Is There Too Much Certainty When Measuring Uncertainty? A Critique of Econometric Inflation Uncertainty Measures with an Application to Brazil*

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Abstract

This paper criticises the econometric inflation uncertainty proxies found in the literature, which show an overly optimistic picture about our real ability to forecast, and highlights the sharp contrast between the evidence portrayed by that literature and the evidence conveyed by the literature on surveys of inflation expectations. While the latter shows that actual forecasts are usually biased and systematic forecast errors are pervasive the former shows a much more optimistic picture, in accordance with the rational expectations paradigm. Also, both literatures have historically shown conflicting evidence on the inflation level – inflation uncertainty link. Next, the performance of inflation forecasts from both the Central Bank of Brazil Inflation Report and the Focus Survey are analysed. The paper then pinpoints some simple measures that could be taken to improve the reliability of econometric inflation uncertainty proxies, and carries out a (pseudo) real-time forecasting simulation exercise to derive a set of such proxies for Brazil. The features of those forecasts are shown to be very similar to those found in surveys.

Keywords: inflation level, inflation uncertainty, in-sample forecasts, out-of-sample forecasts, temporal inconsistency, forecast failure, surveys of expectations.
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"The main challenges facing the theory of economic forecasting, however, are to explain the recurrent episodes of mis-forecasting observed historically, and to develop methods which avoid repeating such mistakes in future."

David F. Hendry (2003)

1 – Introduction

Alan Greenspan (1996) stated "Price stability obtains when economic agents no longer take account of the prospective change in the general price level in their economic decision making". Blinder (1995) definition is similar: "The definition I've long used for price stability is a situation where ordinary people in their ordinary course of business are not thinking and worrying about inflation". Those definitions implicitly reveal two dimensions of price stability. The first could be called the "referee dimension", and is linked to the inflation level. This term is an allusion to an old football saying, which states that a good referee is the one whose presence in the pitch is barely noticed during the match. In the same way, price stability requires an inflation rate that is so low that people do not feel bothered about its existence. The second is the "time dimension", and is related to uncertainty. Even if inflation is low today there is no guarantee that it will be low tomorrow. In other words, price stability requires both low inflation and low inflation uncertainty, otherwise future inflation will still be a concern when economic agents make their medium and long-term plans.

Notwithstanding their qualities, neither definition gives a precise value for the inflation rate compatible with price stability. Meltzer (1997) was a little bit more specific and defined price stability as "… an inflation rate so close to zero that it ceases to be a significant factor in long-term planning". However, even inflation rates close to zero can make much difference over long periods. Suppose that a consumer buys a 25-year zero-coupon nominal bond for his retirement. If he assumes that the current inflation rate of, say, 1.5%, will prevail in the future, but average inflation turns out to be 2.5% instead, which still is a very low rate of inflation, he will incur a 40% unexpected loss. Unless one has some crystal ball revealing the future path of prices, the existence of inflation uncertainty has important implications for both economic theory and policy. Indeed, the literature about the costs and benefits of inflation points out that inflation uncertainty is a major cost of inflation. Not surprisingly, a central part of Friedman's (1977) Nobel Lecture dealt with the real effects of inflation uncertainty, which he claimed affects adversely unemployment, output and productivity.

There is overwhelming evidence that inflation uncertainty is positively related to the inflation level. If such a link exists, it has a direct policy implication, namely: the central bank should keep inflation low so as to keep inflation uncertainty also low. Similarly, one could argue that inflation-targeting countries should aim at setting inflation targets with narrow bands to minimise inflation uncertainty (as long as those bands are credible!). Furthermore, inflation uncertainty underscores the importance of knowing how expectations are formed. If agents' expectations are usually unbiased and efficient, as implied by the rational expectations *hypothesis*, then inflation uncertainty would have minor welfare costs and, consequently, it should not be a major concern for economic policy. However, if forecasts go often astray as Hendry's quote above suggests, then it has important theoretical implications that should be considered. Moreover, in this case one could call into question the usefulness of surveys of expectations for policy makers. If, when setting monetary policy, the central bank puts too much weight on market inflation forecasts, which are often not very accurate, it can produce undesirable effects on inflation control and, therefore, output volatility.

In order to address rigorously these and other questions, as well as test Friedman's hypothesis, it is essential that inflation uncertainty be measured as reliably as possible. By reliability one should understand measures aimed at reflecting *actual* uncertainty, and not measures that are in conformity with some paradigm, such as rationality. However, instead of being treated as a hypothesis that should be tested, rational expectations are usually taken as an axiom by economists. As a consequence, uncertainty has historically had a limited role in mainstream macroeconomics (e.g. certainty equivalence results). The intrinsic optimism conveyed by rational expectations has not been innocuous, though, and often economists' ability to understand real phenomena is hampered as unreasonable assumptions are *imposed* when testing hypothesis.

For example, inflation uncertainty studies usually encompass the 1970s and as it is widely known inflation rose both sharply and unexpectedly during the 1970s. The two oil shocks that hit the world economy at that time were unprecedented events, and no one knew how serious and persistent their effects would be, as well as the reaction of central banks. As a result inflation was highly unpredictable during the 1970s. Unequivocal evidence on this regard can be found in inflation surveys. For instance, commenting on inflation forecasts during the 1970s Croushore (1998) noticed that: "In the early 1980, economists tested inflation forecasts and found that forecasts were very bad. [..] However, the sample period being examined consisted mostly of data from the volatile 1970s, when forecasting was extremely difficult". David Dodge (2003), the current Bank of Canada Governor, has recently stated "Although inflation is now low, stable and predictable, this has not always been the case. Indeed, in the 1970s, inflation was high, unstable, and unpredictable. This led to the establishment of the Anti-Inflation Board (AIB) in 1975, where I worked as Research Director." In its turn, Ball (1990) highlighted the associated policy uncertainty at the end of the 1970s noting that "In the late 70s, it would have been difficult to predict that sharp disinflation would arrive in 1981–1982." Several historical examples show unequivocally that the rise in inflation during the 1970s was not anticipated and that the inflationary surprise was very costly to the economy. The failure of the so-called big macro models in the U.S., which began to perform badly in the 1970s, is another piece of evidence on the difficulties in forecasting at that time. Indeed, from a forecasting viewpoint Hendry (2000a) acknowledges that "…periods of forecast failure and economic turbulence often go hand in glove…"

However, when testing the link between the inflation level and inflation uncertainty, Engle (1983) made a truly remarkable statement. He stated that: "Although the level of inflation in the seventies was high, it was predictable". So, what explains Engle's assessment, which goes against a huge amount of evidence on the contrary, and whose paper has become an obligatory reference in the inflation uncertainty literature? A major problem with Engle's study, as well as with works that derive inflation uncertainty proxies econometrically, is *temporal inconsistency*. By estimating inflation uncertainty using the whole sample, instead of only data available at the time of the forecast, Engle threw out a huge part of the uncertainty forecasters faced.[1] The use of historically unavailable data is the most visible part of such inconsistency, but it is only part of the problem, since the 1970s inflation was obviously much better understood later on, and Engle benefited hugely from that hindsight. For example, he included import prices in his model, which accounted for higher oil prices. Interestingly, Stock and Watson (1999) argue that out-of-sample Phillips curve forecasts that include supply shocks variables, such as the relative price of energy, perform badly when compared to the corresponding models that exclude them, since the coefficients of those variables are poorly estimated for much of the sample. However, this situation changes when the whole sample (1959–1997) is used instead. Hence, including energy prices in whole sample estimation is likely to underestimate actual forecast errors, even if agents used them to forecast inflation at that time.

[1] A different but related problem is pinpointed by Orphanides (2000). He criticises many papers that analysed the optimality of the U.S. monetary policy showing that their conclusions were flawed since they used revised and definitive data.

Another major problem with Engle's approach is that in-sample forecasts are built to produce zero mean one-step ahead forecasts errors, in compliance with the rational expectation paradigm, and *regardless* of model's adequacy. However, if actual forecast errors are biased, any inference from a setting that did not allow for this possibility could be compromised. More importantly, if the econometric model is well specified, in-sample forecast errors should be uncorrelated, ruling out the possibility of long runs of positive and negative errors, a feature that has been widely observed in practice. Therefore, once the strong assumptions underlying in-sample "forecasts" are made clear, Engle's comments seem almost unavoidable. Greenspan (1999), for example, called to attention that "Forecasts of inflation and of growth in real activity for the United States, including those of the Federal Open Market Committee, have been generally off for several years. Inflation has been chronically overpredicted and real GDP growth underpredicted." Pagan (2001) also points out that "Problems in predicting inflation have been a worldwide problem in the mid to late 1990s and it seems that quite new perspectives may be required in order to produce good predictions of it from a model." Greenspan and Pagan's remarks are clearly illustrated by surveys of expectations and show that problems in forecasting inflation were not restricted to the turbulent 1970s as one might think, but are a more pervasive phenomenon.

Temporal inconsistency is also pivotal in some forecasting methods. For example, regime-switching models assume that agents know in advance how many different states there are in the world and are able to assess the probabilities attached to each of them, so that current inflation forecasts depend on information about future unknown regimes. Modern econometric techniques also call to attention another uncomfortable feature of recent econometric inflation uncertainty measures, which could be called theoretical inconsistency. In the same way that is crucial to restrict the information set to only historical available data when assessing forecast uncertainty, it is desirable to forecast inflation using methods similar to those that were actually available to most forecasters, if one wants to proxy the expectations prevailing at that time. Theory inconsistency can be split into two dimensions. The first refers to the forecast technique itself. For instance, it is unrealistic to assume that a forecaster (especially a professional econometrician!) would have predicted inflation before mid-1980s using an ARCH model, or before mid-1990s using an asymmetrical GARCH or Markov switching model, simply because those techniques were either not yet invented or not often used. Of course, one could always argue that those models are only intended to obtain proxies of inflation uncertainty and should not be interpreted literally. Although this argument seems correct, its implementation is problematic, since evidence shows that even qualitative results are highly dependent on the particular specification and method used, as one would expect (see Golob, 1993 and Holland, 1993). Moreover, economists do usually interpret the evidence literally and make strong inferences from it. Finally, since one is aiming at assessing the degree of uncertainty agents in general face, it would remain a puzzle how ordinary economic agents were able to produce forecasts with the same properties as those derived from highly trained, experienced, full time PhD economists using advanced techniques.

Secondly, many techniques were only possible to be implemented – and later on to became widespread used – due to advances in computing technology. Therefore, it does not seem rational (in the common sense of the word) to assume that forecasters outside universities – where technology lags behind – would have used techniques that would have required big processing power or very specific programs before the end of the 1980s and, sometimes, even well into the 1990s. Besides, even when technology is available there is a substantial time lag between inventions and its effective use by others, as the productivity literature shows. Even today, when econometric packages are user-friendly and widely available, informal evidence shows that many forecasters outside universities make predictions based on simple rules of thumb, extrapolations or other simple methods (see, for example, Coyle, 2000).

Finally, another important limitation of Engle's work is the focus on short-run measures of uncertainty, typically one-quarter ahead. This is unexpected since the literature about the costs of inflation makes it clear that the most relevant horizon for inflation uncertainty refers to the medium and long runs. For example, the inflation risk premium is usually an important component in longer-term bonds but not in shorter maturities ones. As a matter of fact, it must be said that one-quarter ahead inflation uncertainty has little relevance in most actual economic decisions (e.g. consumption).[2] This is particularly true in monetary policy decisions due to the lags involved in the transmission mechanism. Therefore, even when reliable, short-run uncertainty measures could be uninformative. Hence, one can characterize the econometric inflation uncertainty literature as focusing too much on estimation techniques and too little on the economic problem being analysed. Why is this so?

One explanation is simply to recognise that traditional one-step ahead in-sample forecasts are much easier to obtain than multi-step forecasts, since they come as a “bonus” with the estimation process. Although this reason seems dismal, very often economists’ choices are much more based on, say, models’ analytical tractability features (e.g. quadratic loss function) or simplicity (e.g. the use of HP filter to calculate the output gap) than on rigorous thinking or realism, and often strong conclusions and policy implications are derived from these flawed frameworks. Another hypothesis is that in-sample forecasts come already packed with rational expectations features (e.g. unbiased), which is not guaranteed in out-of-sample forecasts.

This paper takes temporal inconsistency seriously, and claims that economists have been too optimistic when assessing the degree of uncertainty forecasters actually face. By disregarding key limitations forecasters face in practice, econometric uncertainty proxies found in the literature are bound to underestimate actual inflation uncertainty being misleading. In order to establish and assess the degree of inflation uncertainty likely to be found in practice the international experience portrayed by surveys of expectations will be analysed, as well as some well-known cases of forecast failure. Finally, the historical inflationary experience of Brazil will be used to develop further the issue. Brazil is a very good choice to study inflation uncertainty since it can be characterized as a country with endemic inflation uncertainty.

Section 2 explains and provides evidence on why inflation uncertainty matters. Section 3 shows the pervasiveness of forecast failure in practice, a fact that is in sharp contrast with what one learns in macroeconomic textbooks. It also calls to attention that unbiasedness is a very poor criterion in judging rationality. Section 4 presents a selective review of the inflation uncertainty literature and highlights the conflicting evidence from econometric studies and surveys of expectations. Section 5 shows a dismal picture of forecast failure in Brazil in recent years, and provides some evidence on the significant costs caused by inflation uncertainty. Section 6 derives inflation uncertainties proxies for Brazil taking into account the issues of temporal and theory inconsistency, and shows how relevant both the information set and the forecast horizon are in assessing uncertainty. It also provides evidence on the inflation uncertainty-level link for Brazil. The following section concludes the paper.

2 – Why Does Inflation Uncertainty Matter?

Inflation uncertainty matters because the future is largely unpredictable and inflation is a key variable in economic agents’ decisions. Expected inflation is a key variable to consumers, for example, when deciding which mortgage plan to choose (i.e. fixed-rate or variable-rate) and how much to borrow, or yet how much to save for retirement. It is a crucial variable in firms’

[2] Notice, however, that when inflation is high the long-run is much shorter. In such a case one-quarter ahead inflation uncertainty is much more relevant than in a low inflation economy.

investment decisions since, for instance, it is closely linked to expected real interest rates. Since the tax system is imperfectly indexed, inflation uncertainty also creates uncertainty about future depreciation allowances and real tax rates. Investors care about expected inflation when buying bonds and the Government when making budget and long term plans.

Inflation uncertainty was a major factor behind the disappearance of the 25-year fixed-rate mortgages market in Canada as inflation increased, a phenomenon that was reversed in the 1990s as inflation decreased (see Coletti and O'Reilly, 1998). Another striking example of its costs is the crippled Brazilian credit market, in which medium and long-term fixed-rate financing virtually never existed. Similarly, the maturities of nominal public bonds have rarely been above two years in Brazil. Thus, incomplete credit markets are an unequivocal example of inflation uncertainty costs.

Yet, until recently, uncertainty played a limited role in some important economic subjects. Many models exhibited certainty equivalence results, where future inflation was simply and harmlessly replaced by its rational expectation forecast, which are assumed to be unbiased.[3] However, this is sharply at odds with the empirical evidence, which shows unambiguously that predicting inflation just one year ahead is a real challenge to forecasters. Gavin and Mandal (2003) show, for example, that the range of inflation forecasts made by FOMC members increases sharply when the forecast horizon is greater than one year.

Fortunately, since the 1990s uncertainty has become more than just a nuisance, with the arrival of the real options approach to investment, which unveiled the powerful effects of uncertainty when decisions are irreversible and possible to be postponed. Note, however, that even easy reversible decisions, such as buying a fixed-rate bond, can be highly affected by long-run inflation uncertainty. The major reason is that structural breaks are detectable only after some time. When it becomes clear that the actual inflation path is not in accordance with what had been anticipated (i.e. forecasts have gone systematically awry) the harm would already be done.

2.1 – Ex-Ante and Ex-Post Costs of Inflation Uncertainty

In spite of "uncertainty neutrality" results being commonly found in mainstream macro models, the literature about the costs of inflation has, for a long time, recognized inflation uncertainty as a major cost of inflation (e.g. Fischer and Modigliani, 1978).[4] More broadly, this literature distinguishes between the costs of anticipated and unanticipated inflation (i.e. inflation uncertainty).[5] The most intuitive reason why inflation uncertainty is costly is because things may not happen as expected, and the associated forecast error implies a loss. Those losses are defined as the *ex-post* costs of inflation uncertainty, which also entails defensive actions by economic agents, who seek to mitigate those costs. Those actions are defined as the *ex-ante* costs of inflation uncertainty, since if there were no uncertainty no action would be needed. Although both costs are linked, they are conceptually different. At first, one might think that *ex-post* costs, which are directly linked to the concept of forecast errors, are more relevant than *ex-ante* costs, but this is not necessarily true. For example, by affecting decisions – both qualitatively and quantitatively – and by diverting resources, inflation uncertainty reduces economic efficiency and, therefore, affects productivity. Thus, both types of costs are potentially serious.

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[3] The well known Lucas (1973) limited information model is actually a model of inflation uncertainty, where uncertainty affects real output only in the short-run, since forecast errors are *assumed* to be zero on average. However, Lucas' model is highly stylised. For example, it does not consider the effects of inflation uncertainty on credit markets and investment, which are likely to produce long-term effects.
[4] For a survey on theories about inflation uncertainty see da Silva Filho (2006).
[5] See, for example, Fischer and Modigliani (1978), Golob (1994) and Briault (1995).

Probably the most visible *ex-ante* cost of inflation uncertainty is the decrease on the average maturity of nominal financial contracts. This happens because whenever inflation is, say, higher than expected, creditors engaged in nominal contracts incur a loss and, consequently, debtors obtain a gain. In other words, there is an unanticipated wealth transfer from creditors to debtors. Therefore, under high inflation uncertainty economic agents prefer contracts with shorter maturities in order to protect themselves against unforeseen events. This phenomenon has been widely recognized and documented.[6] Besides moving to shorter maturity contracts agents also move from nominal to indexed contracts, especially in longer-term transactions. Consequently, agents require a risk premium when entering nominal contracts under inflation uncertainty, and this premium increases both with the degree of inflation uncertainty and the maturity of those contracts.

As a result, the real interest rate is likely to be higher in a high inflation uncertainty economy.[7] In its turn, higher real interest rates depress consumption, investment and are an extra burden to the Government, which has to pay more interest on its debt. Hence, the inflation risk premium embedded in nominal interest rates is another important *ex-ante* cost of inflation uncertainty. Not surprisingly, the relatively higher long-term interest rates in the U.S. during the 1980s and the beginning of the 1990s are usually attributed to the increase in the inflation risk after the 1970s high inflation period (Golob, 1994). Moreover, as mentioned above, when inflation uncertainty is high enough it may lead to the disappearance of some markets, which could be interpreted as agents requiring an infinite risk premium, ultimately causing the collapse of the market. Therefore, incomplete markets are an extreme cost of inflation uncertainty.

More broadly, by shortening planning horizons inflation uncertainty has important allocative effects. For example, higher real interest rates depress investment, especially longer-term investment, increasing the *relative* incentive to undertake shorter-term investment. If both types of investment are complementary, there will be an efficiency loss. Since the economy is not fully indexed inflation uncertainty also means uncertainty about future corporate tax rates and uncertainty about future depreciation rates. Both factors imply uncertainty about future corporate profits, which is likely to depress investment. Inflation uncertainty also means uncertainty about other economic variables, such as GDP, exchange rates and demand.

The *ex-post* costs of inflation uncertainty can also be very high. Indeed, the effects of forecasts errors go well beyond simply wealth transfers between individuals. They can be very costly to firms, sectors and even to the whole economy. Two crucial examples are: a) the crisis in the savings and loans industry in the 1980s, which impinged a large cost to the U.S. economy. Although one can argue that the crisis could have been averted or lessened by better banking regulation, as Golob (1994) points out "If the inflation of the 1970s had been less of a surprise, the taxpayer bailout of the industry might have been avoided"; b) the 1980s developing countries debt crisis can also be linked to inflation uncertainty. Indeed, it is argued that the over-borrowing by those countries during the 1970s was due to inflation uncertainty (see Selody, 1990). It seems unequivocal that had those countries anticipated, at least in some extent, the increase in inflation and therefore in interest rates, they would have adopted a different strategy: either by borrowing less or choosing fixed-rates loans, and the costs to their economies of changes in the U.S. monetary policy would have been much lower.

Finally, inflation uncertainty is particularly costly because it is closely linked to policy credibility. Since credibility requires a long time to build but can be suddenly lost, inflation uncertainty is likely to suffer from hysteresis. Once economic agents are stung by the costs of

[6] For example, see Klein (1975) for the effects of inflation uncertainty in the U.S. economy, and Coletti and O'Reilly (1998) and Stuber (2001) for the Canadian economy.

[7] The *ex-ante* real interest rate will certainly be higher, however, if large enough forecast errors are committed then the *ex-post* real interest rate may actually turn out to be lower during some periods.

higher unexpected inflation, as happened during the 1970s and 1980s, the inflation risk premium is likely to increase and remain high for some time after inflation decreases. Indeed, Gagnon (1997) argues that the higher inflationary past in Canada and New Zealand vis-à-vis the U.S. and Australia respectively, explains the higher long-term real interest rates observed in the former countries relatively to the latter, despite the fact that at the time of the analysis they had smaller inflation rates than their neighbours in the previous five years. This finding implies that by keeping inflation low for a long enough period the central bank could reduce sharply inflation uncertainty and, therefore, the inflation risk premium.

