Título: An Application of Quah and Vahey's SVAR Methodology for Estimating Core Inflation in Brazil

Autores: Paulo Picchetti (pichetti@usp.br)
Fabio Kanczuk (kanczuk@usp.br)

Universidade de São Paulo – Departamento de Economia
Av. Luciano Gualberto, 908, Cidade Universitária
São Paulo, SP, 05508-900, Brasil
Fone: (011) 3818 6012
Fax: (011) 3818 6013

Resumo: A questão da mensuração do núcleo inflacionário e sua relevância para a realização de política econômica foi largamente discutida na literatura internacional, e na literatura aplicada ao Brasil. A despeito disso, não existe consenso acerca da melhor medida de núcleo inflacionário. Várias metodologias diferentes já foram empregadas para dados brasileiros, com resultados distintos. Aqui, nós empregamos a metodologia proposta por Quah e Vahey (1995) para dados do Brasil. Essa metodologia é atrativa dos pontos de vista de requerimento de dados e computação, e é a única baseada em argumentos de teoria econômica. Também discutimos como os resultados do modelo estimado podem ser utilizados para fornecer uma medida de produto potencial, também de grande relevância para a realização de política econômica.

Palavras-Chave: Núcleo Inflacionário, Estimação de Vetores Auto-Regressivos Estruturais, estimação de produto potencial.

Abstract: The issue of core inflation measurement and its relevance for policy making has been thoroughly discussed both in the international, and on the Brazilian applied literature. Despite this relevance, there is no consensus on how best to measure core inflation. Several different methodologies have been employed for Brazilian data, with different results. Here we apply Quah and Vahey's (1995) methodology to Brazilian data. This methodology is attractive in computational and data requirement aspects, and is the only one based on economic theory. We also discuss how the results from the estimated model can be used to provide a measure of potential product, which is also a very relevant issue for policy making.

Key-Words: Core Inflation, Structural VAR estimation, Potential Product estimation

Área de Classificação da ANPEC: 02 (Macroeconomia)

Código JEL: C22, E31

1 Introduction

The issue of core inflation measurement and its relevance for policy making has been thoroughly discussed both in the international, and on the Brazilian applied literature. Despite this relevance, there is no consensus on how best to measure core inflation. For two very good references concerning applications of different techniques to Brazilian data, the reader is referred to Figueiredo (2000) and Bryan and Cecchetti (2001).

Several different methodologies have been employed for Brazilian data, including trimmed means estimators, common stochastic components (a reference for these two methods in the Brazilian case is Picchetti and Toledo (2000)), and zero weighting of seasonal components. One of the methodologies implemented in the international literature is the one proposed by Quah and Vahey (1995). This methodology has three main attractive features: it uses relatively much less data than its alternatives, it is computationally simple, and it is the only one based on economic theory justifications.

Here we apply Quah and Vahey's methodology to Brazilian data, and compare the results with the shocks identified by Bogdanski et alli (2000). We also discuss how the results from the estimated model can be used to provide a measure of potential product, which is also a very relevant issue for policy making.

2 Quah and Vahey's Model

Essentially, we estimate a VAR system where Y – the log of output – and π – the log of price-level – are the endogenous variables. Taking first differences to guarantee stationarity, we have:

$X_t = \begin{bmatrix} \Delta Y_t \\ \Delta \pi_t \end{bmatrix}$, $\varepsilon = \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix}$ (vector of "shocks"), where

$$\begin{aligned} E[\varepsilon_1] &= E[\varepsilon_2] = 0 \\ Cov[\varepsilon_1, \varepsilon_2] &= 0 \end{aligned}$$

From the VMA representation, we know that:

$$\begin{aligned} X_t &= C(0)\varepsilon_t + C(1)\varepsilon_{t-1} + C(2)\varepsilon_{t-2} + \dots \\ &= \sum_{j=0}^{\infty} C(j)\varepsilon_{t-j} \end{aligned}$$

where $C(j) = \begin{bmatrix} c_{11}(j) & c_{12}(j) \\ c_{21}(j) & c_{22}(j) \end{bmatrix}$

