

**A USEFUL TOOL TO IDENTIFY  
RECESSIONS IN THE EURO-AREA**

**2004**

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**Documentos de Trabajo  
N.º 0419**

BANCO DE **ESPAÑA**



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(\*) This paper was written while the second author was visiting DG ECFIN in June and October 2003, under the DG ECFIN "Visiting Fellows Programme". The views expressed here are those of the authors and do not reflect those of the European Commission, the Bank of Spain or the European System of Central Banks.

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ISSN: 0213-2710 (print)

ISSN: 1579-8666 (on line)

Depósito legal:

Imprenta del Banco de España

## **Abstract**

This paper investigates the identification and dating of the European business cycle, using different methods. We concentrate on methods and statistical series that provides timely and accurate information about the contemporaneous state of the economy in order to provide the reader with a useful tool that allows him or her to analyze current business conditions and make predictions about the future state of the economy. In this spirit, we find that the European Commission industrial confidence indicator (ICI) is useful in providing that information.

**JEL classification:** C22, C32, E32, E37

**Key words:** Business Cycle, Confidence Indicators, Markov Switching, Turning Points.

## 1 Introduction

A common feature of industrialized economies is that economic activity moves between periods of expansion, in which there is broad economic growth, and periods of recession in which there is broad economic contraction. Understanding these phases, collectively called the business cycle, has been the focus of much research over the past century. Investment decisions and government policies require acceptable knowledge of the state of the economy in the medium and long run in particular, analyzing the question of whether there will be a slowdown or an expansion in economic activity.

The introduction of the common European currency has increased the interest and the need for business cycle analysis of the euro zone. Even though there is no consensus on how representative this common euro area cycle is of the business cycle of the individual economies that belong to the euro area, it is a reference for economic agents because, monetary policy decisions are a function of it. Then, given the importance of characterizing this cycle, we need a reference series which represents the aggregate activity of the euro area. The reference series is usually GDP or the industrial production index. In most cases practitioners are interested in constructing an accurate index that can be used to forecast the turning points of these reference series.

The purpose of the paper is to find a useful tool to identify and date the euro area business cycle. The main new contribution to the literature can be summarized in the word "useful". We mean "useful" as something that the practitioners can incorporate easily in their inference about the current state of the business cycle and their forecast about future developments.

The identification and the dating of the business cycle is well covered in the literature of the euro area cycle. Special attention is deserved by the effort of the CEPR which created a group of experts to date the business cycle<sup>1</sup>. However, in most cases, the effort is made in describing the past, not analyzing the current state or predicting the future. An illustration of their descriptive purpose is that they do not compromise by attempting to define the state for the most recently available data<sup>2</sup>.

In order to reach our goal of defining the state of the economy and predicting in real time, we use the Markov-switching (MS) model proposed by Hamilton (1989). We adopt this methodology because, in addition to providing a description of the state of the economy in the past, it provides the practitioner information about the current state of the economy which is the key for forecasting future economy activity.

This approach is not new in the literature. There are already MS-models of the euro area business cycle circulating (Artis and Zhang, 1999; Artis, Krolzig and Toro, 1999; Krolzig, 2001; Krolzig and Toro, 2001; Krolzig, 2002; Mitchell and Mouraditis, 2002; Harding, 2002; Massman and Mitchell, 2003; Artis, Marcellino and Proietti, 2003). However, most of the previous papers use GDP as the reference series for the cycle. We think the use of Euro-area GDP series present serious problems. The published statistics are too short to make inference and the estimated series are subject to some aggregation and standardization caveats that make the link with the official series problematic. We consider that it is more appropriate to use as reference for the Euro-area cycle the IPI series because, even though it only refers to the manufacturing sector, the series is more homogeneous across economies, and therefore, the aggregation issue is a problem of smaller scale. In addition, the IPI is one of the most important series used when obtaining the GDP quarterly data from annual European

1. Details of the dating and the results found by this group can be found on the CEPR web page ([www.cepr.org](http://www.cepr.org)).

