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**Searching for the Natural Rate of Unemployment in a
Large Relative Price Shocks' Economy: the Brazilian Case**

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Searching for the Natural Rate of Unemployment in a Large Relative Price Shocks' Economy: the Brazilian Case*

Tito Nícias Teixeira da Silva Filho**

Abstract

The Working Papers should not be reported as representing the views of the Banco Central do Brasil. The views expressed in the papers are those of the author(s) and do not necessarily reflect those of the Banco Central do Brasil.

This paper contributes to fill the large existing gap in the literature on the Brazilian natural rate of unemployment. It reveals not only that the correlation between inflation and unemployment has changed radically since the stabilisation of the economy but, more surprisingly, that it has become positive in the recent past. In other words, there has apparently been no trade-off between inflation and unemployment. However, this fact is due to – and highlights – the paramount importance of supply shocks in recent inflation dynamics in Brazil. The paper then shows that the exchange rate has been the major source of shocks to inflation, even though it is not enough to explain the magnitude and persistence of those shocks. Part of the answer comes from the large and wide effects produced by privatisation on the price dynamics in Brazil. The evidence presented here suggests that the Brazilian natural rate of unemployment has been constant since 1996. Despite the high degree of uncertainty involved in natural rate estimations, point estimates seem to lie somewhere between the 7.4%–8.5% range. The paper also sheds light on why real interest rates have been so high for extended periods of time in Brazil, a feature that has puzzled many economists. Finally, it calls to attention that one important core inflation measure in Brazil has not been able to capture underlying inflation properly and, therefore, has to be used with caution.

Keywords: Natural rate of unemployment, NAIRU, Unemployment Gap, Phillips Curve, inflation, supply shocks, relative prices.

JEL Classification: C22, C51, E24, E31, E32, E52

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“Economists are a long way from having a good quantitative understating of the determinants of the natural rate, either across time or across countries”

(Blanchard and Katz, 1997)

1 – Introduction

Among the variables that are part of the selected menu of economic indicators followed closely by central banks those aimed at measuring the degree of slackness in the economy stand out. Among them a key variable is the natural rate of unemployment or, more precisely, the unemployment gap. The natural rate is crucial to monetary policy and plays a central role in two key economic concepts: money neutrality and potential output. Moreover, despite some controversy the Phillips Curve (PC) is considered by many economists a valuable tool for predicting inflation. Blinder (1997), for example, has praised the reliability of the PC framework by stating that it is “[...] the “clean little secret” of macroeconometrics’. However, surprisingly, despite its theoretical and empirical relevance, there is barely any work done on the natural rate of unemployment in Brazil.

This scarcity is similar to the one found at the beginning of the century regarding potential output estimates in Brazil, a situation called to attention by da Silva Filho (2001). At the time he argued that the macroeconomic instability and the inflation disarray that Brazil had faced for so many years had turned the economic debate away from long term issues and focused it on daily matters. Nevertheless, since then macroeconomic stability has built up, and after much time the long run has finally entered economists` agenda. Indeed, growth prospects were a major subject in the 2006 presidential election. Accordingly, the lack of studies on the natural rate of unemployment is even more puzzling given that in recent years there has been a growing interest on potential output estimation. So how could one reconcile those two facts?

Although a fully satisfactory answer seems unavailable, some factors could help explaining this shortage. For example, in recent years unemployment rates have been well above their historical average, so that agents might have taken for granted the existence of a comfortable slack on the labour market. Moreover, this assessment might have been reinforced since 2002, when the main unemployment survey went

through a major methodological review, and the new rates have been much higher than the historical ones. In such a situation the natural rate becomes less relevant. Even so, potential output estimates usually require estimates of the natural rate of unemployment, so where do they have been coming from? Mostly due to its simplicity (it is just a matter of pressing a button!) that need has been fulfilled by the application of the widely known HP filter to the unemployment series. However, the HP filter has frequently been much more of a curse than a solution to the profession, often preventing economists to delve into the subject at hand.

This paper has accepted the challenge and estimates the natural rate of unemployment for Brazil using the Phillips curve framework. Among the several methods available in literature the Phillips curve framework seems to provide a good balance between a-theoretical setups, like univariate filters, and more structural approaches. Moreover, it can be obtained as the reduced form of several types of structural models.¹ Another appealing feature is that it takes explicitly into account the link between unemployment and inflation. Finally, the PC framework is quite flexible and can be used jointly with the unobserved components (UC) technology, opening the possibility of estimating a time-varying natural rate of unemployment. Indeed, it has been widely used elsewhere and is the preferred method of the OECD (see Richardson et al., 2000).

Before proceeding it must be said that this paper shares the unbending belief that an essential part of any successful empirical modelling strategy is a deep understanding of the economic phenomenon under analysis. Therefore, the “search for robustness” here does not come from applying several methodologies and comparing their results – a common procedure – but rather from analysing and understanding what seems to have driven unemployment in Brazil, and confronting those findings with the empirical results. A “side-effect” or “by-product” of such a strategy was that while searching for the Brazilian natural rate of unemployment important evidence on several related subjects came up. For example, it was found that one popular core inflation measure in Brazil has not been reflecting underlying inflation properly and, therefore, has to be used with caution when guiding monetary policy. The paper also provides valuable evidence on why real interest rates have been so high for so many

¹ Note, however, that structural models are not a panacea since, for example, there is no agreement on the “true” structural labour market model. Moreover, several known key natural rate determinants, such as institutional factors and labour regulations, are very hard to be properly measured and inserted in those models.

years in Brazil, a feature that has puzzled many economists. In addition, it offers interesting insights on the transmission mechanism of monetary policy, especially regarding possible asymmetric effects on inflation of changes in the exchange rate.

Like many others (e.g. Gordon, 1997; Staiger et al., 1997; Stiglitz, 1997; Mankiw, 2001; Ball and Mankiw, 2002) this paper considers the terms natural rate of unemployment and NAIRU as synonyms and, therefore, both are used interchangeably throughout. The paper is organised as follows. Section 2 examines the behaviour of inflation and unemployment in recent decades in search for stylised facts, and tries to uncover the reasons behind the sharp increase in unemployment since the 1990s. Section 3 carries out a preliminary analysis on the inflation-unemployment link and reveals the unexpected absence of trade-off between both variables in the recent past in Brazil. Section 4 investigates the main reasons behind that finding. Section 5 provides estimates of the natural rate of unemployment in Brazil. The following section concludes the paper.

2 – A First Look at the Data

The first major challenge one faces when investigating the natural rate of unemployment in Brazil is how to cope with the major methodological break that took place in 2002 within the Monthly Unemployment Survey (PME), rendering the new and old surveys incompatible.² The new PME survey has changed in several ways. The working-age population now includes those aged ten or older, instead of fifteen or older as before. Also, the geographic area covered by the survey was broadened, with the inclusion of several municipalities, even though the six metropolitan regions surveyed remained the same. Finally, several changes were implemented in order to better capture employment features and unemployment conditions, such as conceptual changes in work definition and in the way information is gathered and classified (see IBGE, 2002). As a result unemployment rates faced a big jump in the new survey, increasing more than 50% when compared to the old series. Indeed, attempts to make the new survey comparable with the old one by correcting it both in terms of geographic and age coverage were unsuccessful, producing only marginal changes. Hence some assumption, hoped to be relatively harmless, had to be made in order to

² The PME is a household survey carried out by the Brazilian Institute of Geography and Statistics (IBGE), which investigates unemployment in the urban areas of six metropolitan regions.

create a longer unemployment series, enabling research about the NAIRU and other related subjects.

Since both surveys overlapped during some period one “solution” is to calculate the difference in average unemployment levels between them, and use the resulting level factor to extend the new survey backwards. In doing so the underlying assumption is that both surveys differ essentially in their levels, but not in their dynamics. Unfortunately, they were published simultaneously for a very short period of time only, which makes this “solution” much less reliable than one would hope. Even so, such a procedure was carried out and a longer unemployment series going back to 1985 was obtained (named UN1).³ Another “solution” is to apply the same procedure but now using the survey carried out jointly by the SEADE Foundation and Dieese instead, which measures unemployment in the metropolitan area of São Paulo only. In this case besides the crucial assumption that the level gap between both surveys remained relatively constant through time, one also assumes that unemployment changes in São Paulo reflect “national” developments accurately, which seems a reasonable assumption given that SP contains a very large share of the labour force covered by the PME.⁴ Even though this last assumption was not needed in the first procedure, note that both the new PME and the Dieese surveys have been overlapping since the first was implemented, making the level shift factor much more reliable. More importantly, when one compares both series since 2003 not only they almost coincide in levels but their difference seems to be quite stable.⁵ Hence another longer unemployment series was constructed going back to 1985 (named UN2), and both series are used in Section 5 together with the Dieese unemployment series itself (named UND) in order to check which one produces the best models.⁶

Figure 1 plots the UN2 series together with the old PME survey series, and some stylised facts emerge.⁷ First, both series show unemployment rising since 1990, although it seems to be down trending since 2004. Second, there are two important

³ The average level shift was calculated using data from January 2002 to December 2002.

⁴ Indeed, around 43% of the labour force surveyed by the PME is in São Paulo.

⁵ Comparing the old PME and Dieese surveys, which overlapped for eighteen years, one finds a growing level difference along time, what makes one conclude that had it been possible to compare the new and old PME for a longer period the difference would not have been stable. Such evidence suggests that the first “solution” is inappropriate.

⁶ The average level shift between the new PME and Dieese surveys was calculated using data from January 2003 to December 2006.

⁷ Note that, by construction, the UN2 and the Dieese unemployment series are very similar before 2003.

breaks in average unemployment during this period: one around 1990 and another about 1996. Hence one can divide unemployment dynamics into three (approximate) periods. In the first (1985.4–1990.1) average unemployment was 5.9%. In the second period (1990.2–1995.3) it increased to 8.1%, and in the last one (1995.4–2006.4) average unemployment jumped to 10.7%. Although not shown in the graph, note that according to the old PME unemployment rates were much higher in the beginning of the 1980s than in the first period (i.e. 1985.4–1990.1), with rates similar to those observed in the 1998.1–2002.4 period. From that perspective, recent rates are not unusually high on historical grounds.

Figure 1
Quarterly Unemployment Series

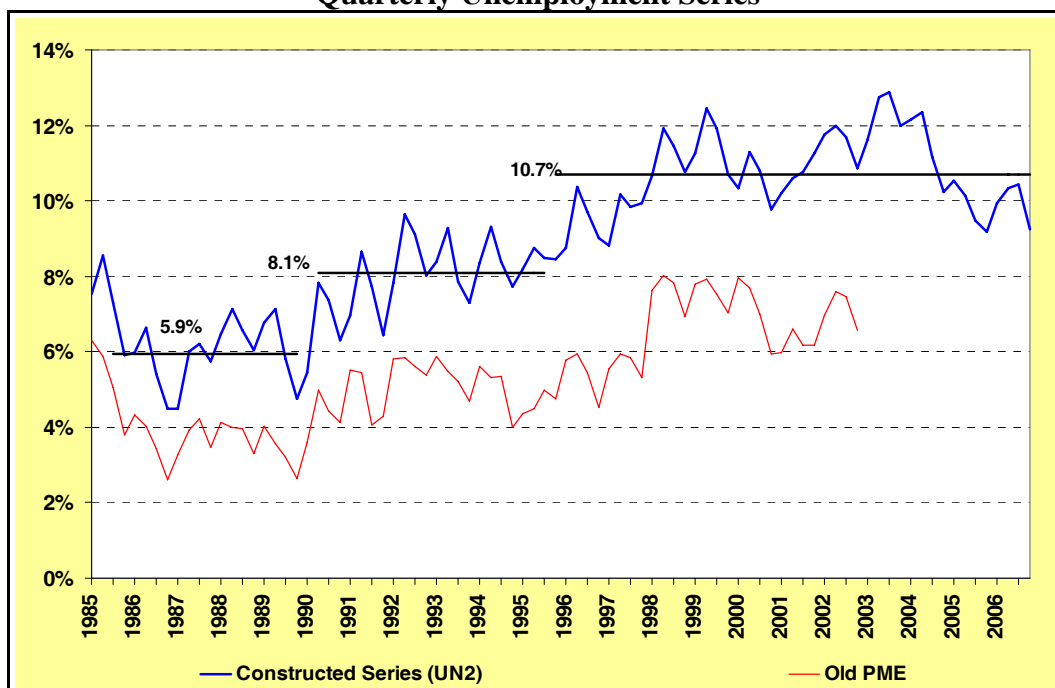


Figure 2 plots CPI inflation according to the IPCA, the official inflation targeting index in Brazil, since 1980, when inflation began to rise very rapidly. Due to the high figures involved, monthly rates are shown to better visualisation. It shows how chaotic was inflation up to mid-1990s in Brazil, and highlights the several structural breaks caused by stabilisation plans. Figure 2 also shows the huge success of the Real Plan in curbing inflation. In its turn, Figure 3 shows quarterly inflation rates since 1994.3, when the Real Plan was implemented.

