Estimating and Interpreting a Common Stochastic Component for the Brazilian Industrial Production Index*

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Summary: 1. Introduction; 2. The data; 3. The common stochastic component model; 4. Interpretation of results and conclusions.

Key words: time series econometrics; brazilian industrial production index; business fluctuations.

JEL codes: C32 and E32.

This paper employs a state-space formulation to model a common stochastic component in four different series that constitute the aggregate index of industrial production in Brazil. This estimated common component is then interpreted as a measurement of behavior of fundamentals in the brazilian economy and compared to the actual aggregate index.

A partir de uma formulação em espaço de estado, modelamos um componente estocástico comum para quatro séries distintas que compõem o índice agregado de produção industrial calculado pelo IBGE para o Brasil. Esse componente estocástico comum estimado é então interpretado como uma medida do comportamento de fundamentos da economia brasileira, e comparado com o índice agregado efetivo.

1. Introduction

The Brazilian Institute for Geography and Statistics (IBGE) collects survey data from different sectors of nationwide industrial activity, in order to produce a monthly index. This series is considerably robust in methodology and measurement, providing a source for Brazilian national accounts. The aggregate index for industrial production is built from a weight structure applied to four basic components: capital goods, intermediate goods, durable consumer goods, and non-durable consumer goods. The idea of this paper is to apply Stock and Watson's (1991) methodology to extract a common stochastic component from these four factors, and then compare it with the aggregate index. The purpose of this exercise is to obtain a measurement of the underlying fundamentals of production in the industrial sector, especially

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considering the period of the sample, during which the Brazilian economy experienced large shocks from different sources. Departing from this analysis, we propose to address some issues concerning the Brazilian economy.

The estimated stochastic common component can be interpreted as an indicator of the state of the economy in relation to the business cycle, and can potentially be forecasted through other models incorporating leading variables. As shown below, when converted to the lower frequency at which the GNP is available in Brazil during the whole sample, the estimated common stochastic component is highly correlated with the GNP (more so than the aggregate production index). Applied researchers estimating models in which aggregate product plays a fundamental role are usually constrained by Brazilian data for this series being currently available only on a quarterly frequency. Our estimated common factor for the industrial production index seems to capture relatively well the fundamentals driving aggregate production and can in principle be considered as a potential proxy available on a monthly frequency inside the sample.

2. The Data

The monthly industry survey carried out by IBGE provides a source for the national accounts. Figure 1 depicts the monthly industrial output, which is a weighted average of 19 industrial genres of the manufaturing industry and the mineral extraction class, for the period between January 1975 and February 2000. The weights are based on a comprehensive industrial survey conducted by IBGE in 1991.

In the first growth boom promoted by the Real Plan stabilization, before the liquidity shock of March 1995, capital goods and durable consumer goods were the major responsibles for the economic growth. While figure 1 depicts the behavior of the raw series during our sample, figure 2 shows the series seasonally adjusted and free of stochastic shocks, which makes the referred strucutural breaks more evident.

In what follows we comment very briefly on the stylized driving forces of those movements. The so-called “miracle” years were characterized by heavy public investments, the setting up of multinational companies and the high absorption of external savings. The shift in the international conditions in the beginning of the 1980s made the model unsustainable. The 1980s were marked by several unsuccesful attempts to stabilize the economy. The chronic inflation process produced some bad consequences: widespread indexation; income concentration; short horizons and uncertainty. The Real Plan has been considered a succesful stabilization attempt so far. The reduction of inflation and the return of some consumer credit lines that were virtually inexistent during the high inflation years stimulated the (repressed) demand for durable goods. The credit squeezes due to external problems and the saturation of the market reversed this process after two years.

