 Five Largest Eigenvalues Companion Matrix

Eigenvalues r unrestricted	*Eigenvalues* $r = 1$
0.9971	1.0000
0.7997	1.0000
0.6948	0.7222
0.6948	0.7222
0.6874	0.6989

Table 6.8 Cointegration Statistics VAR (1980/1 – 1986/2)

r	*0*	*1*	*2*	*3*
Trace Test	120.04	7.33	0.008	
p-value	0.00	0.54	0.93	
Eigenvalue		0.782	0.094	0.0001

From table 6.7 there is only one eigenvalue close to unity whereas the result of the trace test indicates that we cannot reject the null of $r \leq 1$. Both results indicate that we have then one cointegrating vector. We therefore proceed with the assumption that $r = 1$ and impose this restriction on the cointegrated VAR. The system was re-estimated and the five largest eigenvalues of the companion matrix are re-assessed again as shown on table 6.7 $(r=1)$, since the number of unit roots is equal to 2 $(N-r=3-1=2)$ we rule out the hypothesis of the data being I(2). Imposing the restriction implied by equation 6.9 lead to the rejection in the LR test of over-identifying restrictions[10] which led us to re-estimate the VAR imposing the following restriction $\beta'=[1, *, -1]$.

Table 6.9 Cointegrating Vector and Adjustment Coefficients VAR 1980(1) – 1986(2)

Cointegrating Vector	$\hat{\alpha}_i$ (se)	$i=1$
$\Delta cpi - 2\Delta p^* - \Delta e$	Δcpi	-0.028 (0.080)
LR test of Restrictions	Δp^*	0.014 (0.023)
Equilibria and Feedback: $\chi^2(2)=1.2163[0.5444]$	Δe	0.783 (0.063)

The estimated long run relationship became then $\Delta cpi - 1.9374\Delta p^* - \Delta e$, since the estimated parameter for Δp^* is close to 2 I re-estimated once more the VAR imposing this value to the variable. The results are presented in table 6.9 from which we can infer that the restriction is not rejected leading to the over-identified cointegrating vector which has the signals in accordance to equation (6.9). I consider henceforth this estimated cointegrating vector as the empirical counterpart of (6.9) and use this vector in testing if it is relevant in the SEM derived in chapter 5.

6.3.1.2) Forecast Encompassing: Empirical Results

In carrying on the forecast encompassing analysis two different models are considered. The first model (M1) is the SEM derived in chapter 5 and therefore without considering the role played by the nominal wage inflation and the AER hypothesis. The second model (M2) is the augmented SEM derived from testing the significance of both the nominal wage inflation and the AER hypothesis. The estimation results are presented in table 6.10[11] whereas the diagnostic tests are presented in table 6.11. The model includes the nominal wage inflation in the equation for Δip only. The AER cointegrating vector derived

[10] The over-identifying restrictions test in this case means the LR test for identifying the cointegrating vector and not the LR test used for testing if the SEM encompasses the VAR.
[11] All SEM presented in this chapter were estimated by Full Information Maximum Likelihood (FIML).

in section 6.3.1.1 was not significant at all in the system and consequently excluded from all equations. Such result is somewhat in line with the findings in Durevall (1998) where the author pointed out that from 1979 onwards the PPP hypothesis broke down given the fact that the AER test is very similar to the PPP test in its weak version.

Table 6.10 SEM (M2) 1980/1 – 1986/2

$$\underset{SE}{\Delta ml - cpi} = -\underset{0.020}{0.040} - \underset{0.397}{0.497}\,\Delta\Delta cpi_{t-1} - \underset{0.009}{0.023}\,CIa_{t-1} + \hat{\varpi}\mathbf{D}_t \qquad \hat{\sigma} = 0.039$$

$$\underset{SE}{\Delta ip} = -\underset{0.014}{0.034} - \underset{0.030}{0.136}\,\Delta cdb_{t-1} - \underset{0.273}{0.514}\,\Delta\Delta cpi_{t-1} + \underset{0.084}{0.195}\,\Delta\Delta nw + \underset{0.077}{0.019}\,CIa_{t-1}$$

$$+\hat{\varpi}\mathbf{D}_t \qquad \hat{\sigma} = 0.025$$

$$\underset{SE}{\Delta cdb} = \underset{0.042}{0.100} - \underset{0.087}{0.218}\,\Delta cdb_{t-1} - \underset{0.841}{1.159}\,\Delta\Delta cpi_{t-1} + \underset{0.020}{0.059}\,CIa_{t-1} + \hat{\varpi}\mathbf{D}_t \qquad \hat{\sigma} = 0.082$$

$$\underset{SE}{\Delta be} = -\underset{0.016}{0.050} + \underset{0.039}{0.178}\,\Delta ip_{t-1} - \underset{0.331}{0.453}\,\Delta\Delta cpi_{t-1} - \underset{0.008}{0.031}\,CIa_{t-1} + \hat{\varpi}\mathbf{D}_t \qquad \hat{\sigma} = 0.032$$

$$\underset{SE}{\Delta\Delta cpi} = -\underset{0.007}{0.0312} + \underset{0.137}{0.216}\,\Delta\Delta cpi_{t-1} - \underset{0.003}{0.015}\,CIa_{t-1} + \hat{\varpi}\mathbf{D}_t \qquad \hat{\sigma} = 0.013$$

$\mathbf{D}_t$ stands for a vector with centered seasonal dummies. For the first equation there is also a pulse dummy for 1984/2. In the second equations there is also a pulse dummy for 1981/3 accounting for the 1981 recession beyond the 1984/2 dummy. In the third equation we have only the 1984/2 dummy. In the equation for Δbe there is only a pulse dummy for 1980/11 which represented the end of pre-fixed monetary correction policy. This measure implied that the monetary correction would follow the consumer price index and the exchange rate devaluations would cover the difference between the internal and external inflation rates. Finally in the last equation we do not have pulse dummies at all.

The sign for Δnw throws some light on the difficult interpretation of the sign for $\Delta\Delta cpi$ in chapter 5. Indeed this last variable presented a negative signal in the SEM derived in chapter 5 whilst the expected signal would be positive in such way that increasing inflation would lead to an accelerating economic activity. Now considering the nominal wage inflation it becomes clearer how the economic activity is related to inflation. The positive sign for Δnw is clearly showing that the impact on the industrial activity was originated in the nominal wage inflation likely because of the accommodating monetary policy implemented in the period. Such conclusion is also based on the fact that the coefficient for $\Delta\Delta cpi$ which is marginally significant only as in the model presented in chapter 5. This contrasts with the conclusion derived in chapter 5 that the level of indexation in the economy did not allowed increases in inflation to have a positive impact in the industrial sector, and consequently on the real sector of the economy. Further contrary to the conclusions presented by Durevall (1998) there is a role to play by nominal wage as a propagation mechanism for inflation in Brazil. The equation for inflation dynamics is in accordance to the hypothesis of inertial inflation being basically driven as an autoregressive process, though with a marginally significant coefficient, and the long run money demand.