Figure 2
Monthly IPCA Inflation and Stabilisation Plans

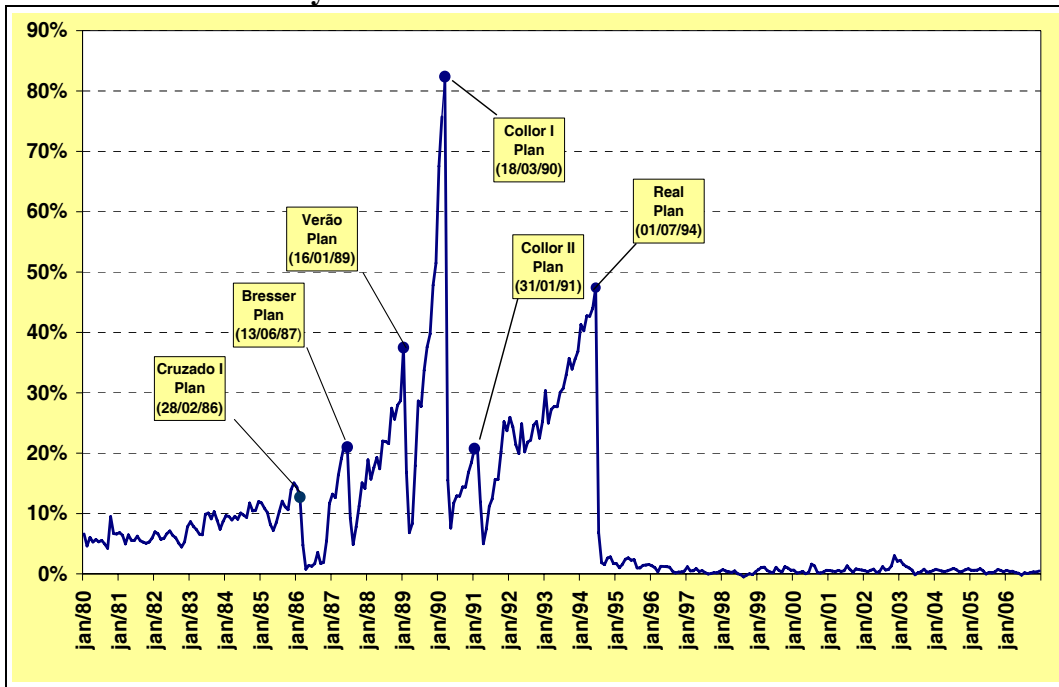
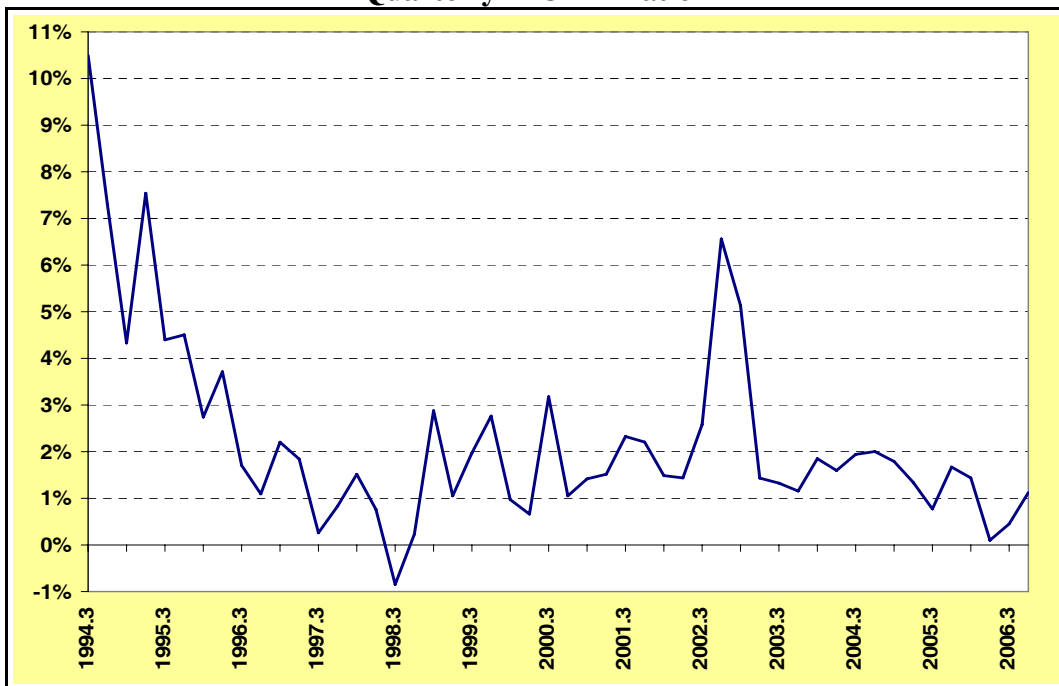


Figure 3
Quarterly IPCA Inflation



Comparing Figures 1 and 2 it becomes evident that after the Real Plan unemployment rates rose sharply while inflation rates plunged. So, before estimating the NAIRU one would like to get some intuition on what is behind those dramatic changes in unemployment dynamics, especially from the second to the third, more

recent, period, when average unemployment jumped almost three percentage points. More specifically, was there any apparent structural reason behind those movements (i.e. an increase in the NAIRU), or are they largely due to policy, shocks or cyclical factors? More broadly, do increases in average unemployment necessarily mean that the natural rate has also increased, as implicitly assumed by many economists when, for example, the HP filter is used to obtain the NAIRU, or persistent and large deviations are feasible?⁸

The first jump in average unemployment took place in 1990, and is unambiguously linked to the implementation of the Collor Plan I, which produced a huge recession. In a nutshell: $\frac{3}{4}$ of M4 was confiscated overnight disrupting the economy and causing GDP to fall 4.35% in 1990, the biggest documented recession in Brazil. Given the failure of the Collor Plan I, in the following year another stabilisation plan, the Collor Plan II, was implemented and failed as well. As a result, during the 1990–1992 period GDP fell 3.9% in Brazil, and the strong growth in the following two years (4.9% in 1993 and 5.9% in 1994) meant basically a cyclical recovery from the previous recession. Indeed, in the four-year period from 1990 to 1993 while the Brazilian economy grew just 0.8% the labour force increased almost 7%, a fact that largely explains the jump in unemployment.

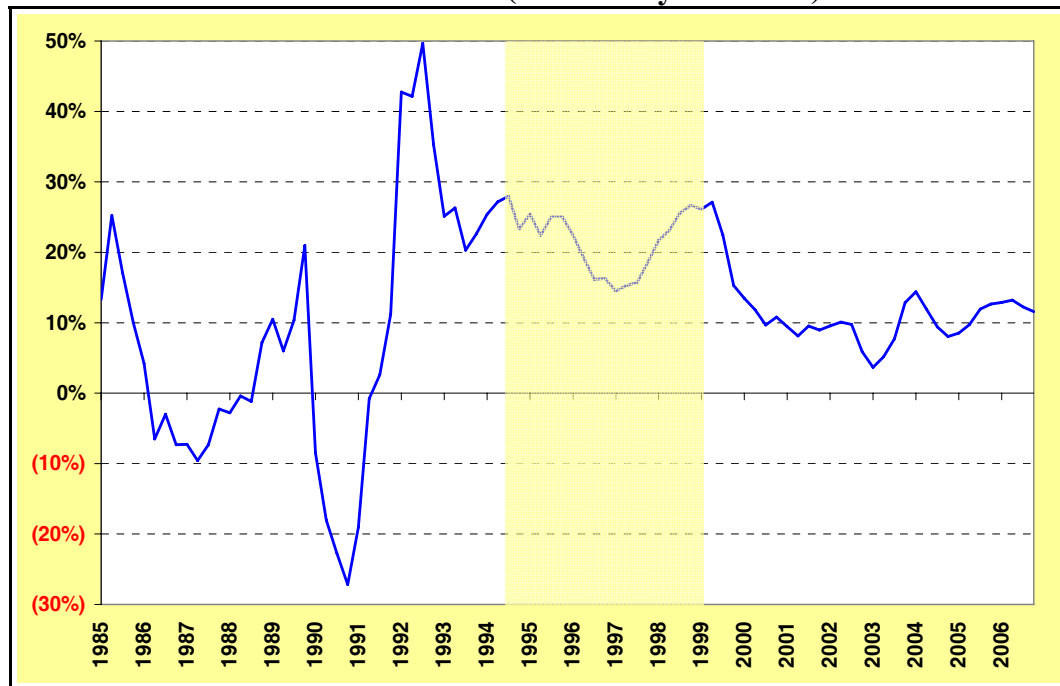
Although it is easy to see why average unemployment soared and remained high in the first half of the 1990s, it is less evident why there was another jump as of 1996. A major part of the reason seems to lie in the characteristics of the Real Plan, which was an exchange-rate-based stabilisation plan and, in contrast to money-based stabilisation plans, initially produces an expansionary effect in the economy while inflation falls (i.e. does not induce the usual Phillips curve trade-off) and postpones the recessionary costs.⁹ The latter effect arises due to the stylised fact that exchange-rate-based stabilisation plans produce real exchange-rate overvaluation leading to trade and current account deficits, requiring restrictive monetary policy to maintain the peg. Indeed, while inflation fell from 2,477% in 1993 to 22% in 1995, GDP growth increased from 4.9% in 1993 to 5.9% in 1994, and remained high in 1995, at 4.2%. However, along with reducing inflation the Real Plan also produced, in a very short period of time, a large current account deficit, which required high real interest

⁸ In this case one is implicitly assuming that the NAIRU itself suffers from hysteresis.

⁹ See Kiguel & Liviatan (1992) on the stylised facts associated with exchange rate-based and money-based stabilisation plans.

rates, as shows Figure 4, to both attract foreign capital and slow down the economy. Indeed, by early 1996 the exchange rate overvaluation had already reached its peak.

Figure 4
Real Interest Rates (Deflated by the IPCA)¹⁰



The large current account deficits were one key ingredient behind two speculative attacks that took place in October 1997 and September 1998 in Brazil, and forced the Central Bank to sharply raise interest rates as high as 46% p.a. to defend the parity. As a result, average GDP growth fell from 5.0% in 1994–1995 to just 1.4% in the 1996–1999 period, a pace clearly well below the one required to prevent unemployment from rising. Hence during the 1990s the Brazilian economy was characterized by erratic growth due to stop and go policies, and needed high real interest rates to cope with recurrent imbalances. High unemployment was just the reflection of that environment of low growth and high uncertainty.