Figure 1

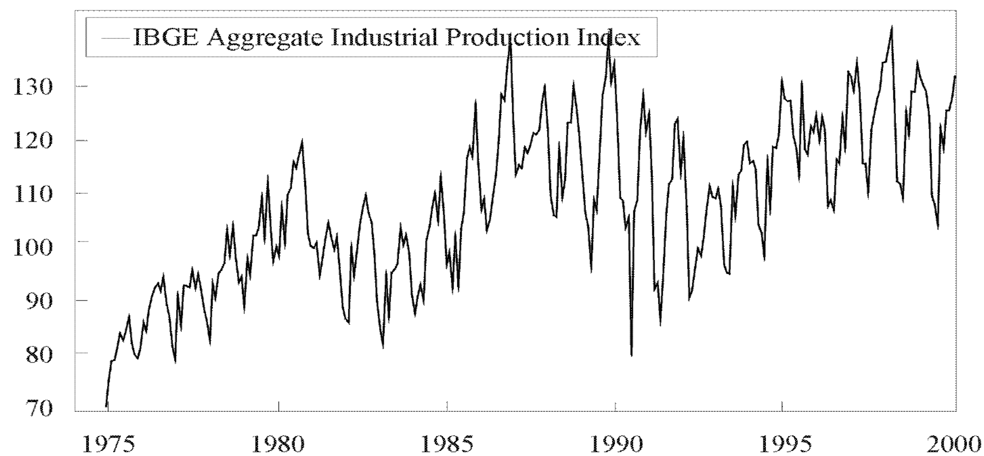
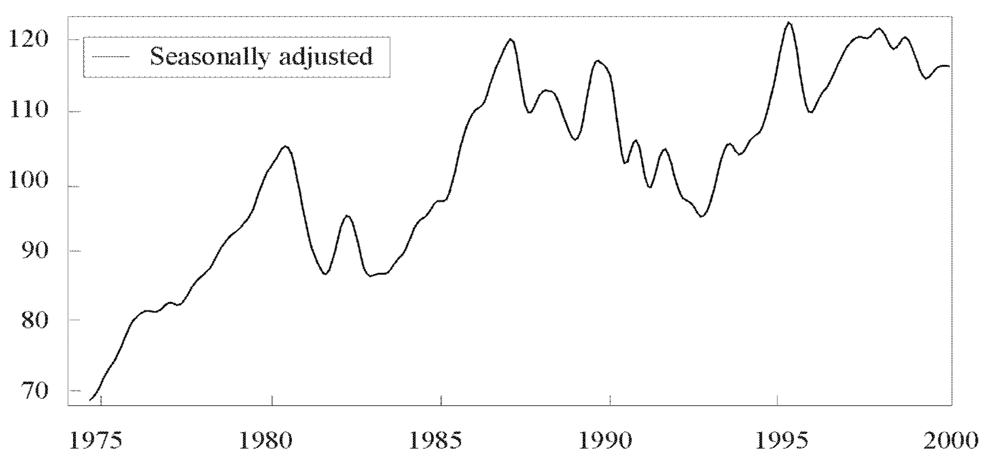
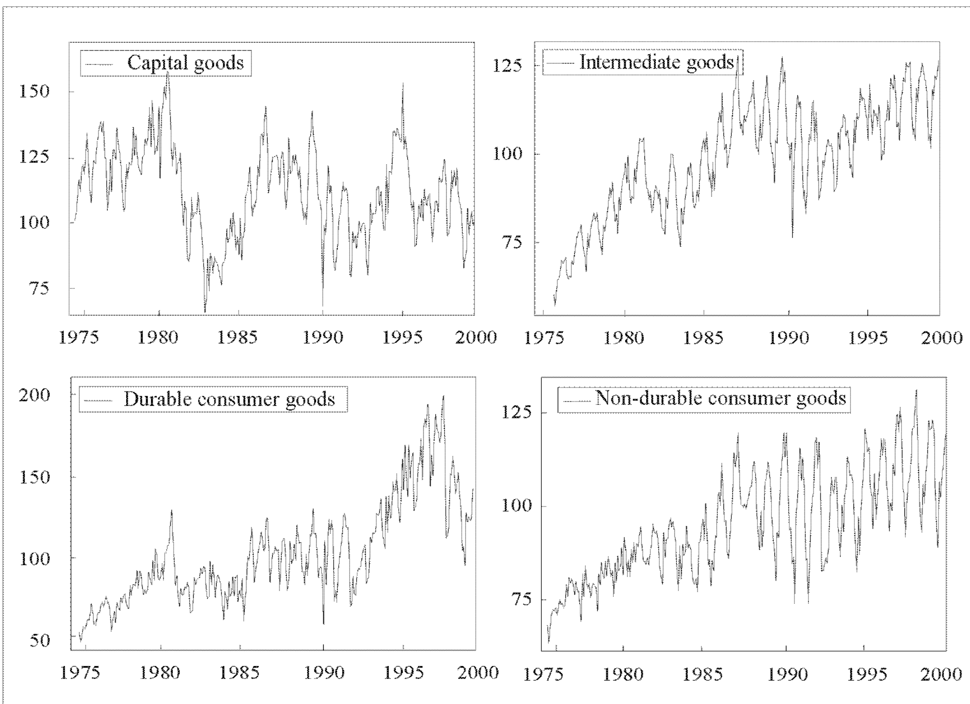