The diagnostic test results show no sign of non-congruence in the residuals at the system's level and the results for the break point Chow test presented in figure 6.2 indicate the same structure of those presented in figure 6.1, namely evidence of parameter instability in equation for Δcdb and in the final sample for the system as a whole and inflation individually

Table 6.11 Diagnostic Tests SEM (M2) 1980/1 – 1986/2

Test\Equation	$\Delta m1 - cpi$ *(p-value)*	Δip *(p-value)*	Δcdb *(p-value)*	Δbe *(p-value)*	$\Delta\Delta cpi$ *(p-value)*	*System* *(p-value)*
AR 1-5	2.63*	2.27	2.75*	2.26	2.78*	0.96
	(0.035)	(0.06)	(0.029)	(0.06)	(0.027)	(0.59)
Normality	0.34	3.40	0.97	0.18	3.36	10.28
	(0.84)	(0.18)	(0.61)	(0.91)	(0.18)	(0.41)
ARCH	0.71	0.15	2.07	0.55	1.28	
	(0.61)	(0.97)	(0.08)	(0.73)	(0.28)	—
Hetero	1.18	0.67	1.03	1.15	0.35	0.84
	(0.31)	(0.80)	(0.44)	(0.33)	(0.98)	(0.92)

A totally different structure emerges in the impulse response functions as shown in figure 6.3. The effect of a one standard deviation shock on $\Delta\Delta cpi$ is basically concentrated on $\Delta\Delta cpi$ itself showing that changes in the rate of growth of inflation are incorporated in the inflation dynamics in accordance with the hypothesis of high levels of indexation with the shock on $\Delta\Delta cpi$ showing the same degree of inertia as in the SEM presented in chapter 5.

As shown in table 6.12 the empirical counterpart of equation 6.6 in the HC test does not reject the hypothesis that $\alpha = 0$ indicating that model 2 does not add information to model one's forecast error. Unfortunately the empirical counterpart of equation 6.7 had no significant values for testing which led us to conclude that model 2 cannot forecast encompass model 1. Such result is somewhat expected given that both models have very close forecasts for the period since their dynamic properties are very similar and suffer from severe forecast failure caused by the sequence of interventions that followed the Cruzado plan cast in February 1986.

Figure 6.2 One Step Residuals and Chow Breakpoint Tests SEM (M2)

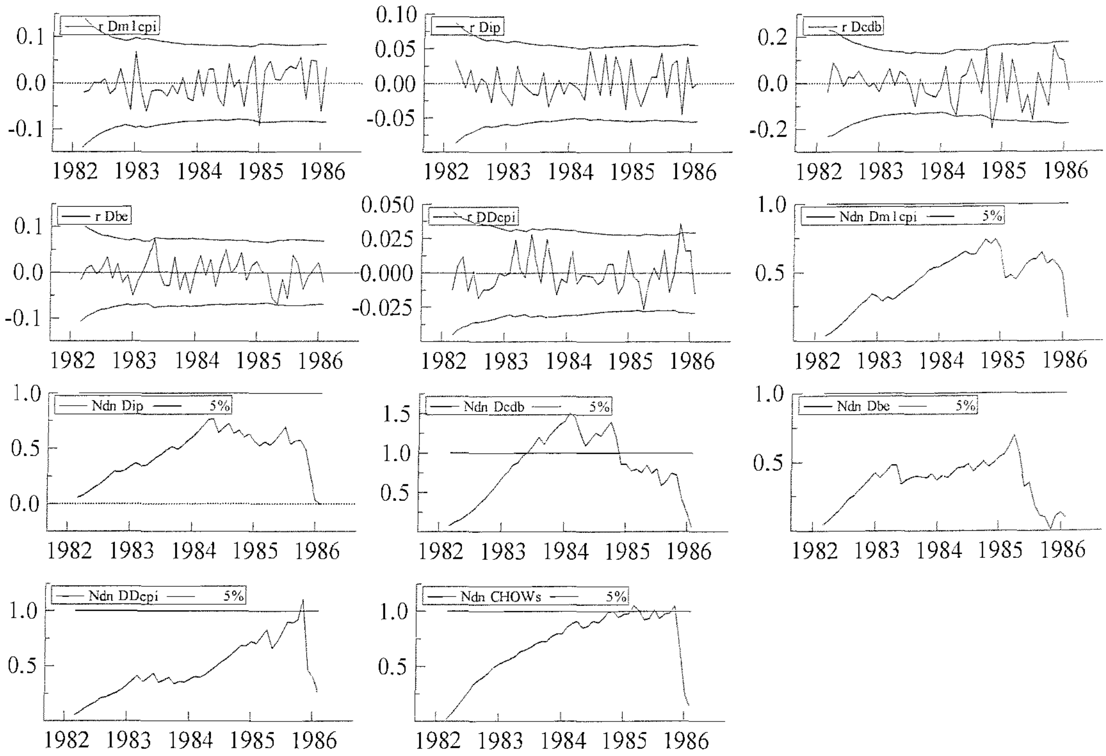
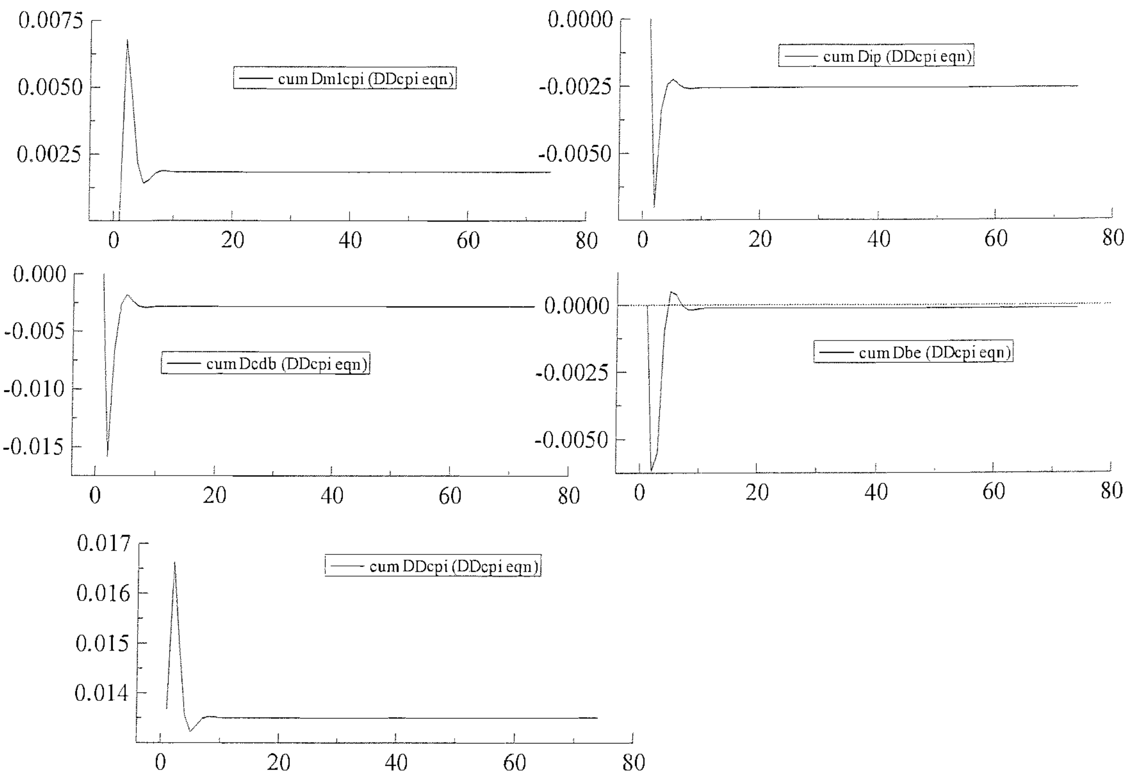


Table 6.12 Empirical Estimates Forecast Encompassing Equations[12]

$$e_{1t} = -\underset{0.6742}{0.6803}\phi_2 \quad RSS = 0.0474 \quad \hat{\sigma} = 0.0454$$

[12] The forecasts generated are out of sample dynamic forecasts for 24 periods (1986/3 to 1988/2). The variable under analysis is $\Delta\Delta cpi$. Values below coefficients are standard deviations and values inside square brackets are p-value. All regressions are OLS based.