2. They define the last period neither as a recession nor as an expansion. They call it a "prolonged pause in aggregate economic activity" with no statement towards one or the other state.

national accounts. Additionally, manufacturing is the sector more affected by business cycle fluctuations.

A subset of these papers, Mitchell and Mouraditis (2002), Artis, Krolzig and Toro (1999), and Artis and Zhang (1999) use the industrial production index corrected by outliers and smoothed as reference series for the Euro area business cycle. We differ from these authors because we use the data without any transformations. We think that transforming the data as they do implies a loss of the most important feature of the Markov switching approach, the possibility of addressing the question of what is the current state of the economy. In addition, smoothing implies a set of technical misspecifications that will be analyzed in the paper.

As a way of checking the robustness of our results, we also apply the classical approach proposed by the NBER for dating the Euro-area cycle. The use of this non-parametric methodology vs. the parametric approach proposed by Hamilton (1989) allow us to check the consistency of the stylized facts obtained from the Markov switching approach<sup>3</sup>.

But none of previous work address the "usefulness" of the proposed tool at all. Even though the MS approach allows the econometrician to make inference about the current state of the economy, the delays in the release of the data make difficult the timely use of the predictions. These models predict the future with information at least two periods delayed, making a poor job in predicting timely turning points.

In order to avoid the publication lags of the series of reference, we look for series that, being closely linked to the IPI do not present these publication lags. The most popular of these series are the "Confidence Indicators" In particular, we use the one more closely related with industrial activity, the European Commission industrial confidence indicator (ICI). We will include this series in predicting the state of the euro area business cycle.

We think that we are the first in providing a tool for addressing in each period of time, not the dating of the Euro-area business cycle, but, conditional to the available information, the inference about the state of the Euro-area economy.

An additional contribution of the paper, more methodological than purely applied, comes from the particular form of mixing the information of the two series to obtain the probability of recession. IPI and ICI present slightly different information about the business cycle. These series neither are independent nor do they completely share the state of the economy. To our knowledge we are the first in the literature proposing a mixture of these two extreme cases to capture the dynamics of two macroeconomic series.

The paper is organized as follows. Section 2 describes the data. Section 3 presents a summary of the NBER methodology. Section 4 provides a review of the Markov-switching model used in this paper. Section 5 presents the empirical evidence and Section 6 concludes.

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<sup>3</sup>. We actually use the NBER methodology first as a way of creating a framework to evaluate the MS methodology, as it is usually done in the US where the ability of alternatives methodologies for replicating the NBER business cycle chronology are evaluated.

## 2 Data

### 2.1 The Euro Area Industrial Production Index (IPI)

The data used for our empirical analysis are the natural logarithms of the seasonally adjusted industrial production index of the euro area (IPI) published by Eurostat. The data are monthly and the sample period goes from 1980:1 to 2003:12<sup>4</sup>. As we mentioned in the introduction, we understand that choosing the industrial production index as a measure of aggregate activity could be controversial versus the obvious choice of analyzing GDP. However, in addition to the reasons stated above, the monthly periodicity is also an advantage of the IPI (vs. the quarterly frequency of the GDP), but more importantly, data for the GDP are interpolated using indicators<sup>5</sup>.

There are no national quarterly accounts for most of the euro economies therefore, the quarterly series depend on the weight given to the indicators vs. the weight given to the smoothing, and the revisions are very serious (quarterly data must add up to the annual data coming from national accounting)<sup>6</sup>. Figure 1 plots the level of the IPI series.