Nonetheless, given that the exchange rate floated in early 1999 one might ask why unemployment did not fall consistently afterwards. This may come as a surprise, but a major part of the answer hinges, once again, on the behaviour of real interest rates, which have remained too high after the floating, although they did begin to fall subsequently. Initially, high rates were necessary to prevent devaluation from turning into inflation and, later on, to cope with the large and persistent supply shocks that hit

¹⁰ The shaded area refers to the period from the beginning of the Real Plan until the floating.

the Brazilian economy during the 1999–2004 period, as will become clear in Section 4. Hence, a major factor that seems to explain the jump in unemployment since 1996, as well as its persistency, is monetary policy, which had to react to macroeconomic imbalances and shocks. This felling gets stronger as we note that since 2004, when fundamentals began to improve and the Brazilian economy to grow faster, unemployment appears to be trending downwards, while inflation is falling.

Whether and to what extent the increase in unemployment since 1990 and, more specifically, since 1996, also reflected an increase in the natural rate of unemployment requires a more detailed analysis, however some remarks are useful at this point. First, it seems unequivocal that the increase in unemployment in the first half of the 1990s is much more linked to the 1990–1992 recession than to increases in the natural rate. Nonetheless, it should be called to attention that the Brazilian economy was overheated during most of the 1985–1989 period – as the negative real interest rates shown in Figure 4 suggest – experiencing unsustainably low unemployment rates, so that an increase in average unemployment was to be expected afterwards. This fact is likely to partially explain the rise in unemployment in the first half of the 1990s. Second, one must recognize that regardless of whether the natural rate increased or not the labour market did went through important structural changes in the first half of the 1990s, such as the steep rise in informality and changes in sectoral employment, with jobs moving from the industrial to the service sector, a phenomenon that has also been witnessed worldwide. Behind those changes laid not only the effects of the 1990–1992 recession but also the process of trade liberalisation that began in 1990, which exposed inefficient domestic firms to foreign competition.¹¹ Whether and to what extent those events changed the natural rate is unclear, however, note that heightened globalisation has been cited elsewhere as one of the reasons behind the decrease in the natural rate of unemployment.¹² One might also argue that a higher degree of informality could change the reservation wage, thus affecting the natural rate of unemployment.¹³ In such a case, however, the reservation wage is likely to reduce, since not only informal workers have lower wages than formal ones but they are likely to pay a premium for joining the formal market again, hence decreasing rather than increasing the natural rate of unemployment. Finally, although

¹¹ See da Silva Filho (2006b) for a detailed analysis of the Brazilian labour market during the 1990s.

¹² For example, see Weiner (1995), Stiglitz (1997) and Ball and Mankiw (2002) for the U.S. case. The former has a critical view on this argument.

¹³ Note that PME's unemployment rate encompasses both formal and informal workers.

controversial, another factor that has been cited elsewhere as to why the natural rate decreased during the 1990s in the U.S. is productivity gains.¹⁴ Since there was a clear productivity increase in Brazil as of early 1990s this factor would, once more, act to decrease the natural rate.^{15,16}

Apparently, possibly more structural – labour market-related – reasons for changes in the natural rate of unemployment during the 1990s could only have stemmed from changes in labour regulations made by the 1988 constitution. The main amendments were:¹⁷ a) the maximum number of weekly working hours was reduced from 48 to 44; b) the maximum daily journey for continuous work shift decreased from 8 to 6 hours; c) the price of overtime hours was raised from 1.2 to 1.5 times the normal wage rate; d) paid vacations were raised from the normal wage rate to 1.33 that rate; e) the fine for non-justified dismissal was raised from 10% to 40% of the FGTS;¹⁸ f) The creation of unions was made easier and they became more autonomous.

The 1988 changes in labour regulations had basically two direct effects: a) an increase, *ceteris paribus*, in the relative price of labour;¹⁹ b) (non-justified) firings became more costly to firms. Hence it is tempting to claim a link between the 1988 constitutional changes and the increase in average unemployment during the 1990s. However, some caution is clearly needed at this stage, for several reasons. First, the increase in labour costs seems too small to explain such a large jump in average unemployment during the 1990s. Second, for many firms some of those changes were probably not binding. For example, Gonzaga et al. (2002) claim that almost half of the workers already worked less than 48 hours per week in 1988. Also, more expensive overtime matter the most when the economy is growing fast, but growth was dismal during the 1990s. Third, the effects of some changes were relatively simple to be offset. For example, since what really matters to firms is the overall hourly labour cost, the increase in paid vacations could easily be offset by a tiny reduction in

¹⁴ See Ball and Mankiw (2002) for a discussion on the U.S. case.

¹⁵ See da Silva Filho (2006b) for a detailed analysis on industrial productivity in Brazil during the 1975–2001 period, with special emphasis on developments since the opening of the economy.

¹⁶ Even assuming that productivity does not affect the natural rate in the long run, it is very likely to affect it in the short term.

¹⁷ For more details see Barros *et al.* (1999).

¹⁸ The FGTS is an individual fund on behalf of the employee (not related to social security), created in 1966, that obliges firms to deposit each month in the fund 8% of the employee monthly wage. The FGTS can only be withdrawn by the employee upon unjustified dismissal or in a couple of other cases.

¹⁹ An increase in the relative price of labour will lead firms to substitute capital for labour.

monthly real wages. Fourth, the change that seems to be the most binding is the increase in the cost of firing, which certainly affected all firms. However, it seems more likely to affect the volatility of unemployment and, possibly, of the natural rate, than their levels. More importantly, it is highly unlikely that changes occurred back in 1988 are actually behind increases in unemployment that took place eight years or more later. Furthermore, as calls to attention da Silva Filho (2006c), in contrast to the international experience, the relative price of capital has been increasing in recent years in Brazil. Finally, and most importantly, the above analysis is only partial. Besides changes in labour regulations the literature also points to changes in socio-demographic factors as the main determinants of the natural rate of unemployment. However, demography has probably acted to decrease the natural rate in recent years, not only because the Brazilian population is getting older but also because by 1996 the large increase in women's participation in the labour force had already taken place. So together with more openness, higher informality, and higher productivity gains demography points to the other direction (i.e. a decrease on the natural rate). Since what we are looking for is the net effect of all those changes, large increases in the natural rate seem very unlikely. As a matter of fact, even the sign of all those changes looks difficult to establish.

Given the absence of any obvious structural factors behind the rise in unemployment, mainly after 1996, one would wonder whether the sole fact that unemployment remained high for such an extended period could have caused the natural rate to rise. In other words: were there any hysteresis effects upon the natural rate of unemployment that accounts for the high unemployment rates, and if so to what degree? Despite being a very popular hypothesis in explaining high and persistent unemployment rates, the empirical evidence regarding hysteresis effects is actually weak. Indeed, many times not only such reasoning seems to be largely a rationalisation in face of the difficulties in explaining the persistency of high unemployment rates, but its rationale faces serious difficulties when the opposite situation holds (i.e. unemployment is decreasing). Moreover, as call to attention Blanchard and Katz (1997), hysteresis is far from enough in explaining the magnitude of changes in European unemployment. In their words: "The empirical case for hysteresis is far from tight, however. [...] But the evidence on the relative and absolute importance of the specific channels for hysteresis is weaker". This

assessment should not come as a surprise since at closer scrutiny the alleged channels through which hysteresis operate are not as convincing.

For example, the loss of skills argument is very popular but hardly persuasive enough. While it is certainly true that a worker unemployed for a long time can become “obsolete”, this can usually be sorted out, or minimised, in a short period of time with on-the-job training or career recycling programs. If one could graduate in 4 years, or do an MBA in just one, how much time does one need to do a career update or recycling? Explaining high unemployment rates that sometimes last more than one decade based on such reasoning is hard to accept. Note that this channel is very similar to another one that has gained popularity since the 1990’s: skill mismatch. The argument runs as follows: in a world of fast technological change and jobs displacement from the industrial to the service sector, many workers would lack the required skills to find a job, either because they changed sectors or because newer skills are required. Although apparently compelling, the evidence on this seems weak as well. For example, during the high tech 1990s unemployment rates have plunged in both the US and the UK.

To conclude, unemployment rates have increased substantially since 1990 in Brazil. Nonetheless, as argued above and discussed further in Section 4, the reasons behind that seem clear and do not appear to be tightly linked to increases in the natural rate of unemployment, mainly after 1995.

3 – The Inflation-Unemployment Trade-off: An Exploratory Analysis

The main implication of the natural rate theory is the prediction that, conditional on the slackness of the labour market – given by the unemployment gap –, one should at least be able to forecast the direction of change of inflation. In other words, the natural rate theory should be good at making qualitative forecasts. So, Table 1 answers the following simple question: assuming a constant NAIRU during 1996–2006, how often next year’s inflation increased (decreased) given that in the previous year the unemployment gap was negative (positive), for different NAIRU levels? Hence, it provides an assessment of the natural rate theory’s qualitative forecast accuracy. It also shows for those years in which the forecast was wrong what type of forecast error was committed: under-prediction (+) or over-prediction (–). The analysis is carried out for the 1996–2006 period since the results from the previous

period are highly affected by the several interventions caused by stabilisation plans (see Figure 2).

Table 1
Qualitative Accuracy and Errors Type (1996–2006)

Nairu	5%	6%	7%	8%	9%	10%	HP
	72.7%	72.7%	72.7%	72.7%	63.6%	36.4%	54.7%
Error (+)	100.0%	100.0%	100.0%	100.0%	100.0%	75.0%	20.0%
Error (-)	0.0%	0.0%	0.0%	0.0%	0.0%	25.0%	80.0%

Some interesting evidence emerges from this simple non-parametric exercise. First, based solely on the bivariate inflation-unemployment link, there seems to be an upper bound of around 8% for the Brazilian NAIRU during the 1996–2006 period, a much lower figure than the average unemployment for that period (see Figure 1). Note, however, that the same forecast accuracy of around 73% was obtained using several assumptions regarding the NAIRU.²⁰ More precisely, NAIRU figures equal or below 8% produce the same qualitative results, since unemployment rates were above that level during the sample. Such a result suggests a large degree of uncertainty regarding the precise value of the NAIRU, evidence that has been widely found elsewhere.²¹ For example, Staiger et al. (1997) found that a 95% confidence interval for the U.S. NAIRU in 1994 spanned almost four percentage points (3.9%–7.6%) when inflation was measured by the CPI and nearly two and a half points (4.5%–6.9%) when the core CPI was used.