Figure 6.3 Cumulative One Standard Deviation Impulse Response Functions Shock To (From) M2 1980/1 – 1986/02



6.3.2) The High Inflation Period: 1986(4)-1991(12)

For the analysis in this sub-sample following equation (6.4) I estimate initially a VAR (2) in the following variables: $m1 - cpi, ip, cdb, be$ *and* Δcpi plus Δnw. The VAR includes also a restricted trend centered seasonal dummies and the following unrestricted dummies: *dfm2, dfm3, dfm4, dfm5, D1, D3 and D4 as defined in chapter 5.*

The exogeneity test follows the same structure as section 6.3.1 using the nominal wage index calculated for the São Paulo manufacturing industry. Table 6.13 displays the results for the diagnostic tests.

The diagnostic tests show some sign of non-normality in two equations and in the system test, nevertheless the test rejects only at 5% significance level but not at 1% which led us to conclude that the system is reasonably a congruent representation of the data generation process. Further the assumption of normality in the residuals is not an essential hypothesis in the cointegration analysis following Johansen (1995).

Table 6.13 Diagnostic Tests VAR Exogeneity Test (1986/4 – 1991/12)

Test\Equation	$m1-cpi$ *(p-value)*	ip *(p-value)*	cdb *(p-value)*	be *(p-value)*	Δcpi *(p-value)*	Δnw *(p-value)*	*System* *(p-value)*
AR 1-5	0.67	2.73*	0.47	0.33	2.29	1.35	0.96
	(0.64)	(0.0236)	(0.78)	(0.89)	(0.06)	(0.26)	(0.57)
Normality	1.38	1.23	11.41**	17.79**	3.24	3.93	23.05*
	(0.50)	(0.53)	(0.003)	(0.0001)	(0.19)	(0.14)	(0.027)
ARCH	0.15	0.18	0.20	0.12	0.16	0.07	
	(0.97)	(0.96)	(0.95)	(0.98)	(0.97)	(0.99)	——
Hetero	0.22	0.14	0.18	0.13	0.16	0.22	509.88
	(0.99)	(1.00)	(0.99)	(1.00)	(0.99)	(0.99)	(0.86)

In table 6.14 we present the modulus of the five largest eigenvalues of the companion matrix and table 6.15 presents the results of the trace test for testing the hypothesis of $r \leq k$. Despite the clear rejection of the hypothesis of the number of cointegrating vectors being less than three in table 6.15, the moduli of the eingenvalues in table 6.14 suggest that we have only two unit root with the remaining values being far lower than the first two largest modulus which led us to assume that we have just two cointegrating vector in the system. The over-identifying restrictions[13] were not rejected and led to the following estimated vectors:

Table 6.16 presents the results of estimating equation (6.4) including the over-identified cointegrating vector in (6.17) and in (6.18). Since the F-test clearly does not reject the null we cannot find evidence in the data against excluding the cointegrating

[13] The Chi-squared test refers to the restrictions imposed on the long run vectors only. The reader should notice that we have two restrictions that correspond to excluding the trend from the vectors and in this case they should not count as valid restrictions for over- identification. Nevertheless even excluding these restrictions we have a total of 6 restrictions which suffice the criteria proposed in Peasaran and Shin (2002) as discussed in chapter 5. The final form presented in equations (6.17) and (6.18) corresponds to testing further restrictions on the dynamics of the system.

vector and therefore it is possible to conclude that nominal wage inflation is weakly exogenous to the system in the present sub-sample. I proceed therefore with the analysis based on equation (6.2) conditioning on nominal wage inflation.

Table 6.14 Five Largest Eigenvalues Companion Matrix

Eigenvalues r *unrestricted*
0.8896
0.8896
0.6713
0.6279
0.6279

Table 6.15 Cointegration Statistics VAR Exogeneity Test (1986/4 – 1991/12)

R	*0*	*1*	*2*	*3*	*4*	*5*	*6*
Trace Test	276.23	182.02	113.90	54.114	16.043	2.4357	
p-value	0.000	0.000	0.000	0.002	0.497	0.921	
Eigenvalue		0.7447	0.6274	0.5795	0.4240	0.1789	0.0346

$$\Delta cpi - \Delta nw + 0.016be \quad (6.17)$$

$$\frac{m1}{cpi} - 2ip - 2cdb + 3.20be - 2\Delta nw \quad (6.18) \quad \chi^2(8) = 7.3535$$

Table 6.16 Nominal Wage Weak Exogeneity Test[14]

$$\Delta\Delta nw = \underset{0.292}{0.210}\,CIa - \underset{0.0375}{0.0376}\,CIb + \sum_{i=1}^{1}\hat{\Pi}_i \Delta nw_{t-i} + \sum_{i=1}^{1}\hat{\Theta}_i \Delta \mathbf{y}_{t-i} + \hat{\upsilon} \quad \hat{\sigma} = 0.0868$$

$$F(2,49) = 0.559[0.575]$$

After concluding that the nominal wage inflation is weakly exogenous, the VAR in the I(0) space represented by equation (6.16) is estimated The estimation results are presented in table 6.17 where we focus on the diagnostic tests only. The VAR does not

[14] Figures below coefficients are standard deviations and inside square brackets are p-values.

present any sign of non-normality, autocorrelation, heteroskedasticity and ARCH effects in the residuals.

Table 6.17 Diagnostic Tests Open VAR (1980/1 – 1986/2)

Test\Equation	$m1 - cpi$ (p-value)	ip (p-value)	cdb (p-value)	be (p-value)	Δcpi (p-value)	*System* (p-value)
AR 1-5	0.67	2.24	1.41	0.66	1.10	1.24
	(0.64)	(0.07)	(0.24)	(0.64)	(0.37)	(0.17)
Normality	3.32	1.55	1.10	5.83	4.65	13.56
	(0.18)	(0.45)	(0.57)	(0.054)	(0.09)	(0.19)
ARCH	0.77	0.08	0.98	0.19	0.39	—
	(0.57)	(0.99)	(0.44)	(0.96)	(0.85)	
Hetero	0.29	0.33	0.39	0.45	0.28	0.25
	(0.99)	(0.98)	(0.97)	(0.95)	(0.99)	(1.00)

The first cointegrating vector has a similar specification than the first vector in chapter 5 showing a long run relationship between the bill of exchange interest rate and inflation but now extended to include the nominal wage effect. The second cointegrating vector seems to represent a long run money demand equation with a relatively close specification to equation (6.15) except perhaps that we observe a weighted interest rate being discounted by nominal wage inflation in the present case whereas in equation (6.15) we had an interest rated discounted by a weighted inflation rate. The signs are nevertheless difficult to interpret since the industrial production index, the nominal wage inflation and the CDB interest rate all have the same coefficient.

The over-identified SEM derived using equation (6.14) as a benchmark is presented in table 6.18. The model consists of the system presented above where we impose restrictions aiming to identify a short run equation as (6.14). In particular the equation of interest is $\Delta\Delta cpi$ where this variable is a function of nominal wage inflation with the same lag structure and signs as equation (6.14) and the long run cointegrating vectors presented in equations (6.17) and (6.18). Such result shows the nominal wage relevance in explaining the rate of growth in inflation rate and differently from the SEM derived in chapter 5 $\Delta\Delta cpi$

lagged one period enters in the equation with a positive sign highlighting the short run increases in inflation dynamics that were present in the period therefore clarifying the difficult interpretation given its negative signal in the SEM presented in chapter 5.

Nevertheless it should be noticed that equation (6.14) is a reduced form equation from the general model proposed by Novaes (1991) and as it stands implies a theoretical equation that imposes a causality direction from nominal wage and a measure of excess demand to prices. In contrast the present analysis does not assume such causality with respect to the excess demand on the extent that the system used is a VAR where the demand variable, namely the industrial production, is modeled.

It is worthwhile to notice also that nominal wage inflation enters in the equation for the two interest rates (CDB and BE) with the same lag structure as observed in the equation for $\Delta\Delta cpi$. Further the industrial production index only enters in its own equation being the money demand, the inflation dynamic, and the two interest rate equations being driven basically by the nominal variables (interest rates and price and wage inflation). Such dynamic properties indicate the high level of indexation present in the economy, a contrast result to the model presented in chapter 5 and in accordance to the hypothesis of nominal wage playing a central role in inflation dynamics in the period fuelling the consumer price index. Such conclusion follows basically because the BE equation is driven by past inflation whereas the money demand and CDB equations are driven by past inflation and the interest rates lagged one period.