Figure 2



Our concern here is to try to get some "fundamental" measure out of such a non-homogeneous growth performance that has had to come along under different and somewhat unfavorable conditions: first because of inflation and then because of the current account deficit. Figure 3 shows the raw behavior of the four basic components of the aggregate index.

Figure 3



3. The Common Stochastic Component Model

The basic question goes as follows: is there a way to define this "fundamental" measure of economic activity that is less affected by sector-specific shocks and, thus, reflects better the underlying economic environment? Of course the answer to this question is far from trivial.

Our strategy here is to characterize this essencial feature of the economic activity as a common component removed from the different series exhibited in figure 3. We assume that there is a mutual unobserved element sustaining the comovements in the several economic sectors that are individually affected in different ways by economic shocks. This "macroeconomic building block" would, in principle, better reproduce the real "state" of the economy than a simple fixed-base average of the various series. For instance, an economic expansion lead by consumption, allowed by a brief (and unsustainable) stabilization, certainly would give, in one hand, a good feeling to the analyst that only cares about the GDP numbers. It would, on the other hand, appear unpleasant for someone that can see the precarious foundations of such a performance. If the GDP is based on an average of, say, consumer and investment goods, the good performance of consumer goods will, given the investment decisions, push upwards the GDP average. Instead, a measure of the common component out of these different sectors would "recognize" that the fators affecting consumption would not be affecting investment and, therefore, could not be considered "fundamental".

Visual inspection of the four components of the aggregate index in figure 3 provides evidence of the presence of trends in all components but capital goods. In standard analysis under this context, unit-root tests should be able to determine whether these observed trends are stochastic or not. Under various lag specifications, ADF tests reject the hypothesis of unit-roots in all series representing these components. These results are strenghtened by the fact that these series were subject to large shocks during the sample period, resulting in structural breaks both on the intercepts and the rates of growth, especially the intermediate and durable goods comoponents. Accordingly, to search for a cointegrating relation between these variables does not seem like the best option. Instead, we proceed by estimating a dynamic factor model in first differences of the four components, following Stock and Watsons's (1991) methodology for constructing a coincident indicator for the US economy. The model is based on the relationship between each series and a common component:

$$\Delta Y_{it} = D_i + \gamma_i \Delta C_t + e_{it};\ i = 1, 2, 3, 4 \tag{1}$$

Index t points to each period in the sample, whereas index i here selects each of the four components of the aggregate industrial production index, whose differences are represented as ΔY. The common (unobserved) components of each of these series is represented in first difference by ΔC, and is related to each of the four series via a specific weight given by γ_i, which will be estimated here along with the other parameters. In addition, the behavior of each of the four series is determined by an individual component given by $D_i + e_{it}$, more of which below. Equation (1) will be directly interpreted as the transition equation in the state-space formulation of the model. The stochastic terms of the individual components can be formulated so as to incorporate a dynamic effect from shocks as:

$$e_{it} = \theta_{i1}e_{i,t-1} + \theta_{i2}e_{i,t-2} + \ldots + \theta_{iq}e_{i,t-q} + \varepsilon_{it} \tag{2}$$

where $\varepsilon_{it} \sim NID(0, \sigma_i^2)$; $i = 1, 2, 3, 4$. The transition equation for the state-space formulation can be represented as:

$$\Delta C_t - \delta = \phi_1(\Delta C_{t-1} - \delta) + \phi_2(\Delta C_{t-2} - \delta) + \ldots + \phi_p(\Delta C_{t-p} - \delta) + u_t \tag{3}$$

where $u_t \sim NID(0, \sigma_u^2)$.