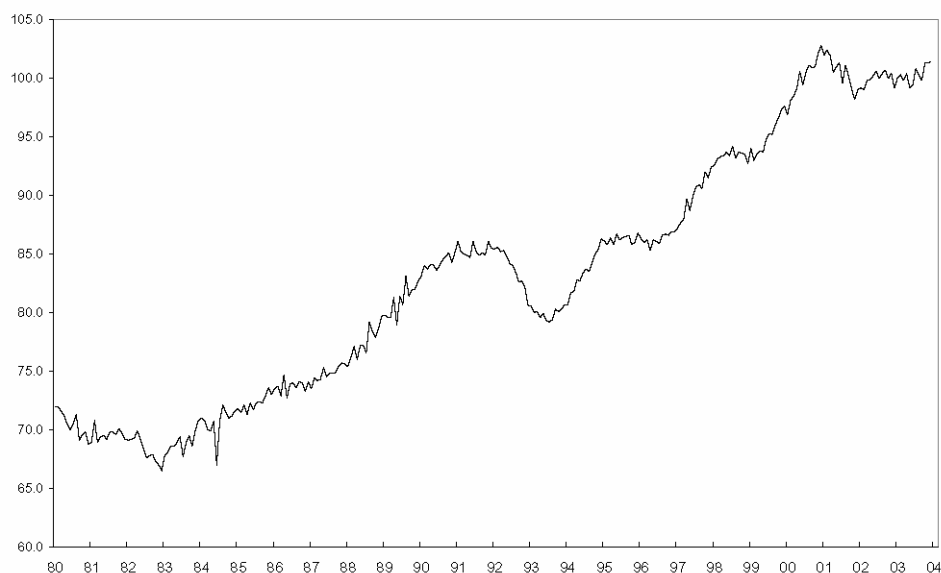


Figure 1: The Industrial Production of the euro area (IPI), 1980-2003

### 2.2 The Euro Area Industrial Confidence Indicator (ICI)

Since the Index of Consumer Sentiment was introduced in 1953 by Katona (1951) in the US, the usefulness of sentiment indicators to forecast economic activity has been the subject of many studies. Although data series derived from business surveys have received less attention as leading indicators of recessions than the ones derived from consumer surveys, they also have a long tradition of being used as indicators.

The National Association of Purchasing Managers (NAPM) survey of manufacturers goes back to 1931. In Europe, the first business survey dates back to the late 1940s (IFO in

4. The latest data published by Eurostat do not go back that far. The problem is that France has changed the base for their IPI series. However the differences between the previously released series and the new one are so small that, while waiting for the official link, the series can be linked without major problem.

5. Only UK relies on the quarterly national accounts as the main building blocks for the annual account. The rest of countries, i.e. France, Italy and Spain, rely on annual accounts and rely on mathematical and statistical methods to estimate quarterly series and Germany produces annual accounts separately and integrates the quarterly data with the annual estimates.

6. See Handbook of Quarterly National Accounts published by Eurostat for details.



Germany in 1949) and early 1950s (INSEE in France and ISCO in Italy, 1951). For the euro area in the framework of the joint harmonized EU programme of business and consumer surveys, data series from industry surveys are available since 1980. Industry surveys have played a prominent role in the assessment by business cycle analysts of conjunctural developments above all in the early 1990s after a large decline in industrial confidence indicator of the euro area coincided with the deep recession that finished in 1993. This fact was interpreted as a strong evidence that industrial confidence indicators could be a useful indicator to predict recessions and expansions of economy or the euro area.

This survey is fully harmonized and the existence of a long series of results can make it a useful tool of analysis at euro area level. The Commission calculates and publishes this composite indicator, named the Industrial Confidence Index (ICI), every month with data for the current month for the euro area. The ICI is defined as the arithmetic mean of the answers (seasonally adjusted balances) to the questions on production expectations, order books and stocks (the latter with its sign inverted). The choice of these variables and the linear combination that is used in calculating the indicator is justified by the Commission as the most appropriate way to summarize accurately the industrial climate.

The two latter series (order books and stocks) have been considered very useful to identify periods of expansion and recession in the production growth of euro area. These two indicators show the same developments but inverted. When order books go up, stocks of finished products go down. In a cyclical trough the distance between two series is at maximum while in a cyclical peak, it is at minimum. The production expectations series has been used in the applied literature to forecast future movements of industrial production index. Figure 2 plots the Industrial Confidence Index.