However, it might actually have been the case that the NAIRU was not constant during the above period, and allowing for that possibility could have produced more precise forecasts. In order to get some idea on that the same exercise was made using the unemployment gap obtained by applying the HP filter, which is widely used by economists with that precise aim. However, as Table 1 shows, in that case the accuracy would have been much worse than under the constant NAIRU assumption. Finally, note that in the constant NAIRU case all the errors were under-predictions, meaning that although the unemployment gap was positive inflation actually increased, suggesting the occurrence of important supply shocks in those specific years. This result is in sharp contrast with that from the HP case, when only

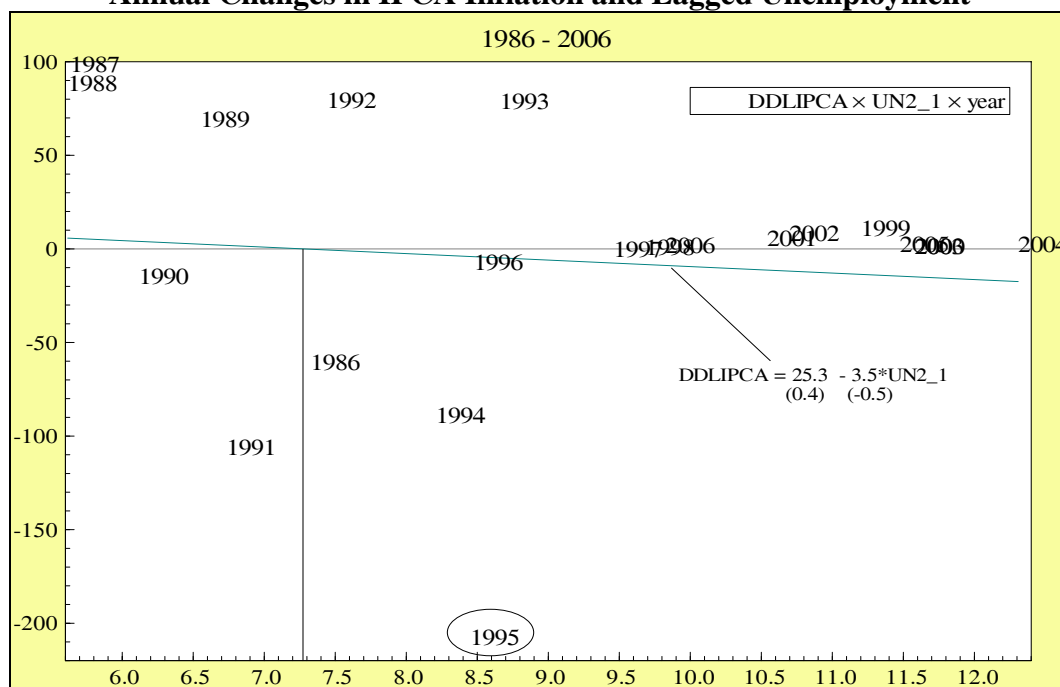
²⁰ Fisher *et al.* (2002) claim a success rate between 60% and 70% for the U.S. Analysing this link on a quarterly basis Stiglitz (1997) argues for an 80% success rate in the U.S.

²¹ This is hardly surprising since inflation is a much more complex phenomenon than implied by the simple textbook Phillips Curve.

20% of the errors came from under predictions, suggesting that supply shocks played only a minor role in explaining inflation forecasting errors, evidence that is highly at odds with the recent Brazilian experience. This is a pretty worrisome performance for such a widely used method.

Indeed, the three forecasting mistakes in the constant NAIRU case occurred in the years 1999, 2001 and 2002. In early 1999 the fixed exchange rate regime collapsed and the Brazilian currency depreciated sizable 60% in the first three quarters of that year, increasing inflation. And, during 2001 and 2002, there was a big election-related scare in Brazil (see Figure 7). As a result, the exchange rate began to depreciate in early 2001, when the market began to take seriously the possibility that a leftist could win the presidency in the following year's election. Between the first quarter of 2001 and the third quarter of 2002 depreciation reached 100%, adding significant pressure on prices, even though the exchange rate began to appreciate soon after the confirmation of the Labour Party's victory. Indeed, those shocks meant large forecasting errors by both the Central Bank of Brazil and private agents.²²

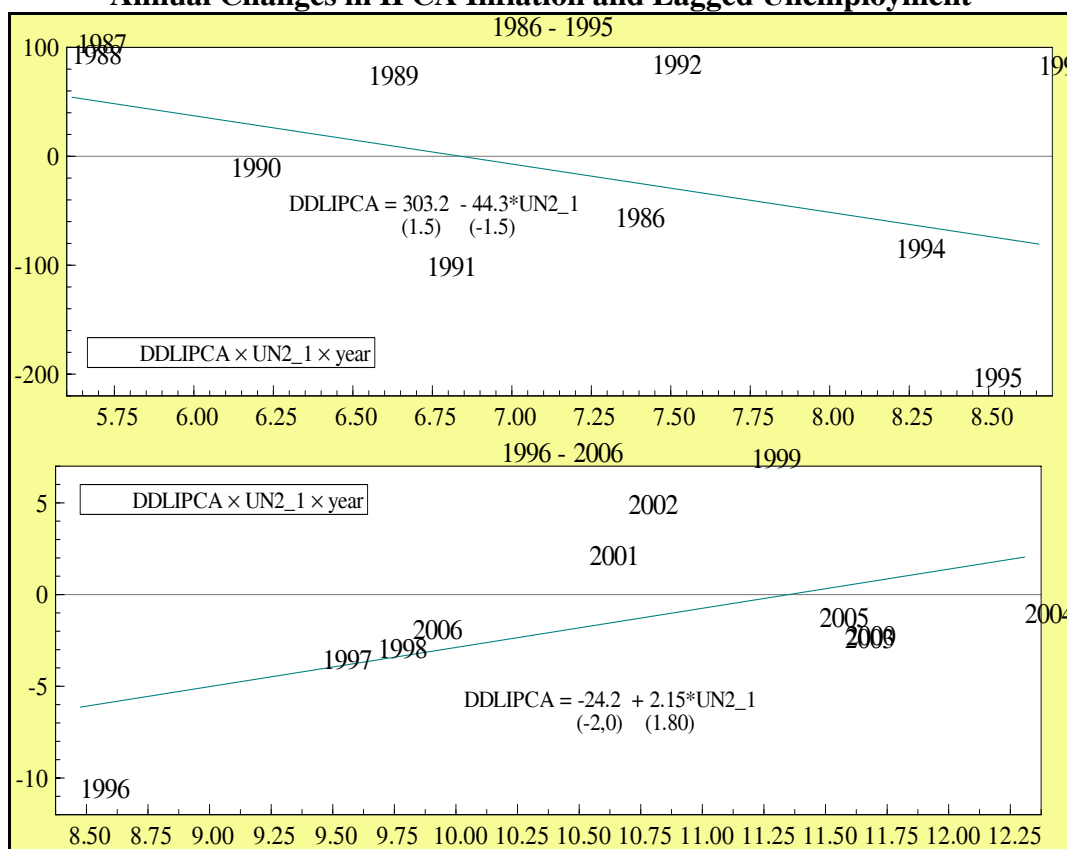
Figure 5
Annual Changes in IPCA Inflation and Lagged Unemployment



²² Da Silva Filho (2006a) provides evidence on the forecasting performance of both the Central Bank of Brazil Inflation Report forecasts and market forecasts.

Another simple exercise aimed at obtaining some quantitative idea on the NAIRU is to plot changes in inflation against one-year lagged unemployment, as does Figure 5 for the 1986–2006 period. The implied NAIRU lies around 7.3%. However, the wide scatter around the regression line suggests once again large uncertainty regarding the precise value of the NAIRU. Note that although (slightly) negative the slope of the regression line is statistically insignificant. Moreover, when the 1995 year is disregarded the NAIRU estimate jumps to 9.9%, a sizable difference that shows how fragile could be such a simple exercise.²³

Figure 6
Annual Changes in IPCA Inflation and Lagged Unemployment



Unfortunately the situation is much more complex than just taking an outlier's effect into account or dealing with imprecise estimates. Figure 6 divides the sample into two distinct periods. The first goes from 1986 to 1995 and the second goes from 1996 to 2006, spanning the period after the stabilisation of the economy, when inflation rates have been much lower and stable. As could be seen, there was a major

²³ In middle 1994 the Real Plan, which finally defeated inflation, was implemented producing a huge change in inflation from 1994 to 1995.

break in the (pairwise) unemployment-inflation link after 1995. Instability in the inflation-unemployment link has also been found elsewhere. For example, Atkeson and Ohanian (2001) report evidence that the PC became much flatter after 1983 in the U.S. Indeed, there is vast evidence on the recent flattening of the PC in many countries. Note, however, that the evidence here is not one of flattening but actually one of absence of a trade-off between inflation and unemployment (i.e. a positive slope). This happens even though inflation has been more stable in Brazil in recent years. Moreover, the positive slope is borderline significant at 10%. This fact should pose great difficulties ahead, when trying to uncover the Brazilian NAIRU.

Although the positive slope does come as a surprise, especially in a period of global disinflation and domestic economic stabilisation, inflation is a multivariate phenomenon and, therefore, much more complex than the simple bivariate relation implied by the natural rate theory. Indeed, the above evidence calls to attention that simple PCs are likely to be mis-specified, even when there is a trade-off involved.

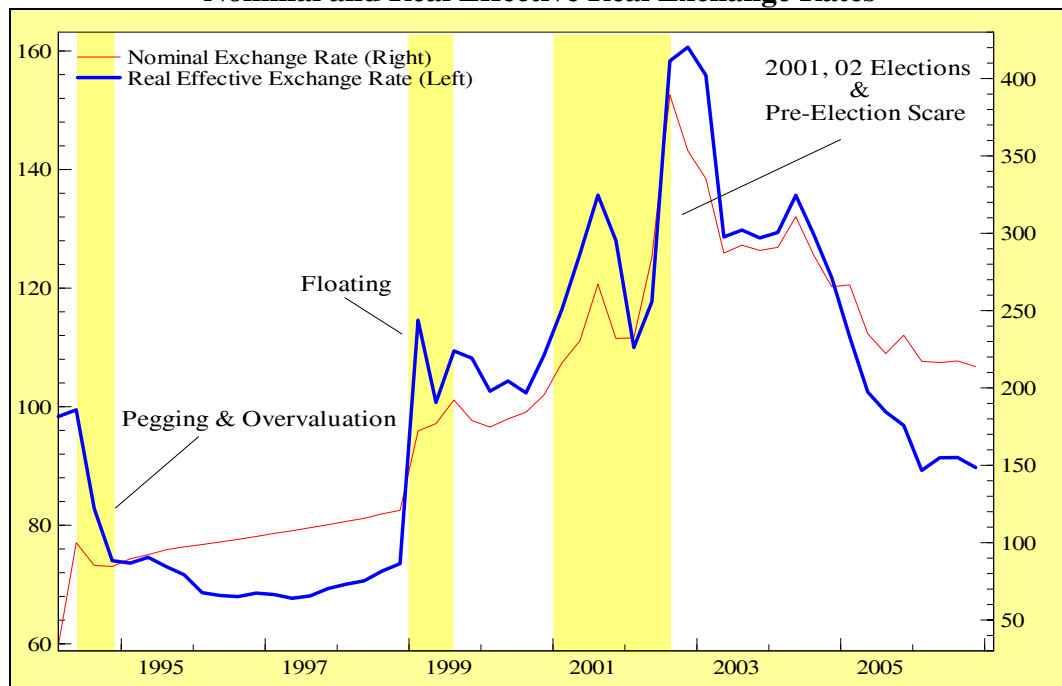
4 – Shocks and Relative Prices

This section investigates what has been “wrong” with the Brazilian (textbook) PC since the stabilisation of the economy in mid-1990s. As will be seen, although Section 3’s “wrong slope” finding has actually been a surprise, the major suspect is indeed one of the main culprits. Despite the sharp and fast disinflation that took place since the Real Plan, as well as the greater inflation stability that ensued, the Brazilian economy has been systematically hit by adverse supply shocks in recent years, mainly since 1999. Without taking those properly into account one can neither fully understand recent inflation dynamics in Brazil, especially its high persistence, nor the inverted slope of the textbook PC. Furthermore, supply shocks are crucial for understanding Brazilian monetary policy, by shedding light on why real interest rates have been so high for so many years after the floating. Indeed, the outlier status of Brazilian real interest rates has been frequently cited as a puzzle when compared to other countries. However, such “multi-country reasoning” is usually too simplistic and prevents one from understanding what really lies behind the phenomenon. As will be seen, although they do have been very high there is no puzzle involved.

The major source of price shocks in Brazil has come from the exchange rate. Figure 7 gives a good idea of how volatile have been both nominal and real exchange

rates. From mid-1994 until early 1999 a fixed exchange rate regime was in place in Brazil, more specifically a crawling peg. As mentioned before, it was a major feature of the Real Plan, which produced a sizable exchange rate overvaluation in a very short period of time leading to large current account deficits. After two speculative attacks in 1997 and 1998 the exchange rate ended up floating in early January 1999, and the real depreciated 60% in the first three quarters of that year pressuring inflation. Later on, in 2001, the exchange rate began to depreciate further amongst fears of a leftist win in the following year's presidential election. As a result between 2000.1 and 2002.3 the exchange rate soared 100%, adding significant pressures on prices. Both episodes, especially the second one, meant large inflationary shocks on the tradable sector and, as a consequence, on overall inflation.²⁴ However, as will become clear soon exchange rate shocks are only part of the story.