2.2 – Indexation and Inflation Uncertainty

When analysing the costs of *anticipated* inflation Fischer (1981) argued that some of its costs are "almost entirely avoidable", especially those stemming from the perverse interaction between inflation and the tax system. Although he focused on the costs of anticipated inflation, it is obvious, as argued above, that indexation also lessens sharply the costs of unanticipated inflation. Given this assessment, economists have been struck by the fact that indexation is not nearly as widespread as it should be, a puzzle that has been highlighted by Shiller (1997). The evidence shows that only when inflation reaches fairly high levels does "the public resistance to indexation" fade away more consistently.

Fischer and Summers (1989) note that "The absence of indexation is not an accident. Policies directed at mitigating the effects of inflation are often seriously put forward. For example, the original Reagan Administration proposal for tax reform called for the use of indexing in measuring capital income; and a transition advisory team for that administration recommended the issue of indexed bonds. Both proposals were quickly discarded". Indeed, only in 1997 were inflation-indexed bonds finally introduced in the U.S. However, even though indexation sharply reduces tax-related distortions caused by inflation, its efficacy in mitigating the costs of inflation uncertainty is not as obvious and large as many economists seem to assume. Notwithstanding Shiller's argument that there seems to be some non-rational factors behind such puzzle, Stockman (1993) notes that "Perhaps economists have overstated the gains from indexing – if they were so large, we would see more indexing in private contracts".

In fact, Schultze (1997) argues that Shiller's conclusions are based on the demand-side evidence for indexation, but not on the supply side, from where, he claims, most of the resistance to indexation comes from. In that case, he argues, the resistance to indexation is partially justified, making the evidence less puzzling. He gives the following example, reproduced partially here: "Take the case of indexing a private bond issue. There are three reasons why indexation might increase the risks faced by a firm. First, some inflation surprises originate from supply shocks. In such cases, the increase in average product prices that gives rise to an additional nominal obligation under indexation will not be matched by an equivalent increase in a firm's ability to pay. Second, monetary shocks work their way through the economy by complex processes, which, in the transition period, may involve substantial changes in the relative prices and fortunes of individual firms". Indeed, whenever incomes and revenues received by households and firms respectively are not perfectly correlated to expenditures made by the former and costs faced by the latter, indexation could involve important risks, and does not provide full insulation from inflation (and other types of) uncertainty. Hence, due to risk aversion, many consumers prefer to pay a high-risk premium in nominal contracts to avoid such kind of unpleasant surprise. Therefore, even under indexation, consumption and investment decisions are likely to be affected by inflation uncertainty. Likewise, investment decisions become more difficult under inflation uncertainty, as nominal and real returns are harder to assess.

Even in those cases when indexation is desirable it might not fully insulate economic agents from inflation uncertainty. In other words, indexation is usually imperfect. One reason is that it typically lags behind inflation. As Friedman (1977) notices "Price indexes are imperfect; they are available only with a lag and generally are applied to contract terms only with a further lag." A related but different problem is that indexation might occur with "the wrong frequency". For example, even during high inflation in Brazil rent prices were not as frequently corrected as many other prices in the economy. That sometimes meant huge differences between the real value of the first and the last rent payments within the same contract, causing many distortions. Schultze (1997) cites evidence on "the substantial difficulties faced by private firms in providing protection in pension formulas during the working life of an individual…" Indexation can also be imperfect due to other reasons. For example, if housing loan instalments are not allowed to exceed a certain proportion of an individual's income, and the real interest rate rise sharply or his income does not keep in pace with inflation, then an outstanding residual, which can be substantial, will remain to be paid at the end of the contract. Problems similar to this were frequent in Brazil and caused a huge deficit in the public housing finance scheme.

Due to the above asymmetries, under some circumstances, agents might feel more comfortable with nominal contracts, since they know in advance how much they will pay or receive in the future.[8] Thus, nominal contracts are not dominated by indexed contracts in all states of the world. Indeed, interestingly, notice that even in countries where indexation is widespread and easily understood by agents, such as in Brazil, the evidence shows that whenever inflation fell following stabilisation plans, the share of nominal public bonds increased (see Graph 6 in Section 5), indicating that indexed and nominal bonds are not perfect substitutes.

Although most indexation supply seems to come from the public sector, there are many reasons why the Government may not desire to or should not index the economy. For example, Fischer and Summers (1989) argue that decreasing the cost of inflation through indexation could be dangerous and end up causing more inflation. Indeed, in countries with high inflation history such as Brazil indexation is seen as a bitter remedy (even though it contributed decisively to avoiding dollarisation), since while it lessens the costs of inflation it also increases its persistence, making stabilisation more difficult. Coping with inflation inertia due to widespread indexation was a major issue in all stabilisation plans in Brazil, and the decrease in indexation after the successful Real Plan, was celebrated as a key evidence of victory in the fight against inflation.

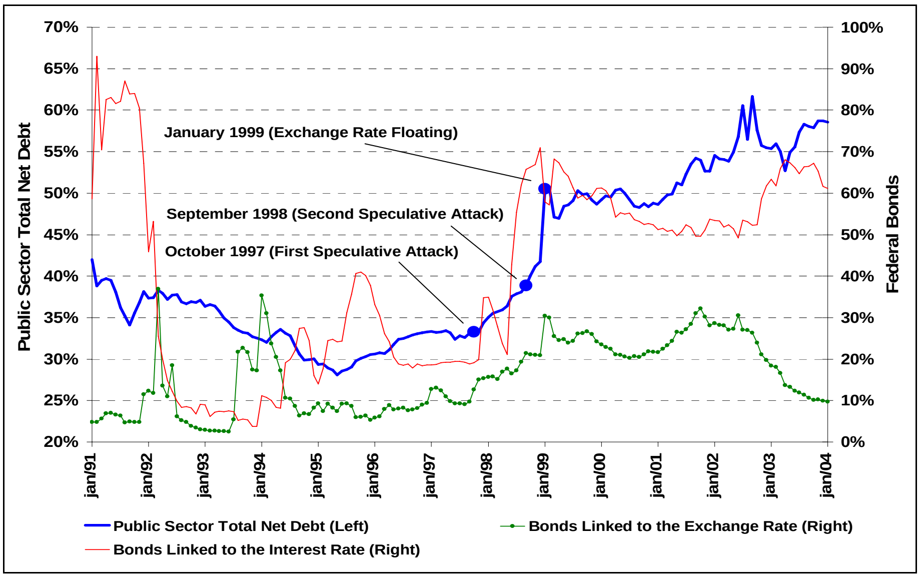
Indexation has also other important effects for public policy. For example, the indexation of public bonds to the short-term interest rate can decrease the efficiency of monetary policy, since an increase in interest rates lead to an increase in bondholders' wealth. By making the short-run Phillips curve more vertical wage indexation affects the trade-off between inflation and unemployment (see Fischer and Summers, 1989; and Landerretch *et al.* (2002). Moreover, indexation of prices, and wages in particular, can hinder price flexibility in face of supply shocks (Landerretch *et al.*, 2002). Indeed, even strong supporters of indexation such as Shiller (1997), are cautious when talking about wage indexation. Schultz (1997) notices that it is easier to implement real wage cuts through inflation than by decreasing nominal wages, and argues that the lower degree of wage indexation in the U.S. compared to Europe explains the lower NAIRU in the former relatively to the latter.

Graph 1 provides a recent and shocking picture of how costly indexation could be when things do not go according to plans. From 1994 until 1998 Brazil had the well-known combination of a fixed exchange rate regime, an overvalued currency and large current account deficits. Given that fragile position, there was a speculative attack against the real

[8] For example, a very common way people do calculations when making such kind of decisions is by assessing the size of nominal instalments relatively to their income.

following the Asian Crisis in 1997, and the Central Bank was obliged to increase sharply the interest rate from 19% to 46% per year to defend the parity. Then, following the Russian default in 1998 there was a second speculative attack, and once again the Central Bank decided to raise the interest rate, now from 19% to over 40%. Since a large share of public bonds was indexed to the overnight interest rate, both rises meant a sharp increase in the debt to GDP ratio, adding worries about the fiscal side to the already fragile economic outlook.

Graph 1
Fiscal Performance and Indexed Public Bonds in Brazil



Moreover, imprudently, since the onset of the Asian Crisis the Government had decided to provide an extra amount of hedging to the private sector and increased sharply the share of bonds indexed to the exchange rate. As a result, when the fixed exchange rate regime collapsed in January 1999 the debt to GDP ratio soared almost immediately, and more serious concerns about fiscal sustainability came to haunt the market. To make matters worse, that strategy remained unchanged and fears of a leftist win in the 2002 elections caused further sizeable exchange rate depreciation and the debt to GDP ratio reached very high levels prompting fears of default once again. The final outcome was a striking increase in the debt to GDP ratio from 33% to almost 60% in just five years (from the last quarter of 1997 to the last quarter of 2002), imposing great costs on the Brazilian society for many years ahead.

To summarise, although indexation is a key measure to mitigate the costs of inflation it is not a panacea. First, there seems to be a somewhat puzzling resistance to indexation, which means that indexation is likely to be limited. Second, even when desirable indexation is not perfect so that it does not fully insulate the economy from inflation uncertainty effects. Third, indexation may involve important risks. As Friedman (1977) nicely puts “In addition, indexing is, even at best, an imperfect substitute for the stability of the inflation rate.”

3 – Forecast Failure, Inflation Uncertainty and Rational Expectations

> "Cynics have suggested that God made economic forecasters to make weather forecasters look good. But at least weather forecasters can look out the window, and with reasonable accuracy know what the weather is at the present time. Economic forecasters do not have that advantage."
>
> Donald Brash (1998)

In one of the most ironic and embarrassing situations in economics, while mainstream macroeconomics assume axiomatically that agents' forecasts are accurate and no systematic errors are committed, jokes about economists' ability to forecast flourish outside universities.[9] Indeed, Clements and Hendry (2000) stated that "Forecast failure has occurred sufficiently frequently in macroeconomics that 'economic forecasting' has come to have some of the same connotations as 'military intelligence'.", while Zarnowitz (1991) had already recognized that "There has been much disenchantment with economic forecasting." Worse, there is wide evidence that forecast failure is particularly high when forecasts are most needed: in turning points, increasing its pernicious effects (see Zarnowitz, 1991; Loungani, 2000). Nonetheless, the rational expectations paradigm continues to be widely used by economists, both in theoretical and applied work, and this has also been the rule in the inflation uncertainty econometric literature. For example, Holland (1984) shows how one could test the inflation uncertainty-level link: "First, we need an inflation expectations model that provides unbiased forecasts over both lower and high inflation periods; we can then test whether the error variance is larger for the higher inflation period."

Surprisingly, it seems that a major reason underlying the gap between theory and practice is simply rhetoric. The term rational expectations tailored by Muth (1961), is probably the most unfortunate definition in the history of economics. By naming a given expectation formation mechanism with the very attribute that distinguishes man from all other living beings, it has become extremely difficult to argue against "rationality", even when used in a very specific context and, in fact, has little to do with rationality itself. Indeed, the association is inevitable as calling one irrational is pretty much like an insult, which embeds a moral judgment. For example, Poole (2001) is extremely careful when arguing that expectations may not be rational by stating that: 'I use the word "nonrational" rather than "irrational" because the latter sometimes carries connotations that I do not intend. Expectations may depart from full rationality without being "crazy," "silly," "emotional," or "stupid".'

As a result, one is able to find many papers in the literature, dealing directly or indirectly with rationality, whose conclusions do not match the evidence presented. In some cases, when economists find (reluctantly) any evidence against "rationality" they act almost as if apologising for that finding. And, when the evidence is overwhelmingly convincing they usually try to *rationalise* features such as bias and systematic forecasts errors and simply *redefine* rational expectations, making it one of the most volatile concepts in economics.[10] For example, Evans and Wachtel (1993, p. 476), argue that: "An alternative explanation [for biased and persistent forecast errors in surveys], which has received less attention, is that forecasters are acting rationally, but face a complicated forecasting problem that makes systematic forecast errors unavoidable. (…) their forecast errors, although rational, may be serially correlated and systematically different from zero." Similarly, Thomas Jr. (1999)

[9] The main point here is not to assess whether most criticism are soundly based or not, but rather to recognize the existence of substantial forecast failure in practice.
[10] Another common procedure is to say that expectations are not *fully* rational, whatever that means.

notices that "…unforeseeable "regime changes" can result in forecasts that result in systematic errors in certain periods, even when agents are fully rational".

Regardless of its veracity, such kind of explanation conflicts with the very definition of rational expectations, which states that the agent knows the "true model" of the economy.[11] More importantly, what matters for economic theory is not whether forecasts can bear the noble attribute of "rationality", but the consequences of much evidence against its main implications: that forecasts should be both unbiased and efficient. Indeed, Cukierman and Wachtel (1979, p. 597) explain that "Expectations regarding the general price level are formed rationally in the sense that given the currently available information, participants in each market use the structure of the economy, which is known to everyone, to form optimal forecasts." Poole (2001) defines in the same way: "By "rational expectations" I mean that market outcomes have characteristics as if economic agents are acting on the basis of the correct model of how the world works and that they use all available information in deciding on their actions".[12] Hence, the main implication of rational expectations is that there is no room for systematic forecasting errors and biased forecasts. However, given our limited understanding of how the economy works (indeed, disagreement is the rule not the exception among economists!), the countless practical difficulties involved in forecasting, such as the costs involved in acquiring and processing information, it may not be rational to assume rational expectations.[13] As Hendry notices (1995) "In general, Muthian expectations are economically rational expectations only if there are no costs to discovering the true data generating process (d.g.p.), or collecting and processing information: in other words, only if econometrics is not needed." Ironically, one of the first to acknowledge the unreasonable assumptions behind Muth's definition of rationality was Sargent (1993) himself, one of the very founders of the rational expectations revolution, who stated that "rational expectations models input much more knowledge to the agents within the model … than is possessed by an econometrician, who faces estimation and inference problems that the agents in the model have somehow solved."

The pervasiveness of systematic forecast errors in practice shows that economists still have much to learn about how agents form their expectations. Even so, as Carroll (2001) points out "Yet in recent decades macroeconomists have devoted almost no effort to modelling actual empirical expectations data, instead assuming all agents' expectations are rational." Ironically, one of the most robust evidence that has emerged during this period is that agents' expectations are heavily influenced by past events and, in general, they follow rather than anticipate facts. Nordhaus (1987), for example, shows that one prominent feature of actual expectations is that they are smooth, which is a sign of inefficiency, since it indicates that news are incorporated slowly. Notwithstanding the fact that rational expectations continues to be a religion in mainstream macroeconomics new theories are slowly emerging, such as the unavoidable "bounded rationality" (see Sargent, 1993), once again not the most appropriate name, adaptive learning (see Evans and Honkapohja, 2001) and epidemiological expectations (see Carroll, 2001).

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[11] Note that the term regime change has frequently been inappropriately used as a catchall for justifying unexpected outcomes. Moreover, such reasoning leaves many issues answered, such as why after so many periods (sometimes years) of, say, inflation underprediction, agents do not review their priors about regime change. Such slow learning is difficult to understand from a rational expectations perspective. Note also that forecasts produced by such models generate systematic forecast errors by construction, in order to match the empirical evidence. This forecasting mechanism is not optimal (see Hendry, 2000b, 2003) and may imply large losses in practice.

[12] First impressions on the contrary the expression "all information" is very loose for practical purposes, and therefore does not provide a useful benchmark for forecasts to be judged on. Therefore, "rationality" is usually divided in its weak and strong forms, in accordance with the information set used, but the problem remains unsolved.

[13] One major difficulty is forecasting in a non-stationary world, which is constantly subjected to structural breaks (see Clements and Hendry, 1999).

One of economists' major misconceptions is the overwhelming emphasis on unbiased forecasts as a major proof of "rationality", as the following simple example shows. Consider a given period in which inflation first rises and then drops, a dynamics similar to the U.S. inflationary experience during the 1970s and 1980s. More specifically, consider that in each period inflation is driven by the following two-regime random walk with drift process.

$$\pi_t = \begin{cases} 0.6 + \pi_{t-1} + \varepsilon_t & 1 \le t \le T_1 \\ -0.6 + \pi_{t-1} + \varepsilon_t & T_1 < t \le T \end{cases} \tag{1}$$

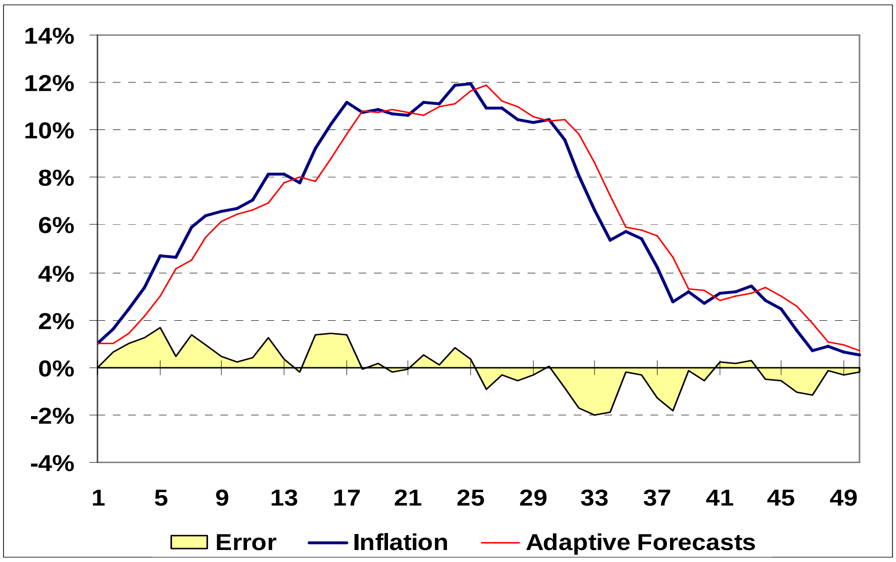
where: π_0 = 1 and $-1 \le \varepsilon_t \le 1$ comes from a uniform distribution and T_1 = 25 and T = 50. Also, assume that expectations are adaptive and evolve according to the following simple mechanism.

$$\pi_t^e = \pi_{t-1}^e + 0.7\varepsilon_{t-1} \tag{2}$$

where $\varepsilon_{t-1} = \pi_{t-1} - \pi_{t-1}^e$.

Graph 2 shows the simulated inflation series and one-step ahead forecasts (for one sequence of draws from the assumed distribution). Although expectations are purely adaptive and systematic errors are committed (underprediction in the first half and overprediction in the second half), the bias over the whole sample is statistically equal to zero. Therefore, finding that a given sequence of forecasts is unbiased does not mean very much in terms of rationality. Indeed, when comparing the performance of inflation expectations from the Livingstone and Michigan Surveys with that of a naïve, purely backward-looking forecast, during the 1960.1–1997.4 period, Thomas Jr. (1999) found that the latter produced a bias equal to zero, well below that found in both surveys. When analysing the performance of Federal Open Market Committee (FOMC) members' inflation forecasts, Gavin and Mandal (2003) concluded that "Interestingly, the naïve inflation forecasts was less biased than the FOMC forecasts at the 12-month horizon and they were essentially the same for the 18 and 6-month horizons." Graph 2 also shows that the existence of bias depends crucially on the sample period considered. Indeed, given a carefully chosen period or a long enough sample for a cyclical variable, it would be a surprise if forecasts weren't unbiased.

Graph 2
Adaptive Expectations and Unbiased Forecasts



Finally, notice that equation (2), which represents the usual textbook adaptive expectation mechanism, assumes that the adjustment coefficient is constant over time. However, one could devise more elaborate mechanisms, for example one in which the size of the adjustment coefficient varies accord to the size and persistence of forecast errors, for example.

$$\pi_t^e = \pi_{t-1}^e + \theta_t \varepsilon_{t-1} \tag{3}$$

where: $\theta_t = f\left(\varepsilon_{t-1}, \varepsilon_{t-2}, \cdots\right)$ and θ_t is *not* restricted to be $0 \le \theta_t \le 1$, as usually assumed. In this case, after a run of systematic errors or few large errors agents may decide, for example, to overcorrect (i.e. adjust their expectations by more than the last forecast error, in order to catch up with actual inflation). This is a much more plausible adaptive mechanism to consider than the didactic but simplistic one given by (2). However, it is much more difficult to be dealt with on mathematical grounds.