The impulse response functions analysis reflects this clear cut between nominal and real impacts in the long run, with one standard deviation shocks to $\Delta\Delta cpi$ being concentrated to inflation dynamics itself as well as the two interest rates as figure 6.4 shows.

The diagnostic tests in table 6.19 show the presence of autocorrelation in residuals in the equations for Δip and $\Delta\Delta cpi$. In contrast at the system level there is no signal of non-normality or autocorrelation in the residuals which led us to conclude that the model is a congruent representation of the DGP.

Figure 6.4 Cumulative One Standard Deviation Impulse Response Functions Shock To (From) M2 1986/4 – 1991/12

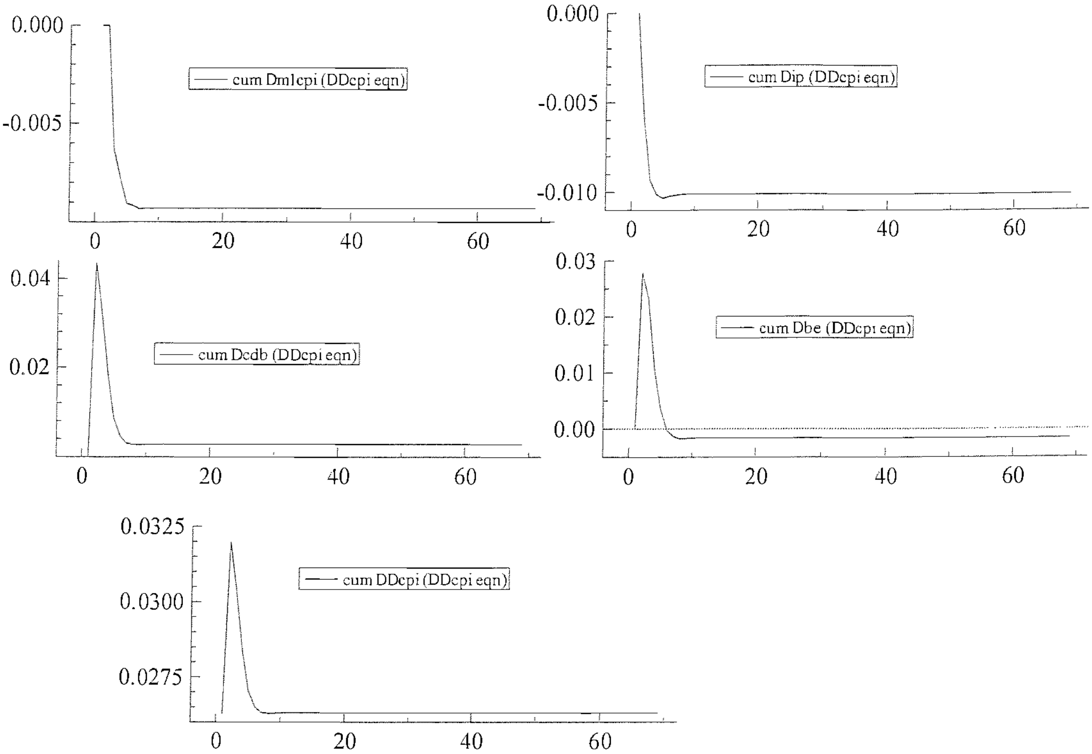


Table 6.18 SEM (M2) 1986/4-1991/12

$$\underset{SE}{\Delta ml - cpi} = -\underset{0.02}{0.13} - \underset{0.04}{0.28}\Delta cdb_{t-1} + \underset{0.05}{0.30}\Delta be_{t-1} - \underset{0.126}{0.121}\Delta nw_{t-1} - \underset{0.02}{0.14} CIb_{t-1}$$

$$+\hat{\varpi}\mathbf{D}_t \quad \hat{\sigma} = 0.080$$

$$\underset{SE}{\Delta ip} = \underset{0.008}{0.02} - \underset{0.09}{0.37}\Delta ip - \underset{0.019}{0.029}\Delta be - \underset{0.13}{0.22}\Delta\Delta cpi_{t-1} + \underset{0.11}{0.55}\Delta\Delta nw + \hat{\varpi}\mathbf{D}_t$$

$$\hat{\sigma} = 0.042$$

$$\underset{SE}{\Delta cdb} = \underset{0.03}{0.23} - \underset{0.07}{0.29}\Delta cdb_{t-1} - \underset{0.11}{0.34}\Delta be_{t-1} + \underset{0.59}{1.65}\Delta\Delta cpi_{t-1} + \underset{0.34}{1.72}\Delta nw - \underset{0.42}{1.60}\Delta nw_{t-1}$$

$$-\underset{0.58}{2.80} CIa_{t-1} + \hat{\varpi}\mathbf{D}_t \quad \hat{\sigma} = 0.187$$

$$\underset{SE}{\Delta be} = -\underset{0.03}{0.002} + \underset{0.40}{1.05}\Delta\Delta cpi_{t-1} + \underset{0.21}{2.07}\Delta\Delta nw - \underset{0.30}{0.60}\Delta nw_{t-1} - \underset{0.39}{1.13} CIa_{t-1} - \underset{0.04}{0.24} CIb_{t-1}$$

$$+\hat{\varpi}\mathbf{D}_t \quad \hat{\sigma} = 0.150$$

$$\underset{SE}{\Delta\Delta cpi} = -\underset{0.009}{0.05} + \underset{0.08}{0.21}\Delta\Delta cpi_{t-1} + \underset{0.05}{0.45}\Delta\Delta nw_t - \underset{0.05}{0.22}\Delta\Delta nw_{t-1} - \underset{0.08}{0.55} CIa_{t-1} + \underset{0.009}{0.03} CIb_{t-1}$$

$$+\hat{\varpi}\mathbf{D}_t \quad \hat{\sigma} = 0.026$$

The vector $\mathbf{D}_t$ comprises a different set of variables for each equation. Indeed for all equations it comprises the centered seasonal dummies but for the first equation it includes also *dfm3, dfm4,dfm5 ,D3, D4,* as defined in chapter 5 *and 1989.1*. For the second equation includes *dfm2, dfm3, dfm4, dfm5 and D4*. For the third equation includes *dfm2, dfm3, dfm4, dfm5 and 1989.1*. For the fourth equation it comprises *dfm3, dfm4, dfm5, D1, D3 and 1989.1*. Finally for the fifth equation it comprises *dfm3, dfm4, D3 and D4*.

Finally concerning the forecast encompassing tests displayed in table 6.20 we observe different results among the tests. The HC test shows that model 2 forecasts are significant in explaining the errors made by model 1 (Chapter 5 SEM) so clearly indicating that model 2 forecast encompasses model 1. On the contrary the FS test shows that model 1 forecast encompasses model 2 in such way that there exists a linear predictor derived from imposing the restriction in equation (6.7) whose forecasts cannot be improved in a square error sense. Nevertheless the DL test rejects the hypothesis $(\alpha, \beta_1, \beta_2) = (0,1,0)$. Given the DL test rejection and the indication that model 2 encompasses model 1 in the HC test it seems reasonable to state that model 2 forecast encompasses model 1 and in this condition should be preferred at the expense of model 1. Such ordering in preferences is based not only in the forecast encompassing tests but also in the earlier findings where model 2 admits a better interpretation of its parameters than model 1.