Figure 7
Nominal and Real Effective Real Exchange Rates



What distinguishes the Brazilian case from other countries' experiences is not how large or frequent changes in the exchange rate have been, but rather the impact of exchange rate shocks on the non-tradable sector of the economy, more specifically on utilities prices, as well as their long lasting effects on inflation. This is unexpected

²⁴ It is important to note that since in 1998 the real was overvalued the 1999's depreciation was not as inflationary as in 2001-2002, when the exchange rate was already undervalued.

given that public utilities have a non-tradable nature – a key feature of the service sector – and, therefore, should be little affected by changes in the exchange rate. Moreover, utilities services are crucial in firms' production costs and consumption baskets, having a large influence on prices, especially on consumer price indexes. So, what lies behind such odd price behaviour? The answer hinges on the way privatisation was made in Brazil.

A key issue in the utility companies' privatisation contracts is the one that rules on how utilities tariffs are adjusted over time. In order to maximise sales revenue and attract foreign capital to finance the large current account deficits created by the Real Plan, the government decided to provide a crucial hedge to investors and, at variance with the international experience, virtually indexed those tariffs to the exchange rate.²⁵ More specifically, electricity, telephony and water tariffs, toll fares and other regulated prices began to be corrected according to the so-called General Price Indexes (IGP), a Brazilian idiosyncrasy.²⁶ Those indexes are highly affected by the exchange rate since they are a weighted average of three other indexes: WPI (IPA), CPI (IPC) and the Civil Construction Price Index (INCC). The former, which is heavily affected by the exchange rate, enters with a 60% weight, while the CPI and INCC enter with 30% and 10%, respectively. Hence, as the exchange rate soared so did utility prices and, as a consequence, consumer price indexes.²⁷

Figure 8 shows some effects of exchange rate shocks in Brazil in recent years under different perspectives.²⁸ Panel A plots how (households) electricity and telephony tariffs – two key utility services – have evolved since the floating, together with the IGP-DI, which is one of the two indexes used to adjust utilities prices in

²⁵ From another viewpoint: instead of welfare maximisation the policymaker objective function was revenue maximisation.

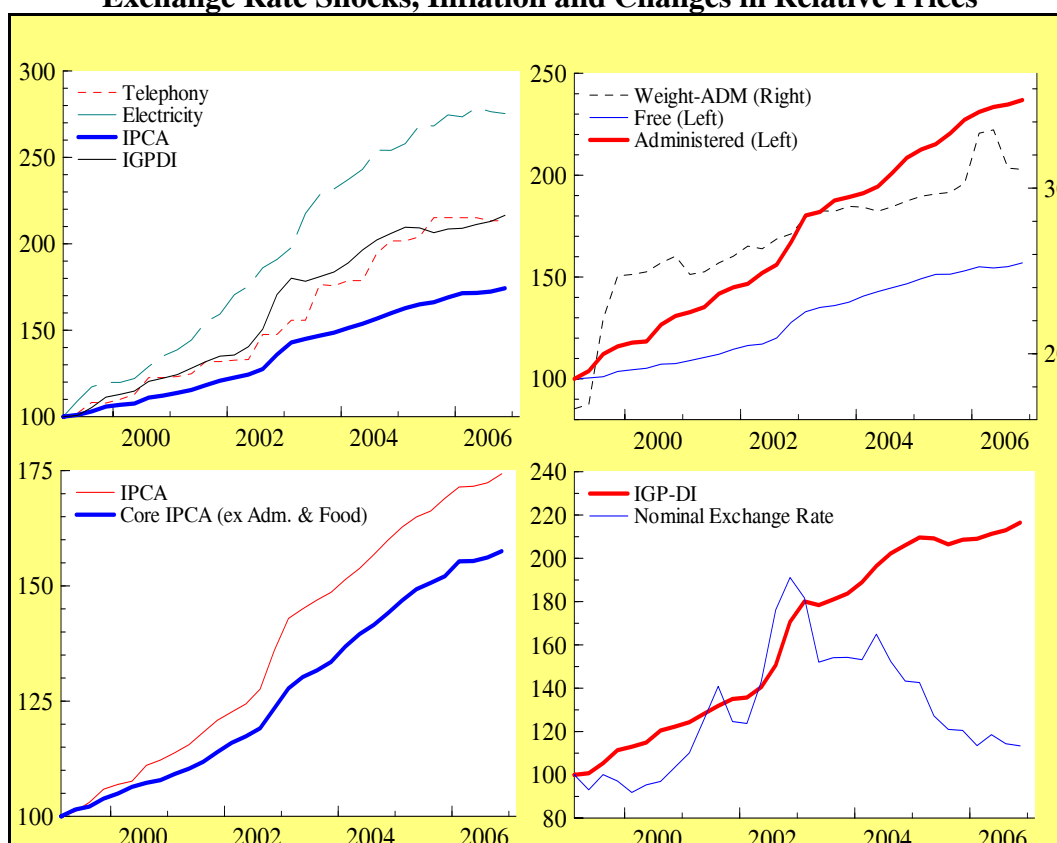
²⁶ Brazil has two of those indexes, IGP-DI and IGP-M, which differ according to the period inflation is calculated, otherwise being equal. Note that although they are central, other variables are also involved in utility prices adjusting rules.

²⁷ The systematic and large increases in telephony and electricity fares – well above CPI inflation – led to many complaints and judicial actions. After some lower courts decisions, in 2003, favouring consumers' pleas and suspending the indexation of telephony tariffs to the IGP-DI, the Supreme Court overruled those decisions and re-established the IGP-DI as the legal index in 2004. However, in 2005, when the old contracts expired, a sectoral index was created to index telephony tariffs. Ironically, given that the exchange rate has been appreciating since 2004, telephony rates would probably have fallen had the old indexing scheme remained. However, consumers did not benefit from that movement. Indeed, after many years, electricity fares finally began to decrease in 2007, after having remained virtually stable in 2006. Due to the sizable exchange rate appreciation that took place in recent years, after a long period, administered prices inflation have stopped from being a major concern since 2006.

²⁸ Graph panels are lettered notionally as A, B, C and D, row by row.

Brazil, and the IPCA, the official inflation targeting index.²⁹ Some interesting findings arise. For example, increases in utilities prices have been well above IPCA inflation since 1999. The increase in the relative price of electricity, a key production input, is particularly striking. While IPCA inflation increased 78% from January 1999 until December 2006, electricity bills soared 275%, more than threefold.³⁰ It is also noteworthy the similarity between the dynamics of telephony tariffs and the IGP-DI.³¹

Figure 8
Exchange Rate Shocks, Inflation and Changes in Relative Prices



Panel B also highlights the huge relative price shocks that have been hitting the economy in recent years, but now taking into account the whole set of the so-called administered prices, which are the ones either controlled by the Government, such as health insurance plans, or regulated by contracts, such as those from privatised utilities. It is stunning for how long and how much further those prices have increased beyond the so-called free prices (i.e. those prices that are basically determined by

²⁹ See footnote 26.

³⁰ Note that the real difference is actually higher, since IPCA inflation already captures the effects of those increases.

³¹ Recently, in 2005, after many protests from consumers and judicial battle

market forces). Panel B also uncovers the tremendous shocks that Brazilian families have faced in recent years regarding their consumption patterns. There has been a huge increase in consumers' expenditures with administered goods and services, whose weight nearly doubled from 1999 to 2006.³² Panel C plots headline IPCA and one of the main core inflation measures calculated by the Central Bank of Brazil (BCB): the one that excludes food at home and administered prices inflation. This comparison should give some idea of how large have been the effects of exchange rate shocks' on administered prices inflation and, ultimately, on consumer price inflation. It is amazing how both indexes have been consistently drifting apart since at least 1999.³³ Note that the drift widened sharply since 2002, in agreement with the large depreciation that took place during 2001-2002. This comparison also brings very interesting issues.

First, it makes clear how difficult has been the job of the Central Bank of Brazil in curbing inflation since the floating, and sheds light on why real interest rates have been so high in recent years. Not only adverse supply shocks have been recurrent and large in Brazil in the recent past but, as Panel B shows, an increasing part of the IPCA has becoming interest rate insensitive.³⁴ Second, the growing discrepancy between both indexes reflects an important limitation of this particular core inflation measure. Instead of purging just transitory relative price shocks from the overall index, permanent shocks are the ones that have been systematically excluded, so that one ends up with two completely different price trends: one that acknowledges the large permanent and persistent relative price changes that have been taking place in the Brazilian economy and another one which completely ignores that phenomenon.³⁵ Indeed, the annual headline inflation has been, on average, 1.3 percentage points above the exclusion core inflation since 1999. This fact could have major implications

³² It should be called to attention that the jump in 1999 was due to new weights from a newer POF (a household consumption profile survey). Note also that even after the update the importance of administered goods and services in households' expenditures kept increasing consistently and sharply, which makes clear the large impact of those shocks on the economy.

³³ Actually, this evidence is even more significant than it looks, given that during most of the period the relative price of food decreased. See

Figure 9a.

³⁴ Aron *et al.* (2004) also calls to attention the same phenomenon for South Africa inflation.

³⁵ Hence both measures do not seem to be cointegrated.

for monetary policy. For example, if the Central Bank puts too much weight on such types of core measures, it could end up implementing a too lenient monetary policy.³⁶

Turning a typical non-tradable sector into a highly exchange-rate sensitive one was not the only oddity caused by privatisation in Brazil. Perhaps even more importantly was the increase in inflation persistency that followed, which had a great impact on monetary policy. Panel D shows that although the IGP-DI is highly affected by the exchange rate it has much more persistency than the latter. Indeed, note that even though the nominal exchange rate has consistently been appreciating since 2004 the IGP-DI continues to rise. Therefore, it suggests that the effects of exchange rate shocks on administered prices have been highly asymmetric, with the inflationary effects from depreciation being much larger than the deflationary effects from appreciations. Moreover, since utilities prices are adjusted once a year, based mostly on the last twelve months' inflation, current exchange rate developments (and monetary policy) will affect those prices only with a reasonable lag. Thus, although sensitive to exchange rate the "administered price sector" behaves quite differently from the typical tradable sector, a feature that has important consequences to the monetary transmission process, such as the requirement of higher real interest rates to curb inflation. More crucially, note that with the soaring of utility prices around one third of IPCA inflation is currently interest rate insensitive (Panel B).