3.1 – Forecast Failure

This section provides a glimpse on the pervasiveness of forecast failure in practice, more specifically, on the evidence portrayed by surveys. The focus is obviously on inflation but GDP forecasts will be mentioned too, given its link to inflation through the output gap. Loungani (2000) analysed private sector GDP forecasts during recession years for 63 countries, both developed and developing, from October 1989 to December 1998, and a very dismal picture about forecasters' abilities to predict turning points emerged: among 60 recession episodes he showed that by the last quarter of the preceding recession year only 3 cases were predicted. In April of the recession year two thirds of the episodes were not yet anticipated although forecasts became more pessimistic, which means that forecasters failed to forecast recessions even when they were already underway! Moreover, when the recession scenario was finally identified (typically in the last quarter), its magnitude was usually underestimated. Therefore, the evidence of bias should not come as a surprise. Indeed, forecasts made in April of the recession year presented a significant bias of 1.84 percentage points in developed countries and of 4.89 percentage points in developing countries.

Fintzen and Stekler (1999) noticed that U.S. recessions "have generally not been predicted prior to their occurrence". They also pointed out that the 1974, 1981 and 1990 U.S. recessions were not recognized even as they occurred. Even considering data revisions and information lags this is a very poor record, however it should not come as a shock. Zarnowitz (1986), for example, had already noticed for the U.S. that "major failures of forecasting are related to the incidence of slowdowns and contractions in general economic activity. (…) Forecasters tend to rely heavily on the *persistence of trends* in spending, output, and the price level.", which means that expectations have a big backward looking component. This finding should not be unexpected since this is exactly what is behind econometrics. Econometric-based forecasts are intrinsically backward looking, since they rely on three conditions: a) that there are some empirical regularities to be captured; b) that the model is able to capture those regularities; c) that the future can be predicted using those regularities. Hence, if there are no regularities to be captured econometrics is worthless.

Bakhshi and Yates (1998) investigated the "rationality" of the one-year ahead inflation forecasts from the Gallup UK employees' survey of inflation expectations, during the 1984–1996 period, and from the Barclays Basix survey, during the 1986–1997 period. They found that expectations in the former survey systematically overstated inflation by 2.5 percentage points on average, and that a one percentage increase in actual inflation led to nearly 0.75 percentage point increase in expected inflation. Bias was also found in all professional categories surveyed by the Barclays Basix survey, although in smaller magnitudes. Moreover, he showed evidence that different categories varied sharply in their inflation expectations. Brischetto and de Brouwer (1999) analysed a very detailed Australian household survey and, not surprisingly, also found that average inflation expectations vary widely according to personal characteristics. People who have better access to information or more developed information-processing skills, such as those in professional jobs, more educated or older people, tend to have more accurate expectations. Moreover, although higher income earners and better-educated people do seem to produce more accurate expectations, they bear some problematic features such as "… there is little evidence that people form their expectations about future inflation on the basis of the sort of economic relationships highlighted by economists." Indeed, expectations were found not to be correlated with key structural determinants of inflation, such as the output gap.

Thomas Jr. (1999) analysed the performance of the one-year-ahead CPI forecasts in the U.S. from both the Livingstone and Michigan Surveys during the 1960.1–1997.4 period, and found no bias in both surveys when the whole 38 years sample was analysed.[14,15] However, when the sample was divided in two periods, 1960.1–1980.2, in which inflation trended upwards, and 1980.3–1997.4, in which inflation trended downwards, he found very persistent forecast errors. There was recurrent under prediction in the former case (mean errors equal to –1.6 and –0.3 percentage points, respectively) and over prediction in the latter (mean error equal to 0.84 and 1.07 percentage points, respectively). Also, expectations were significantly biased in both periods for the Livingstone Survey and in the second period for the Michigan Survey. He also pointed out that inflation forecasts turning points lagged behind actual inflation turning points suggesting "… a strong adaptive or backward-looking element in the formation of inflation expectations." Croushore (1998) also investigated both surveys and the qualitative results are similar to those of Thomas Jr (1999), namely: systematic errors during certain sub-samples but unbiased forecasts over the whole sample. He also investigated the Survey of Professional Forecasts (SPF), finding the same pattern once again.

3.2 – Do "Conspiracy Theories" Explain Forecast Failure?

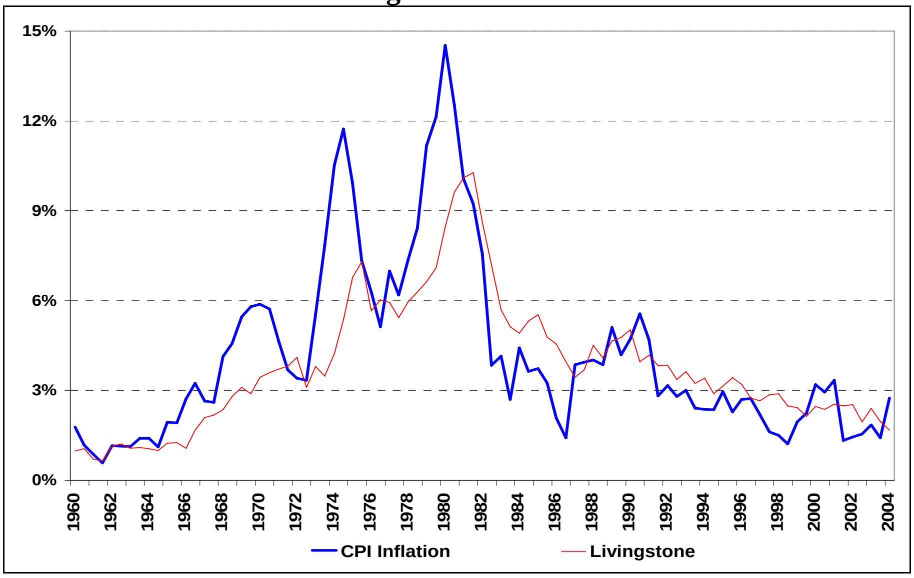
As the last section has shown there is a sharp contrast between the evidence portrayed by surveys of expectations and the implications of the rational expectations paradigm. Graphs 3 and 4 show that discrepancy explicitly, comparing actual U.S. inflation with the mean of one-year ahead inflation forecasts from the Livingstone and Michigan Surveys. Each point in the graph gives actual annual inflation and the corresponding forecast made one year *earlier*. As it can be seen there have been systematic inflation forecasts errors in both surveys. Notice also that: a) despite the very different groups being surveyed (economists and households, respectively), the pattern of forecast errors is very similar, with systematic underprediction during the 1980s, when inflation was rising, and systematic overprediction during the 1980s, when inflation was falling. That is, agents usually react to rather than anticipate movements in inflation; b) the overprediction continued during the calm 1990s, suggesting that the large economic shocks that hit the U.S. economy during the 1970s and first half of the 1980s were not the only or perhaps even the main factor behind forecast errors. In other words, forecast failure is a much more pervasive phenomenon than one could have thought. Although both being U.S. surveys, the same evidence is portrayed by other countries' surveys as well.

Ironically, this conflicting evidence emerged following economists interests on expectations in the wake of the rational expectations revolution in the 1970s. That unexpected situation led economists to conclude that either surveys were wrong, not capturing expectations properly, or agents were "irrational". Very conveniently they picked the first option, and turned their backs on surveys of expectations. As Croushore (1997) explained when commenting on some early scepticism on surveys: "If the survey [the Livingstone Survey] did represent true forecasts, people weren't rational, according to his statistics tests. And that's hard to believe

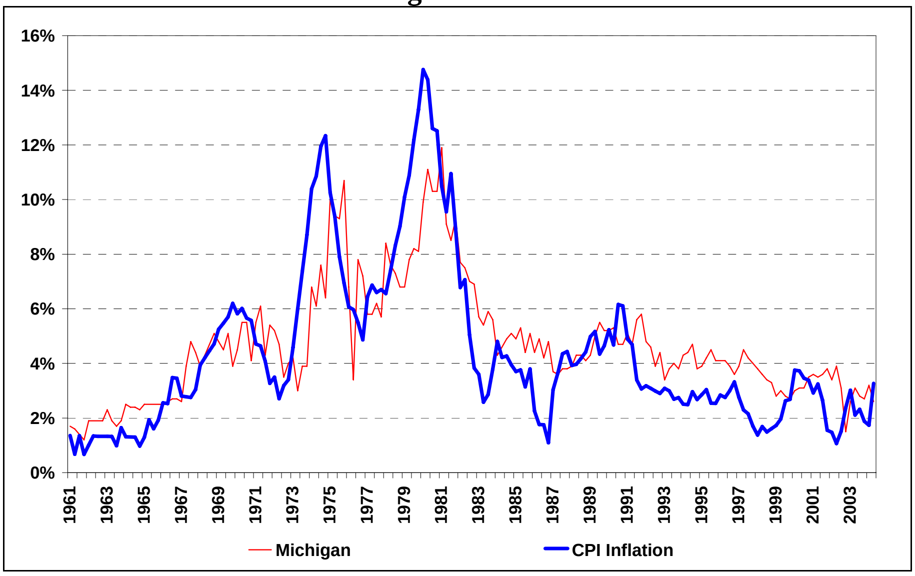
[14] Croushore (1998) provides a concise summary on those surveys.
[15] However, it should be pointed out that the size of mean errors are probably *economically* relevant, and amounted to –0.48 and 0.33 percentage points, respectively.

because people would lose money in financial markets if they weren't rational." This kind of conclusion that emerged early on in the survey literature is both simplistic and flawed.

Graph 3
One-Year Ahead Livingstone Forecasts vs. CPI Inflation



Graph 4
One-Year Ahead Michigan Forecasts Vs. CPI Inflation



Despite the disbelief from the economics profession, surveys of expectations mushroomed after the 1970s, and today they have turned into a valuable source of information both to businessman and the government alike, especially central banks. And, although the bulk of the profession continues to ignore such evidence, as it became clearer that the initial disappointing results were actually correct, economists came up with more elaborate arguments to cope with that embarrassing situation.[16] The reasons usually hinge on the notion of "strategic behaviour" by agents, in which either they do not have the proper incentive to provide their true expectations, due to several reasons, or they have other objectives when

[16] Moreover, economists who have taken seriously the evidence portrayed by surveys have found that empirical macro models work better when model-consistent expectations are replaced by survey-based expectations [e.g. Roberts (1997, 1998)].

predicting.[17] For example, it has been argued that disclosure may influence agents' reporting, since once individual forecasters are identified they may also seek to market themselves producing bold forecasts instead of providing their best ones. According to Croushore (1997) this is the reason why the Livingstone Survey does not identify individual forecasts. It has also been argued that there is herding behaviour (i.e. forecasters seek to stick close to the consensus, so as to when forecasts are wrong they do not look bad relatively to others).

Although the sort of "conspiracy theories" mentioned above is plausible in theory, it is really difficult to believe that they are responsible for both the bulk and pervasiveness of forecast failure in practice. Rather, they are likely to be, to a large extent, rationalisations. Moreover, there is no way to get rid of some of them. For example, one can always argue that whenever a survey does not identify individual forecasts one has little incentive to be accurate, since getting it right will not be translated into higher reputation. However, one could also argue that visibility could either induce someone to make bold forecasts to gain publicity or to converge to the consensus in order to hedge against large forecast errors. Therefore, one's objection is another one's solution. Furthermore, instead of strategic herd behaviour there could be a genuine consensus given that most forecasters share basically the same information (although backgrounds do vary a lot). The argument of publicity is also hard to be taken seriously. While it is certainly possible that once in a while one tries to stick out from the crowd, just a few large forecasts errors could ruin one's reputation if the forecasts are far from the consensus. Finally, and most important, the evidence portrayed by surveys is basically the same regardless whether the survey is anonymous or not, and whether those surveyed are common citizens or professional forecasters, as Graphs 3 and 4 have shown.

However, one could argue that the ultimate evidence in this regard is provided by central banks' forecasts, since the usual objections concerning private surveys do not apply to forecasts from high reputable central banks, especially those operating under inflation targeting frameworks. Those central banks have all the incentives to produce good inflation forecasts, since price stability is their main objective. Furthermore, accurate forecasts are directly linked to obtaining and maintaining credibility. Not surprisingly central banks have large research staffs, with high-qualified economists, working exclusively to understand how the economy works and using several different models, which are constantly updated, to produce good forecasts. Finally, central banks are intrinsically forwarding looking and their forecasts are the result of both carefully designed econometric models and inputs from experts' judgments.

Brash (1998) gives a very good account of what is behind the Reserve Bank of New Zealand forecasts, the first central bank to adopt inflation targeting: "The Reserve Bank devotes very considerable effort to its projections. We study a very wide range of data from New Zealand sources of production, prices, wages, money supply, bank credit, business and household confidence, and much more. (…) Before each quarterly projection, a group of Reserve Bank Staff fans out across the country and talks to upwards of 40 businesses and business organisations to get an up-to-the-minute impression of what a small number of – hopefully – representative firms are experiencing. (…) We talk to Statistics New Zealand to try to get an understanding of what lies behind some of the statistics. We talk to the producer boards to get an understanding of what is happening in the agricultural sector. As a result, we go into each quarterly projection "round" armed with a very great deal of information on the New Zealand Economy." Although being just a partial quote, it should be more than enough to convince one about the huge effort behind central banks' inflation forecasts. Even so, Brash does not share the same certainties of academic rational expectations economists and points out humbly that: "The only way the Reserve Bank could avoid the embarrassment of being wrong about the future at least as often as being right would be to stop publishing our projections."

[17] See, for example, Ehrbeck and Waldmann (1996) and Laster *et al.* (1999).

Indeed, McCaw and Ranchhod (2002) analysed the Reserve Bank CPI forecasts from December 1994 to September 2002 and showed that CPI inflation had been systematically under-predicted during that period. The under prediction amounted to almost 0.7 percentage points in one year ahead forecasts and nearly 0.9 percentage points in two years ahead forecasts. Those biases are large by themselves, however when one considers that during most of this period inflation was supposed to be kept below 3%, they are even more meaningful. They noticed that the usual assumption of unchanged interest rates when forecasts are made changed after mid-1997, when a path for interest rates (and also the real exchange rate) has begun to be assumed. However, interestingly, when they compared the forecast performance in the two periods, one-year ahead average forecast errors turned out to be higher in the second period. Despite the smaller magnitudes involved, the Bank of England has also been criticised by committing systematic inflation forecasts errors. Wadhwani (2002) a former member of the Bank's MPC notices that "… the actual outturn for inflation has always been lower than the MPC's two-year ahead forecast, with an average error of up to around 0.5%". He also pointed out that "Moreover, inflation appears to have come in below the published Inflation Report forecasts in the pre-Bank independence period as well (Table 2)." Then he shows that from the first quarter of 1995 until the last quarter of 2001 two-year ahead inflation forecasts overestimated inflation by nearly 0.3 percentage points on average.

Gavin and Mandal (2003) evaluated the performance of FOMC members' inflation forecasts for the 1979–2001 period, which are highly relevant since they pertain to those that actually take monetary policy decisions. They analysed calendar year inflation forecasts made 18, 12 and 6 months in advance, and showed evidence of "… substantial bias in inflation forecasts", as well as systematic forecast errors during the whole period. More specifically, inflation was systematically overpredicted in all three forecast horizons. The bias amounted to 0.47, 0.36 and 0.23 for the 18, 12 and 6 months forecasts, respectively, which is a very meaningful result given the long span involved. They also compared FOMC members' forecasts with those produced by their research staff to support them in their monetary policy decisions, which are the ones included in the well-known Green Book, and the results remained unaltered.

It has been suggested that analysing central banks' inflation forecasts based on the assumption of unchanged interest rates may not be appropriate (e.g. Blix *et al.*, 2001). However the evidence does not seem to support this claim as McCaw and Ranchhod (2002) showed for New Zealand. Indeed, according to their study the opposite result (i.e. less bias) is more likely to be true. The same evidence was found by Wadhwani (2004) for England who notices that "We use constant interest rate forecasts in the analysis here. However, the results obtained with forecasts conditioned on market interest rates are very similar." It is not difficult to come up with some reasons why this is so. First, monetary policy acts with lags, so one-year ahead inflation is in a great extent given at current interest rates. Second, in economies close to their long run equilibrium path interest rates moves are usually gradual and small, with limited influence on the forecast horizons analysed. Third, like other financial variables nominal interest rates are very difficult to forecast, and trying to predict a *path* for future rates adds another source of errors in predictions. Therefore, this point seems to be overemphasized.

4 – Empirical Measures of Inflation Uncertainty

The study of inflation uncertainty gained prominence since the seminal work of Okun (1971). Arguing against proposals that the U.S should accept higher inflation rates, he claimed a very intuitive idea: that inflation variability (and, therefore, uncertainty) is positively related to the inflation level. He showed the existence of a positive correlation between average inflation and inflation variability (measured by its standard deviation) for a cross-section of the 17 most industrialized OECD countries. Since Okun's paper the above link has become a hot and controversial topic amongst economists. Indeed, in that same issue, Gordon (1971) dismissed Okun's claim, arguing that his results were conditional on the chosen sample period (1951–68). He noted that in the aftermath of the Korean War prices behaviour was unusual, and divided Okun's sample in two periods, showing that for the second (supposedly normal) period (1960–68) that correlation was much weaker.

Using a larger sample (41 countries) and a longer period (1949–1970), Logue and Willet (1976) reproduced Okun's work reaching the same conclusion, even when they divided the sample into two periods: 1949–1959 and 1960–1970. However, when the sample was divided according to countries types, they did not found the same evidence for highly industrialized countries, except for the first period. The same lack of support was found when countries were split according to their inflation rates.[18] In that case, Okun's claim was not supported for low inflation countries (2%-4% range), a similar result from Gordon's (1971). Calling into question claims that the U.S. inflation, which had been high but steady, should not be reduced, Klein (1975) highlighted a very important point: the difference between short-run and long-run price uncertainty. He showed that under the "new" fiduciary monetary standard inflation was not negatively autocorrelated as it used to be during the gold standard years, which meant that price increases were no longer expected to be reversed. He argued that even though short-term inflation variability was relatively low at the U.S. at that time, high long-run uncertainty was behind the observed decrease in the average maturity of corporate debt issues. Although Ibrahim and Williams (1978) called into question Klein's measures of short and long-run price unpredictability (which were based on moving averages), their findings supported Klein's conclusions.

Some years after Okun's work, his claim gained the important support of Friedman (1977) who, during his Nobel Prize Lecture, stated that "Rather, the higher the [inflation] rate, the more variable it is likely to be" and "… it is unlikely that inflation would be as fully anticipated at high as at low rates of inflation". Hence, for Friedman more variable inflation also meant more uncertain inflation. Foster (1978) called into question the use of standard deviations as a measure of inflation uncertainty, by giving the following example: assume that inflation is increasing following a deterministic linear trend. In this case, both the inflation level and its standard deviation are increasing over time, nonetheless inflation is perfectly anticipated. He argued that measures reflecting year-to-year changes in inflation are more suitable to measure variability, and used the average absolute change in inflation from year-to-year as a measure of variability. Even so, Foster did find strong support for Okun's claim. However, he remained somewhat cautious about taking strong conclusions from cross-section studies, noting that the results could be reflecting only differences amongst countries' economic and governmental structure (e.g. ineptness of controlling inflation).

Taylor (1981) reproduced Okun's study with fewer countries and a longer period, and also found support for Okun's claim. Similarly to Gordon's (1971), he found the correlation to be much weaker in the 1960s than in the 1970s. He then estimated simple inflation forecasting

[18] They tested the above hypothesis running a simple regression of variability (measured by the standard deviation of inflation) on a constant and the average inflation rate.

models for each of the 7 countries and showed that the forecasts' error standard deviation was strongly correlated to the average inflation rate. Fischer (1981) found evidence for the U.S. of a positive correlation between inflation variability and its level. Acknowledging that variability and uncertainty are not necessarily the same thing, he found evidence of a positive association between inflation uncertainty, measured by the variance of survey inflation forecasts, and both actual and expected inflation.[19] Next he ran a regression of Engle's (1983) estimated conditional variance on a constant and quarterly GNP deflator and did not find a significant relation between them.

Few years after Friedman's influential statements, the controversy was boosted when Engle (1983), using his new ARCH technique, found evidence for the U.S. that "the variance of inflation in the seventies was only slightly greater than in the sixties and both were well below the variance in the late forties and early fifties". As a result, Engle dismissed claims that the inflation level was positively correlated to inflation uncertainty in the U.S. and, in spite of an overwhelming amount of evidence to the contrary, made the remarkable statement that "Although the level of inflation in the seventies was high, it was predictable". This remark was even more surprising given that Engle (1982) had previously stated that "Thus, the standard deviation of inflation increased from 0.6 per cent to 1.5 per cent over a few years, as the economy moved from the rather predictable sixties into the chaotic seventies"

Pagan *et al.* (1983) also criticised the loose use of the concept variability. They developed a theoretical model akin to Lucas (1973) in order to investigate commonly used measures of variability and criticised the traditional tests of regressing variability on the inflation level, suggesting some measures in order to get robust inferences from that framework. They showed that the inflation level-variability hypothesis could be investigated by testing for heteroscedasticity, and investigated the link using consumers' expectations data from the Australian Morgan Poll, finding a positive association. They also tested the hypothesis by deriving inflation expectations from an econometric model and once more found (weaker) evidence that higher inflation means more uncertain inflation. Holland (1984) estimated two inflation-forecasting models for the U.S. and showed that the positive correlation disappeared when relative energy prices were included in the model. Indeed, Taylor (1981) had previously shown that a great deal of inflation variability in the U.S. was due to supply shocks, and Engle (1983) conclusions were based in a regression that included energy prices. Then Holland showed that inflation uncertainty, measured by both the standard deviation of six-month inflation forecasts among respondents and the root mean squared error of individual forecasts in the Livingstone Survey, were positively correlated to both the actual and expected inflation rates. He concluded that the inflation uncertainty-level link hypothesis depends on both the chosen econometric specification and the method used for measuring uncertainty.