Table 6.19 Diagnostic Tests SEM (M2) (1986/4 – 1991/12)

Test\Equation	$m1 - cpi$ (p-value)	ip (p-value)	cdb (p-value)	be (p-value)	Δcpi (p-value)	*System* (p-value)
AR 1-5	1.96	3.66**	2.29	1.37	2.65*	1.35
	(0.10)	(0.009)	(0.06)	(0.25)	(0.03)	(0.06)
Normality	3.60	0.67	1.84	3.74	3.63	11.19
	(0.16)	(0.71)	(0.39)	(0.15)	(0.16)	(0.34)
ARCH	0.66	0.12	1.01	0.23	0.40	
	(0.65)	(0.98)	(0.42)	(0.94)	(0.83)	—
Hetero	0.45	0.45	0.35	0.31	0.40	0.26
	(0.96)	(0.96)	(0.99)	(0.99)	(0.98)	(1.00)

A possible drawback in this conclusion rely on the fact that model 2 has more dummy variables than the model presented in chapter 5 which in other words represents more exogenous variables that are not related directly to the high inflation in Brazil and which were added to the model to account for features in the data that the model dynamics itself cannot. Nevertheless it should be noticed that such dummies are defined exclusively for the periods that the stabilization plans were cast and, because of the exogenous nature of this sort of economic policy, it seems that the number of dummies included in any of the models should not be used as a criteria to counter-argue against the order implied by the forecast encompassing test results.

Table 6.20 Forecast Encompassing Equations

$$e_{1t} = -\underset{0.189}{0.518}\phi_2 \quad RSS = 0.0195 \quad \hat{\sigma} = 0.0259$$

$$y_t = \underset{0.0042}{0.0038} + \underset{0.2157}{0.3012}\phi_1 - \underset{0.2633}{0.1038}\phi_2 \quad R^2 = 0.2094$$

$$FS : F(1,27) = 0.1553[0.6965]$$

$$DL : F(3,27) = 7.0304[0.001]$$

6.3.3) The Low Inflation Period: 1994(10)-2002(2)

Similarly to the other two preceding sections I start with the weak exogeneity test of nominal wage inflation with respect to the long run parameters in the cointegrating vectors. The test follows the same structure than the observed in the last two sections where I estimate a VAR (3) including the following variables: $m1-cpi$, ip, cdb and Δcpi plus Δnw, a trend, centered seasonal dummies and unrestricted dummies defined as assuming value one in the following dates: 1995.3, 1995.11, 1997.1, 1997.11, 1998.9.10, 1999.2.3, 2000.7 and zero otherwise. Diagnostic test results are presented in table 6.21. These tests only show a small sign of autocorrelation in the residuals for the real money equation individually but not at the system level so we consider the VAR a congruent system moving to the cointegration analysis. Table 6.22 displays the modulus of the five largest eigenvalues of the companion matrix and table 6.23 presents the results of the trace test for testing the hypothesis of $r \leq k$. The trace test indicates that we cannot reject the hypothesis of having more than two cointegrating vectors whereas the eingenvalues of the companion matrix show the largest modulus very close to one with the other being a bit far from the first largest. Such result in conjunction to the findings of chapter 5 which indicated only one vector which admitted the interpretation of a long run money demand equation led us to conclude that we possibly would have just one cointegrating vector with a similar interpretation.

Nevertheless the over-identification restrictions led to the vector presented in equation (6.19) which merely describes a long run relationship between the inflation rates (consumer and wage).

Table 6.21 Diagnostic Tests VAR Exogeneity Test (1994/10 – 2002/2)

Test\Equation	$m1-cpi$ (p-value)	ip (p-value)	cdb (p-value)	Δcpi (p-value)	Δnw (p-value)	*System* (p-value)
AR 1-5	2.60*	1.47	0.98	0.35	1.04	1.17
	(0.029)	(0.20)	(0.44)	(0.90)	(0.40)	(0.21)
Normality	0.91	1.18	2.39	4.77	5.12	14.11
	(0.63)	(0.55)	(0.30)	(0.09)	(0.07)	(0.16)
ARCH	0.61	0.42	0.57	0.37	0.31	
	(0.72)	(0.86)	(0.74)	(0.89)	(0.92)	—
Hetero	0.39	0.44	0.29	0.31	0.57	0.24
	(0.98)	(0.97)	(0.99)	(0.99)	(0.91)	(1.00)

Table 6.22 Five Largest Eigenvalues Companion Matrix

Eigenvalues r *unrestricted*
0.9991
0.8207
0.8207
0.7459
0.6056

The weak exogeneity test results displayed in table 6.23 show a clear rejection of the hypothesis of nominal wage inflation being weakly exogenous to the parameters in the cointegrating vector. As discussed in section 6.1 if nominal wage inflation is not exogenous it is advisable to restart modelling by including the variable in the system. On the contrary if the variable is weakly exogenous we define an unrestricted model which is an extended system to that used in chapter 5 and assess the congruence of the system relative to the data. Considering the clear rejection of the hypothesis of weak exogeneity I use the system estimation for the exogeneity test as the system against which the new SEM is tested.

Table 6.23 Cointegration Statistics VAR Exogeneity Test (1994/10 – 2002/12)

R	0	1	2	3	4	5
Trace Test	174.21	89.227	36.268	16.853	3.1386	
p-value	0.0000	0.0000	0.1999	0.4434	0.850	
Eigenvalue		0.6277	0.4597	0.2020	0.1474	0.0358

$$\Delta nw - \Delta cpi \quad \chi^2(5) = 8.41 \quad (6.19)$$

Table 6.24 Nominal Wage Weak Exogeneity Test[15]

$$\Delta nw = \underset{0.16}{-0.57}\, CIa + \sum_{i=1}^{2} \hat{\Pi}_i \Delta nw_{t-i} + \sum_{i=1}^{2} \hat{\Theta}_i \Delta \mathbf{y}_{t-i} + \hat{\upsilon} \quad \hat{\sigma} = 0.013$$

$F(1,63) = 11.71[0.0011]$

Table 6.25 Diagnostic Tests SEM (M2) (1994/10 – 2002/2)

Test\Equation	$m1 - cpi$ *(p-value)*	*ip* *(p-value)*	*cdb* *(p-value)*	Δcpi *(p-value)*	Δnw *(p-value)*	*System* *(p-value)*
AR 1-5	3.04*	1.96	2.06	1.42	4.19**	1.21
	(0.0129)	(0.08)	(0.07)	(0.22)	(0.001)	(0.11)
Normality	2.37	3.57	1.79	2.16	1.78	16.89
	(0.30)	(0.16)	(0.40)	(0.33)	(0.41)	(0.07)
ARCH	1.30	0.97	0.27	0.36	1.38	
	(0.27)	(0.45)	(0.94)	(0.89)	(0.23)	
Hetero	0.72	0.94	1.05	0.48	1.78*	0.78
	(0.81)	(0.55)	(0.43)	(0.97)	(0.049)	(0.99)

Testing the restrictions implied by the SEM presented in table 6.26 lead us to the following statistic: $\chi^2(47) = 39.303[0.78]$ which shows that the restrictions implied by the

15 Figures below coefficients are standard deviations and inside square brackets are p-values.

SEM are not rejected and therefore that it encompasses the VAR. The diagnostic test results presented in table 6.25 show the presence of autocorrelation in the residuals for the real money equation and the nominal wage inflation but at the system level the test does not reject the null of no autocorrelation in the residuals. These tests also do not indicate the presence of non-normality and heteroskedasticity and the parameter stability tests displayed in figure 6.5 indicate that the model has constant parameters. All these results in conjunction can be interpreted as that the SEM is a congruent representation of the data.