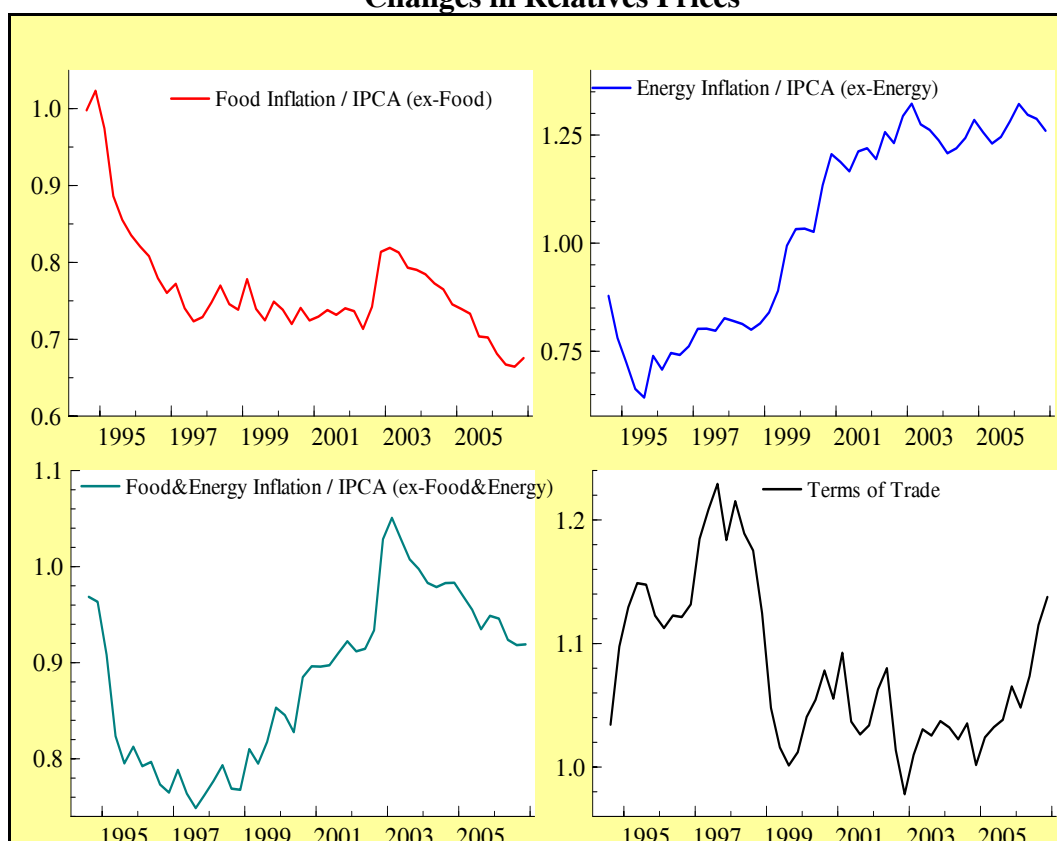
Although the above shocks largely explain the breakdown of the textbook Phillips Curve in Brazil since 1995, it is obvious that the Brazilian economy must have been hit by other types of shocks as well, and some of them could have well been benign. Figure 9 displays evidence on this regard. Panels A and B show how the relative prices of food and energy have evolved since the Real Plan. Since both items are considered to be very volatile and subjected to transitory exogenous influences they are excluded from the U.S. CPI in order to compute that country's underlying inflation. Panel A shows that relative food prices decreased sharply after the Real Plan, being one important source of benign shocks to inflation.³⁷ On the other hand, Panel B illustrates that after falling in the period just after the Real Plan, relative energy prices began to soar, especially after the floating when the increase intensified. Panel C takes both effects together into consideration, and shows that until 1998 the

³⁶ Mishkin (2007) calls the attention to the same phenomenon in the U.S. since 2002, given that "... headline [PCE] inflation has averaged more than ½ percentage point above core inflation since this period."

³⁷ Note that food here means food at home only, which is the most volatile item of that group.

net effect on inflation was still negative, despite increasing energy prices. However, since the floating the combined effects of food and energy prices have been highly inflationary. Finally, Panel D plots the behaviour of terms of trade, which have been quite volatile during the entire period.

Figure 9
Changes in Relative Prices³⁸



Given the pivotal importance of supply shocks and changes in relative prices in explaining both recent inflation dynamics in Brazil and the trade-off (or its absence) between inflation and unemployment, several proxies were constructed in order to capture such effects. Broadly speaking, three types of proxies were built. The first aims at capturing the direct effects of shocks to the exchange rate on inflation, either on nominal or real grounds and either in absolute or relative terms. Within this group lie changes in nominal and real exchange rate and the difference between those changes and inflation. The second type aims at measuring the effects of changes in relative prices between groups or types of goods, which could be mostly attributed to

³⁸ Food stands for food at home. Energy encompasses home fuel, coal, cooking gas, vehicle gas, electricity, gasoline, diesel and ethanol.

changes in the exchange rate. Among those lies the difference between tradable and non-tradable inflation and changes in import prices and terms of trade. The third type of proxy tries to capture changes in relative prices that are not necessarily linked to the exchange rate, such as the difference between inflation and inflation (ex-food) or changes in productivity. Table 2 lists some of those proxies.

Table 2
Supply and Relative Price Shocks: Some Proxies³⁹

S_t^{trad}	$\pi_t^{ipa} - \pi_t^{igp}$
S_t^{ntrad}	$\pi_t^{ipca(non-tradable)} - \pi_t^{ipca}$
S_t^{reer}	$\Delta \ln REER_t - \pi_t^{ipca}$
S_t^{tt}	$\Delta \ln TT_t - \pi_t^{ipca}$
S_t^{adm}	$\pi_t^{ipca(adm. prices)} - \pi_t^{ipca}$
S_t^{food}	$\pi_t^{ipca} - \pi_t^{ipca(ex-food)}$
S_t^{core}	$\pi_t^{ipca} - \pi_t^{ipca(ex-food \& energy \& adm)}$

Obs: All the proxies are expressed as deviations from their means.

5 – Empirical Results

The evidence put forward so far strongly suggests that uncovering the Brazilian NAIRU will be a major empirical challenge. Besides the difficulties from the stylised fact that NAIRU estimates are usually measured very imprecisely, Brazilian data bears the additional complication that there has been no trade-off between inflation and unemployment since the stabilisation. On the contrary, the correlation has been positive. This evidence points strongly towards the importance of supply shocks on recent inflation dynamics in Brazil. However, such shocks are not directly observed and proxies should be used instead. Hence the success of any estimation is tightly linked to the quality of those proxies, a fact that could not be taken for granted. Additional noise comes from the fact that the major unemployment survey in the country underwent a major methodological change just a few years ago, and the unemployment series used here was built based on assumptions that might not work as expected. Finally, the official unemployment survey is not nationwide, but rather investigates unemployment in six metropolitan areas only. Hence, questions

³⁹ Where $\pi_t^{index} = \Delta \ln Index_t$.

arise as to whether it is a precise enough representation of unemployment dynamics in the rest of the country.

As mentioned earlier the Phillips Curve (PC) framework was chosen as the preferred method for estimating the Brazilian NAIRU. Its most general specification could be stated as

$$\Delta\pi_t = \alpha(L)\Delta\pi_{t-1} + \beta(L)(u_t - u_t^n) + \gamma(L)\mathbf{X}_t + \varepsilon_t, \quad \varepsilon_t \sim \text{NID}(0, \sigma_\varepsilon^2) \quad (1)$$

where $\pi_t = \Delta \ln IPCA_t$, u_t is the (seasonally adjusted) unemployment rate, u_t^n is the (unobservable and possibly time-varying) natural rate of unemployment and \mathbf{X}_t is a vector of inflation determinants, among which supply shocks proxies are central, and which have been normalised so that they have a zero net effect on NAIRU measurement. Some of them have already been shown in Table 2. Finally, $\alpha(L)$, $\beta(L)$ and $\gamma(L)$ are lag polynomials.

Note that equation (1) assumes implicitly a vertical PC and random-walk expectations (i.e. $\pi_t^e = \pi_{t-1}$). This assumption has not only been widely used elsewhere (e.g. Staiger et al., 1997; Ball and Mankiw, 2002) but is supported by empirical evidence, which shows that actual expectations have a large backward looking component.⁴⁰

One particular case of interest is obviously the one in which the NAIRU is assumed to be constant. In that situation equation (1) simplifies to

$$\Delta\pi_t = c + \alpha(L)\Delta\pi_{t-1} + \beta(L)u_t + \gamma(L)\mathbf{X}_t + \varepsilon_t \quad (2)$$

$$\bar{u} = -c/\beta(1) \quad (3)$$

and could be easily estimated by OLS. Now the NAIRU is simply the ratio of the constant term to the sum of the unemployment's coefficients. However, one difficulty comes from assessing how precise are NAIRU's estimates, since it is a non linear function of regression coefficients.⁴¹

⁴⁰ See, for example, da Silva Filho (2006a) for evidence on Brazil and Thomas Jr. (1999) for the U.S. evidence. See also Gruen *et al.* (1999) and Aron *et al.* (2004), who find a very small role for inflation expectations in Phillip curves for Australia and South Africa, respectively.

⁴¹ See Staiger *et al.* (1996) on the two main methods for calculating confidence intervals in such a case.

If one wants to allow for the possibility of a time-varying NAIRU (TV-NAIRU), then one must specify a statistical model for it. One popular statistical assumption is that the NAIRU evolves according to a random walk. In this case one has that

$$\Delta\pi_t = \alpha(L)\Delta\pi_{t-1} + \beta(L)(u_t - u_t^n) + \gamma(L)X_t + \varepsilon_t \quad (4)$$

$$u_t^n = u_{t-1}^n + \xi_t \quad (5)$$

$$\varepsilon_t \sim NID(0, \sigma_\varepsilon^2), \xi_t \sim NID(0, \sigma_\xi^2) \quad E(\varepsilon_t, \xi_t) = 0 \quad (6)$$

The model can be estimated using the unobserved components (UC) framework. It can be expressed in state space form and estimated using the Kalman Filter. One advantage of this framework is that the NAIRU can be allowed to vary without having the need to specify its determinants. Note that if $\text{var}(\xi_t) = 0$ then the model (4)-(6) collapses into the model (2)-(3).

5.1 – The Smoothness Problem

The appealing feature of the PC-UC framework, which allows a TV-NAIRU without needing to make explicit its determinants, could end up being its weakest point as well, namely: NAIRU estimates could show excess volatility. This might be particularly relevant in the widely used random-walk specification for the NAIRU, which could jump around erratically. Indeed, as puts Gordon (1997) “If no limit were placed on the ability of the NAIRU to vary each time period, then the time-varying NAIRU could jump up and down and soak up all the residual variation in the inflation equation.”

The literature has dealt with this problem by restricting the extent by which the TV-NAIRU can vary (e.g. King et al., 1995; Gordon, 1997). However, excess volatility could actually stem from mis-specification and not from actual behaviour, leading to wrong inferences. This is particular true in this literature, where simplistic specifications are often used. Therefore, even though restricting variances will indeed produce more stable NAIRU estimates inference could still be unreliable. Moreover,

the issue of how volatile one should allow the NAIRU to be remains open, since this decision bears a large degree of arbitrariness.

5.2 – Estimation Results

In order to estimate the Brazilian NAIRU a general-to-specific modelling strategy was used when searching for congruent parsimonious encompassing specifications. Five lags of each regressor were usually included in the general unrestricted model (GUM). The period under analysis begins after the Real Plan. This choice seems obvious, since the correlation between inflation and unemployment breaks down after the stabilisation of the economy. Moreover, with a shorter sample the chances of finding a constant NAIRU increase, which should make estimation easier. Even so, estimation was everything but easy, as expected.

Indeed, although in the post stabilisation period inflation has been reasonably low and stable, especially when compared to the chaotic previous ten years, the Brazilian economy has been hit by persistent adverse supply shocks in recent years. Those shocks, together with the difficulties mentioned above, posed serious difficulties in finding good and sensible NAIRU models for Brazil. For example, in many PC specifications unemployment was wrong signed and/or insignificant. Also, since many shock variables carry some information in common, it was not unusual to find wrong signed shocks. Moreover, NAIRU estimates proved to be very sensitive to the inclusion and choice of supply shocks in the Phillips Curve. Nonetheless, some empirical regularities seem to have emerged, as shows Table 3.