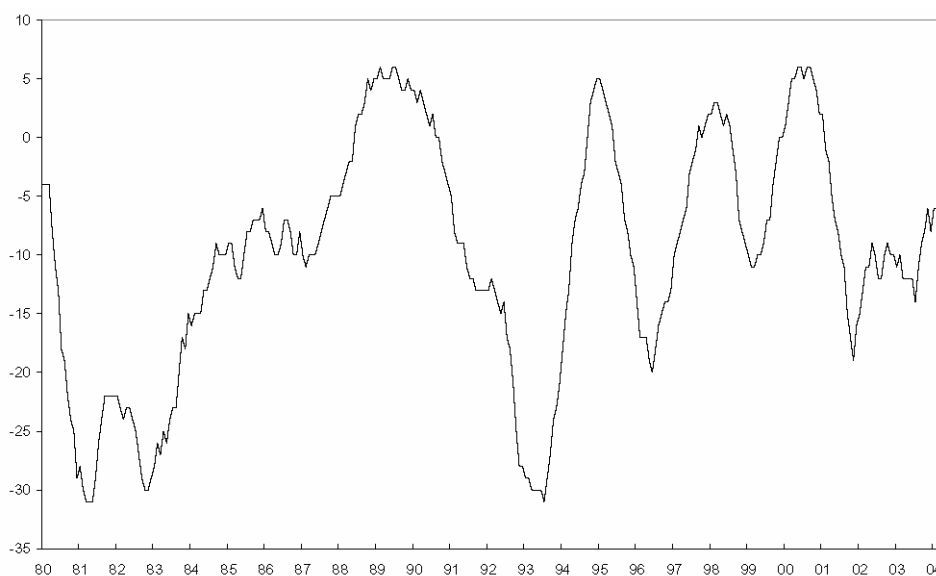


Figure 2: The Industrial Confidence Indicator of the Euro Area (ICI), 1980-2003

### 2.3 Comovements between the IPI and the ICI

To our knowledge the performance of the ICI has been evaluated by its ability to track the evolution of the growth of industrial production (annual rates of growth) of the euro area (OECD, 1996; EC, 1997). This relationship has been obtained examining the time cross-correlation coefficients of ICI with growth rate of the IPI. Cross-correlation is a measure of how closely aligned the timing of cyclical fluctuations are for two indicators over their cycles. Table 1 and Figure 3 show that: i) there is a strong correlation between the ICI and the growth rate of the IPI; ii) The ICI is a coincident indicator of the growth rate of the IPI of the euro area.

The explanation of these findings could be that respondents seem to relate the concept of a normal level of their order books to the one observed in the previous year, behaving as if a comparison had been asked between the current level of order books and the level in the same month of the previous year. In this sense the ICI could be considered as a backward-looking indicator. Just because of these high correlations levels, we could obtain the first conclusion about the usefulness of the ICI. We have reliable information about the industrial production index, but two months before (this is the difference in publication time of the IPI index and the ICI). However, we will explore other relations across these variables that will go further from these simple relation.

Table 1: Cross-correlations of annual rates of growth the IPI of the euro area and the ICI, 1981-2003.

Note: High cross-correlation at negatives lags indicates that the ICI is leading with respect to the IPI.

	Cross-correlations of IPI with						
	Lag						
	-3	-2	-1	0	1	2	3
<b>ICI</b>	0.78	0.84	0.87	0.90	0.90	0.89	0.86

### 3 Dating the IPI and ICI of the Euro Area

#### 3.1 NBER Methodology

As a first approach we apply the well-known NBER methodology to determine the reference chronology of business cycle in the euro area. Although the NBER method uses a set of series for dating to business cycle, we apply this methodology only to IPI. Even though identifying a chronology on a single series has the advantage of simplicity and concreteness, it also has the disadvantage that it takes into account of only one dimension of economic activity. However, since other series used by NBER such as employment, sales, income, etc. may not always be available for the euro area, we consider IPI as a good reference variable.