To illustrate his new GARCH technique Bollerslev (1986) also estimated inflation uncertainty measures, reaching basically the same conclusions as Engle (1983). Using the actual data employed in Engle (1983), Cosimano and Jansen (1988) criticised Engle's work claiming that his model was highly mis-specified: not only did the errors showed strong autocorrelation but the fitted model ignored a structural break around 1954. When the structural break was taken properly into account and appropriate lag lengths were used, their results showed that the heteroscedasticity vanished. Nonetheless, their results implied that inflation level and uncertainty were uncorrelated for the U.S. Ball and Cecchetti (1990) argued that the conflicting evidence was due to the fact that different studies had measured uncertainty over different time horizons. They developed a statistical model in which inflation is subject to both temporary and permanent shocks, and estimate it both across countries and over time. While the latter shift trend inflation, the former only produce short-run deviations from trend. Some of their conclusions are: a) next quarter's uncertainty is basically determined by the variance of temporary shocks, while long-run uncertainty depends mainly on the variance of

[19] He used both the Livingston and Michigan Surveys of expectations.

permanent shocks; b) current inflation level affects mainly long-run uncertainty; c) the inflation uncertainty-level link across countries differs from the relation over time in a given country, since in the former case both short and long-run uncertainty rise with inflation; d) high inflation raises both the variability and the inflation uncertainty.

Evans (1991) estimated a time-varying autoregressive equation, AR(1), with ARCH errors to obtain both short-run and long-run inflation uncertainty measures. He shows evidence that after 1970 long-run uncertainty and actual inflation are positively linked. However he found an unexpected negative link between short-run uncertainty and the inflation level.[20] Brunner and Hess (1993) argued that the symmetry assumption underlying ARCH models (i.e. both positive and negative shocks have the same effect on uncertainty) is inconsistent with Friedman's hypothesis. They estimated a state-dependent model, which allows the conditional moments to be nonlinear functions of the state variables, including lagged values of inflation, forecast errors and the conditional variance, and found that symmetry is easily rejected for the U.S., and that higher inflation is indeed less predictable, contradicting Engle and Bollerslev's findings. Inflation uncertainty was found to be higher during the 1970s and 1980s than in the late 1950s and 1960s. Moreover, once symmetry was imposed they found the same results as Engle (1983), Bollerslev (1986) and Cosimano and Jansen (1988). Finally, they found strong evidence linking uncertainty to past forecast errors and to a lesser extent to past inflation.[21]

Kim (1993) investigated the inflation uncertainty-level link estimating an unobserved components model with a Markov–switching heteroscedasticity. Like Ball and Cecchetti (1990), Kim tried to distinguish between short and long-run uncertainty by modelling inflation as having both a stochastic trend and a stationary component. Like Cosimano and Jansen (1988) he also found a structural break in inflation in the mid-1950s. Kim modelled U.S. inflation as having four different regimes and found evidence that higher inflation was positively related to higher long-run uncertainty. However, as did Evans (1991) he found that short-run uncertainty increases when inflation falls, which is not an intuitive result.[22] Golob (1994) argued that those studies that had not been able to find a (positive) link were flawed because they ignored a downtrend in inflation uncertainty in the U.S. over time, and once that factor is taken into account the evidence is unambiguous. He obtained inflation uncertainty proxies from inflation forecasting models for both the CPI and its core, and regressed those proxies on a constant and lagged inflation, including also a time trend. He did find that higher inflation increases uncertainty, but the time trend was (negatively) significant only in the core inflation equation, which shows that the evidence on his hypothesis cannot be seen as robust for the CPI.

Since around Golob's paper the inflation uncertainty-level link (econometric) debate has lessened somewhat, and the overwhelming majority of papers have basically shared the same methodology: using in-sample conditional variance estimates from GARCH-type models as proxies for inflation uncertainty.[23] Two recurrent issues have been: testing for asymmetric effects and the direction of "causality" between the inflation level and inflation uncertainty.

[20] The conditional standard deviation of next month's inflation and next month's expected inflation were supposed to measure short run uncertainty, while the conditional standard deviation of steady state inflation was supposed to measure long run uncertainty. The first two measures were significantly differently, especially their levels, what is an unexpected result. Also, the short-run measure of uncertainty was much higher than the long run, which is another counter-intuitive result.

[21] The authors noticed that there was a trade-off between the inclusion of lagged forecast errors and lagged inflation in the conditional variance.

[22] In his model short and long run uncertainty were measured by the probability of a high variance state for temporary and permanent shocks, respectively.

[23] For example, Grier and Perry (1998) investigate the inflation-uncertainty link for the G7 countries. Both Fountas (2001) and Kontonikas (2004) investigate the link for the UK, while Daal *et al.* (2005) investigate the inflation-uncertainty link for the G7 countries as well as some emerging countries. All of them use GARCH-type models.

Most papers find a positive link and, to a lesser extent, asymmetric effects.

4.1 – Surveys

Another way of measuring inflation uncertainty is to use surveys of expectations.[24] A major point of discussion in the inflation-uncertainty survey literature is to what extent disagreement among forecasters can be taken as a proxy for uncertainty. Cukierman and Wachtel (1979) built a model of disagreement akin to the Lucas limited information model where, despite having rational expectations, economic agents in different markets have different inflation expectations, since each market faces idiosyncratic shocks. Analysing the evidence, using both the Livingstone and Michigan surveys, they found that periods when people disagree more tend to come together with periods of large inflation and nominal income variances, confirming their model's predictions. The authors claimed that their results supported the idea that the inflation level and disagreement are positively correlated and that higher disagreement leads to more frequent forecast errors.

Bomberger and Frazer (1981) investigated the effects of expected inflation and inflation uncertainty on interest rates. They argued that current uncertainty should be affected by recent forecasts errors and, therefore, if disagreement is to be a useful *proxy* of uncertainty it has to be correlated with a measure that quantifies the extent of forecast errors. They show that a geometric declining weighted average of squared past forecast errors series from the Livingstone Survey tracked really well disagreement over the 1952–1977 period, concluding that disagreement is a good *proxy* of uncertainty. Fischer (1981) showed some evidence, for both the Livingstone and Michigan surveys, that disagreement was positively correlated to past, current and expected inflation during the 1954–1980 period. Moreover, for the latter survey he also found a positive link between uncertainty and lagged unanticipated inflation (i.e. past forecast errors). Holland (1984) also showed that disagreement in the Livingstone Survey six-month ahead inflation forecasts was positively correlated to both actual and expected inflation rates during the 1954.2–1983.2 period.

In an interesting paper Zarnowitz and Lambros (1987) pointed out that although Bomberger and Frazer results were suggestive, past forecast errors are only one part of uncertainty, which also includes forwarding looking components. In order to measure uncertainty one needs to know the probability distribution associated with each individual forecast. So they used some data rare in economics, the Survey of Professional Forecasts (SPF), which captures not only point forecasts from respondents but also the uncertainty around those forecasts, and found that disagreement (measured by the standard deviation of point forecasts across survey respondents) understates uncertainty (measured by the average standard deviation of individual probability distributions), mainly for short horizons. Moreover, they found the former to be much more volatile than the latter. Indeed, uncertainty was found to be surprisingly stable. Also, while disagreement increased strongly and monotonically with the forecast horizon, uncertainty barely increased, which is not a very intuitive result. At the end they found evidence that disagreement was weakly correlated to uncertainty during the period analysed (1968.4–1981.2). However, intriguingly, they found a very strong correlation between disagreement in the Livingston Survey and uncertainty in the SPF, providing (indirect) evidence in favour of using the former as a useful *proxy* of uncertainty. Overall they found strong evidence that higher inflation also means higher inflation uncertainty.[25]

Lahiri *et al.* (1988) also investigated whether disagreement is a good *proxy* for uncertainty

[24] Note that Fischer (1981), Pagan (1983) and Holland (1984) have also used surveys in their investigation.
[25] Notice, however, that when point forecasts and disagreement were used in the SPF, this link was not found. This was another puzzling result, but the authors did not analyse it.

using the SPF, and like Zarnowitz and Lambros (Z&L) (1987) found evidence that the former understates the latter. The results showed two important differences, though. First, the two measures' magnitudes were closer to one another, while in Z&L´ work disagreement was much lower. Second, uncertainty was found to be much more volatile than in Z&L' study. The two measures, therefore, were much more correlated than in Z&L. Nonetheless, based apparently solely on visual inspection they concluded unwarrantedly "On the whole, the disagreement measure does not seem to be a good *proxy* for the underlying uncertainty." Finally, the authors ran a regression of uncertainty on inflation and found some evidence that higher inflation increases uncertainty. Using data from the Livingstone Survey Golob (1994) provided evidence that expected inflation for the next 6 and 12 months were positively correlated to disagreement.

Bomberger (1996) revisited the question whether disagreement is a good *proxy* for uncertainty, but using a different approach and dataset from Z&L.[26] He argued that the conditional variance of inflation about an individual forecast (i.e. individual uncertainty) should be positively related to disagreement if the hypothesis is to be confirmed. By decomposing individual error into consensus error and disagreement error, he found that a major component in individual uncertainty, measured by the mean squared error of individual forecasts, is due to consensus uncertainty, and that the former is around four times larger than disagreement. Therefore, he argued that if disagreement is to be a good *proxy* for individual uncertainty it must also track consensus uncertainty. He tested the hypothesis econometrically and found evidence that consensus uncertainty was proportional to disagreement and, therefore, to individual uncertainty, supporting the use of disagreement as a measure of uncertainty. Therefore, Bomberger does not find evidence that disagreement is more volatile than uncertainty, as suggested by Z&L.

4.2 – An Assessment of the Evidence

Despite the lack of consensus in the inflation uncertainty-level literature, when one weighs carefully the evidence some clear conclusions arise. First, there has historically been a sharp contrast between the evidence conveyed by econometric models and that portrayed by both surveys of expectations and simple uncertainty measures. While the last two show overwhelming evidence that inflation uncertainty is positively related to the inflation level, the former has often find no such a link. Second, there has been nonetheless a convergence between the econometric and survey literatures, as the evidence from the latest econometric studies has been similar to what surveys have been showing for a long time. Once dismissed by economists as not representing expectations properly, surveys have proven to be reliable. Third, while it is theoretically true that variability does not mean uncertainty, this distinction has not proven to be very relevant in practice. It has been widely recognized that the more volatile a given variable is the more difficult it is to be forecast. Indeed, Hendry (2000a) states that "…periods of forecast failure and economic turbulence often go hand in glove…", while Zarnowitz and Lambros (1987) argue that "For any time series, increased volatility tends to be associated with decreased predictability."

More specifically, the evidence shows, not surprisingly, that econometric inflation uncertainty proxies and the qualitative evidence thereof are very sensitive to the specification and methodology used. Holland (1993), for example, points to the different results from fixed and non-fixed parameter studies. Indeed, lack of robustness has proven to be one major drawback of econometric proxies relative to those derived from surveys, where the forecasting method is not an issue. While the former usually rejects Okun's hypothesis the latter provides wide support. Note, however, that one important exception has been found in recent studies that use asymmetric (G)ARCH models. This evidence is highly relevant since those models show that the symmetry restriction embedded in traditional (G)ARCH models, which have been widely

[26] He used The Livingston Survey over the 1949–94 period.

used to deny Okun's hypothesis, is usually rejected by the data.[27] Even so, it remains an open issue to what extent (G)ARCH-type models are actually the result of mis-specificaton since, for example, outliers and autocorrelated errors could produce such type of errors. Ironically, although Engle (1983) had warned that: "The weakness of the procedure is that if the model [ARCH] is mis-specified, the estimates of the conditional variances will be biased. This points out the importance of carrying out various specification tests.", Cosimano and Jansen (1988) showed that Engle's ARCH effects were due to mis-specification.

Despite the recent convergence, one should note that: first, it seems that one factor behind the conflicting evidence is that the econometric proxies found in the literature almost always focus on short-run uncertainty, typically one quarter-ahead. In its turn, survey proxies focus on longer term uncertainty, usually derived from six and twelve months ahead forecasts. This is odd since the short-run is not the most relevant uncertainty dimension pinpointed by economic theory. Second, despite the *qualitative* convergence brought by recent studies the *quantitative* evidence remains highly dependent on the specification/method used. Therefore, care should be taken if one aims at deriving econometric inflation uncertainty proxies for hypothesis testing. Finding support for the inflation uncertainty-level link and measuring uncertainty reliably are two connected but different matters, and this leads us to the next point. Third, and more importantly, as noted before the econometric proxies found in the literature are temporally inconsistent, since they come from (in-sample) "forecasts" that use future information. In contrast, survey proxies comes from surveys forecasts, which, by definition, are out-of-sample forecasts, since no forecaster knows the future. This temporal restriction should also be imposed in econometric studies, and very likely accounts for the bulk of the divergence between both literatures.

As called to attention earlier on, the temporal inconsistency problem is a much broader issue than just using future information to "forecast" a variable. It could also arise due to hindsight, since in the future the forecaster will obviously have a much better understanding of the variable dynamics, and the "forecasts" will benefit from that *ex post* knowledge. It was also pointed out that an uncomfortable feature of recent studies is that they are theoretically inconsistent, since they use modern techniques to estimate inflation in periods when those techniques and the necessary technology were actually unavailable. Curiously, the convergence mentioned above has arisen with the most recent studies, suggesting that those models may end up actually providing better *proxies* for uncertainty. One explanation for this paradox is that even though they are theory inconsistent, those proxies are more realistic since they come from models that impose fewer restrictions on the data. For example, time-varying parameter models and asymmetric ARCH models do not impose parameter constancy and symmetry, respectively. This fact highlights that imposing untested restrictions in econometric models may produce very misleading results. However, other factors could also lie behind this convergence, and a more detailed analysis of those studies is certainly needed.

For example, one problem regards how some recent models measure long-run uncertainty. Ball and Cecchetti (1990) and Kim (1993) distinguish short and long run uncertainty by modelling inflation as having both a permanent (random walk) and a stationary component. This leads to the question of how able agents are in practice in differentiating temporary from permanent shocks to inflation (see Brash's comments above). Even if a shock is claimed to be permanent (say, a one time jump in oil prices) policy could counteract and keep inflation under control, so that the definition depends on policymaker's reactions and credibility. It seems unrealistic to assume that agents have this kind of knowledge unless until some time after the events. Moreover, both types of shocks are usually treated as orthogonal which cannot be taken for granted. One can also question the relation between long run uncertainty and the permanent component of inflation, since there is no explicit forecast horizon involved.

[27] Golob (1994) argues that ARCH models are inadequate since they constrain uncertainty to change slowly over time.

This opens the possibility, for example, that uncertainty about next-quarter inflation is labelled as long run as long as it refers to the permanent component of inflation, which could be problematic. Finally, in many industrial countries inflation has been very well behaved since the 1990s, and it could well have become a stationary process. If this is true, the above definition of long-term uncertainty does not make sense. In ts turn regime-switching models are problematic also since in order to assess how many inflationary regimes the economy faced one needs to know the whole history of inflation, and even so the task is not straightforward. For example, Kim (1991) modelled US inflation as having four different regimes but Evans and Watchel (1993) considered only two.

Finally, even though asymmetric (G)ARCH models are much more sensible than their symmetric counterparts, the underlying presumption remains that a negative inflation shock is bad news and, therefore, harmful. However, this may be inadequate, and the following odd situation may arise: inflation has been decreasing and economic agents overpredicting it, but uncertainty is considered to be increasing and harmful. In this case of negative errors it is more plausible that inflation uncertainty not only falls but also is beneficial, since inflation is decreasing faster than expected, which is good news. In other words: things are improving faster than anticipated. This situation is relevant since the evidence shows that agents usually underpredict inflation when it is rising and overpredict inflation when it is falling. This problem may help to explain why both Evans (1991) and Kim (1993) found evidence that short-run uncertainty increases when inflation falls. A better alternative is to include both forecast errors themselves and their absolute values in the models, since in this case no symmetry restriction is imposed and negative errors are allowed to act as good news, which should decrease uncertainty. Finally, another limitation of econometric uncertainty proxies is that they usually do not take into account both parameter and model uncertainty. However, it is not easy how to solve satisfactorily those problems.

In its turn, the inflation level-uncertainty survey literature is much smaller than its econometric counterpart and shares a much wider agreement.[28] A major issue in the former is whether *disagreement* is a valid proxy of *uncertainty*. Although there are compelling theoretical reasons why both should be closely related (e.g. no one knows the true model), this link has been difficult to formalise. Also, a key part of the empirical evidence, which is based on probability forecasts from the SPF, is not as convincing as one would like. Moreover, a crucial issue that has been overlooked is to what extent inferences from the SPF probability forecasts are actually reliable. Three main reasons ask for caution: first, the SPF inflation probabilistic forecasts refer to the GDP deflator (and not the CPI), which is not the index people in general are more interested in.[29] This lack of interest probably lies behind the fall in the number of SPF respondents through time, and helps to explain why the survey briefly ended in early 1990.[30] Second, what forecasters are judged is on their point forecasts and not on their underlying probability distributions, which "are not subject to any market test." (Batchelor and Dua, 1993). This fact certainly explains why not every forecaster provides probability forecasts for the SPF. Thus, more weight should be put on point forecasts. Third, and more serious, even though one has to assume a probability distribution in order to extract the implied expected inflation, Zarnowitz and Lambros (1987) found important differences between point forecasts and individual expected values in the SPF. Although they minimised that discrepancy, the evidence is very disturbing. Defining large discrepancies as differences between the two measures exceeding one percentage point, they say that "only about one in four of the regular respondents had 20 percent or more of such deviations on the record, and only one in twenty had 40 percent or more." Those are large

[28] Note that although the literature on surveys of expectations is large, many papers do not focus on inflation uncertainty nor on the level-uncertainty link, but on the rationality of forecasts.
[29] Thirteen years after the survey had begun, in 1981, the CPI began to be surveyed, but only point forecasts are asked.
[30] Later in 1990, the Federal Reserve Bank of Philadelphia took over and revived the survey.

numbers to be ignored! The fact that individual expected inflation values frequently did not match inflation point forecasts, should make one very cautions about using the former for inference.

It should be noted, however, that although no strong consensus has yet been formed on whether disagreement is a good proxy for uncertainty, some stylised facts emerge from this literature evidence. First, the magnitude of forecast errors is positively related to the inflation level. This is crucial evidence in favour of the inflation uncertainty-level link, since it is exactly the variance of forecast errors which is the measure of forecast uncertainty obtained from econometric models. Second, forecast errors are also positively linked to disagreement. This means that at times when individuals commit more errors are also times in which they disagree more, reflecting the greater underlying uncertainty about the future economic outlook. Also, one should be more uncertain about one's own forecasts if forecasts produced by other forecasters are very different from one's own, given that no one knows the true model. Third, there is broad evidence that disagreement increases with the inflation level, expected inflation and the forecast horizon. These stylised facts provide significant support for the use of disagreement as a *proxy* for inflation uncertainty.

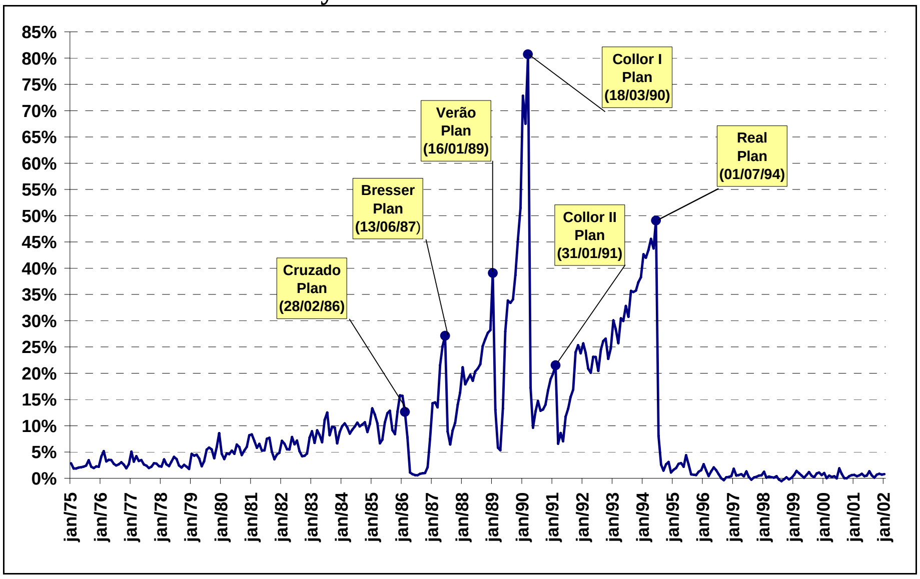
Surveys also show that the higher volatility that comes with higher inflation also means more inflation uncertainty, supporting the findings from earlier studies that used simple variability measures to *proxy* inflation uncertainty. Indeed, Brunner and Hess (1993) found evidence that changes in inflation are even more relevant in explaining inflation uncertainty in their model than forecast errors. Crawford and Kasumovich (1996) mentioned (but did not present evidence) that research at the Bank of Canada found that although one-year ahead forecast errors from a Canadian survey were related to inflation level they were more related to changes in inflation. Finally, one must recognise that despite the existence of a clear link between the inflation level and the degree of inflation uncertainty, the latter can be high even when inflation is low. For example, inflation uncertainty can be high when agents assess that there is some probability that, say, a fixed exchange rate regime could collapse in the near future and the associated devaluation could boost inflation. This is the well known peso problem, and if it is not taken into account properly when testing the inflation uncertainty-level link, then misleading inferences might arise.