We can estimate the vector of disturbances $e = \left[e_1 \vdots e_2 \right]'$ from the estimation of the VAR in reduced form, but we cannot directly estimate the vector of shocks, since the parameters in $C(j)$ are the ones from the standard form, not identifiable unless we pose some restrictions. The problem is, as always happens in identification issues, to be in a situation where we have more unknows than equations. The relationship between the estimated residuals and the original shocks is given by:

$$\begin{aligned} e_{1t} &= c_{11}(0)\varepsilon_{1t} + c_{12}(0)\varepsilon_{2t} \\ e_{2t} &= c_{21}(0)\varepsilon_{2t} + c_{22}(0)\varepsilon_{2t} \end{aligned}$$

so that if we knew $c_{11}(0), \ldots, c_{22}(0)$, we could directly recover the original shocks from the estimated residuals, which are composites of them. But we know that $c_{11}(0), \ldots, c_{22}(0)$ involve coefficients from the standard VAR, and these are not identifiable by the estimated coefficients of the reduced form. The main idea behind Blanchard and Quah's decomposition method is to impose four additional restrictions which create four equations that can be solved for $c_{11}(0), \ldots, c_{22}(0)$. Three of these restrictions come from the covariance matrix of the estimated residuals, while the fourth and final one come from the restriction of one of the original shocks not having any long-run impact on one of the VAR variables. This restriction is motivated on economic grounds. In our application it translates into aggregate demand shocks not having any long-term effect on product. The two shocks resulting from the above restriction can then be interpreted as an aggregate demand shock, and an aggregate supply shock. The underlying movement in core inflation is associated with the disturbance having no long-run effect on output.

This first restriction comes from the variance of the first VAR residual:

$$\begin{aligned} Var[e_1] &= Var[c_{11}(0)\varepsilon_{1t} + c_{12}(0)\varepsilon_{2t}] \\ &= c_{11}(0)^2 + c_{12}(0)^2 \end{aligned}$$

Similarly, we obtain the second restriction from the variance for the second estimated residual, in the same manner:

$$Var[e_2] = c_{21}(0)^2 + c_{22}(0)^2$$

The third restriction comes from the covariance between the estimated residuals. Note that, as said before, these are both composites of the original shocks, so that their expected value is zero, while their covariance is not. These two facts imply that their covariance is simply the expected value of their product:

$$\begin{aligned} Cov[e_1, e_2] &= E[(e_1 - E[e_1])(e_2 - E[e_2])] \\ &= c_{11}(0)c_{21}(0) + c_{12}(0)c_{22}(0) \end{aligned}$$

again using the facts that the variance of each shock is normalized to unit, and their covariance is zero. The fourth restriction says that the long-run effect of one of the shocks in one of tha variables is zero:

$$\sum_{k=0}^{\infty} c_{11}(k)\varepsilon_{1,t-k} = 0$$

after some algebra (since we don't know ε_1), we get

$$\left[1 - \sum_{k=0}^{\infty} a_{22}(k)\right] c_{11}(0) + \sum_{k=0}^{\infty} a_{12}(k)c_{21}(0) = 0$$

So, now we have four equations and four unknowns:

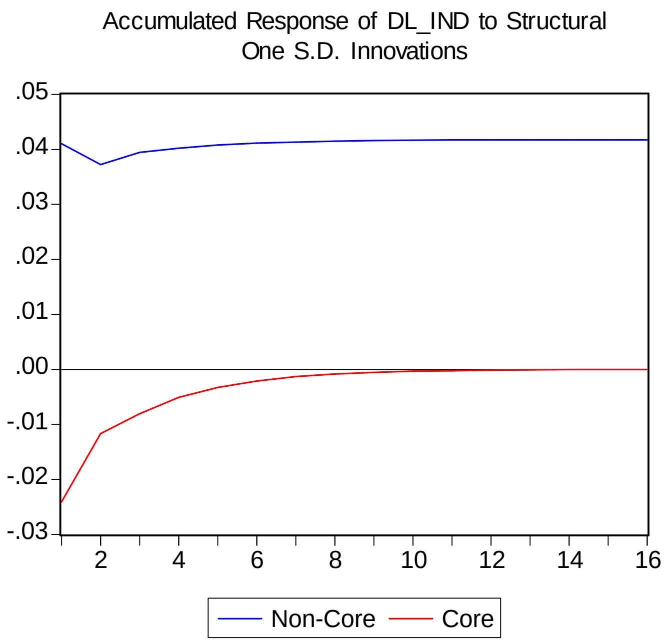
$$\begin{aligned}
Var[e_1] &= c_{11}(0)^2 + c_{12}(0)^2 \\
Var[e_2] &= c_{21}(0)^2 + c_{22}(0)^2 \\
Cov[e_1, e_2] &= c_{11}(0)c_{21}(0) + c_{12}(0)c_{22}(0) \\
0 &= \left[1 - \sum_{k=0}^{\infty} a_{22}(k)\right] c_{11}(0) + \sum_{k=0}^{\infty} a_{12}(k)c_{21}(0)
\end{aligned}$$