Table 6.26 SEM (M2) 1994/10-2002/2*

$$\underset{(SE)}{\Delta ml - cpi} = \underset{0.003}{0.007} - \underset{0.12}{0.36}\,\Delta ip_{t-2} - \underset{0.001}{0.036}\,\Delta CDB_{t-2} - \underset{0.569}{0.988}\,\Delta\Delta cpi_{t-2} + \underset{0.271}{1.039}\,\Delta\Delta nw_{t-1}$$

$$-\underset{0.338}{0.596}\,CIa_{t-1} + \hat{\varpi}\mathbf{D_t} \quad \hat{\sigma} = 0.031$$

$$\underset{(SE)}{\Delta ip} = -\underset{0.0029}{0.0001} + \underset{0.056}{0.106}\,\Delta ml - cpi_{t-2} - \underset{0.089}{0.520}\,\Delta ip_{t-1} - \underset{0.094}{0.245}\,\Delta ip_{t-2} - \underset{0.008}{0.037}\,\Delta CDB_{t-1}$$

$$+\underset{0.178}{0.362}\,\Delta\Delta nw_{t-1} + \hat{\varpi}\mathbf{D_t} \quad \hat{\sigma} = 0.026$$

$$\underset{(SE)}{\Delta CDB} = -\underset{0.019}{0.082} - \underset{0.648}{1.414}\,\Delta ip_{t-1} - \underset{0.677}{1.686}\,\Delta ip_{t-2} - \underset{0.064}{0.244}\,\Delta CDB_{t-1} - \underset{1.364}{4.472}\,\Delta\Delta nw_{t-1}$$

$$-\underset{1.273}{3.080}\,\Delta\Delta nw_{t-2} + \underset{3.262}{13.270}\,\Delta\Delta cpi_{t-1} + \underset{2.154}{10.242}\,CIa_{t-1} + \hat{\varpi}\mathbf{D_t} \quad \hat{\sigma} = 0.170$$

$$\underset{(SE)}{\Delta\Delta cpi} = -\underset{0.0004}{0.0008} - \underset{0.018}{0.064}\,\Delta ip_{t-1} - \underset{0.018}{0.057}\,\Delta ip_{t-2} - \underset{0.0017}{0.004}\,\Delta CDB_{t-2} - \underset{0.084}{0.203}\,\Delta\Delta cpi_{t-1}$$

$$-\underset{0.083}{0.230}\,\Delta\Delta cpi_{t-2} - \underset{0.039}{0.088}\,\Delta\Delta nw_{t-2} + \underset{0.053}{0.205}\,CIa_{t-1} + \hat{\varpi}\mathbf{D_t} \quad \hat{\sigma} = 0.0044$$

$$\underset{(SE)}{\Delta\Delta nw} = -\underset{0.0013}{0.0016} - \underset{0.102}{0.705}\,CIa_{t-1} + \hat{\omega}\mathbf{D_t} \quad \hat{\sigma} = 0.011$$

*The dummies specification varies among the equations. In the first equation the following dummies were included 1995.3, 1997.1, 1997.11 1998.9.10, 1999.2.3. In contrast in the equation for Δip only the 1997.11 dummy is actually included. The equation for ΔCDB has the following dummies included: 1995.3; 1997.11; 1998.9.10; 1999.2.3. In the fourth equation the dummies included are: ,1995.3, 1997.1, 1999.2.3 and 2000.7. Finally in the last equation the dummies included are: 1995.3, 1995.11, 1997.1 and 1999.2.3.

The model short run dynamics is a bit more complex than the SEM in chapter 5 but not necessarily because the extra equation since the equation for $\Delta\Delta nw$ has a very simple short run dynamic being basically driven by the cointegrating vector and the dummies variables despite we cannot condition the SEM on this variable. The equation for inflation dynamics shows a short run negative impact of the interest rates on prices. Wage and consumer price inflation have also negative impacts on the dynamics highlighting the end of indexation. The real money equation as expected reacts negatively to the interest rate and consumer inflation growth but surprisingly positively to nominal wage inflation growth. For the industrial production equation as expected the interest rate has a negative impact whereas nominal wage inflation growth has a positive impact. Finally the interest rate equation has a short run dynamics that is very difficult to interpret but merits consideration the strong positive reaction to accelerating consumer price inflation reflecting the use of interest rate as the main instrument to control inflation.

Figure 6.5 One Step Residuals and Chow Breakpoint Tests SEM (M2) – 1994/10 - 2002/2

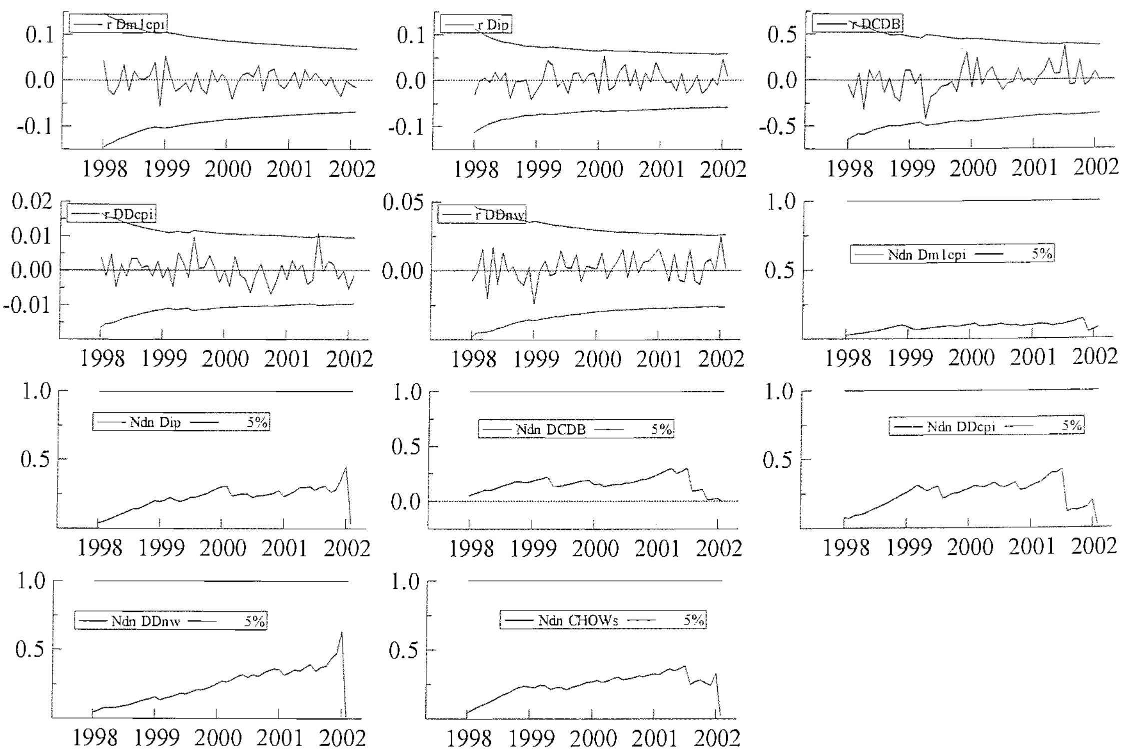


Table 6.27 Empirical Estimates Forecast Encompassing Equations[16]

$$e_{1t} = -\underset{0.104}{0.3310}\phi_2 \qquad RSS = 0.4177 \qquad \hat{\sigma} = 0.134$$

$$y_t = -\underset{0.053}{0.010} + \underset{0.794}{0.62}\phi_1 - \underset{0.717}{0.133}\phi_2 \qquad R^2 = 0.127$$

$$FS : F(1,21) = 0.034[0.8541]$$

$$DL : F(3,21) = 1.198[0.3346]$$

[16] Considering the end of data available for inflation I opted for using the interest rate in the forecasting encompassing exercise because its relevance in the monetary operations carried out by the Brazilian Central Bank.