5 – Endemic Inflation Uncertainty and Forecast Failure in Brazil

Brazil has a history of chronic macroeconomic instability, in which the major component was the persistent inflationary disarray that lasted until 1994. From 1950 until 1979 the average annual CPI inflation rate in Brazil was around 32% and its standard deviation 21%. The outlook got much worse after 1980, when annual inflation rates exceeded the 100% mark and began to increase very rapidly forcing policymakers to implement several stabilisation plans, which by themselves became an extra source of uncertainty. Indeed, from 1980 until 1996 the average annual CPI inflation rate in Brazil was about 370% and its standard deviation amounted to staggering 790%. Moreover, given the obvious links between economic variables, the inflation disarray also produced uncertainty on other key economic variables such as interest rates and the exchange rate, worsening the macroeconomic uncertainty.

Graph 5 shows the dismal history of chronic high inflation in Brazil in the 27-year period from January 1975 to January 2002. It also shows the several stabilisation plans that were put in place to curb inflation. Monthly rates are shown since the magnitudes involved in quarterly and annual figures makes it even harder to visualise the lower inflation periods. However, in order to provide an idea of the annual magnitudes involved some remarks are useful: a) inflation reached the 100% barrier in 1980, and began to increase very rapidly thereafter; b) the first stabilisation plan, The Cruzado Plan, was implemented in March 1986, after inflation left behind the 200% mark in the previous year; c) inflation reached 1,000% in 1988; d) in the last twelve months before the implementation of the successful Real Plan, in July 1994, inflation had reached staggering 5,000%; e) in 1975 inflation was 31%, the lowest level before 1995, and reached its peak in the last 12 months before The Collor Plan, in March 1990, when it soared to almost 6,000%. The smallest annual rate occurred in 1998, only 1.67%, the year just before the collapse of the fixed exchange rate regime due to a speculative attack against the Real, and by 2001 inflation had increased to 8%.

Graph 5
IPCA Monthly Inflation And Stabilisation Plans[31]



The Real Plan, which finally defeated the chronic high inflation that was the major feature of the Brazilian economy until 1994, was actually the last one following five failed attempts to stabilise the economy between 1986 and 1991. The effects of those plans can be clearly seen in Graph 5. Many of them included heterodox measures such as price controls, intervention in private contracts and even asset confiscation, adding extra uncertainty to the macroeconomic outlook. High inflation also meant institutional instability as, for example, it was the major factor behind changes of central bank governors and finance ministers. Those institutional “side effects”, together with the higher inflation uncertainty brought by both high and variable inflation rates, should provide some, yet very limited, idea of the endemic inflation uncertainty environment that has been the hallmark of the Brazilian economy, and that has imposed great costs on the economy. Many deep rooted macroeconomic concepts like money super neutrality seem very odd in this type of world. For example, it is really hard to believe that, say, a 50% annual inflation rate economy is as efficient in allocating its resources as a 2% inflation rate economy.

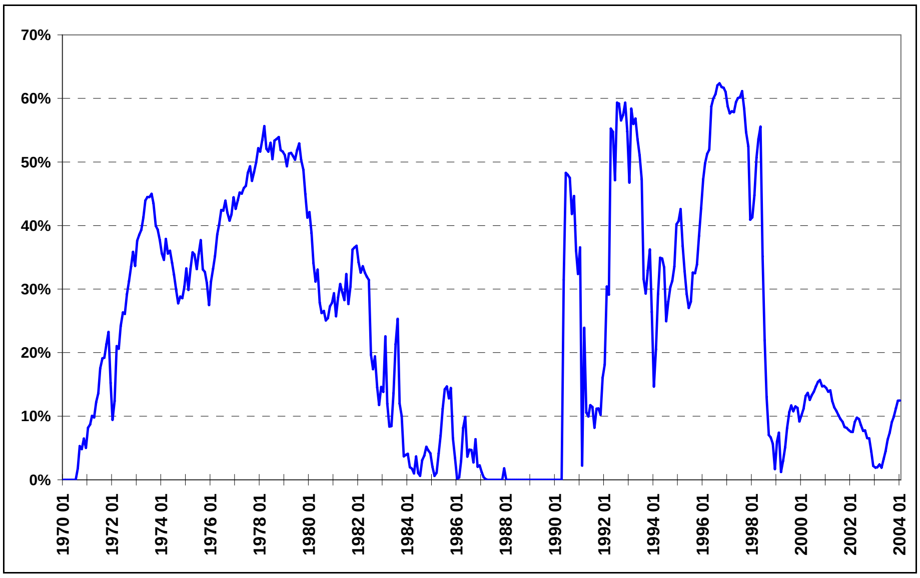
As mentioned earlier, an important cost of inflation uncertainty lies in the functioning of credit markets. Graphs 6 and 7 show clear-cut evidence that inflation uncertainty has been a major deterrent to the development of credit markets in Brazil. Graph 6 reveals clearly that in periods of high inflation and/or high inflation uncertainty economic agents tend not to carry nominal bonds, since they can incur in big losses should inflation happens to be higher than anticipated. This phenomenon is particularly clear during the 1984–1989 period, when

[31] Consumer Price Index – Domestic Supply (CPI-DI). Until 1990 the CPI-DI measured inflation from the city of Rio de Janeiro only. From 1990 until 2001 it reflected inflation from both Rio de Janeiro and São Paulo cities. From 2001 until March 2006 it became a national index encompassing 12 capital cities. However, since then there has been a step backwards and now it encompasses 7 capital cities.

inflation increased very fast and three failed stabilisation plans were implemented. Note that from the beginning of 1987 until the end of 1989 the share of nominal bonds dropped to zero. During that period inflation increased from 64% in 1986 to 1759% in 1989, and even predicting one-month ahead inflation became a risk business.

Graph 6 also shows that there is usually an increase in that share as inflation falls following stabilisation plans and uncertainty is reduced. Note that the steep decrease in nominal bonds share during the second half of 1998, when inflation was very low, is closely linked to fears of a sharp rise in interest rates to defend the exchange rate regime than to a more uncertain inflation outlook, although both events are clearly related. This fear was particularly high since the Central Bank had more than doubled the interest rate in October 1997 (from 19% to 46%) to defend the currency against a speculative attack following the Asian crisis. Indeed, the share of nominal bonds began to decrease as early as June 1998 and in September the Central Bank was forced to double the interest rate once again (from 19% to 40%) to defend the Real against a second speculative attack following the Russian default in August. In January 1999 the fixed exchange rate regime finally collapsed, and since then the share of nominal bonds has never recovered its previous levels. Indeed, even though the Government adopted an inflation targeting regime as early as June 1999, the higher inflation uncertainty brought by the floating exchange rate regime has not been offset.

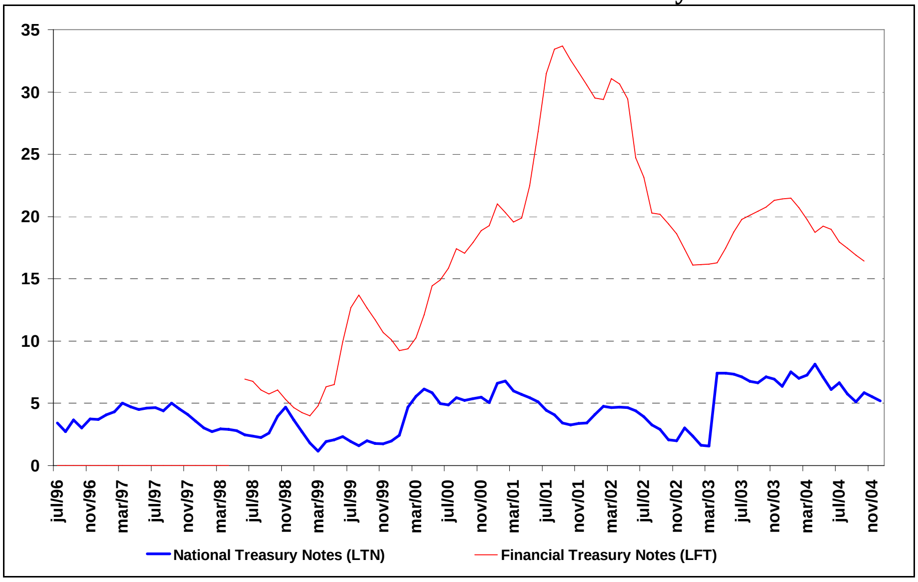
Graph 6
Nominal Bonds Share in Public Bonds Stock



The share of nominal bonds portrays a limited picture of how well a given credit market is functioning, the other part is given by the maturity of that debt. A high proportion of nominal bonds but with a low average maturity shows that the credit market is not allocating resources efficiently, as it would do in a more stable outlook, since long term finance is absent. Inflation uncertainty reduces both the share of nominal bonds in agents' portfolios and its duration. Graph 7 shows another dismal picture of the Brazilian public bonds market. Two features should be highlighted: first, and obviously, the shocking low maturity attached to the National Treasury Notes (LTN), the main *nominal* (zero coupon) bond issued by the Brazilian Treasury. From July 1996 onwards the average maturity of those notes has been around four months. Second, unfortunately this data are only available from mid-1996 onwards, but since this refers to the post-stabilisation period in which inflation was very low historically, it suggests not only that the average maturity during the high inflation period was much lower, but also that even though inflation has been low in recent years agents have a very long inflation memory, a finding which has already been found for other countries (e.g. Gagnon, 1997). It certainly will require a long period of low and stable inflation before inflation uncertainty drops significantly, longer maturities of nominal bonds become desirable and both the public and private credit markets are able to work efficiently in Brazil.

Given the history of low credibility of the Brazilian Government, the low maturity attached to public bonds clearly reflects a perceived default risk. However, Graph 7 also shows the duration of the main *real* bond issued by the Brazilian Treasury: the LFTs, which are bonds indexed to the overnight interest rate. Although also very low, their duration is much higher than that of nominal bonds. Therefore, the low duration of nominal public bonds in Brazil mainly reflects the inflation uncertainty risk agents face, rather than political and/or regime change uncertainties. The situation in the private credit market is pretty much the same, although no formal evidence is presented here.

Graph 7
Average Duration (in Months) of the Main Nominal and Real Brazilian Treasury Bonds



Note that one does not need rates as high as those shown in Graph 5 to take the harmful effects of inflation uncertainty seriously. As the U.S. experience during the 1970s and 1980s has shown, even annual inflation rates around 10% or lower can entail large and persistent forecast errors with significant economic costs. Moreover, even well into the 1990s King (2002) provides revealing evidence of a significant drop in the inflation risk premium on the announcement of the Bank of England independence, in 1997. Graphs 6 and 7, together with the qualitative evidence presented below regarding recent inflation forecast errors in Brazil, support not only this assessment but also the early findings of the Livingstone and other surveys during the 1970s and 1980s, corroborating their reliability despite earlier criticisms.

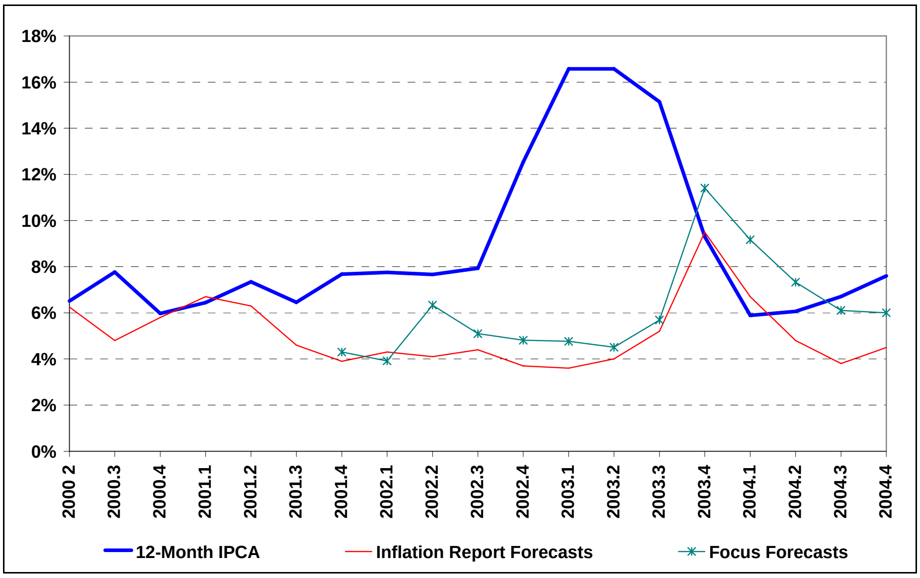
Graph 8 shows quarterly figures for the IPCA annual inflation rate and the associated one-year ahead Central Bank of Brazil (BCB) Inflation Report forecasts made since June 1999, when the first inflation report was published jointly with the implementation of the inflation targeting framework.[32] As one can see one-year ahead inflation forecasts have been well off track since then.[33] The BCB has committed systematic forecast errors, underpredicting inflation during most of the period. A particular dismal result concerns the behaviour of forecasts for the 2002.3–2003.3 period, when inflation rose sharply reflecting the large

[32] The IPCA, which has been chosen as the official inflation target index for Brazil, stands for Broad Consumer Price Index.
[33] Note that Graph 8 shows actual inflation and the associated forecast for that date (i.e. forecasts are not shown according to the date when they were made but rather according to the period they refer).

currency depreciation that happened in 2002, as it became clear that the leftist candidate would be elected president. The graph strongly suggests that the increase was completely unexpected, with forecasts reacting to the actual inflation rise rather than anticipating it.

Another revealing way of seeing that dismal performance is by analysing what Nordhaus (1987) called *fixed-event* forecasts, where successive forecasts regarding the same *terminal event* (i.e. a forecast for a specific or *terminal date*) are ordered chronologically. Graph 9 shows nineteen series of such forecasts, in which the terminal event is inflation over the next 4 quarters when measured in relation to the first forecasting date.[34] As can be seen, a very clear pattern emerges: forecasts were systematically revised upwards during the 4-year sample considered. No formal test is needed to conclude that this picture is in sharp contrast with the rational expectations paradigm.

Graph 8
IPCA Inflation, BCB *Inflation Report* and Focus One-Year Ahead Forecasts



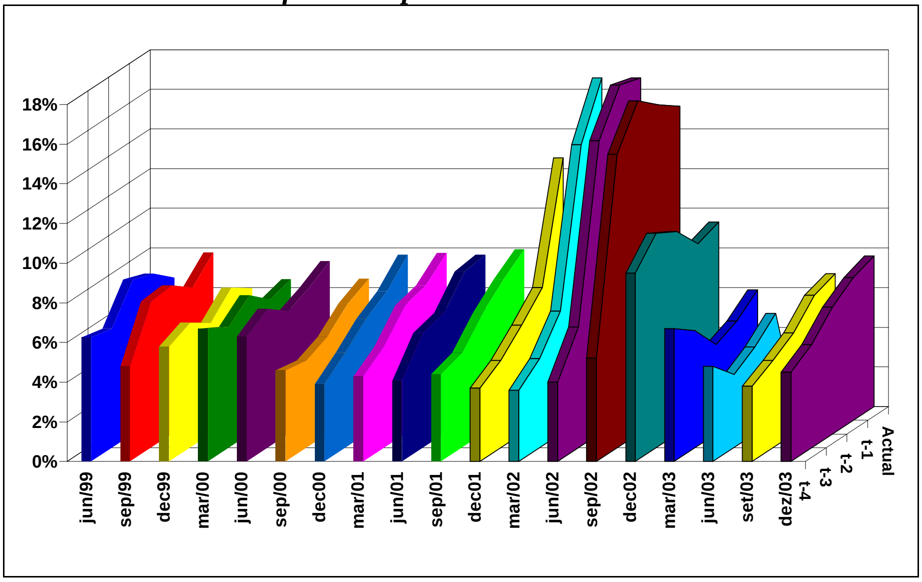
In its turn, Graph 10 shows the BCB Inflation Report average inflation forecast errors as the forecast horizon grows from one-quarter ahead to six-quarter ahead, computed from forecasts made between 1999.2 and 2004.2.[35] Forecast horizons are labelled as t+i, for $i = 1,\ldots,6$, and the associated forecasts are given by $E_t[(P_{t+i} - P_t)/P_t]$, which are compared to the accumulated inflation over the same period. As one can see, forecast errors increase monotonically with the forecast horizon in that particular sample. The size of average errors is particularly worrisome, mainly at those horizons relevant to monetary policy. Moreover, the poor performance took place in a relatively low inflation environment. Once one sees the above evidence, it does not come as a surprise to know that preset inflation targets have been

[34] For example, consider, say, the seventh "column" in the graph, which is dated (end of) December 2000. At that that date the first fixed-event forecast was made aiming at predicting inflation over the next four quarters (i.e. the year 2000 inflation rate is the terminal event to be forecast), hence the t-4 mark on the r.h.s. axis. Then, remaining in the same column, in March 2000 a new forecast for the year 2000 inflation was made, but now the forecast horizon had shrunk to three-quarter ahead, since the first quarter inflation was already known to the forecaster (hence t-3 on the r.h.s. axis). Subsequently, in June 2000 and September 2000 new forecasts for the year 2000 inflation were made, now with only two (t-2) and one quarter (t-1) ahead to go, respectively. Therefore, Graph 9 shows 19 streams of such fixed events forecasts.

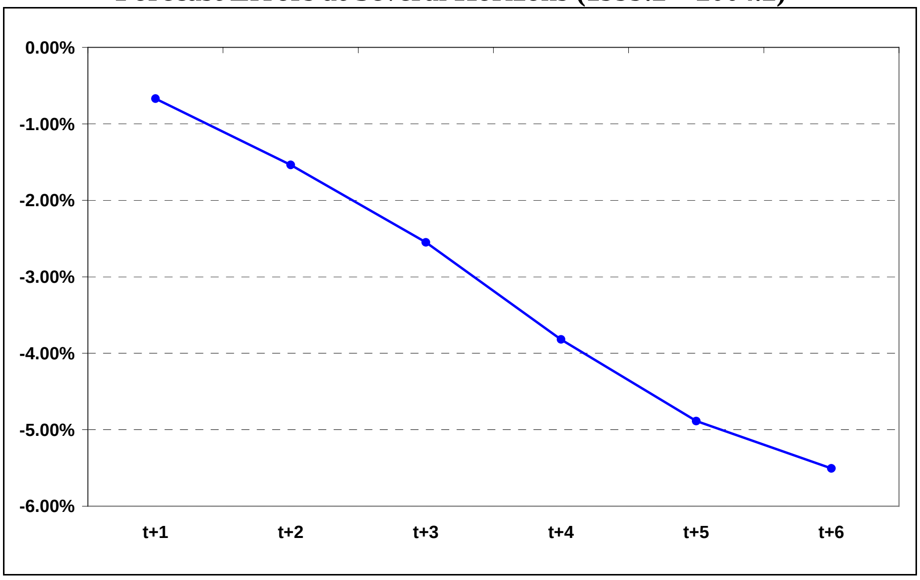
[35] The number of forecasts for each horizon beginning with the shortest is: 20, 19, 18, 17, 15, 12, respectively.

systematically changed upwards in Brazil since 2002, endangering the credibility of the inflation targeting regime, as targets lost their main role as anchors for inflation expectations.

Graph 9
BCB *Inflation Report* Fixed Event Forecasts



Graph 10
BCB *Inflation Report* Average Inflation Forecast Errors at Several Horizons (1999.2 – 2004.2)[36]



One would obviously be very interested in knowing whether private forecasts show the same dismal performance as BCB forecasts. Together with the implementation of the inflation targeting framework in June 1999 the BCB set up a very refined survey of market expectations, whose results are released every week to the press and investors in the so-called Focus Report.[37] The Focus is a unique survey of expectations since it collects real time (daily) expectations of many economic variables including the inflation rate.[38] The public surveyed

[36] Note that forecast errors in the survey literature are often defined as the forecast less the outcome, so that negative errors mean under-prediction and positive errors mean over-prediction.
[37] Therefore, from now onwards it will be referred as the Focus Survey.
[38] For details about the Focus Survey see Marques *et al.* (2003).

have all the incentives to forecast inflation accurately, since it is basically composed by several domestic economic consultancy firms (which one of the main jobs is to provide forecasts) and financial institutions, including both domestic and foreign banks with branches in Brazil. Moreover, even though participants' forecasts are kept anonymous, based on the recent performance of individual forecasts the Central Bank of Brazil releases periodically the Top-5 best short, medium and long run forecasters, which gives an extra incentive to agents to do their best when forecasting and boost their reputation.