In order for the parameters of (1)–(3) to be estimated, we set the transition equation as a Markovian process, so that we can apply the Kalman filter in conjunction with maximum likelihood to account for the unobserved components. In selecting a particular specification, we followed the Schwarz information criterion, which penalyzes the likelihood for the inclusion of unnecessary parameters. The final specification chose $p = q = 2$ for the four equations, written in deviations from means. Therefore, in matrix form we can represent the measurement equation as:

$$\begin{bmatrix} \Delta y_{1t} \\ \Delta y_{2t} \\ \Delta y_{3t} \\ \Delta y_{4t} \end{bmatrix} = \begin{bmatrix} \gamma_1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \gamma_2 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ \gamma_3 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ \gamma_4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} \Delta c_t \\ \Delta c_{t-1} \\ e_{1t} \\ e_{1,t-1} \\ e_{2t} \\ e_{2,t-1} \\ e_{3t} \\ e_{3,t-1} \\ e_{4t} \\ e_{4,t-1} \end{bmatrix} \tag{4}$$

or simply $\Delta y_t = H\alpha_t$. The transition equation was estimated as:

$$\begin{bmatrix} \Delta c_t \\ \Delta c_{t-1} \\ e_{1t} \\ e_{1,t-1} \\ e_{2t} \\ e_{2,t-1} \\ e_{3t} \\ e_{3,t-1} \\ e_{4t} \\ e_{4,t-1} \end{bmatrix} = \begin{bmatrix} \phi_1 & \phi_2 & 0 & 0 & \cdots & 0 & 0 \\ 1 & 0 & 0 & 0 & \cdots & 0 & 0 \\ 0 & 0 & \theta_{11} & \theta_{12} & \cdots & 0 & 0 \\ 0 & 0 & 1 & 0 & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \ddots & 0 & 0 \\ 0 & 0 & 0 & 0 & \cdots & \theta_{41} & \theta_{42} \\ 0 & 0 & 0 & 0 & \cdots & 1 & 0 \end{bmatrix} \begin{bmatrix} \Delta c_{t-1} \\ \Delta c_{t-2} \\ e_{1,t-1} \\ e_{1,t-2} \\ e_{2,t-1} \\ e_{2,t-2} \\ e_{3,t-1} \\ e_{3,t-2} \\ e_{4,t-1} \\ e_{4,t-2} \end{bmatrix} + \begin{bmatrix} u_t \\ 0 \\ \varepsilon_{1t} \\ 0 \\ \varepsilon_{2t} \\ 0 \\ \varepsilon_{3t} \\ 0 \\ \varepsilon_{4t} \\ 0 \end{bmatrix} \tag{5}$$

or simply $\alpha_t = T\alpha_{t-1} + v_t$.

The parameters of the above state-space formulation were estimated by maximum likelihood, using the prediction-error decomposition proposed by Harvey (1989). The estimated coefficients and respective standard errors are reported in table 1.

Table 1

Parameter	Estimated coefficient	Standard error
ϕ_1	-0.18418	0.060923
ϕ_2	0.15337	0.060560
θ_{11}	-0.40823	0.069294
θ_{12}	-0.041662	0.014144
θ_{21}	-0.29222	0.093766
θ_{22}	-0.021348	0.013700
θ_{31}	-0.38708	0.067133
θ_{32}	-0.037457	0.012993
θ_{41}	0.33573	0.094691
θ_{42}	-0.028179	0.015895
σ_1	24.441	2.4537
σ_2	5.3614	0.78354
σ_3	61.635	5.9507
σ_4	9.1779	1.3022
γ_1	7.7104	0.43583
γ_2	6.0135	0.28545
γ_3	10.625	0.64173
γ_4	7.0574	0.33902
	Log-Likelihood	-1923.4348

It can be seen, using the standard asymptotic distribution from maximum likelihood for these parameters, that the chosen specification produced very significant estimates for the parameters. The resulting estimated common component can be more easily seen when compared visually with the actual IBGE production index in figure 4.

It is also interesting to look graphically of the rate of variation for the above indexes (figure 5).