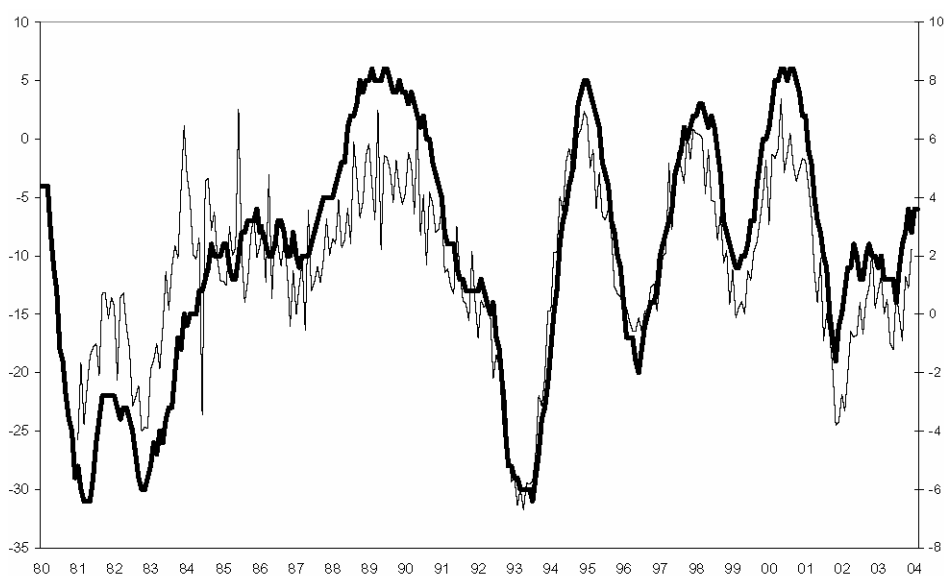


Figure 3: Annual rates of growth of the IPI and ICI (levels), 1980-2003. The solid line represents the levels of the ICI. The dotted line represents the annual rate of growth of the IPI

The rules for cyclical timing of classical business cycle described by Burns and Mitchell (1946) in their book *Measuring Business Cycles* constitute the cornerstone of the NBER method for determining turning points in time series. Briefly stated, the selection of the cyclical turning points of a single indicator is done in accordance with the following rules: a) the distance from peak to peak or from trough to trough should be at least fifteen months; b) the distance between two turning points of opposite signs should be at least five months; c) if the indicator registers equal values around a particular turning point, the rule is to choose the last one as the cyclical turn; d) strike activity or other special factors should be ignored when their effects are transitory and reversible. In 1971, these rules were formalized by G. Bry and C. Boschan in an algorithm that we use in this paper. The business cycle chronology of the IPI and ICI is presented in Table 2.

Figure 4 (a) presents the IPI series with the shading of recession with the NBER methodology applied to the IPI and Figure 4 (b) presents the same series with the shading obtained with the ICI series. Something can be obtained from this first exercise. According to Figure 4, it seems that some information about the changes in the dynamic behavior of the IPI series can be obtained from the dating of the ICI series business cycle, even though the actual dating of both series are not so deeply correlated themselves. Basically, we can observe that the ICI has "too many" recession periods compared to the IPI. We will come

back to this regularity later when analyzing the joint behavior of these two series. This approach is merely descriptive of the data but nothing can be said about the current state of the economy. The methodology is silent about the last six months of the sample, making impossible to use this approach to forecast.

Table 2: Business Cycle chronology of the IPI and ICI, 1980-2003. Note: P=peak; T=Trough

	IPI	ICI
T	-	81/5
P	-	82/1
T	82/12	82/11
P	-	85/12
T	-	87/2
P	91/11	89/7
T	93/7	93/7
P	-	95/1
T	-	96/6
P	-	98/3
T	-	99/3
P	2000/12	2000/9
T	2001/11	2001/11
P	2002/9	2002/10
T	2003/5	2003/7