Note that Graph 8 also plots quarterly one-year ahead median Focus forecasts, although they begin a little bit later than the BCB forecasts.[39] There one can see that market expectations show pretty much the same behaviour as BCB Inflation Report forecasts, even though they have been a little bit "more pessimistic" throughout. Indeed, the similarity is so striking that it suggests forecasters have probably anchored their expectations on BCB forecasts and then made some small adjustments on them. In its turn Graph 11 plots monthly data on annual IPCA inflation and monthly 12-month ahead Focus median inflation forecasts since November 2001.[40] Graph 11 also compares the Focus forecasts with those generated by two simple purely backward looking mechanisms. The first one (equation 4) is the traditional adaptive expectation mechanism:

$$\pi^{e}_{t+12,t} = \pi^{e}_{t+11,t-1} - 0.9\varepsilon_{t-1} \tag{4}$$

where $\pi^{e}_{t+12,t} = E_t\left[\left(P_{t+12} - P_t\right)/P_t\right]$, $\varepsilon_{t-1} = \pi^{e}_{t+11,t-1} - \pi_{t-1}$ and π_t is IPCA inflation in the last 12 months ending in t.[41] The second mechanism (equation 5) assumes an "adjusting" random walk in the following way:

$$\pi^{e}_{t+12,t} = \pi^{12}_{t} + 0.2\left(\pi^{4}_{t} - \pi^{12}_{t}\right) \tag{5}$$

where $\pi^{h}_{t} = \left[\left(P_t - P_{t-h}\right)/P_{t-h}\right]^{12/h}$ is the h-period inflation at time t reported at an annual rate. That is, expected inflation over the next 12 months equals the current annual inflation plus a correcting term given by the difference between the current quarterly inflation expressed at an annual rate minus the current annual inflation. The rationale for this extra term is to pick up more quickly increases or decreases in trend inflation, since as in equation (4) one is dealing with overlapping forecasts (i.e. forecasts are made on a quarterly basis but the event to be forecast is inflation for the next 12 months). The forecasts generated by this mechanism are labelled as naïve forecasts.

Table 1
Accuracy Statistics (2000.11 – 2004.9)[42]

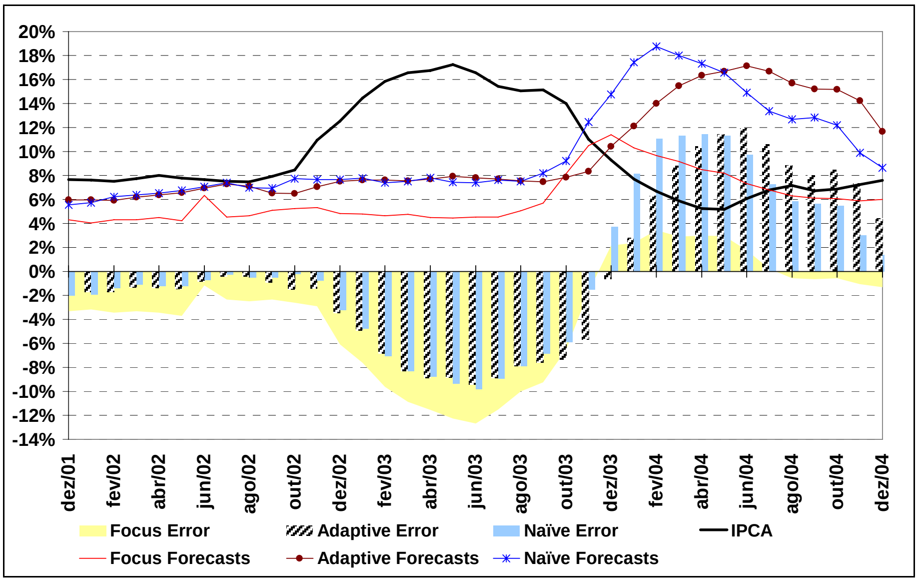
	Bias	MSE
Focus	-3.44%	0.34%
Adaptive	0.04%	0.43%
Naïve	0.01%	0.40%

As Table 1 shows, these two purely mechanical backward looking mechanisms beat easily the Focus forecasts when the performance criterion used is the bias and are just a little bit worse when the criterion used is the mean squared error. This result is very disturbing from a

[39] To obtain the first four quarterly one-year ahead Focus expectations in Graph 8, linear interpolation was used to get forecasts for some specific months.
[40] The forecasts are from the last working day of each month.
[41] The first forecast is assumed to be equal to the last 12-month inflation.
[42] The first forecast was assumed to be equal to actual inflation (i.e. zero forecast error). Since there are 34 forecasts, this assumption does not make much difference.

rational expectation perspective and makes it very clear that the absence of bias is not a very meaningful proof that forecasts are "rational" as it is widely assumed in the literature, a result that Graph 2 had already shown. Indeed, both the adaptive and naïve forecasts have no bias over this particular sample. Both Graphs 8 and 11 show that expected inflation turning points lag behind actual inflation turning points, a feature widely found in practice (see Thomas Jr. (1999) for the U.S. evidence).[43] Note that the Focus and the naïve forecasts start to increase at about the same time suggesting that actual forecasts have a large backward looking component, reacting rather than anticipating future inflation. As mentioned before, this evidence has also been widely found elsewhere. Indeed, all three forecasts have a remarkably similar pattern until the last quarter of 2002, even though the Focus forecasts are much less accurate during this period.[44] After that they start to diverge and the Focus forecasts perform better, since they increased less and started to decline earlier than the other two types of forecasts. The market did not believe that inflation would continue rising for much longer, while the two mechanical simulated forecasts needed some time to "recognise" that.

Graph 11
IPCA Inflation and One-Year Ahead Focus Forecasts



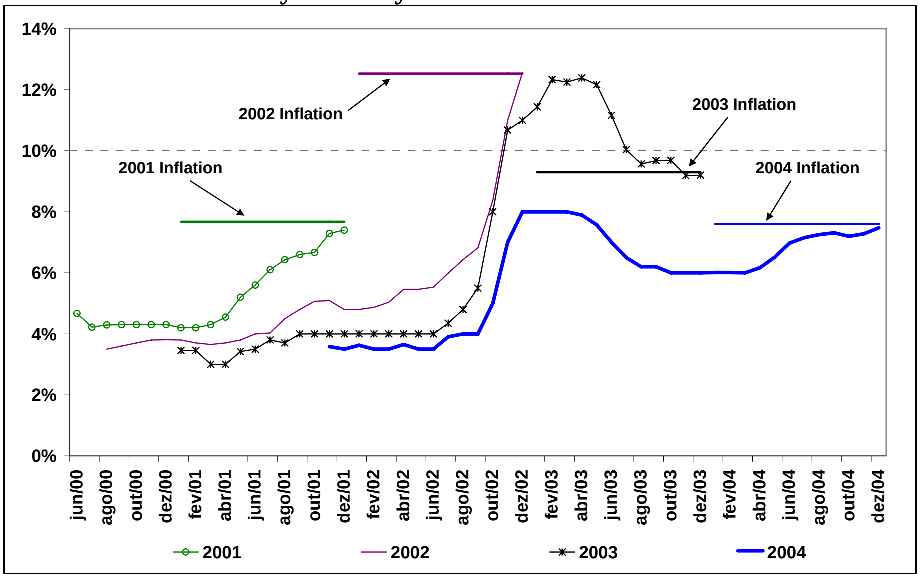
Graph 12 shows four long monthly streams of fixed-event inflation forecasts, but now constructed from the Focus Survey, in which the terminal events are calendar year IPCA inflation rates for the years 2001–2004. The horizontal lines indicate the actual annual inflation rates for each year. Once again it is very clear the large errors private forecasters committed in predicting inflation during that period. Moreover, a striking feature of those forecasts is the sluggishness with which forecasters recognised that their forecasts were well off track. Usually, it was not until a little bit before mid-year of the forecast year, and sometimes even later, as in 2002, that forecasters became really aware that their forecasts were badly wrong for that year. This is worrisome, since it shows that the ability to predict inflation more than two quarters in advance seems to be very low in Brazil.

The significant forecast errors of private forecasters calls into question key issues about central banking and monetary policy such as: a) the convergence of private forecasts to either inflation targets or central bank's forecasts is not necessarily meaningful regarding the

[43] Note that since forecasts are from the last working day of the month it is assumed that the forecaster knows the actual inflation rate for that month. This is a sensible assumption in the Brazilian context, since IPCA inflation is calculated every two weeks, so that by the end of the month the forecaster already knows its partial estimate (i.e. the forecast for that month is actually a 15-day forecast).
[44] Note that forecasts are dated one year earlier in relation to the actual outcomes shown in the graph.

appropriateness of the monetary policy stance; b) consequently, it could be potentially dangerous for central banks to put much weight on inflation surveys to set monetary policy. This is particularly relevant when private forecasts have the central bank's forecasts as their benchmark, creating a phenomenon of circular causation;[45] c) This calls into attention that focusing on forecast dispersion may be as important as the actual "consensus" rate to assess the expected economic outlook. The recent history of inflation forecast errors in Brazil is particularly troublesome since they took place after inflation had been drastically reduced following the Real Plan in 1994. With the exception of 2002, when annual IPCA inflation reached 12.53%, calendar year inflation has been lower than 10% since 1996. It also provides a hint of the huge inflation uncertainty that existed during the high inflation era. Moreover, on historical grounds political and policy uncertainties have been at very low levels, mainly after 1999.[46] In this regard, note that inflation has been chronically underpredicted, a result which is just the opposite of what one would expect in the case of inflation uncertainty being heavily influenced by policy or political uncertainty (i.e. the peso problem).

Graph 12
Focus Survey Monthly Fixed-Events IPCA Forecasts



Against the above background it should not be hard to figure out that inflation uncertainty has been both pervasive and harmful to the Brazilian economy. Moreover, although inflation uncertainty has certainly decreased since the stabilisation of the economy, it is still pretty much present clouding the decision-making process and impairing economic efficiency. Given the chaotic Brazilian inflationary history, it will certainly require a long period of low and stable inflation until inflation uncertainty drops to acceptable levels, especially long run uncertainty, and resources can be efficiently allocated.

[45] The dangers of relying on private forecasts were raised by Poole (2001) within the context of high credibility central banks. Poole argues that when a central bank has high credibility the market can put too much weight on its forecasts, and hence the central bank can be misled if it puts too much weight on market expectations.

[46] Apart from the year 2002, when there were concerns about the likely consequences of a leftist win in the presidential election. However, after the new government took office it very soon became clear that the economic policy would continue to be soundly based.

6 – Estimating Inflation Uncertainty for Brazil

It is a big understatement to say that, due to its latent nature, inflation uncertainty is a difficult variable to measure. The difficulties go much beyond that, since uncertainty is a subjective concept. Its measurement faces several peculiar challenges, beginning with the absence of a representative agent in practice. The evidence shows that agents' views about how the economy works and its future prospects differ widely. This heterogeneity is reflected in the wide variation of forecasts collected by surveys (i.e. disagreement). Worse, there is some disturbing evidence suggesting that some agents have expectations that are not even correlated with structural determinants of inflation (Brischetto and Brower, 1999). Also, there are a plethora of models and techniques available, with different degrees of sophistication, to predict inflation, making inflation uncertainty measurement highly model dependent. Moreover, usual econometric proxies capture only one dimension of uncertainty, since they are based on ex-post errors. Ex-ante uncertainty, which could be understood (but not limited to) as the dispersion of the underlying probability distribution is theoretically closer to the concept of uncertainty. Finally, one key challenge if one wants to get reliable proxies of *actual* inflation uncertainty is (trying) to replicate the economic environment forecasters faced at each point in time when out-of-sample forecasts were being made. This temporal restriction obviously excludes any measure derived from in-sample residuals, which are nonetheless the dominant practice in the inflation uncertainty literature.

Not so obviously, it also puts under suspicion "out-of-sample" forecasts based on specifications which were originally derived using the whole sample (i.e. future information). This could lead to inconsistencies due to two related problems: first, in principle only one specification will be used to make those (pseudo) out-of-sample forecasts. Moreover, an ever-changing economy could ask for different forecasting models at different points in time. Second, the inclusion or exclusion of a given variable in the final specification can be influenced by the use of future information. For example, it is a well-known fact that the (supposedly) stable relation between narrow money and nominal GDP broke during the 1980s in several countries. Therefore, when one estimates a "forecasting" model, say, for the 1970–2000 period, it might happen that money is left out of the final specification since it becomes insignificant in the second half of the sample, decreasing its overall significance. This specification would clearly be historically inconsistent since money was an obligatory variable in multivariate inflation forecasting equations until the mid-1980s. Therefore, despite being very time consuming, the methodological advantages of using just historical available data when generating simulation forecasts should be evident. Out-of-sample temporally consistent forecasts have two crucial additional advantages: they do not impose the restriction embedded in in-sample forecasts that forecast errors should average zero, and they do not imply that autocorrelated errors are the result of mis-specified models. As the evidence presented so far has shown, both "violations" are widely found in surveys. The use of historical available data also deals to some extent with parameter uncertainty, since coefficients are not considered to be constant throughout the sample.

It remains open, however, the difficult issue of what information set agents have actually used and how complex should be the forecasting model. Fortunately, these issues need not be a serious problem, since the use of univariate models deals to a great extent with them. Indeed, the univariate framework has some important methodological advantages in this context. The first is obviously its simplicity, which means that there is a higher probability that univariate forecast errors will be representative of forecasts errors made in practice.[47] Second, although

[47] Although some agents certainly use more sophisticated models to predict inflation, there is no doubt that simplicity is a desired feature when one chooses a method for estimating and/or forecasting. For example, although conceptually flawed as a measure of the output gap, many economists use the HP filter to derive a series of output gaps. Moreover, there is much evidence that many agents use very

a-theoretical, univariate inflation forecasts have proved to be a very though benchmark to beat. For example, in their extensive forecasting exercise on U.S. inflation Stock and Watson (1999) concluded that “in many situations [univariate models] have proven to be surprisingly strong benchmarks”. Canova (2002) finds for the G-7 economies that “bivariate and trivariate models suggested by economic theory or statistical analysis are hardly better than univariate models”. Among those models is the very popular Phillips curve. He notes that “the information contained in the dynamics of past inflation suffices to predict future inflation and very few other variables add marginal predictive content to univariate specifications.” Finally, using a univariate framework guarantees that the information set used is temporally consistent, since agents surely know, and take into account, the history of inflation when making inflation forecasts.

Therefore, 112 univariate forecasting models, one for each quarter from 1974.1 until 2001.4, were estimated in order to generate simulated real time inflation uncertainty proxies for Brazil.[48] Two forecasting horizons will be analysed in more detail: one-quarter ahead (i.e. one-step ahead), $E_t \Delta \ln P_{t+1}$, which is the most common horizon focused in the forecasting literature, and one-year ahead, $E_t \Delta_4 \ln P_{t+4}$, which is also becoming very popular and is a central horizon in the survey literature. Moreover, one year ahead forecasts should also give an idea of medium-term uncertainty. A summary of the entire set of estimated models is placed in Appendix 1. However, it is useful to summarize the main findings of this forecasting exercise. First, and not surprisingly, it was an enormous challenge to find reasonable inflation forecasting models for Brazil, especially concerning their stability properties. Very few other countries have experienced such “rich” inflation dynamics: Brazilian inflation has not only reached and sustained very high levels for several years but it also experienced some spells of hyperinflation, when inflation was clearly an explosive process. As a result inflation shows extreme volatility over the period analysed and faced several structural breaks due to several stabilisation plans. Indeed, the main problem during estimation was caused by those breaks during the 1986–1994 period. Whenever they can, economists choose to avoid such periods by beginning estimation after they occurred but here there is no such option, since people have to continue making forecasts in turbulent times as well, whether or not they are able to come up with well specified models.

Consequently, forecasting models varied greatly over time, which means that there is no unique model that fits the entire data, at least using an univariate approach. This is expected, since there was more than one inflation regime during the sample. Models differed in three main aspects: a) given the very different dynamic of inflation over the sample and the occurrence of several structural breaks, models were estimated using different sub-samples in order to improve their stability. Table 2 shows the different sub-samples used and the date of the first model estimated within each sample; b) the contribution of different lags of inflation as well as the degree of inflation persistency varied across models; c) even using shorter samples the following transformation of the inflation: $400\pi_t/(1+4\pi_t)$, where $\pi_t = \Delta \ln P_t$, was needed to decrease inflation variability for the models estimated between 1989.4 and 1994.2, when inflation was clearly an explosive process. This transformation constrains inflation to be less than 100%, reduced its persistency and produced more accurate forecasts.[49] The estimated models required several intervention variables to cope with the effects of stabilisation plans and other economic shocks such as oil shocks and large discrete exchange rate devaluations. Therefore, the large number of dummies used has clear theoretical justification, although a few of them are not related to any economic event in an obviously

simple methods when forecasting, such as extrapolation, rules of thumb, etc.

[48] Note that in each quarter a new model is estimated using only information available up to that quarter, as if agents were predicting inflation in real time.

[49] Even so, there were signs of a shift in the magnitude of lagged inflation coefficients after 1986, when the first stabilisation plan was implemented. However, recursive Chows tests did not indicate clear structural breaks in the models.

manner. Overall the models passed in all specification tests: only 9 out of 112 models have some diagnostic tests significant at 5% or lower (see Appendix 1). Four of them are in the 1987.3–1988.3 period, following the adoption of two stabilisation plans in 1986 and 1987, and before the 1989 stabilisation plan. Most problems were reflected in significant normality or heteroscedasticity tests, and were expected given the high volatility of inflation.

Table 2
Forecasting Inflation in Brazil: Simulation Results

Estimation[50]			**Degree of Difficulty**[51]	
Sub-Samples	**First Model**			**Period**
1963.1–1986.2	1974.1		**“Easy”**	1974.1–1986.2
1976.1–1987.2	1986.3		**Difficult**	1986.3–1988.1
1979.3–1993.2	1987.3		**Very Difficult**	1988.2–1994.2
1986.4–1994.2	1993.3		**“Tricky”**	1994.3–2001.4
1987.4–2000.4	1994.3			
1990.3–2001.4	2001.1			

Table 2 also shows that the sample can be divided into four periods, according to the difficulty in modelling and/or forecasting. The first period, called the “easy” period begins in 1974.1 and goes until 1986.2, the quarter after the first stabilisation plan was put in place. Although during this period the economy was hit by two oil shocks and faced two large exchange rate devaluations (33% in December 1979 and 39% in February 1983) it was relatively easy to get models with stable parameters and no structural breaks. However, as of 1986.3, just four months after the first stabilisation plan was implemented, the models' quality begins to deteriorate fast, and the use of different (and shorter) samples helped in improving models' adequacy. Therefore, the 1986.3–1988.1 period is classified as difficult. This period can be seen as a transition period to an even more difficult period, the period from 1988.2 until 1994.1, which encompasses three stabilisation plans and ends just before the implementation of The Real Plan. During this period inflation is clearly an explosive process and using the transformation mentioned above helped a lot in getting better forecasts. Finally, models estimated from 1994.3 onwards (i.e. after the Real Plan) produced surprisingly stable coefficients and usually did not have any problems in passing the diagnostic tests. However, this apparently easiness is misleading, since: a) put into an historical perspective many apparently well specified models produced forecasts that were clearly unrealistic (either too high or too low). This is probably because the coefficients were estimated using a sample that includes the very high inflation period, so parameters estimates were “contaminated” by the previous regime; b) often similar specifications produced very different forecasts, so they were not as reliable as one would like. Although from a pure theoretical viewpoint this is undesirable, this fact just highlights both model uncertainty and the importance of judgment in choosing between models that forecasters face in practice; c) in the following five quarters after the adoption of The Real Plan, in July 1994, and the sharp decrease in inflation rates that ensued, models were not able to produce sensible forecasts. Therefore, in three quarters (see Appendix 1) forecasts were made assuming a random walk model, which produced much smaller forecast errors. Hence, the 1994.3–2002.1 period is called the “tricky” period.