Figure 4

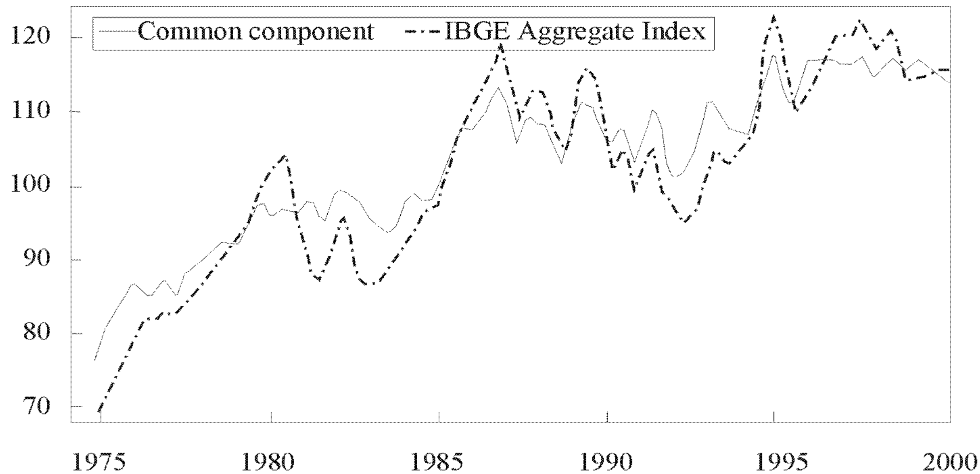
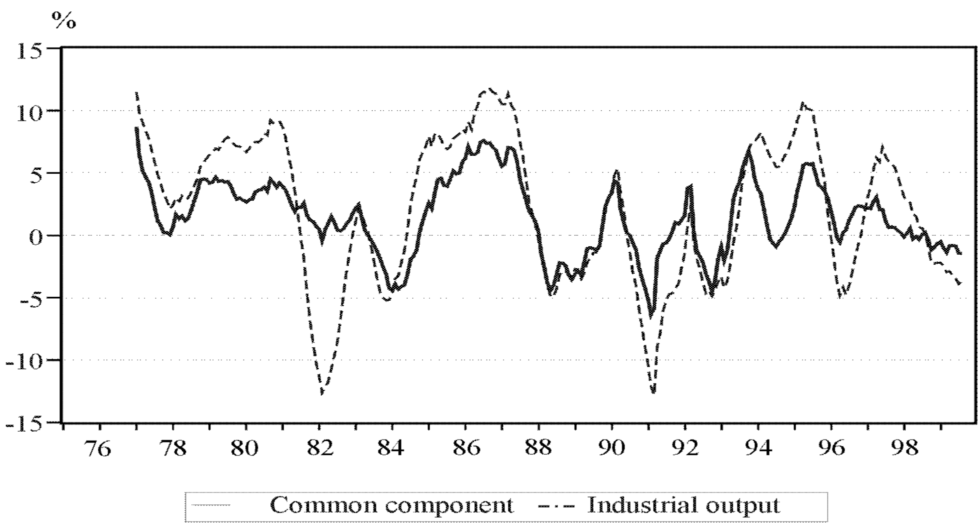