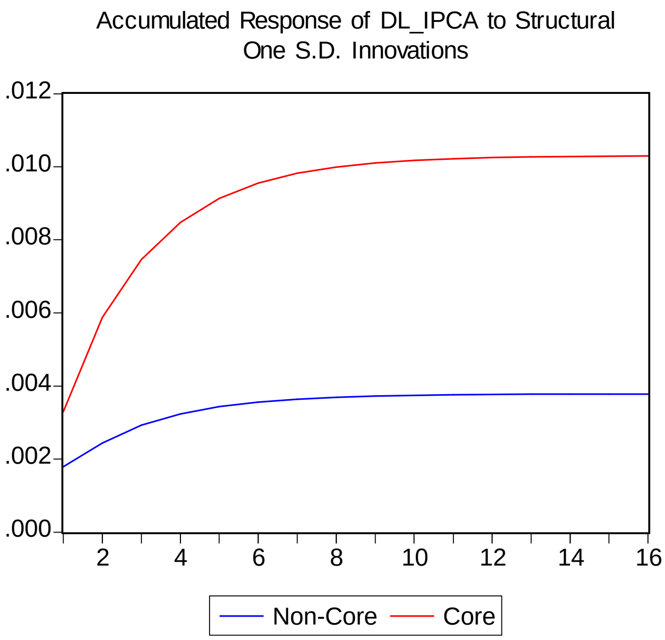
Solving these equations for $c_{11}(0), \ldots, c_{22}(0)$, we can obtain the original shocks, and proceed with the impulse-response and variance-decomposition analysis of the VAR.

We will take IBGE's industrial production monthly index as our measure of output, and will examine, in turn, the results for the VAR with the IBGE-IPCA. The estimated VAR includes nominal interest rates (SELIC) as an exogenous variable, as well as seasonal dummies. The inclusion of interest rates as a variable outside the system in this case is not without problems, since for some part of the sample the monetary regime in Brazil was mainly characterized by inflation targeting setting of nominal interest rates. However, the inclusion of interest rates as endogenous would make the imposition and intepretation of additional restrictions more cumbersome, and so we decided to include this issue in our future research agenda along with the inclusion of other potentially relevant variables, such as the exchange rate, and concentrate on the results we have with the simpler model. The chosen specification turned out to include a single lag of each of the endogenous variables.

3 Results

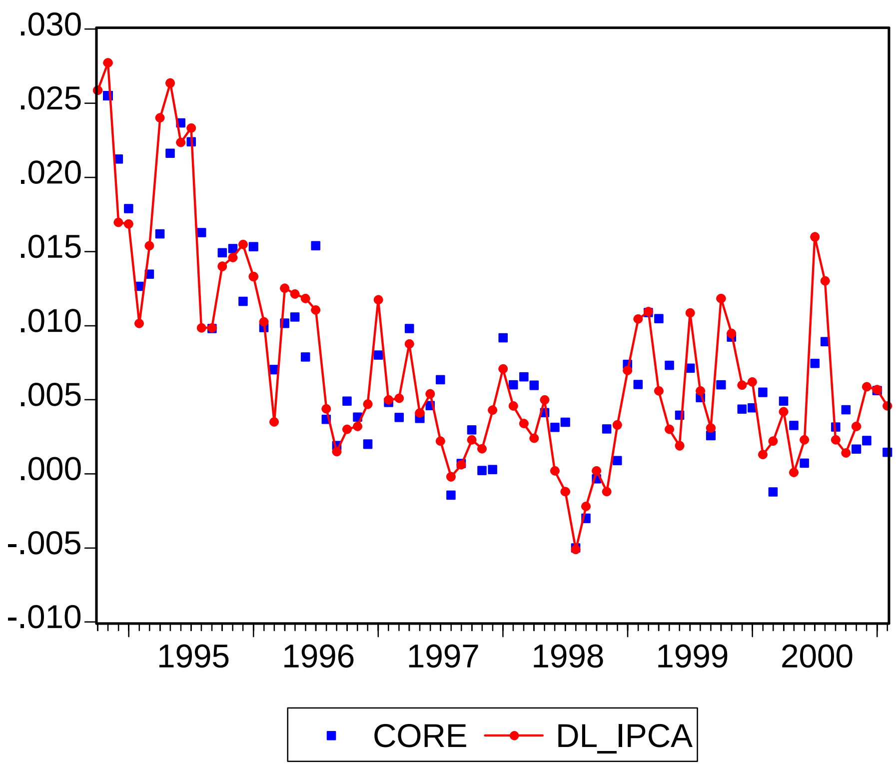
Once the VAR is estimated, and the strutuctural shocks are obtained by the above explained identification restrictions, the impulse response functions are:



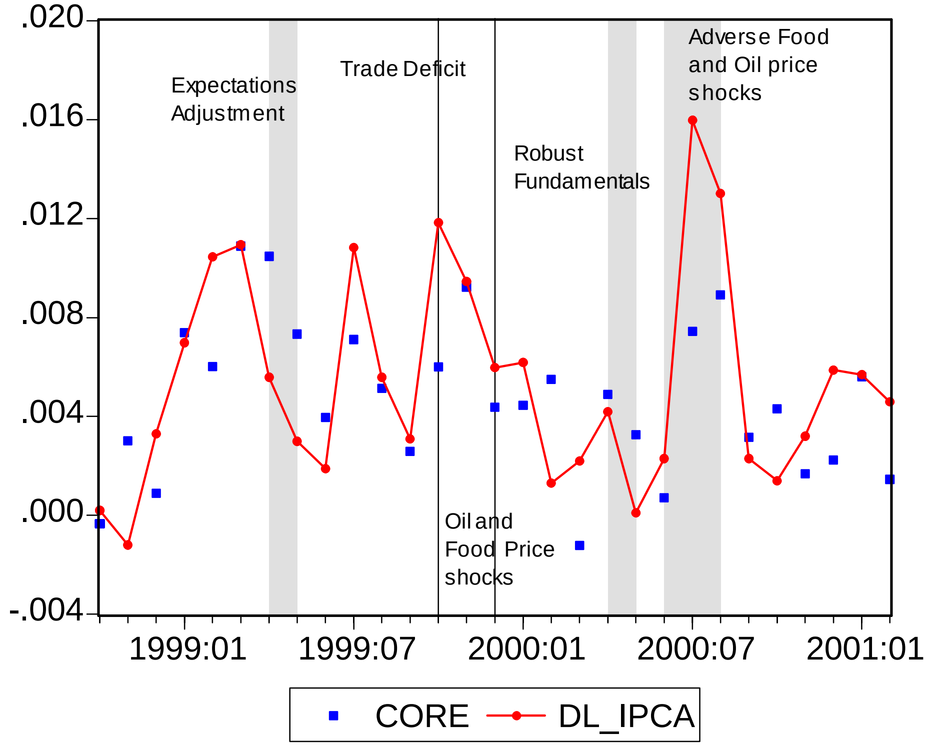


The proposed mesure for Core Inflation can then be obtained by the underlying movement in headline inflation associated only with the disturbances representing “demand shocks”. The difference between measured IPCA and our

Core component can be seen in the graph below:



It is interesting to investigate these results in comparison to the shocks analysed by Bogdansky et alli, for the period after the implementation of the inflation-targeting program in Brazil:



The periods characterized by negative supply shocks in Bogdansky et alli consistently depict a value for headline inflation above our measure of Core inflation. This is an encouraging fact for the use of this measure of Core inflation. Compared to some alternative measures, it presents some significant advantages in termos of data requirement and computational complexity. Whereas our measure depends only on the availability of data for the general price index, the industrial production index, and nominal interest rates, trimmed-means based measures require availability of data on individual components of the index. Also, the structural VAR estimation methods used here are already implemented in some of the standard econometrics softwares, whereas measures such as the ones proposed by Bryan and Cecchetti (1994), applied to Brazilian data by Picchetti and Toledo, require some substantil programming to implement the estimation procedures.

4 Implications for Potential Product Estimation

We now use this methodology to propose a measure of potential GDP. Following the literature on inflation targeting (Taylor (1999)), the convenient definition of potential GDP, or "natural rate of output", is one that can be grasped from the relation

$$\pi_t = a(Y_t - \hat{Y}_t) + b\pi_{t+1} + \varepsilon_t$$

where π is inflation, Y is GDP, $\hat{Y}$ denotes the potential GDP, ε is a white noise, and the coefficients a and b are positive numbers.