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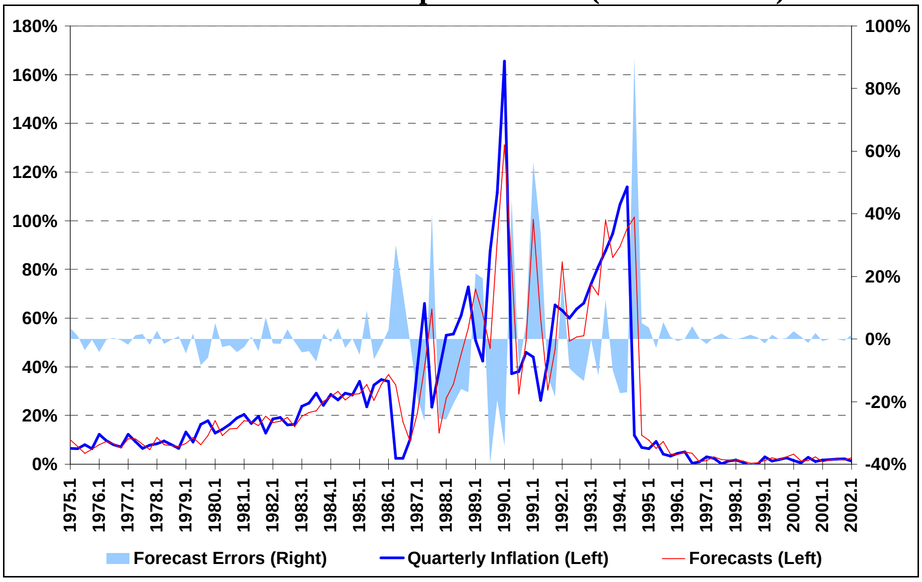
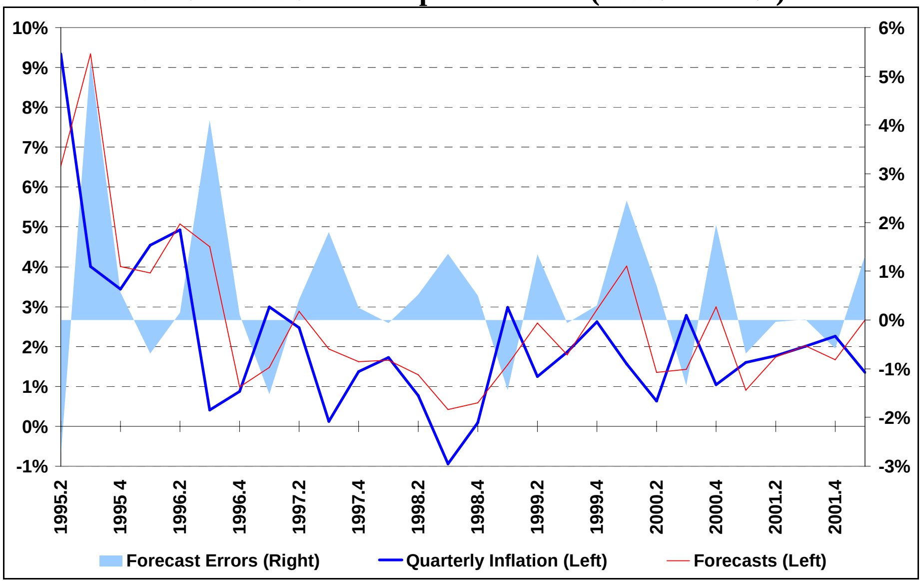
50 The column “First Model” indicates the first model estimated within a specific sub-sample, For example, the first model estimated in the first sub-sample (1963.1–1986.2) was in 1974.1 using data from the 1963.1–1974.1 period. The next model, estimated in 1974.2, uses data from the 1963.1–1974.2 period and so on, until 1986.2, when the sub-sample changes for the first time. In the second sub-sample (1976.1–1987.2) the first model is estimated in 1986.3 using data from the 1976.1–1986.3 period, and so on like before.

51 The estimation sample for each model is shown in the first two columns of this table. For example, the first model estimated in the “easy” period is in 1974.1, which uses data from the 1963.1–1974.1 period. The last model in the difficult period was estimated in 1988.1, using data from the 1979.3–1988.1 period.

Graph 14
Quarterly CPI Inflation and One-Quarter Ahead Simulated Out-of-Sample Forecasts (1975.1–2002.1)

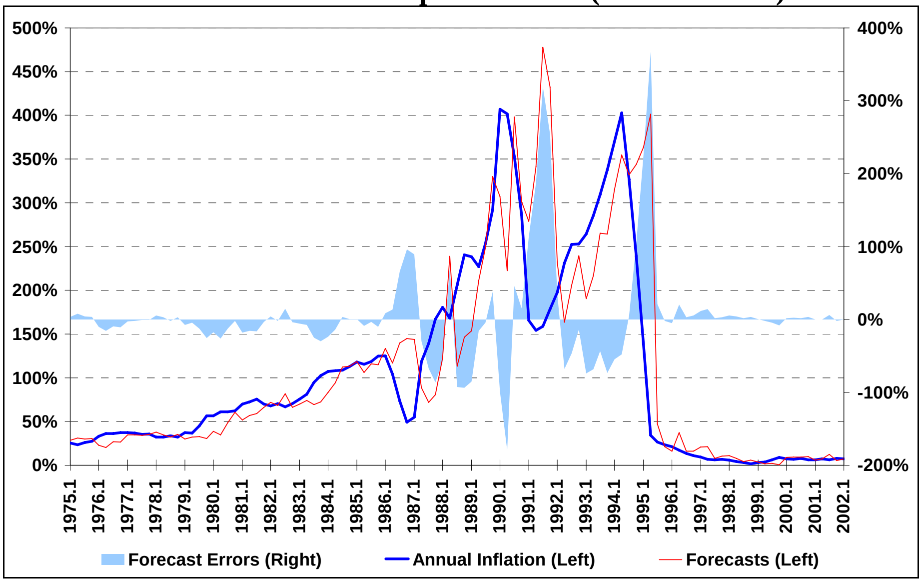


Graph 15
Quarterly CPI Inflation and One-Quarter Ahead Simulated Out-of-Sample Forecasts (1995.2–2002.1)

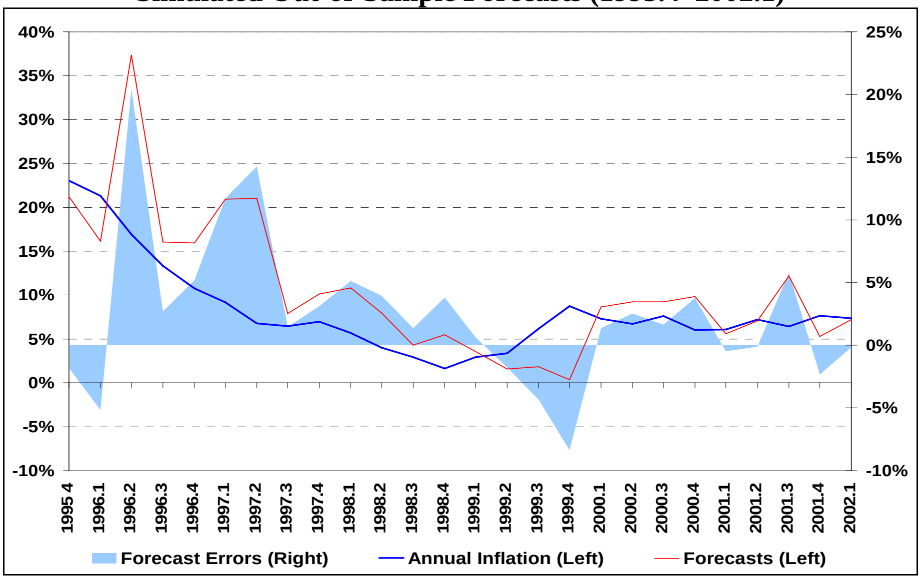


Graph 14 shows the resulting series of one-quarter ahead simulated forecasts ($E_{t-1}\pi_t$) compared to actual quarterly outcomes (π_t), where $\pi_t = \Delta \ln P_t$. The graph also plots the associated forecast errors ($\pi_t - E_{t-1}\pi_t$). Note that since inflation reached very high levels in the middle of the sample those rates overshadow the low inflation period, after 1994. Therefore Graph 15 shows the results from 1995.2 onwards. Note also that the forecasts made during the 1989.4–1994.2 period, which were based on the $400\pi_t/(1+4\pi_t)$ transformation, were converted back to their original units so that the forecast series is homogenous throughout the sample. The findings listed in Table 2 are clearly reflected in these graphs. Until 1985 forecasts follow actual inflation closely despite some consistent underprediction, mainly after 1979 when inflation increases rapidly following the second oil shock. This is the "easy" forecasting period. From 1986 until 1994, when inflation increases very fast and reaches very high levels forcing the adoption of several stabilisation plans, forecast errors become very large, even for just one-quarter ahead forecasts. This is the chaotic inflationary period, in which forecasting was extremely difficult. In the last period, after 1994, when stabilisation finally succeeds, one quarter ahead forecast show the smallest errors in the sample, as Graph 15 shows. However, note that this is to be expected since inflation rates are very low compared to other periods, and should not be understood as an easy forecasting period, as the evidence put forward in last section clearly shows.

Graph 16
Annual CPI Inflation and One-Year Ahead Simulated Out-of-Sample Forecasts (1975.1–2002.1)



Graph 17
Annual CPI Inflation and One-Year Ahead Simulated Out-of-Sample Forecasts (1995.4–2002.1)

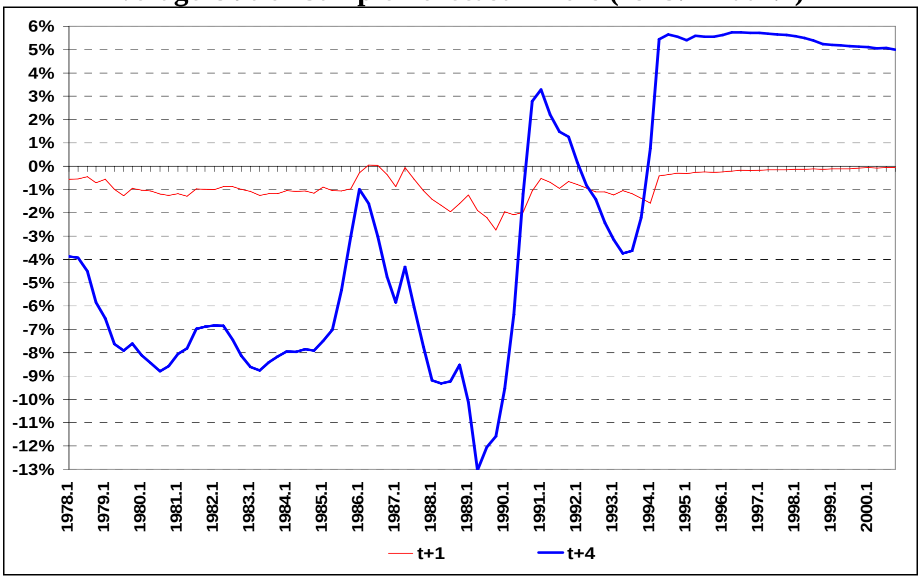


In their turn, Graphs 16 and 17 show how one-year ahead simulated forecasts ($E_{t-4}(\Delta_4 \ln P_t)$) performed compared to actual annual inflation ($\Delta_4 \ln P_t$). The resulting forecast errors ($\varepsilon_t = \Delta_4 \ln P_t - E_{t-4}(\Delta_4 \ln P_t)$) show an even clearer picture of the facts already portrayed by Graphs 14 and 15. Note that: a) there is a sharp deterioration in forecast accuracy at longer horizons. One-year ahead forecast errors are substantially larger than one-quarter ahead, even disregarding errors due to stabilisation plans' effects;[52] b) these forecasts remind those from surveys, which usually show consistent underprediction when inflation is rising and consistent overprediciton when it is falling. Graphs 14 and 16 show clearly that uncertainty increases with the inflation level. This evidence can be seen in more detail in Graph 1 in Appendix 2, which shows the cross-plot between one-quarter to one-year ahead absolute forecast errors and inflation over the same time horizon.

Graph 18 shows the simulated average out-of-sample forecast errors from both one-quarter and one-year ahead forecasts.[53] Note that in opposition to traditional recursive errors, which come from a single specification, in this case a new forecasting model is fitted at each quarter. Note also that forecast errors are defined as being the forecast less the outcome, so that negative errors intuitively mean under prediction and positive errors over prediction. As it can be seen, one-step ahead forecasts do not show bias when the whole sample is considered. However, as argued before, this feature might not be very meaningful about the quality of the forecasts. Indeed, a closer look reveals that inflation was often underestimated during the whole period, and indeed forecast bias was present until 1994. Even so, overall the forecasts seem to be very good, as suggested by Graph 14: the bias seems *relatively* small until 1986, increasing after that partially because of the stabilisation plans effects, and decreasing sharply after 1994.[54] However, the picture conveyed by the one-year ahead forecast errors is not so optimistic: there are large and persistent errors.

Graph 18

Average Out-of-Sample Forecast Errors (1975.1–2001.4)[55]

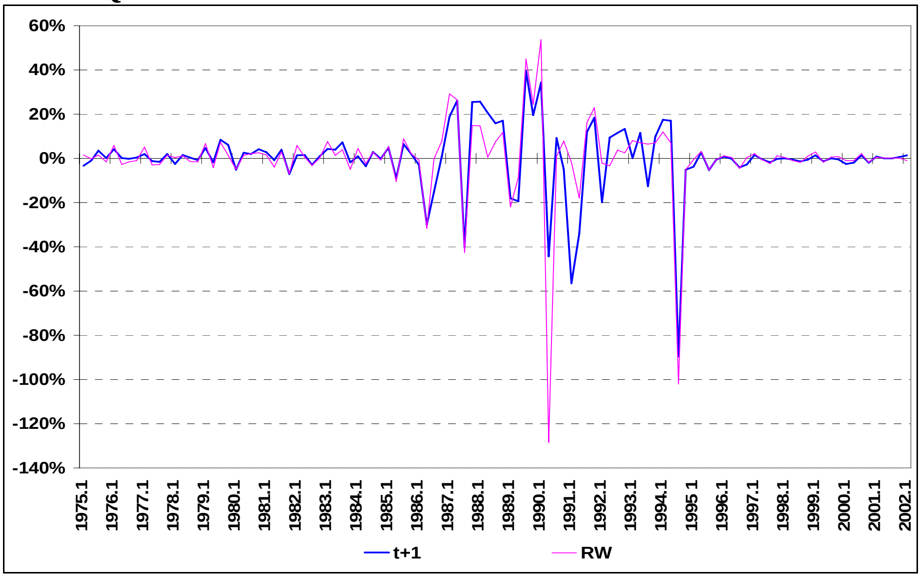


The evidence presented here and elsewhere is unequivocal: a) the zero-mean error restriction embedded in in-sample inflation "forecasts" often does not hold in practice, mainly for longer term forecasts; b) forecast errors are usually persistent; c) agents react rather than anticipate turning points; Hence, the evidence highlights the large difference between modelling and

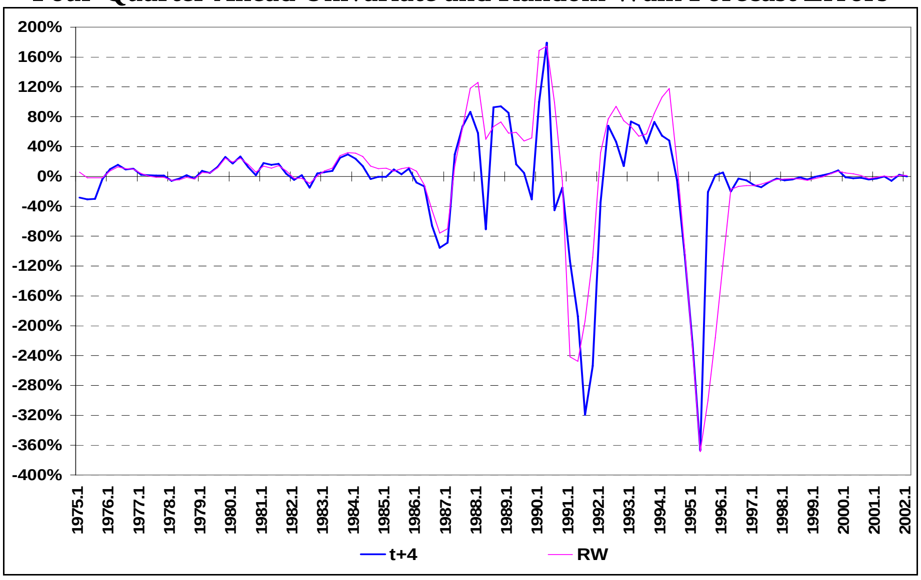
[52] Note that even if agents know when there will be a regime change, it remains a challenge to forecast the new inflation *path* accurately. See da Silva Filho (2006) for some evidence on the Real Plan period using OECD forecasts.
[53] The first observation in both series is given by the average of the first 13 forecast errors. The large swings in the one-year ahead average errors are due to the implementation of stabilisation plans, when inflation is hugely overpredicted, largely offsetting the previous bias.
[54] One should be reminded that inflation is derived from logarithmic numbers so forecast errors magnitudes are underestimated.
[55] Note that here forecasts are dated by the date at which they were made, and not by the date of their realisation.

forecasting, a difference that economists usually do not take properly into account. Consequently, in-sample "forecasts" cannot be taken as a reliable proxy of real life out-of-sample forecasts. Moreover, the role of uncertainty in economic decisions is clearly underestimated when one analyses short-run measures, such as one-quarter ahead forecast errors. This horizon gives a misleading picture of our real ability to forecast accurately on horizons likely to be more relevant for most economic decisions. Finally, note that in the simulation above even though forecasts are biased and persistent errors are being committed, overall forecasts come from apparently well-specified models.

Graph 19
One-Quarter Ahead Univariate and Random Walk Forecast Errors



Graph 20
Four-Quarter Ahead Univariate and Random Walk Forecast Errors



Graph 19 plots the univariate one-quarter ahead out-of-sample forecast errors obtained above and those derived from a random walk model (i.e. last quarter's inflation rate is the forecast for the next quarter inflation rate). Note that they are very similar, suggesting that even at one-quarter ahead Brazilian inflation has been largely unpredictable. Indeed, both types of errors have a correlation coefficient equal to 0.81, and Graph 2 in Appendix 2 shows that correlation explicitly. This makes sense given the history of high and unstable inflation in

Brazil. It implies that, at least in the Brazilian case, inflation uncertainty proxies derived from a simple random walk model of inflation should provide reliable inflation uncertainty proxies.[56] Graph 19 also highlights the very large forecast errors made during the 1986–1994 period. This is certainly unusual for one-quarter ahead forecasts, but it should not come as a surprise since inflation was clearly out of control during that period and several stabilisation plans were adopted during that time. Indeed, this period overshadows the rest of sample giving the false impression that errors in other periods were small. Graph 20 shows the same exercise for one-year ahead forecasts. The picture remains largely same, although one can see some divergence between both series during the 1988–1989 period. Also, now forecast errors are relatively larger in the first third of the sample.

Finally, Table 3 compares the forecasting performance between the two types of forecasts in four different horizons. Note that 1Q refers to inflation forecasts for the next quarter ($E_{t-1}\Delta \ln P_t$), 2Q refers to forecasts for inflation over the next two quarters ($E_{t-2}\Delta_2 \ln P_t$), 3Q over the next three quarters ($E_{t-3}\Delta_3 \ln P_t$) and 4Q over the next four quarters ($E_{t-4}\Delta_4 \ln P_t$). The associated random walk forecast is given by the most recent inflation rate for the same period involved in the forecast. For example, the random walk forecast for inflation over the next three quarters is the accumulated inflation in the last two quarters plus the current quarter.

Table 3
Brazilian Inflation (1975.1–2002.1):
Univariate and Random Walk Forecast Performance

	1Q	2Q	3Q	4Q
	BIAS			
Univariate	-0.03%	0.95%	2.91%	4.94%
Random Walk	-0.03%	-0.15%	-0.46%	0.67%
	Relative RMSE[57]			
	0.82	0.90	0.92	0.88
	Qualitative Performance			
Univariate	62	54	55	56
Random Walk	47	55	54	53

As it was found when both the BCB Inflation Report and Focus forecasts were analysed in Section 5, forecasts from random walks show very low bias. Here, apart from the first forecast horizon, they win in every other horizon, and prove once again to be extremely difficult to beat in this criterion. When it comes to the relative root mean square errors the situation is inverted. Now, for each horizon univariate forecasts beat random walk forecasts, mainly in one-quarter ahead forecasts. Notice, however, that because of the big errors due to stabilisation plans effects this ordering could be distorted by a few outliers. Therefore, it is also useful to analyse the relative qualitative aspect of each type of forecast, expressed by the number of times that each series is closer than the other, in absolute value, to the actual outcome. The bottom part of Table 3 shows a clear superiority of univariate forecasts over random walks when the next quarter inflation is considered, but a very similar performance in the remaining horizons.

[56] Brunner and Hess (1993) found evidence that changes in inflation are more relevant in explaining inflation uncertainty in their model than forecast errors. Crawford and Kasumovich (1996) mentioned that research at the Bank of Canada found that although one-year ahead forecast errors from a Canadian survey were related to inflation level they were more related to changes in inflation.
[57] Defined as the ratio between univariate RMSE and random walk RMSE.

7 – Conclusion

Forecasting is an art, and a very difficult one, especially when one lives in a non-stationary world that is subject to frequent structural breaks. The recurrent episodes of forecast failure observed in practice make those difficulties very clear. They are more clearly connected to turbulent times such as the 1970s (e.g. the failure of the big macro models in the U.S.). Indeed, as Hendry (2000a) points out that "… periods of forecast failures and economic turbulence often go hand in glove …" However, forecast failure is also pervasive in "normal" times, such as the 1990s. For example, Greenspan (1999) notices that "Forecasts of inflation and of growth in real activity for the United States, including those of the Federal Open Market Committee, have been generally off for several years. Inflation has been chronically overpredicted and real GDP growth underpredicted.", while Pagan (2001) points out that "Problems in predicting inflation have been a worldwide problem in the mid to late 1990s …" As a consequence, economists' ability to forecast has often been the subject of jokes. Nothing could be more embarrassing to the rational expectations paradigm, which assumes that forecasts are accurate and no systematic errors are committed. However, when one reads the econometric inflation uncertainty literature one has the impression that forecasting is very easy. For example, even though forecasting in the 1970s was very difficult Engle (1983) stated that "Although the level of inflation in the seventies was high, it was predictable." So what is behind Engle's assessment?