Figure 5

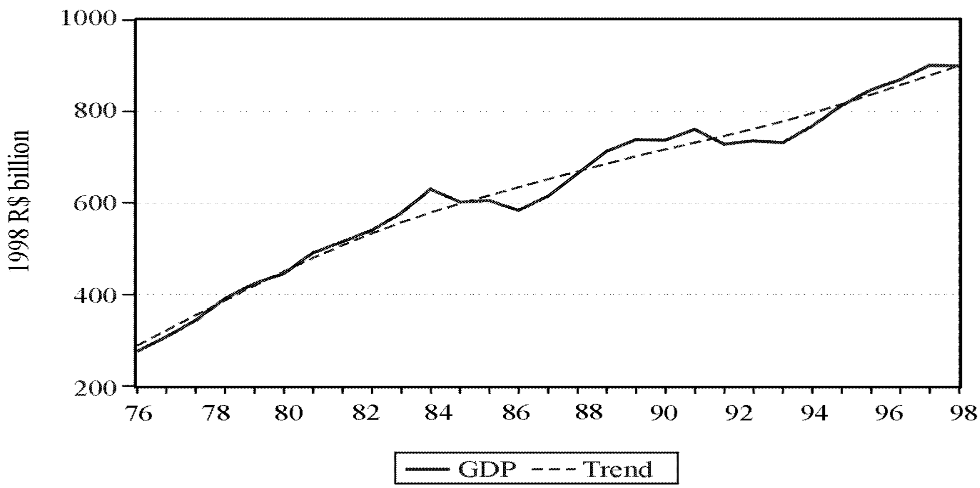


As can be expected, at first glance the estimated stochastic common component is considerably smoother than the original index, fueling the idea of a measure related to the fundamentals of the economy, which should not be as directly affected by the short-term shocks as is the computed industrial production index. In what follows, we pursue further interpretations and uses of this estimated common component.

4. Interpretation of Results and Conclusions

Both the volatile environment that has characterized the Brazilian economy since the beginning of the 1980s and the monetary policy after 1991 had at least three important and readily visible implications for growth. Figure 6 illustrates the brazilian GDP performance along with its smoothed trend since 1970.

Figure 6



First, note that the trend turns downwards in 1980 and starts to show a minor recovery with the Real Plan (1994), despite the monetary restraint illustrated before. Second, the behavior of the economy gets more irregular after the recessions of the beginning of the 1980s. Third, it is remarkable to see that, even with eight years of a 22% annual real interest rate, the economy grew, according to the data above, 2.9% per year during this period.

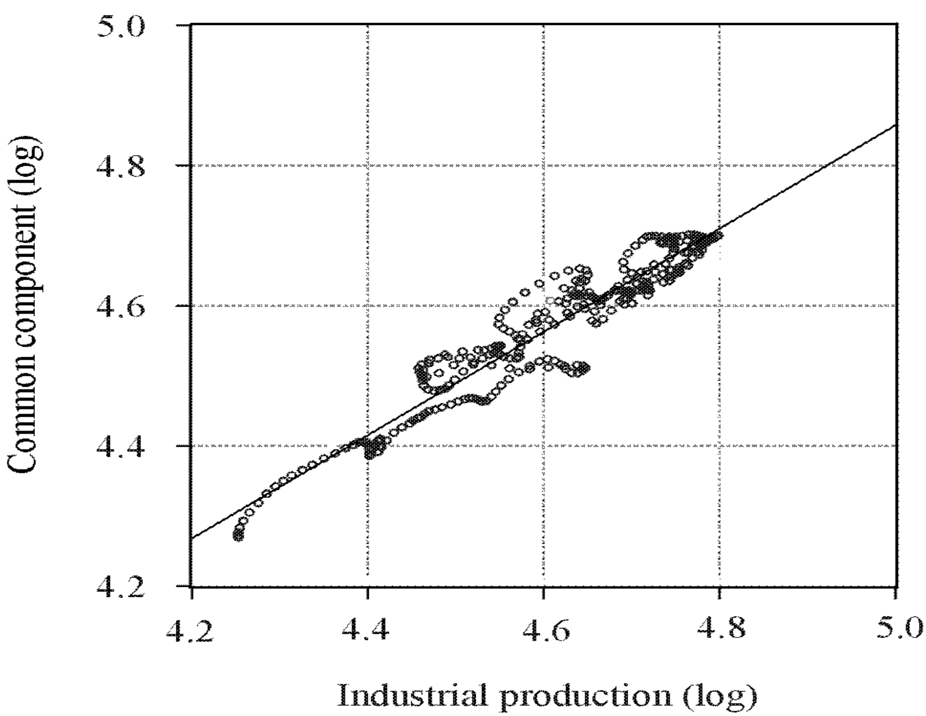
What kind of growth is this? Observe in figures 4 and 5 two different illustrations of the official industrial production index and the common component extracted from the different segments. The following remarks appear promptly:

a) the two series are quite similar;

b) the common component is less volatile as it should be, once its is known that the ups and downs of the Brazilian economy were originated from different shocks affecting the sectors in distinct forms;

c) the common component is rarely above the industrial output, which means that, according to the interpretation that we give to C_t, the actual output series tends to inflate the real "state" of the economy. See this feature in figure 7, where the regression line linking the series is flatter than the 45^o line.