Before proceeding, however, some remarks are needed. First, as expected, the unemployment series obtained from “joining” both the old and new PME (UN1) did not produce sensible models and was often not significant.⁴² Also, although models using the SEADE-Dieese unemployment rate (i.e. UN3) yielded better results, the best models came from using the UN2 unemployment series. Hence, only models using that particular series are reported below. Second, NAIRU confidence intervals are not calculated, since the preference here is to highlight model uncertainty. The main reason for such a decision was that confidence intervals are usually so wide that from a rigorous point of view NAIRU estimates end up being useless from a policy

⁴² See footnote 5.

perspective. For example, Staiger et al. (1997) say that “For these three decades, the 95 percent confidence intervals are wide enough to include most observed values of unemployment, with the exception of some cyclical peaks and troughs”. Moreover, not only people focus mostly on point estimates in practice but the range of NAIRU estimates from the preferred models provides a sensible operational uncertainty range.

Table 3
Constant NAIRU Models: Estimation Results*

	Model 1	Model 2	Model 3
$\sum_{i=1}^5 \Delta\pi_{t-i}$	-1.57 (***) [1,2,3]	-2.06 (***) [1,2,3]	-0.84 (***) [1,2,3]
$\sum_{i=0}^5 S_{t-i}^{trad}$	1.65 (***) [0,1,2]	1.37 (**) [0,1,5]	0.36 (***) [1,2,3]
$\sum_{i=0}^5 S_{t-i}^{trad} $			0.02 (***) [1,2,3]
$\sum_{i=0}^5 S_{t-i}^{ntrad}$	0.58 (***) [1,4]		
$\sum_{i=0}^5 S_{t-i}^{tt}$		0.13 (***) [2,4,5]	
$\sum_{i=0}^5 S_{t-i}^{reer}$			0.04 (***) [2]
$\sum_{i=0}^5 \Delta R_{t-i}$	0.94 (***) [2,4]		
$\sum_{i=0}^5 \Delta r_{t-i}$			-0.44 (***) [0]
$\sum_{i=0}^5 UN_{t-i}$	-0.19 (***) [2,3]	-0.13 (***) [2,3]	-0.05 (**) [2,3]
C	1.65	0.97	0.38
NAIRU	8.5%	7.5%	7.4%
Sample	1996.2–2006.4	1996.2–2006.4	1996.2–2006.4
R ²	0.85	0.84	0.93
Sigma	0.60	0.62	0.53
DW	2.1	2.0	1.9
AR 1-3 test	0.09 [0.96]	0.02 [0.99]	0.32 [0.81]
ARCH 1-3 test	0.94 [0.44]	0.46 [0.71]	0.19 [0.90]
hetero test	0.17 [0.99]	0.28 [0.99]	1.70 [0.16]
Normality test	0.98 [0.61]	0.31 [0.86]	2.19 [0.33]
RESET test	1.04 [0.31]	0.00 [0.99]	0.13 [0.73]

(*) Only significant lags are retained in the model. (*), (**) and (***) mean that the test is significant at 10%, 5% and 1%, respectively. Numbers in brackets shows which lags enter the model. The dependent variable is $\Delta\pi_t$. Discrepancies are due to rounding.

Table 3 lists three selected models, among many, that despite differing in some aspects share important similarities. The most robust result that emerged from the

whole process of modelling and estimation is the importance of one particular proxy aimed at measuring exchange rate shocks: the one built from the difference between WPI inflation (IPA–DI) and overall inflation (IGP–DI). This proxy not only is always significant across specifications but has the correct theoretical sign and, therefore, seems to be the one that better captures the effects of exchange rate shocks on inflation. Another robust result is that in all models unemployment enters at lags two and three, implying that changes in unemployment seem to precede changes in inflation by 6 to 9 months.

Each model contains two proxies, although the second one differs among them. The second proxy in Model 1 could be seen as complementary to the first one, since it measures what one could call “non tradable shocks”. In its turn, the second proxy in Model 2 tries to capture terms of trade shocks, whose effects are partially reflected in exchange rate shocks. Note that from a theoretical point of view its sign is ambiguous. For example, an improvement in a country’s terms of trade could both be inflationary if, for example, it reflects increasing commodity prices, or deflationary, if leads to a large enough exchange rate appreciation. In the Brazilian case – after controlling for exchange rate effects – the outcome seems to be slightly inflationary. Finally, Model’s 3 second proxy tries to gauge shocks to the real exchange rate, so that there is a larger overlap here. Note, however, that it can be interpreted as mainly capturing the direct effects of exchange rate changes on inflation (e.g. on import prices), while the first proxy captures mostly the effects on tradable goods inflation. Overall, the models strongly suggest that the exchange rate seems to be a crucial variable in explaining Brazilian inflation dynamics and, therefore, the monetary transmission mechanism.

Note that Model 1 includes the nominal interest rate as a regressor. However, its sign is unexpected, showing evidence of a possible price puzzle for Brazil. This is a meaningful result, since the equation controls for several shocks. Perhaps those proxies are not capturing fully the relevant shocks or maybe the unexpected sign reflects possible delayed monetary policy responses to increases in inflation during the sample. Another explanation could be that the Central Bank did not react to fully offset the effects of supply shocks (but only their second order effects on inflation). Of course, both factors may have been important. This is an interesting issue that deserves further investigation, but it is not the main aim here. Anyhow, although the sign is unexpected, this model was selected since the nominal interest rate helped to

improve its overall specification. Indeed, the model easily passes in all diagnostic tests and have constant parameters as well as no sign of structural break, as the recursive Chow tests indicate (see Appendix). Moreover, the nominal interest rate could also be partially reflecting economic shocks, as it increased sharply in reaction to both the 1997 and 1998 speculative attacks and following the large devaluation that took place during 2001–2002. Since inflation increased sharply after the last two episodes, this fact could also shed some light on the unexpected sign. Finally, according to Model 1 changes in the nominal interest rate affect inflation between two and four quarters ahead.

In its turn, Model 3 includes the real interest rate as an additional regressor, and reveals interesting evidence on possible asymmetric effects on inflation of exchange rate shocks, with depreciations being more harmful to inflation than appreciations beneficial, a hypothesis that was raised earlier. The inclusion of the real interest rate, which is obviously relevant for inflation dynamics, could have helped to uncover this effect. Note, however, that one must be careful about these results, since the real rate enters at lag zero and, therefore, there is endogeneity problem here. Nonetheless, note that the NAIRU estimate from Model 3 is practically the same as that of Model 2.

It should be mentioned that despite the popularity of food and energy shocks in the literature, they were not found to be relevant in the Brazilian case. Perhaps part of the reason why food shocks were insignificant was that they were overwhelmed by the effects of administered price shocks, which not only had opposite effects (i.e. inflationary) during the sample but were quite persistent. Concerning energy shocks, note that fuel prices in Brazil are not as volatile as, for example, in the U.S. and U.K., since they are controlled by the Government, and that might explain this result.

On the whole the evidence presented here suggests that the Brazilian NAIRU has been roughly constant in recent years. Model uncertainty suggests that point estimates should lie somewhere between 7.4% and 8.5%. Apart from the issues related to the interest rate in Models 1 and 3, the models seem congruent with the data, especially Model 2. Indeed, the diagnostic tests are satisfactory in all cases and recursive estimates show stable coefficients, evidence that makes one more confident on the inferences draw above.

5.3 – TV-NAIRU

Although the above models seem to be congruent with the data, increasing one's confidence that the Brazilian NAIRU has been roughly constant in recent years, one cannot rule out the possibility that it could indeed have changed. One way to test this hypothesis, being aware of the potential problems pointed out above, is to allow the NAIRU to vary. Hence two exercises are carried out here. In the first, Model 2 – the preferred model – was simply re-estimated using the UC model technology instead of OLS, allowing the NAIRU to vary according to (5). In the second exercise, instead of just replicating Model 2, the whole estimation process was carried out once again, starting from the same GUM that produced it.

Table 4
UC NAIRU Models: Estimation Results *

	Model 5	Model 6
$\sum_{i=1}^5 \Delta\pi_{t-i}$	-2.06 (***) [1,2,3]	-2.06 (***) [1,2,3]
$\sum_{i=0}^5 S_{t-i}^{trad}$	1.37 (**) [0,1,5]	0.97 (**) [0,1,4]
$\sum_{i=0}^5 S_{t-i}^{tt}$	0.13 (***) [2,4,5]	0.03 (***) [2,4]
$\sum_{i=0}^5 UN_{t-i}$	-0.13 (***) [2,3]	-0.14 (***) [2,4]
$\mu_{t/T}$	0.97	1.15
NAIRU	7.5%	8.5%
Sample	1996.2–2006.4	1997.1–2006.4
R ²	0.84	0.87
Sigma	0.53	0.47
DW	1.8	2.0
Q (7, 6)	8.49 [0.20]	2.76 [0.83]
H (h)	H (14) = 0.61 [0.82]	H (13) = 1.29 [0.33]
Normality	0.67 [0.72]	2.05 [0.36]

(*) Only significant lags are retained in the model. (*), (**) and (***) mean that the test is significant at 10%, 5% and 1%, respectively. Numbers in brackets shows which lags enter the model. The dependent variable is $\Delta\pi_t$. Discrepancies are due to rounding.

Table 4 shows the results (Model 4 and Model 5, respectively), where $\mu_{t/T}$ is the stochastic trend final state estimate. Nonetheless, from the outset it should be noted that estimates showed that $\text{var}(\xi_t) = 0$, which means that although the stochastic

trend was allowed to vary it remained constant. In other words, the NAIRU was found to be constant once again.

$Q(p,q)$ is the Box-Ljung statistic for residual autocorrelation based on the first p autocorrelations. $H(h)$ is a heteroscedasticity test and $\chi_{DH}^2(2)$ is a normality test based on the Bowman-Shenton statistic with a correction due to Doornik and Hansen (1994). See Koopman et al. (2000) for further details.

Note that not only both models are very similar between them but they are very similar to Model 2. Even so, Model 6 is both more parsimonious and has a better fit than Model 5. However, the latter was estimated using a slightly smaller sample, which starts in 1997.1 instead of 1996.2, since those initial observations were adding some instability to the estimated stochastic trend and, therefore, were excluded. Finally, even though both models produced a constant NAIRU, the estimates were not equal: 7.5% and 8.5%, respectively.

6 – Conclusion

Surprisingly, there is hardly any work on the natural rate of unemployment in Brazil. This paper has accepted the challenge of estimating it and has found a long and bumpy road. Nonetheless, important progress has been made and the journey has produced important insights, results and stylised facts that not only has enhanced one's understanding on the Brazilian natural rate of unemployment but, more importantly, has also laid out the ground for further research on the subject. Moreover, the case study approach used here has also provided important insights and evidence on related topics, such as the transmission mechanism of monetary policy and possible reasons on why real interest rates have been so high for so long time in Brazil. The paper also argues that one widely used core inflation measure in Brazil – the one that excludes administered prices inflation and food at home – has not been capable of measuring underlying inflation properly in recent years, which could lead to policy errors if the policymaker put too much emphasis on it when setting monetary policy.

From the outset two major obstacles were met. The first related to data availability, as the main Brazilian household survey went through a major methodological change just a few years ago. After dealing with data problems the

paper revealed surprising evidence: the link between inflation and unemployment broke down after the stabilisation of the economy, in the sense that the correlation between inflation and unemployment has become positive since 1995. Ironically, this is exactly the period during which inflation has become much lower and stable, both at home (stabilisation of the economy) and abroad (1990s and early 2000s global disinflation). In other words: since 1995 there has been no trade-off between inflation and unemployment in Brazil. Although a positive slope is indeed unexpected, the relation between inflation and unemployment is complex and multivariate, and this finding could serve as a warning that simple textbook Phillips curves are bound to be mis-specified.

That evidence threw the spotlight on the likely importance of supply shocks in recent inflation dynamics in Brazil. Indeed, the paper then shows that the Brazilian economy has been systematically hit by large and adverse supply shocks in recent years, a fact that has impinged great difficulties to the Central Bank's main job of curbing inflation. From that perspective, it is not surprising that inflation targets have been missed in previous years, since not only has inflation been more difficult to forecast but also to control. Curiously, targets have been breached upwards while the Central Bank was criticised for implementing a too tight monetary policy.