This paper has criticised the econometric inflation uncertainty proxies found in the literature, and highlighted the sharp contrast between the evidence portrayed by that literature and the survey literature. While the latter shows overwhelming evidence that inflation uncertainty is positively related to the inflation level, as argued by Okun (1971) and Friedman (1977), the former usually find no such link, as argued by Engle (1983)). So why is that literature so optimistic about people's ability to forecast? This paper claims that one major factor is that the econometric proxies found in the literature are temporally inconsistent, since they come from models that use future information to derive forecasts. In other words, economists have surprisingly been using in-sample "forecasts" to assess inflation uncertainty. Another reason refers to the forecast horizon used. While the survey literature usually focus on one-year ahead forecasts, applied econometric papers traditionally focuses on one-quarter ahead forecasts, which are more accurate than longer term forecasts, giving a misleading idea about the difficulties forecasters are likely to face in practice.

It should have been evident that if one aims at obtaining reliable proxies for the degree of uncertainty a forecaster faces when a forecast is being made a necessary condition is not to use data that was unavailable to the forecaster to that date (e.g. future data or revised data). It was pointed out that in-sample "forecasts" produce, by construction, zero mean average one-step ahead forecast errors *regardless* of the model's quality. Moreover, if the model is well specified one-step ahead in-sample "forecast" errors will be uncorrelated. Those two features mean that uncertainty is likely to be underestimated in such setting, and explain why in-sample econometric forecasts look so good when compared to actual forecasts. Indeed, this paper has shown that empirical forecasts convey a much more cautious message about agents' real ability to forecast. Surveys clearly show that expectations have a large backward looking component, usually reacting rather than anticipating to events, especially turning points. Inflation forecasts, in particular, are found to usually underestimate inflation when it is rising and overestimate inflation when it is falling.

It comes as a surprise that inflation uncertainty, which is at the very centre of the inflation uncertainty-level debate, has not been receiving its due attention from economists. This odd situation is a testimony to the massive influence of the rational expectations paradigm in economics, in which words such as forecast failure and systematic errors have no room, and helps to explain why economists have been deriving inflation uncertainty proxies in such a naïve way. The fact that economists have historically dismissed and systematically ignored the evidence from surveys gives support to this interpretation. As notes Carroll (2001) "… the bulk of the macroeconomics profession has ignored the rich empirical data available on actual household and business expectations in favor of the theoretical purity of rational expectations models." However, surveys have passed the test of time, and have proven to be reliable. The evidence today is pretty much the same as that dismissed in the 1970s. Moreover, recent studies have shown that empirical macro models work better when instead of using model-consistent expectations, survey expectations are used (e.g. Roberts, 1997, 1998).

After having established the sharp contrast between both literatures and uncovered the reasons behind that discrepancy the paper analysed inflation forecasts from both the Central Bank of Brazil Inflation Report and the recently created Focus Survey. The evidence that emerged was grim: inflation has been systematically underpredicted in Brazil since 2000, and forecast errors have been large. At the same time several pre-established inflation targets have been changed upwards, harming the credibility of the inflation-targeting framework. This evidence has some interesting implications. For example, it shows that the Central Bank of Brazil should be very cautions when using private forecasts to assess the adequacy of its monetary policy. It perhaps also suggests that degree of disagreement among forecasters could be as valuable in conveying information about agents' perceptions as the so-called consensus forecasts.

More broadly, it was called to attention the endemic degree of inflation uncertainty observed historically in Brazil, and its associated costs. Clear evidence on this regard is given not only by the striking low average maturity attached to nominal public bonds but mainly by the much shorter maturity of nominal bonds relatively to real bonds. More importantly, this situation remains even after ten years of stabilisation has taken place, highlighting the serious costs of inflation uncertainty in Brazil. These hysteresis effects have also been elsewhere and point towards the potential large welfare gains to Brazil from a policy in which the Central Bank aims at keeping inflation at very low levels for extended periods of time.

In the final part of the paper a forecasting simulation exercise was carried out in order to get out-of-sample temporally consistent inflation uncertainty proxies for Brazil. This was accomplished by estimating different inflation forecasting models, one for each quarter, during the 1975.1–2001.1 period. Although it is an impossible task to figure out what was in people's minds at the time they were forecasting, the results were very interesting. For example, the pattern of inflation forecasts was found to be very similar to what surveys of expectations have been showing elsewhere: systematic underprediction when inflation is rising and systematic overprediction when inflation is falling. The simulation also shows that forecast accuracy decreases very sharply with the forecast horizon in Brazil, which helps to explain the very low maturity of nominal bonds. Finally, the simulated inflation forecasts produced very similar errors to those generated by a simple random walk model, reflecting the high degree of unpredictability of Brazilian inflation, and suggesting that the latter should provide a reliable inflation uncertainty proxy for Brazil. Interestingly, Section 4 mentioned evidence that in both the U.S. and Canada changes in inflation have been found to be closely linked to inflation uncertainty.

Besides the above findings one hopes that the main message from this paper is one of humility. Our ability to forecast is yet very limited and one only needs some volatility for large forecast errors to appear. The evidence from developing countries is crucial to establish this result. The small magnitude and higher accuracy of inflation forecast errors observed in industrialized countries cannot be purely understood as an indicator of our forecasting skills, since they result, to a large extent, of both low and predictable inflation. In order words, when inflation is low and stable it becomes very difficult to make large forecast errors, and this is a very good reason for pursuing price stability.

Appendix 1

Out-of-Sample Historical Estimates

Forecast Date	Y_t	$\sum_{i=1}^{3} S_i$	$\sum_{i=1}^{6} Y_{t-i}$	$\sum_{i=0}^{5} \Delta Y_{t-i}$	$\sum_{i=0}^{4} \Delta^2 Y_{t-i}$	Dummies	MST
1974.1	1	1	1,4,6				12.4%
1974.2	1	1	1,4,6				10.7%
1974.3	1	1	1,4,6				33.9%
1974.4	1	1	1,4,6				35%
1975.1	1	1	1,4,6				20.8%
1975.2	1	1	1,4,6				19.7%
1975.3	1	1	1,4				8.3%
1975.4	1	1	1,4				6.9%
1976.1	1	1	1,4			1,3	21.1%
1976.2	1	1	1,4			1,3	21.4%
1976.3	1	1	1,4			1,3	23.5%
1976.4	1	1	1,4			1,3	22.1%
1977.1	1	1	1,4			1,3	19.7%
1977.2	1	1	1,4			1,3	19.5%
1977.3	1	1	1,4			1,3	18.5%
1977.4	1	1	1,4			1,3	16.7%
1978.1	1	1	1,4			1,3	16.2%
1978.2	1	1	1,4			1,3	16.4%
1978.3	1	1	1,4			1,3	14.7%
1978.4	1	1	1,4			1,3	14.3%
1979.1	1	1	1,4			1,3	12.7%
1979.2	1	1	1,4			1,3	11.2%
1979.3	1	1	1,4			1,3,4	14.9%
1979.4	1	1	1,4			1,3,4	14.9%
1980.1	1	1	1,3,4			2,4	10%
1980.2	1	1	1,3,4			2,4	11.9%
1980.3	1	1	1,3,4			2,4	13.2%
1980.4	1	1	1,3,4			2,4	10.7%
1981.1	1	1	1,3,4			2,4	8.1%
1981.2	1	1	1,4			1,4	8.9%
1981.3	1	1	1,3,4			1,2,4	14.9%
1981.4	1	1	1,4			1,4,5	15.3%
1982.1	1	1	1,4			1,4,5	16.5%
1982.2	1	1	1,4			1,4,5	6.6%
1982.3	1	1	1,3,4			1,4,5	16.3%
1982.4	1	1	1,3,4			1,4,5	15.5%
1983.1	1	1	1,3,4			1,4,5	20.8%
1983.2	1	1	1,3,4			1,4,5	9.8%
1983.3	1	1	1,3,4			1,4,5,7	9.8%
1983.4	1	1	1,3,4			1,2,4,5,7	21.3%
1984.1	1	1,2	1,3,5,6			4,5,6	7.4%
1984.2	1	1,2	1,3,5,6			4,5,6	10.0%
1984.3	1	1,2	1,3,5,6			4,5,6	15.4%
1984.4	1	1,2	1,3,5,6			4,5,6	14.4%
1985.1	1	1,2	1,3,5,6			4,5,6	13.1%
1985.2	1	1	1,4			4,5,7,8	10.1%
1985.3	1	1	1,4			1,4,5,7,8	15.0%
1985.4	1	1	1,3,4			4,5,7,8	6.5%
1986.1	1	1,2	1,3,4			4,8	19.3%
1986.2	1	1	1,3,4			4,7,8,9	7.0%

Forecast Date	Y_t	$\sum_{i=1}^{3} S_i$	$\sum_{i=1}^{6} Y_{t-i}$	$\sum_{i=0}^{5} \Delta Y_{t-i}$	$\sum_{i=0}^{4} \Delta^2 Y_{t-i}$	Dummies	MST
1986.3	1	1	1,5			4,8,9	30.4%
1986.4	1	1	1,5			4,8,9	30.6%
1987.1	1	1	1,5			8,9,11	48%
1987.2	1	2	1			5,9,11,12	10.4%
1987.3	1	1	1,5			9,10,12	0.7%[2]
1987.4	1	1	1,5			9,10,12,13	1.4%[2]
1988.1	1	1	1,2,3			9,10,11,12	24.9%
1988.2	1		1,2,3,4			9,10,11,12	1.1%[3]
1988.3	1		1,2,3,4			9,10,11,12,16	1.1%[3]
1988.4	1		1,2,3,4			9,10,11,12, 16	0.0%[3]
1989.1	1		1,3			9,11,12,13,18	12.5%
1989.2	1	1	1,5			9,10,12,14,15,17	30.2%
1989.3	1	2	1,3			9,11,12,13,18,19	14.8%
1989.4	2	1,3	1,2,5			9,14,17	44.9%
1990.1	2	1,3	1,2,5			9,14,17	47.2%
1990.2	2	1,3	1,2,5			9,14,17,21	49.7%
1990.3	2	1,3	1,2,5			9,14,17,21	56.1%
1990.4	2	1,3	1,2,5			9,14,17,21	54.9%
1991.1	2	1,3	1,2,5			9,14,21	12.2%
1991.2	2	1,3	1,2,5			9,14,21,22	12.2%
1991.3	2	1,3	1,2,5			9,14,21,22	7.4%
1991.4	2	1,3	1,2,5			9,14,21,22	18.4%
1992.1	2	1,3	1,2,5			9,14,21,22	13.1%
1992.2	2	1,3	1,2,5			9,14,21,22	11.8%
1992.3	2	1,3	1,2,5			9,14,21,22	9.0%
1992.4	2	1,3	1,2,5			9,14,21	20.7%
1993.1	2	1,3	1,2,5			9,14,21,22	9.1%
1993.2	2	1,3	1,2,5			9,14,21,22	8.2%
1993.3	2		1			13,21,22	15.9%
1993.4	2		1			13,19,20,21	9.4%
1994.1	2		1			13,21,22	14.1%
1994.2	2	2	1,2			12,21	22.6%
1994.3	1	RW Model[1]					
1994.4	1	2	1			18,19,20,21,25	30.5%
1995 1	1						
1995.2	1	RW Model[1]					
1995.3	1	RW Model[1]					
1995.4	1		1		4	18,19,20,21,25	16.3%
1996.1	1		1		4	18,19,20,21,25	16.0%
1996.2	1		1		4	18,19,20,21,25	14.7%
1996.3	1	2	1			18,19,20,21,25	6.0%
1996.4	1		1			18,19,20,21,22,25	10.0%
1997.1	1		1		4	18,19,20,21,25	11.2%
1997.2	1		1		4	18,19,20,21,25	9.9%
1997.3	1		1	4		18,19,20,21,25	10.5%
1997.4	1		1		1,4	18,19,20,21,25	5.2%
1998.1	1		1		4	18,19,20,21,25	7.1%
1998.2	1		1		1,4	18,19,20,21,25	3.9%[3]
1998.3	1	2	1	1	4	18,19,20,21,25	9.8%
1998.4	1	2	1	1	4	18,19,20,21,25	8.2%
1999.1	1		1		4	18,19,20,21,24,25	7.0%
1999.2	1	2	1	1	4	14,18,19,20,21,24,25	12.3%
1999.3	1	2	1	1	4	14,18,19,20,21,24,25	9.6%
1999.4	1	2	1	1	4	18,19,20,21,24,24	4.1%[3]
2000.1	1		1	1,3,4		23, 24, 25	0.2%[2,4]
2000.2	1	2	1	1,4,5		14,18,19,20,21,24,25	4.8%[4]

Forecast Date	Y_t	$\sum_{i=1}^{3} S_i$	$\sum_{i=1}^{6} Y_{t-i}$	$\sum_{i=0}^{5} \Delta Y_{t-i}$	$\sum_{i=0}^{4} \Delta^2 Y_{t-i}$	Dummies	MST
2000.3	1		1	1	2,4	24,25,26	8.7%
2000.4	1		1	1,3,4,5		14,18,19,20,21,24,25	5.6%
2001.1	1		1	1	2,4	24,25,26	8.0%
2001.2	1		1	1	2,4	24,25,26	7.5%
2001.3	1		1	1	2,4	24,25,26	7.1%
2001.4	1		1	1	2,4	24,25,26	5.7%

Notation:

The General Forecasting Equation is

$$Y_t = cte + \sum_{i=1}^{3} Seasonals_i + \sum_{i=1}^{6} Y_{t-i} + \sum_{i=0}^{5} \Delta Y_{t-i} + \sum_{i=0}^{4} \Delta^2 Y_{t-i} + Dummies + \varepsilon_t$$

$\mathbf{Y_t = 1}$ if $Y = 100\pi$ and $\mathbf{Y_t = 2}$ if $Y_t = 400\pi_t/(1+4\pi_t)$ where $\pi_t = \Delta \ln P_t$ and P = IPC-DI

Dummies: 1965.2 = 1; 1965.4 = 2; 1974.1 = 3; 1979.3 = 4; 1981.4 = 5; 1983.1 = 6; 1983.3 = 7; 1985.2 = 8; 1986.2 = 9; 1986.3 = 10; 1987.1 = 11; 1987.2 = 12; 1987.3 = 13; 1987.4 = 14; 1988.1 = 15; 1988.3 = 16; 1988.4 = 17; 1989.1 = 18; 1989.3 = 19; 1990.1 = 20; 1990.2 = 21 1991.2 = 22; 1991.3 = 23;1991.4 = 24; 1994.3 = 25; 1995.2 = 26;

(1) Random Walk projections assume that inflation in the following quarters will be equal to last quarter inflation.
(2) Heteroscedasticity Test
(3) RESET Test
(4) Normality Test.

MST = Most Significant Test, expressed in terms of the lowest p-value among the followings tests: a) AR 1-3, AR 1-4 or AR 1-5 F-test (depending on the sample size); b) ARCH 1-3 or ARCH 1-4 F-test (depending on the sample size); c) Normality test: Chi^2(2); d) hetero F-test, e) hetero-X F-test; f) RESET test.

OBS 1: Besides the above tests, in every regression coefficients' stability were checked using recursive graphs. The following graphs were also analysed: a) 1-Step Residuals; b) Recursive One-Step Chow tests; and c) Recursive break point Chow tests. See comments in Section 6 regarding the results.

OBS 2: Grey lines indicate a new set of estimations in which the estimation sample changed, according to Table 2 in Section 6.

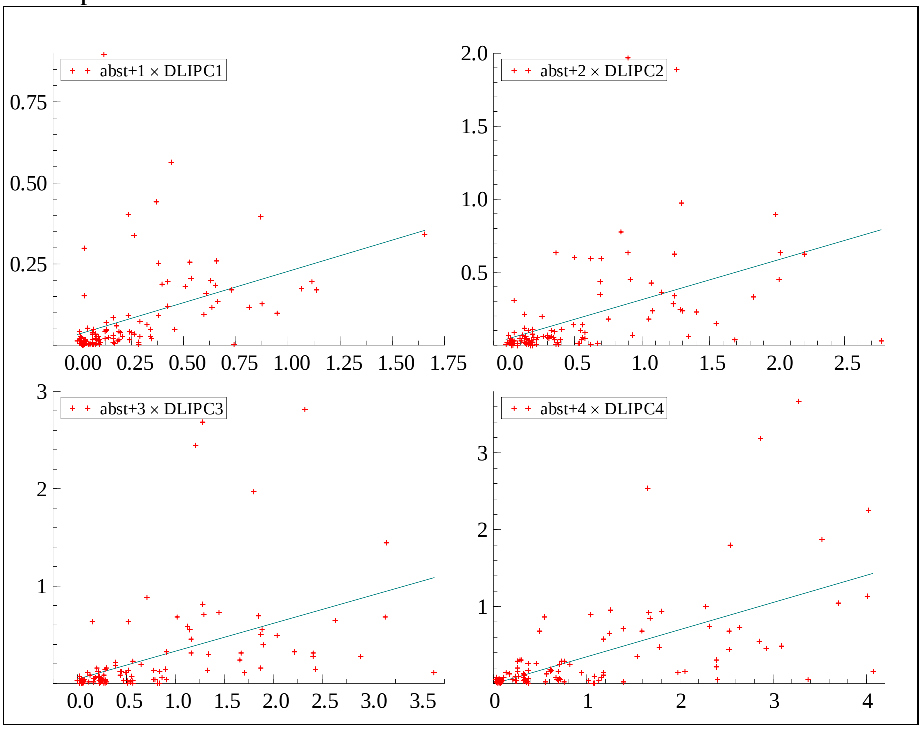
OBS 3: Besides models in levels models using the first difference of inflation were also estimated but during the most turbulent periods they produced poorer forecasts so that their results are not reported.

OBS 4: All estimations were carried out using the PC-Give.

Appendix 2

Graph 1

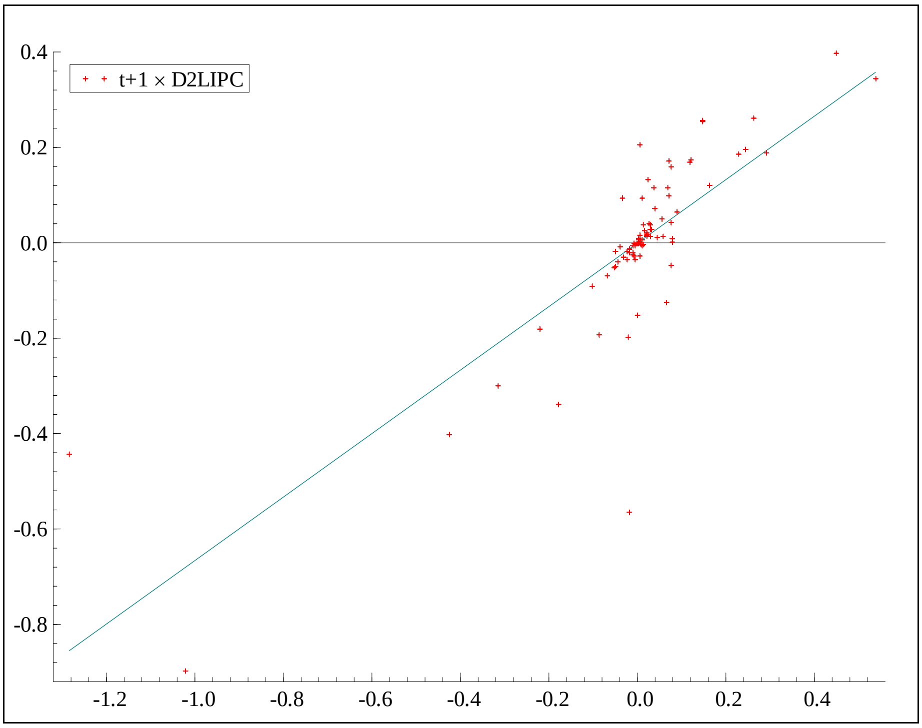
Simulated Real Time Out-of-Sample Absolute Inflation Forecasts Errors
Up to One-Year Ahead and Inflation Rates Over the Forecast Period



Obs: DLIPCi $= \Delta_i \ln P_t$, abst+i $= \left| \Delta_i \ln P_t - E_{t-i}\left(\Delta_i \ln P_t\right) \right|$, i = 1,…,4.

Graph 2

Simulated Real Time One-Quarter Ahead Out-of-Sample
Inflation Forecasts Errors and Random-Walk Errors



Obs: D2LIPC $= \Delta^2 \ln P_t$, t+i $= \Delta \ln P_t - E_{t-1}\left(\Delta \ln P_t\right)$.

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