The above specification is known as the New Keynesian Phillips Curve, but this equation can more generally take other forms that include lagged inflation, wages and government-controled prices (see Bogdanski, Tombini and Goldfajn (2001)). The important point to be taken here, which is common to all specifications, is that the "output gap", or the deviation from current GDP to current potential GDP has a positive impact on inflation. This means that if GDP is higher that potential GDP then inflation is perpetually increasing; and GDP lower that potential GDP implies that inflation is decreasing. The concept of potential GDP is therefore the level of output for which inflation is stable.

The measure of potential GDP that is commonly used both by the academic literature and central banks (see, however, Woodford (2000)) is the one obtained by Hodrick-Prescott filtering the actual output series, or by linear, quadratic or spline fitting through minimum square errors minimization. In all these cases, the previous concept of potential GDP is lost, since these measures of potential GDP are simply different assessments of the low frequency components of the actual GDP.

To better understand the problem with these measures, consider that the economy was hit by a high frequency positive supply shock. Because all these techniques exclude high frequency components from the actual series, the calculated measure of potential GDP is not affected by this suppy shock. On the other hand, as in any positive supply shock, there will be a positive effect on output, and a negative effect on prices. Therefore, the output gap will be positive, and the effect on inflation will be negative, contrary to any Phillips Curve specification.

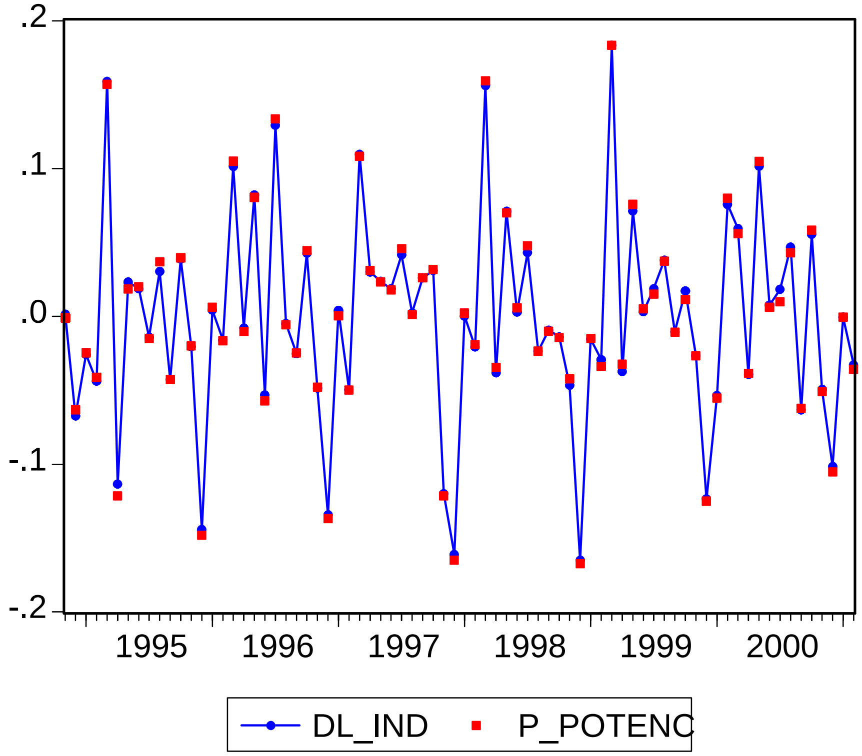
The theoretical explanation for this contradiction (which was already put forward by Wicksell!) resides on the presence of technological shocks, that affect the marginal costs of production, and the pricing of goods. In the inflation targetting language, it means that potential output should move together with the aggregate supply. The empirical relevance of this point, however, is an open question, since it depends on the relevance of high frequency supply shocks. That is exactly the question that we try to answer in what follows.

We advocate that a more appropriate measure of potential GDP is one that captures all supply shocks, including the high frequency ones. Because our methodology to identify the VAR separates the existent supply and demand shocks, such measure of potential GDP is a natural extention. It simply constitutes the GDP that would have been caused exclusively by supply shocks.