Not surprisingly, the major source of shocks to inflation in Brazil has come from the exchange rate. However, it is called to attention that exchange rate shocks are not capable per se of explaining recent inflation dynamics and monetary policy actions, being just part of the story, albeit a crucial one. The other part refers to the wide and significant effects on price dynamics caused by privatisation in Brazil, which have virtually indexed utility prices to the exchange rate, at odds with the international experience. Hence, oddly, an important part of the service sector – a typical non-tradable sector – has become highly exchange rate sensitive after the privatisation. Nonetheless, due to the reasons laid out in the paper, those prices do not behave like a typical tradable good price. For example, the effects of exchange rate shocks on those prices are not only likely to be asymmetric but also take a long time to pass-through. More importantly, a large part of the consumer price index became interest rate insensitive. As a result, inflation has become much more persistent, requiring higher real interest rates to reduce it. Hence, the paper sheds light on the reasons why real interest rates have been so high in Brazil.

The importance of exchange rate shocks on inflation dynamics in Brazil has become clear in the empirical part of the paper. Among several proxies for shocks of different nature a particular one, which captures exchange rate shocks, was the only one always significant across specifications. Despite this empirical regularity, estimation faced numerous difficulties. Moreover, NAIRU estimates proved to be very sensitive to the inclusion and choice of supply shocks. This is not surprising since inflation is a complex and multivariate phenomenon. Indeed, even though the Phillips Curves laid out here are rich in supply shocks, one could easily come up with a list of variables that should affect inflation but are absent from the model. This is a particularity of the framework used, which assumes that the unemployment gap suffices to capture demand side pressures on inflation.

Although uncovering the Brazilian natural rate of unemployment was not an easy task, point estimates from several models seem to suggest that the Brazilian natural rate of unemployment lies somewhere in the 7.5%–8.5% range. From a policy viewpoint the evidence presented here suggests that despite the large increase in unemployment rates since the stabilisation of the economy the Brazilian natural rate of unemployment has been quite stable and lies below current unemployment rates. This finding has important implications. First, it shows that average unemployment based on a sample of the size of the one used here provides a poor estimate for the natural rate of unemployment. Second, unemployment gaps based on measures that follow closely actual unemployment are likely to produce wrong inferences. Indeed, the evidence presented here shows that HP filter-based estimates of the NAIRU are not in accordance with basic facts of the recent Brazilian economic history. Moreover, the qualitative accuracy of inflation forecasts from HP-based unemployment gaps perform very poorly when compared to gaps based on a constant NAIRU assumption. It is really worrisome that Brazilian economists have been using such estimates as inputs for assessing potential output and advocate policy actions based on them. Third, since current unemployment seems to be well above the NAIRU the evidence suggests that should the recent surge in economic growth continues, unemployment rates could decrease without pressuring inflation. Hence this is good news.

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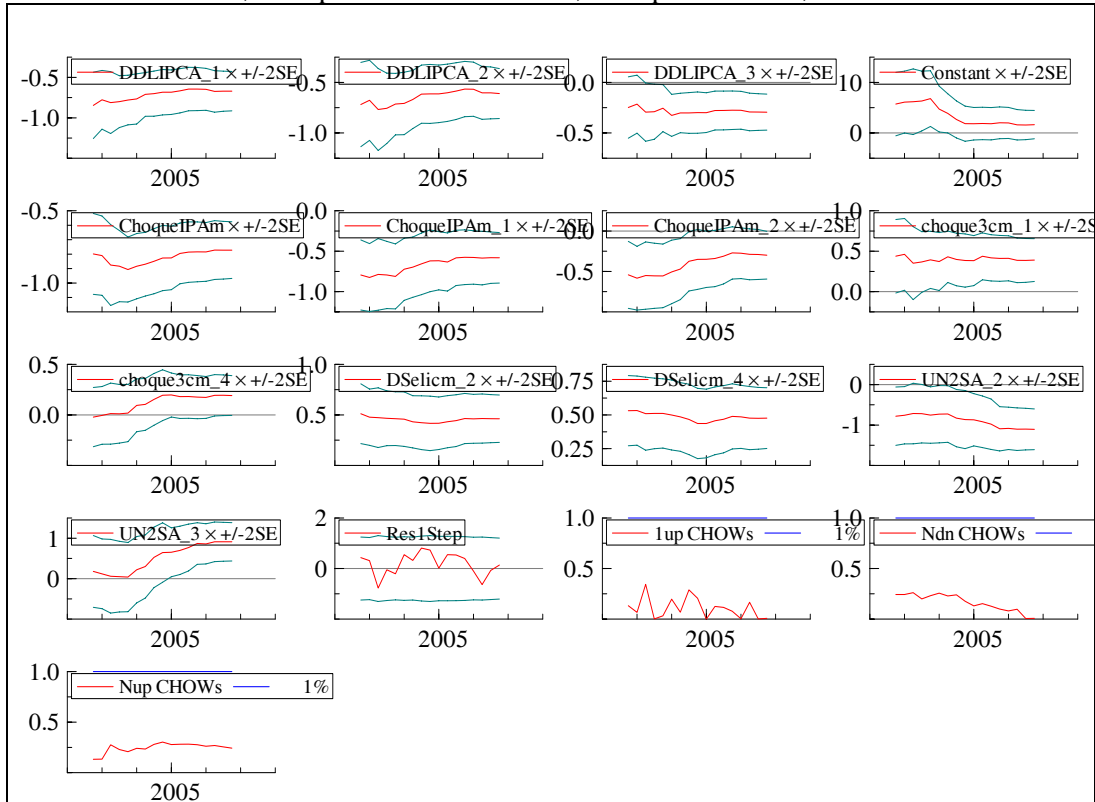
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Appendix

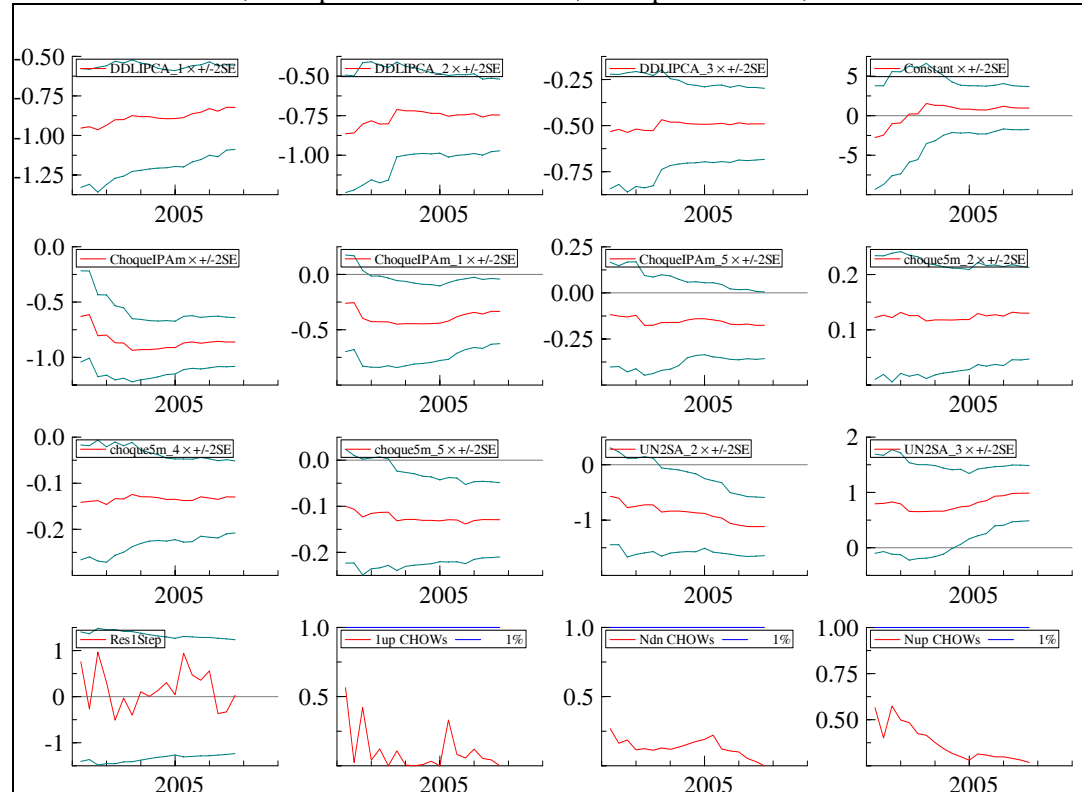
Model 1 (Constant NAIRU)

Recursive estimates, 1-Step Residuals ± 2 S.E., 1-Step Chow Test, Break-Point Chow Test



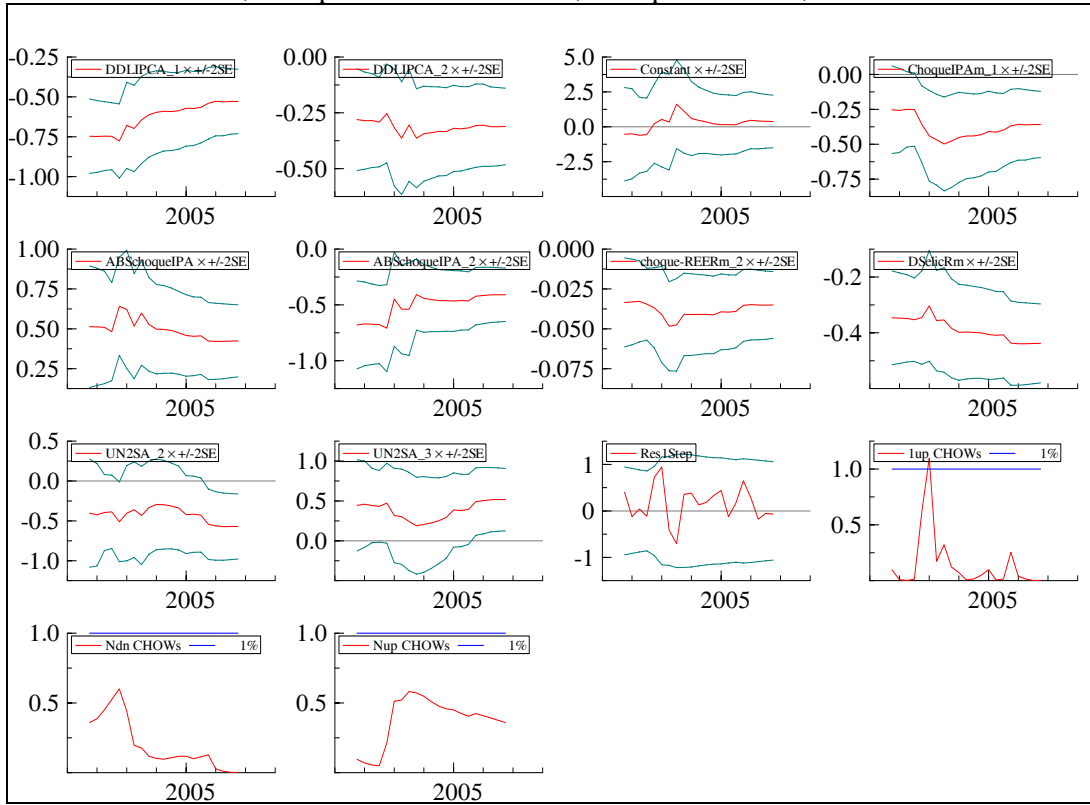
Model 2 (Constant NAIRU)

Recursive estimates, 1-Step Residuals ± 2 S.E., 1-Step Chow Test, Break-Point Chow Test



Model 3 (Constant NAIRU)

Recursive estimates, 1-Step Residuals +/- 2 S.E., 1-Step Chow Test, Break-Point Chow Test



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