Figure 7



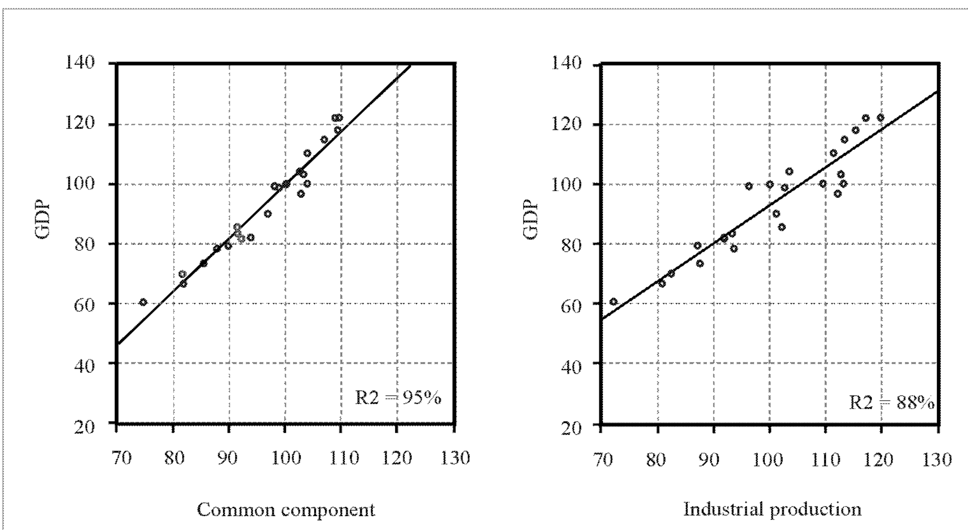
Let's provide an intuitive explication for this element. Starting with the first expansion movement in the period 1975-81, we note that, approximately until 1978, the "fundamentals" and the measured industrial output were walking side by side. When the international conditions started to change, first with the second oil shock (1979) and then with the change in the US monetary policy (1980), the internal decision was to keep the economy growing, despite the swing in the environment. At this point, the "fundamentals" began grow to less than the measured industrial production.

Similar events occur in 1986, with the cruzado stabilization attempt, which was complemented with a populistic wage policy, and also in 1994, after the Real Plan. In both opportunities, the demand expansion was not followed by the "fundamentals".

It is also interesting to note that the common component series has been very flat in the real years in a point equivalent to the one reached temporarily with the Cruzado Plan. A free interpretation of this could be the following. This is the activity level associated with an inflation-free economy. In order to go beyond that level, it would be necessary to "break" other restrictions. This activity level would be the one tolerable given the "external" restriction, or the capitals inflows necessary to maintain price stability. This restriction is linked, in the short run, with the country's export performance and, in the long run, with Brazil's ability to deal with its structural problems. It turns out that, given the opening exposition, this restriction was magnified in 1994-98 by the overvalued exchange rate. Hopefully, the succesful devaluation carried out in January 1999 will help to open the road to sustained growth again. Table 2 shows the industrial output growth rates compared with the "fundamentals" performance and some comments.

We now turn to the examination of some features of the common components series. First, it is interesting to note that the "fundamentals" series is more coherent with the GDP series than the industrial production (figure 8).

Figure 8



The GDP is a broader macroeconomic indicator than the industrial production. It includes the agricultural sector, civil construction and all the services. So, the incidence of specific shocks tend to be diluted or averaged out when compared to the single industrial production indicator and, in thesis, the GDP is closer to the "fundamentals" than the industrial production.

The all important task of linking our measure of the common stochastic component of the industrial production index with the other fundamental driving variables of the economy requires both the formulation of a structural theoretical model and the application of filters similar to the one used here to other key variables, such as the price index and the interest rate. This is the subject of further research.

The interesting and somewhat pretentious interpretations given above deserve, in some extent, a little dosage of self-criticism. Our main concern is that the analysis above depends heavily on the assumption that the proposed model is capable of extracting from some arbitrarily selected macroeconomic series what would be the unobserved "fundamentals" of the Brazilian economy.

Given the enormous implications of such a task, it would be necessary to confront this exercise with other ones to access the robustness of the particular C_t series obtained. In other words, it is desirable to continue the investigation in complementary directions.

The first and more obvious is the discussion of whether the notion of the proposed "core" really exists.