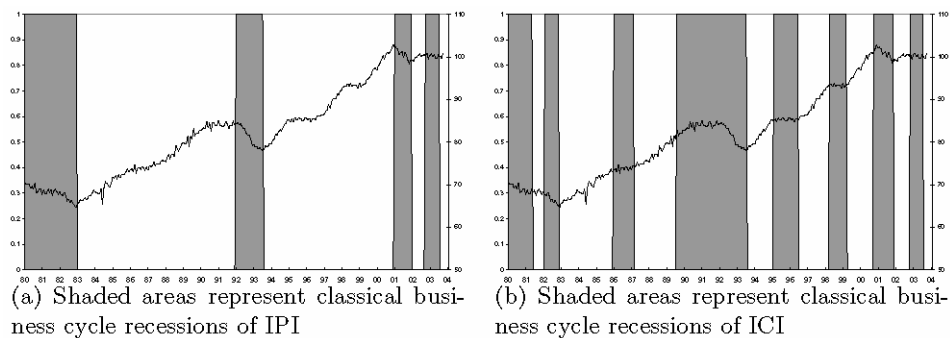


Figure 4: The Industrial Production Index (IPI) of the Euro-area, 1980-2003

#### 4 Markov switching models

A non-linear phenomenon such as a turning point must be detected with a non-linear technique. We have previously seen the dating of the Euro-area business cycle using the Bry-Boschan algorithm. In order to avoid the drawbacks of that methodology, Hamilton (1989) proposed an algorithm that incorporates the main distinctive feature of the recession periods, the change in the data generating process of the data, from expansion to recession periods. The idea behind Hamilton (1989) is the following:

The main feature of a recession period vs. an expansion period is the fact that the expected value of the rate of growth of the series of interest (GDP, Industrial production, etc.) is different in one period versus the other. In this case, we have already explained that we consider that the IPI is a better series to describe the euro area economy. Then, denoting by  $Y_t$  the IPI series, and defining  $y_t = 100 * \ln(Y_t/Y_{t-1})$

$$\begin{aligned} E(y_t) &= \mu_1 \quad \text{if the economy is in an expansion} \\ E(y_t) &= \mu_0 \quad \text{if the economy is in a recession} \end{aligned}$$

The reader might ask why do we look at the rates of growth of the series and not at the levels. The Hamilton filter is defined on stationary series and we have assumed that the IPI series have a unit root (any unit root test on the series accepts the null of a unit root).

The two expected values depending on the state of the economy can be rewritten in equation form as follows:

$$y_t = \mu_{S_t} + u_t \quad (1)$$

Obviously, these two different expected values are not the only forces driving the dynamic behavior of the series. There is autocorrelation in the dynamics of the series. We capture that correlation allowing  $u_t$  to follow a general AR(p) process. Therefore:

$$u_t = \sum_{i=1}^p \phi_i u_{t-i} + \epsilon_t \quad (2)$$

with  $\epsilon_t$  following a standard normal process.

Plugging (2) in (1) we get:

$$y_t = \mu_{S_t} + \sum_{i=1}^p \phi_i u_{t-i} + \epsilon_t$$

and substituting  $u_{t-i}$  by its value defined in (1) we obtain:

$$y_t = \mu_{S_t} + \sum_{i=1}^p \phi_i (y_{t-i} - \mu_{S_{t-i}}) + \epsilon_t \quad (3)$$

Equation (3) is what is called in the Kalman filter literature, the observation equation, where the estimated value of the series  $y_t$  is a function of the unobservable variable  $S_t$  which represents the state of the economy taking the value of 1 in expansions and 0 in recessions.

It is relevant to show that, even though we have only two states of the economy, recessions and expansions, the autoregressive components imply that more states of the economy than just the one corresponding to period  $t$  are important for describing the law of motion of  $y_t$ . In particular, we will have  $2^{p+1}$  states of the economy<sup>7</sup>.

Obviously to estimate the model we need to propose the law of motion for the unobservable variable. Hamilton (1989) proposes a Markov chain of order 1 specification. This type of assumption implies that the

$$Pr[S_t = j | S_{t-1} = i, \Omega_{t-1}] = Pr[S_t = j | S_{t-1} = i] = p_{ij} \quad (4)$$

where  $\Omega_{t-1}$  represents all the available information in period  $t-1$ . Another way of expressing what equation (4) means is to say that  $S_{t-1}$  is a sufficient statistic to derive the probability distribution of  $S_t$ .

What is clear from (4) is that the similarity of the form of (3) with the Kalman filter framework is unhelpful. The law of motion for the state equation is far from linearity and the non-linear form of this equation implies that other techniques should be used to estimate the specification formed by (3) and (4).