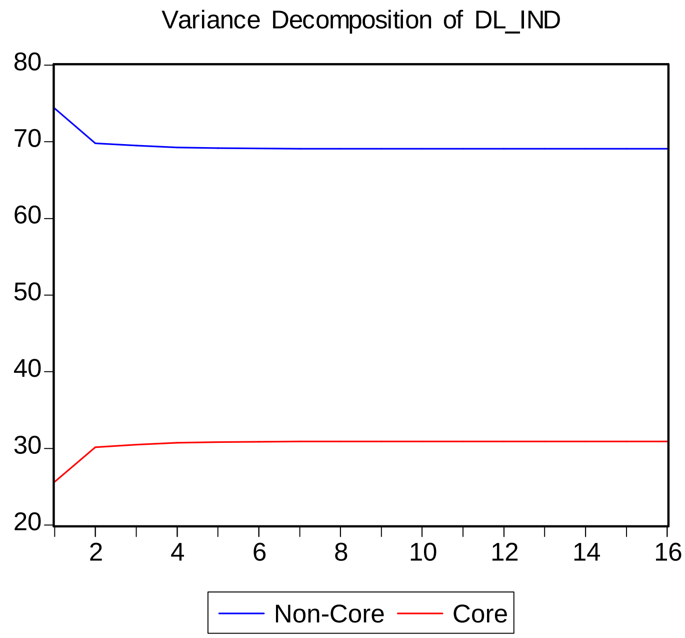
In the graph below we depict the "actual GDP series" (in terms of its rates of change) and our proposed measure of potential GDP in the 1999:1 to 2001:2 horizon (We have actually used the Industrial Production Index, as before). It is clear that the series are very similar, and there seems to be no observation for which they are statistically different.

The conclusion that stems from this figure is that roughly all GDP fluctuations are caused by supply shocks, or, equivalently, that demand shocks have no important impact on output. As a consequence, output gap is virtually zero in all observations, and the Phillips Curve looses its relevance.

Striking as they may be, similar conclusions were already reached by other empirical studies, and by the Real Business Cycle literature.



These assertions seem to be confirmed by examining the variance decomposition results for the two kinds of shocks:



5 Conclusions

The results of the estimated model show that Non-Core shocks have long-run impacts on output, but negligible impact on measured inflation. Also, Core shocks have long-run impacts on measured inflation, and impact on output is slightly positive in the beggining, but negligible in the long-run. These are expected from the restrictions imposed on the model, but seem to fit the data well. Moreover, the Core measure seems a good indicator of turning points of measured inflation, and is able to filter out the main short-run supply shocks identified by the Brazilian Central Bank.

The estimation of potential product from the Structural VAR model differ substantially from the ones obtained by simpler filtering of long-run trends usually produced.

Comparing the Core inflation estimates produced here with the ones based on trimmed means and stochastic common components (Picchetti and Toledo (2000)), the results are considerably different, with less smooth paths for the Core inflation measure. Ideally, all these methodologies are attempts to estimate the same values, representing the long run components if changes in the price level which respond to monetary policy, filtering out what could be considered as short run supply shocks to the price level. However, the comparisons of the results from different methodologies, and different levels of aggregation for price level data in the Brazilian case, show that further research is indeed necessary to point out which methodology is preferable.

The methodology implemented in this paper would benefit, in this context, from further research which would extended in two different dimensions: the inclusion of more variables in the VAR system, and accounting for probable regime-switching events.

6 References

Blanchard, O. and Quah, D. (1989) "The dynamic effects of aggregate demand and supply disturbances", *American Economic Review*, Vol. 79.

Bogdanski, J., Freitas, P., Goldfajn, I. and Tombini, A. (2001) "Inflation Targeting in Brazil: Shcoks, Backward Looking Prices, and IMF Conditionality", *mimeo – Programa de Seminários Acadêmicos do IPE/USP*, Seminário n. 07/2001.

Bryan, M. and Cecchetti, S.G. (1994) "Measuring Core Inflation" In: Mankiw, G. (ed.), Monetary Policy: Chicago: The University of Chicago Press.

Bryan, M. and Cecchetti, S.G. (2001) "A Note on the Efficient Estimation of Inflation in Brazil", *Working Paper Series 11*, Banco Central do Brasil.

Figueiredo, F. (2000) "Evaluation of a measure of core inflation" , *Manuscript – Studies and Research Department, Central Bank of Brazil.*

Picchetti, P. and Toledo, C. (2000) "How Much to Trim ? A Methodology for Calculating Core Inflation, Wich an Application for Brazil", *Economia Aplicada*, Vol.4 – N. 4

Quah, D. and Vahey, S. (1995) "Measuring Core Inflation", *Economic Journal*, 105.

Taylor, J. B. (1999), *Monetary Policy Rules*, The Univ. of Chicago Press

Woodford, M. (2000) "A Neo-Wicksellian Framework for the Analysis of Monetary Policy", Princeton Working Paper