Second, and provided the answer before can be (hopefully) considered affirmative, it is necessary that this "core" of the economy be relatively independent of the chosen set of macroeconomic series.

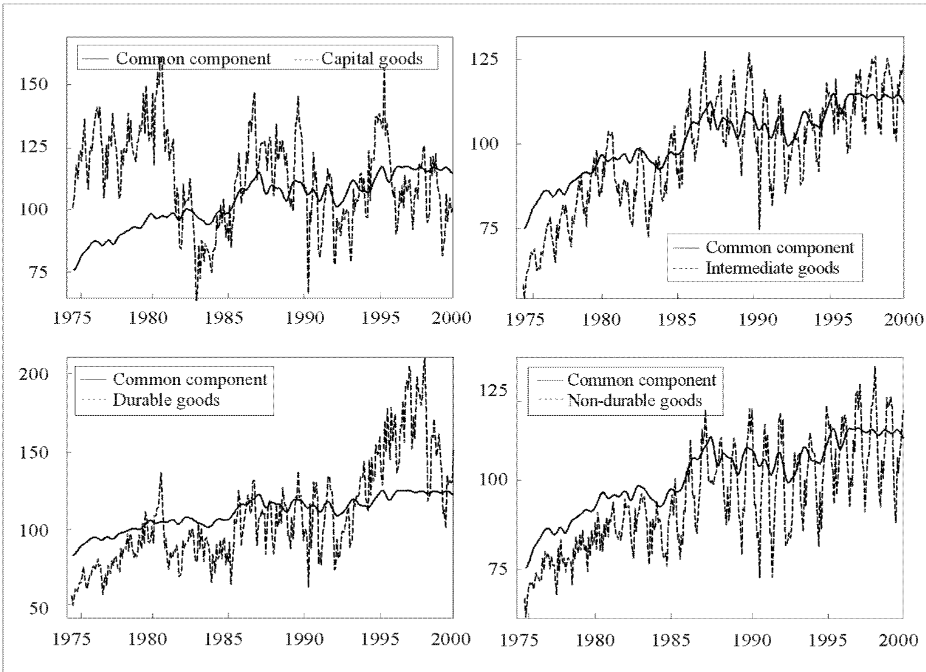
Third, and more subtly, there should be some desirable properties of this "fundamentals" measure of economic activity. For instance, it should be more appropriate to perform long-run forecasts, once they reflect the underlying economic fundamentals that, in the long-run, supposedly the measured indicators must converge to.

Finally, from what can be seen in figure 9, the comparion between the common stochastic component and each of the four individual components of the aggregate index seems to indicate that some very important structural changes occurred in the Brazilian economy during the sample period, affecting differently each of these components. It would be highly desirable to be able to represent these shifts in regime endogenously determined in a correctly specified statistical model. One possible step in this direction is the estimation of a state-space system similar to the one presented here, but subject to Markov-switching time-varying parameters, in the spirit of Kim (1994).

Table 2
Industrial output and common components
(1976-98)

Year	Industrial production	Common component	Comments
1976	11.9	9.5	
1977	2.1	0.1	
1978	6.1	4.5	
1979	7.0	2.8	The growth envisaged after the materialization of the international signs that conditions
1980	9.2	4.2	would be shifting could be considered “artificial”, as reflected in the common
1981	-10.2	0.8	component series.
1982	0.0	1.7	
1983	-5.2	-4.2	
1984	7.1	1.9	
1985	8.5	5.8	
1986	10.9	6.1	
1987	0.9	1.1	
1988	-3.2	-3.5	
1989	2.9	3.0	
1990	-8.9	-4.2	The recession initiated with the Collor Plan had animportant immediate impact, but did
1991	-2.6	1.2	not alter the “fundamentals”.
1992	-3.7	-2.0	
1993	7.5	4.6	
1994	7.6	1.3	The dynamics of the Real Plan appear more consonant with the “fundamentals” series.
1995	1.8	3.0	Consolidation of stability allowed higher growth in 1995 and 1996, since the 1994 boom
1996	1.7	2.2	was similar to previous expansions. In 1997, the international restrictions were already
1997	3.9	0.2	showing their effects upon growth capacity.
1998	-2.2	-0.6	

Figure 9



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