However, before getting into details on how the model can be estimated, it is convenient to relate our work with previous papers in the literature that deal with the Euro-area business cycle in the Markov switching context. In our opinion, two major concerns arise from these papers:

- All these papers consider that the IPI series are too noisy. Thus, they smooth the series by taking a moving average of the series.
- Some of these papers estimate what it is called a Markov switching process in the intercept. This model implies an specification as:

$$y_t = \mu_{S_t} + \sum_{i=1}^p \phi_i(y_{t-i}) + \epsilon_t \quad (5)$$

With respect to the first point, obviously, the series of the IPI are too noisy and it is difficult to estimate a parsimonious model with this amount of noise (see Figure 5) but smoothing the series with a moving average representation generates all kinds of misspecifications.

Firstly, the model estimated needs at least as many lags as the number of elements used in the smoothing. Secondly, the changes in regimes are more difficult to interpret due to the smoothing and a change in regime in period  $t$  will come from the influence of changes from  $t-x$  to  $t+x$  where the  $2x$  represent the order of the moving average. It is convenient to point out that this concern also affects all the papers that deal with the series in annual rates of growth taken as differences of order 12, because these differences are no more than a moving average of differences of order 1.

Additionally, any model estimated with smoothed data implies that it is no longer useful to predict the movements of the series of interest. At any point in time, the model uses information of the future, not available until  $x$  period ahead. Unfortunately it is probable that in period  $t+x$  the prediction about the state of the economy in period  $t$  is no longer a relevant question.

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7. For a detail explanation of the number of necessary states the interested reader can check Hamilton (1994).

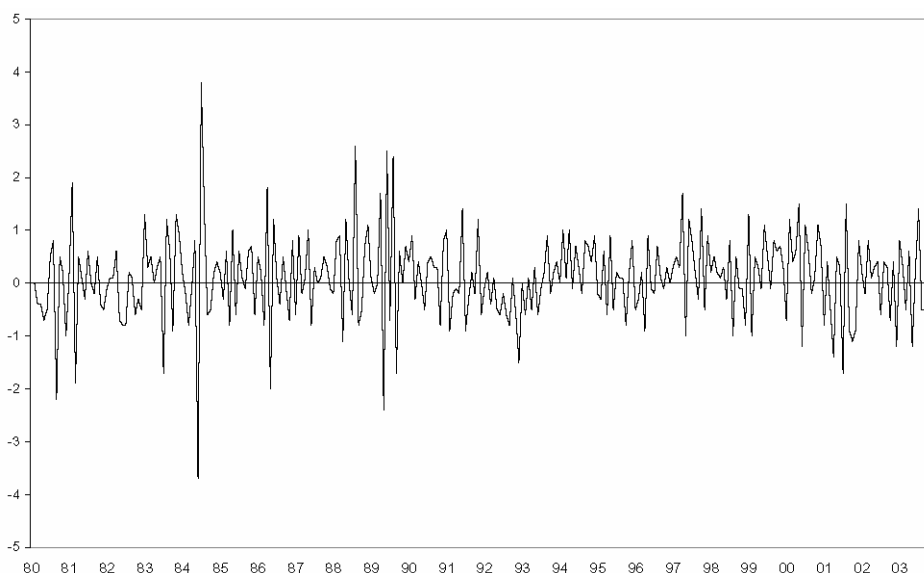


Figure 5: Monthly rates of growth of the IPI, 1980-2003

With respect to the second point, a model such as the one presented in (5) simplifies a lot the number of states. The model does not have any more the  $2^{p+1}$  possible states with the correspondent complication in the estimation, but we think that (5) could potentially contain serious misspecifications. Suppose that there is a change in regime in period  $t$ , for example the beginning of a recession. The data in period  $t-1$  (still an expansion) is still very high. The constant  $\mu_0$  has to bring down the series to the recession levels. However, in period  $t+1$ , when the data in period  $t$  is already low, the constant does not necessarily has to bring the series to a lower level. The model is misspecified exactly in the most interesting periods, the turning points!