Testing if the model including nominal wage forecast encompasses the model derived in chapter 5 leads us to the common result in all tests indicating that this is not the case as the results presented in table 6.27 suggest. The final conclusion therefore is that the model derived in chapter 5 is a congruent representation of the data and should be preferred at the expense of the model including nominal wage inflation if not by the forecast encompassing tests at least by parsimony criterion since the SEM M2 has a total of 103 estimated parameters whereas the SEM derived in chapter 5 has 80. Further the long run money demand equation is a much more interpretable result than the long run cointegrating vector derived in the system analysis and included in the model derived in the present chapter.

6.4) Conclusions

This chapter extends the main results obtained in chapter 5 by implicitly assuming that two forces had a significant effect on the price dynamics in Brazil during the high inflation period, namely the administered nominal exchange rate devaluations and nominal wage inflation. In particular two main questions are of interest. The first one is, to what extent did the administered exchange rate policy followed by the government during the first half of the 1980's influence the price dynamics? The second question is did the nominal wage inflation have a role to play in price dynamics during the period of high inflation? This last question has been discussed in the theoretical models that generate persistence in inflation but, in the empirical attempts, doubts were cast on the relevance of such variable in determining the price dynamics during the first half of the 1980's in Brazil. Further in the empirical literature for the high inflation period, namely from the Cruzado Plan cast onwards, the evidence is scanty, not to say nonexistent. Given the sample size we opted for including the variable in the SEM but without assuming its exogeneity to the long run parameters of the cointegrating vectors derived in chapter 5. So I carry out the weak exogeneity test of nominal wage inflation. In doing so I preserve the LSE general to specific approach, considering therefore the SEM a restricted model derived from testable hypotheses against a (congruent) general system and avoiding a priori hypothesis about the exogeneity of nominal wage inflation. The first question is addressed in the chapter through the use of the AER hypothesis in deriving an equation for the administered devaluations which is estimated separately as a long run solution to the exchange rate devaluations policy equation. Since this long run cointegrating vector includes Δcpi like the long run cointegrating vectors derived in chapter 5 I derive a new SEM incorporating not only the equation for the nominal exchange rate devaluations but also the nominal wage inflation effects but do not test weak exogeneity. A comparative analysis between the new SEMs and those derived in chapter 5 is carried out using forecast encompassing tests.

In section 6.3.1 a new SEM is presented focusing on the first period (1980-1986) including the nominal wage inflation and the long run solution to the administered exchange rate policy. The section presents a long run solution to the exchange rate policy in accordance with the theoretical model proposed with the expected signs. The long run vector nevertheless is not significant in the SEM as a whole, a result that is somewhat in accordance to the result obtained in Durevall (1998) who shows that the PPP hypothesis which has a similar specification than the AER theoretical model proposed broke down after 1979. A long run money demand equation is identified being positively related to the output and real interest rate where inflation is measured as a weighted average between consumer and wage inflation, a result difficult to explain.

The equation for $\Delta\Delta cpi$ in the SEM with a positive sign for Δnw is clearly showing that the impact on the industrial activity was originated in the nominal wage inflation likely because of the accommodating monetary policy implemented in the period, a contrasting result to the findings in Durevall (1998) who found no role to play for nominal wage inflation in price inflation dynamics in Brazil. The equation for inflation dynamics is in accordance to the hypothesis of inertial inflation being basically driven as an autoregressive process, though with a marginally significant coefficient, and the long run money demand. The effect of a one standard deviation shock on $\Delta\Delta cpi$ is basically concentrated on $\Delta\Delta cpi$ itself showing that changes in the rate of growth of inflation are incorporated in the inflation dynamics in accordance with the hypothesis of high levels of indexation with the shock on $\Delta\Delta cpi$ showing the same degree of inertia as in the SEM presented in chapter 5.

In the forecast encompassing exercise the model derived in this chapter does not encompass the SEM derived in chapter 5.

In section 6.3.2 a new SEM including nominal wage inflation is derived to the high inflation period (1986-1991). Nominal wage inflation is considered weakly exogenous to the long run parameter of interest and a new system including this variable is estimated The new SEM derived including nominal wage inflation is based on the theoretical model proposed in Novaes (1991, 1993) that when solved yields equation (6.15). In particular the equation of interest is $\Delta\Delta cpi$ where this variable is a function of nominal wage inflation with the same lag structure and signs as equation (6.15) and the long run cointegrating vectors presented in equations (6.17) and (6.18). Such result shows the nominal wage relevance in explaining the rate of growth in inflation rate and differently from the SEM derived in chapter 5 $\Delta\Delta cpi$ lagged one period enters in the equation with a positive sign highlighting the short run increases in inflation dynamics that were present in the period therefore clarifying the difficult interpretation given its negative signal in the SEM presented in chapter 5. The difference from the theoretical model is that the excess demand variable proxied by the industrial production growth in the present case does not enter in the equation.

The same lag structure for nominal wage inflation enters in the equations for the two interest rates. Further the industrial production index only enters in its own equation being the money demand, the inflation dynamic, and the two interest rate equations driven basically by the nominal variables (interest rates and price and wage inflation). Such dynamic properties indicate the high level of indexation present in the economy, a contrast result to the model presented in chapter 5

Finally in section 6.3.3 I readdress the nominal wage inflation role in the low inflation period. The weak exogeneity tests rejected the null hypothesis leading to a re-estimation of the system including an equation to nominal wage inflation. The cointegration analysis based on the trace test demonstrates that we cannot reject the hypothesis of having more than two cointegrating vectors whereas the eingenvalues of the companion matrix show the largest modulus very close to one given that this opposite results replicated the findings in chapter 5 I decided to carry out the analysis based on the hypothesis of just one cointegrating vector trying to identify a long run money demand as did in chapter 5. Nevertheless imposing over-identifying restrictions led to the identification of the cointegrating vector in equation (6.19) which merely displays a long run relationship between price and wage inflation. The SEM identified presented a more complex structure than the SEM in chapter 5 but with the result that nominal wage inflation growth – the extra equation in the system – is just driven by the cointegrating vector and the dummies, in conjunction to the forecast encompassing test results showing that the model in this chapter does not encompasses the model in chapter 5, led to the conclusion that the model in chapter 5 should be preferable than the present SEM.

Chapter 7

Conclusions

In this chapter I shall attempt to summarize the main results and conclusions of this doctoral thesis and present possible areas of research that merit attention in the near future.

The present thesis concentrated its attention in investigating the monetary sector in Brazil deriving a structural econometric model for a very particular period when the high inflation phenomenon took place. Such phenomenon has received considerably little attention in the literature when we consider empirical analysis. Most of the existent literature is concentrated in testing the adequacy of the Cagan (1956) model which noticeably has been used to explain hyperinflations but not long periods of high levels of inflation rates. These works in their majority are also restricted to the period that preceded the first stabilization plan cast in 1986 when the inflation rates actually were moderated. This gap in the literature is partially covered in the present doctoral thesis following nevertheless two different routes.

The first route concentrated attention to the Cagan (1956) model exploring the time series properties of the theoretical model and innovating with respect to the existent literature by covering a gap in the literature on this subject since previous attempts had not dedicated attention to the second period as a whole and furthermore the evidence available in the literature were based on a very general assumption about the long run properties of the data. The main question behind this analysis is can the Cagan model describe the demand for real balances for the long period of high inflation in Brazil?

The second route turned attention to the development of a structural econometric model to the same period exploring different economic relationships than those implied by solving Cagan's theoretical model using the rational expectations hypothesis. The questions that drove the analysis were can we identify a long run money demand equation and how the real variables are related? In particular considering the high inflation a further question merits attention namely, does the model account for the inertial component present in the price dynamics?

Chapter 3 innovates by assuming explicitly that the sequence of stabilization plans that took place in the 1980's and the first half of the 1990's changed the agent's expectations towards inflation leading to a sample division into three different periods and testing the Cagan model in each one of these periods. The empirical results show surprisingly that the Cagan's model does not constitute a reasonable description of the demand for money in the second period that includes the hyperinflation episode measured by the consumer price index. Using the wholesale price index the result supports the same conclusion as that for the CPI for the second period since cointegration between inflation measured by the wholesale price index and real money is rejected. Also contrary to what was expected using both price indexes the Cagan's model describes very well the money demand in the first period despite the relatively low rates of inflation and in accordance to the findings in Phylatkis and Taylor (1993) and Engsted (1993a). These results and the findings of Juselius (2001) and Durevall (1998) indicated that subtle economic relationships beyond that those derived from solving Cagan's model assuming rational expectations could merit attention. Chapter 4 presents the methodological basis for the analysis carried out in chapter 5 and 6 and discusses the findings in chapter 3 under the lights of the LSE methodology.

Juselius (2001) found that the expansion of money stock used to finance recession and devaluations increased inflationary expectations in the US dollar black market, which then gradually spread to the whole domestic economy. Nevertheless the brief institutional analysis presented in chapter 2 led to a contrasting hypothesis, namely that the expansion of money observed by Juselius was indeed the growth in non-monetary but indexed assets observed following the increases in inflation and after expectations of a currency devaluation being materialized in 1983. They were representing an increasing demand for indexed money in an environment of soaring rates of inflation. The results presented in chapter 5 led to the following alternative scenario: The accommodating monetary policy (M1) followed in the period after the 1984 economic upturn and represented by the growth in the industrial production index in a highly indexed economy allowed the increase in the inflation rates as shown by the equation for price dynamics in the SEM.

Given the model's dynamic any negative shock to the economy as an increase in the oil prices would magnify the inflation rate and represent in the short run a change in its level. The economic recovery observed from 1984 onwards seems to have represented this negative role with its associated perverse connotation. The balance of payments adjustment and the constant surplus in the trade balance were followed by a monetary policy that only accommodated the demand pressures thus generating a spiral on the inflation rates.

Two further questions of interest to the period were raised following the findings of Durevall (1998) namely: 1) To what extent did the administered exchange rate policy followed by the government during the first half of the 1980's influence the price dynamics? 2) Did the wage policy play a significant role as an inflation propagating mechanism?

Interestingly both relations, the AER and wage inflation were not significant in the equation for price dynamics with the AER actually not being significant at all in the model. Nominal wage inflation has nevertheless a positive impact on the growth in the industrial production index clearing the interpretation of how the economic activity was related to inflation when compared to the chapter 5 SEM. In fact the positive sign shows clearly that in the short run the impact of inflation on the industrial activity was originated in the nominal wage inflation not in price inflation acceleration, a result that contrasts with Durevall's 1998 paper where the author did not find any role for nominal wage inflation in his model.

In the long run the effects of a shock in inflation were concentrated on inflation itself showing that changes in the rate of growth of inflation are incorporated in the inflation dynamics in accordance with the hypothesis of high levels of indexation with the shock on inflation showing the same degree of inertia as in the SEM presented in **chapter 5** Such result was in accordance with the findings in Novaes (1991, 1993) to the extent that the author did find persistence to inflation despite being at low levels.

A different picture emerged from the SEM when considering the period of high inflation (1986-1994). A stable long run money demand equation was identified being negatively related to inflation and positively related to the growth in the industrial production index both consistent with the economic theory. The long run money demand equation shows that the hypothesis of inflation being insensitive to demand policies was misleading. Further a similar specification was found for the subsequent period when inflation stabilized with real money being positively influenced by the detrended industrial production and negatively by the real interest rate demonstrating that interest rate has a role to play in the monetary system reflecting the tighter monetary police imposed after the Real plan cast in 1994.

The short run price dynamics depicted the presence of memory in the process but possibly reflecting the sequence of attempts for bringing down inflation. When considering the long run response to shocks in inflation a positive impact is found which shows the contrasting short-run impacts of the stabilization plans and a long run effect of increasing inflation rates given their successive failures.

The second cointegrating vector found showed that there was a link between the real interest rates measured by the CDB and the economic activity reinforcing the role monetary policy would have had in controlling the industrial output levels in the long run.

A theoretical model composed of a wage rule, a mark-up price rule for prices, a monetary rule and an aggregate demand equation is proposed and tested assuming that the wage rule follows a backward adjustment as well as the monetary rule which accommodates immediate past inflation.

The empirical model presented an equation for inflation which is close to the reduced form equation derived from the theoretical model with nominal wage inflation entering the model with the expected lag structure augmented by the two over-identified cointegrating vectors derived in section 6.3.2. The difference from the theoretical model is that the excess demand variable proxied by the industrial production growth in the present case did not enter in the equation.

In particular this new SEM emphasized the importance of nominal wage inflation in the sense that the industrial production index only enters in its own equation being the money demand, the inflation dynamic, and the two interest rate equations being driven basically by the nominal variables (interest rates and price and wage inflation). Such dynamic properties indicate the high level of indexation present in the economy, a contrast result to the model presented in chapter 5.

The impulse response functions analysis reflects this clear cut between nominal and real impacts in the long run, with one standard deviation shocks to the rate of growth in consumer inflation being concentrated to inflation dynamics itself as well as the two interest rates.

Given the DL forecast encompassing test rejection and the indication that the SEM in chapter 6 encompasses the model in chapter 5 in the HC test it seems reasonable to state that the SEM presented in chapter 6 forecast encompasses the SEM in chapter 5 and in this condition it should be preferred at the expense of model in chapter 5. Such ordering in preferences is based not only in the forecast encompassing tests but also in the earlier findings where the SEM in chapter 6 admits a better interpretation of its parameters than model 1.

Possible extensions to the analysis proposed would include the use of a Markov switching vector equilibrium correction model for the high inflation period given the sort of structural changes observed in the period. Nevertheless such models are developed to capture changes in regimes in business cycles whereas the interventions observed in the Brazilian case had they timing well defined in the sense that the plans cast had specific points in time.

Further research could also turn attention to the labour market in Brazil on the grounds of Marcellino and Mizon (2001) given the specific role played by nominal wages in price dynamics through modelling unemployment inflation and wages. Possibly a clearer picture on the links present between inflation and wage dynamics in determining the inflationary spiral observed from 1986 onwards would evolve than those presented here. Such research nevertheless is beyond the scope of the present doctoral thesis where attention was concentrated into the monetary system under high inflation.

The price stabilization reached from 1994 onwards allowed a comparative analysis in describing the monetary sector properties under low inflation rates. Similarly, to the second period a long run money demand was identified being negatively related to the real interest rate based on the CDB what, in accordance with the stabilization, indicates the end of the indexation in the economy.

Finally in the equation for inflation dynamics both lags of the industrial index growth had a negative impact on the rate of growth of inflation, which implies that growth in the industrial activity has no longer the accelerating impact on the inflation rate; a contrast to the positive impact observed for the first period (1980-1986), when the economy was indexed and the monetary authorities had lost their control on the monetary policy.

The model short run dynamics is a bit more complex when we consider nominal wage inflation but interestingly not necessarily because the extra equation included in the SEM after concluding that nominal wage inflation was not weakly exogneous, since the equation for $\Delta\Delta nw$ has a very simple short run dynamic being basically driven by the cointegrating vector and the dummies variables despite we cannot condition the SEM on this variable.

Testing if the SEM with the extra equation for nominal wage forecast encompasses the model derived in chapter 5 leads us to the common result in all tests indicating that this is not the case. The final conclusion therefore is that the model derived in chapter 5 is a congruent representation of the data and should be preferred at the expense of the model in chapter 6 if not by the forecast encompassing tests at least by parsimony criterion since the SEM in chapter 6 implied extras 23 parameters to be estimated when compared to the SEM derived in chapter 5. The loss of relevance in the role played by nominal wage inflation became apparent confirmed therefore.

Further research in this area might include the definition of a theoretical structural model for the third period and evaluation through testing the restricted model against the system and comparative evaluation through encompassing analysis.

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