We propose a specification that estimates the data, with no smoothing and with a specification that we think does not present any problems of specification. We estimate the system using maximum likelihood<sup>8</sup>. The idea of the estimation is as follows:

We want to maximize the likelihood function:

$$L = \sum_{t=1}^T \ln f(y_t | \Omega_{t-1})$$

where  $f(y_t | \Omega_{t-1})$  represents the density function of  $y_t$  given the information available in  $t-1$ .

Applying the total probability theorem and knowing that the two (or the  $2^p$ ) states of the economy have no intersection,

$$f(y_t | \Omega_{t-1}) = \sum_{i=1}^k f(y_t | S_t = i, \Omega_{t-1}) * P(S_t = i | \Omega_{t-1}) \quad (6)$$

where  $k = 2^p$ .

<sup>8</sup>. Details of the estimation procedure can be found in Hamilton (1994).

Obviously, given that  $\epsilon_t$  follows a normal process,  $f(y_t|S_{t-1} = i, \Omega_{t-1})$  follows a normal distribution, with mean given by (3) and variance given by the variance of  $\epsilon_t$ . The other term of (6) requires some additional decomposition. Again applying the total probability theorem:

$$\begin{aligned} P(S_t = i|\Omega_{t-1}) &= \sum_{j=1}^k P(S_t = i|S_{t-1} = j, \Omega_{t-1}) * P(S_{t-1} = j|\Omega_{t-1}) \\ &= \sum_{j=1}^k p_{ij} * P(S_{t-1} = j|\Omega_{t-1}) \end{aligned} \quad (7)$$

And now, applying Bayes theorem:

$$\begin{aligned} P(S_{t-1} = j|\Omega_{t-1}) &= P(S_{t-1} = j|y_{t-1}, \Omega_{t-2}) = \\ &= \frac{f(y_{t-1}|S_{t-1} = j, \Omega_{t-2}) * P(S_{t-1} = j|\Omega_{t-2})}{\sum_{i=1}^k f(y_{t-1}|S_{t-1} = i, \Omega_{t-2}) * P(S_{t-1} = i|\Omega_{t-2})} \end{aligned} \quad (8)$$

As we can observe, equation (8) is basically a function of  $P(S_{t-1} = i|\Omega_{t-2})$ , which is the left hand side of equation (7) lagged one period. Therefore iterating in (7) and (8), we get the likelihood function just as a function of the parameters to estimate and the initial conditions on the state of the economy in period 0, which can also be expressed as a function of the parameters to estimate<sup>9</sup>.

<sup>9</sup>. Although, from the derivations, it seems that there are different  $p_{ij}$  depending if we go from each state  $i$  to each state  $j$ , it can be shown that for most of the states these are 0 (some transitions are, by definition, impossible) and the others are just a function of two parameters,  $p$  (the probability of going from expansion to expansion) and  $q$  (the probability of a recession following a recession). For a detail explanation, see Hamilton (1994).



## 5 Empirical Results

We estimate the model stated in (3) and (4) for the IPI series. The results are displayed in Table 3.

Table 3: Parameters estimates of univariate Markov switching model. IPI. Standard errors are written in parenthesis on the right of the parameters estimates IPI.

Parameter		
$\mu_1$	0.2282	(0.0469)
$\mu_2$	-0.2494	(0.1306)
$\phi_1$	-0.4600	(0.0544)
$\sigma$	0.6709	(0.0592)
p	0.9460	(0.0492)
q	0.9820	(0.0135)

Figure 6 plots the probability of being in a recession at each period of time conditional on the information up to that period of time (what it is known in the literature as filtered probabilities). We present two different specifications. One is the estimation of the model with the original data. The second is dummied out the clearly atypical observation in 1984:06 that is due to the clearly data in Germany which presents a decrease in this month of more than 3% (42% on an annualized rate). This second specification is the one displayed in Table 3. As we can see, out of a very noisy signal, a simple markov switching specification without any kind of data transformation, allows us to date specific periods as recessions.

In addition, considering a probability of being in a recession bigger than .5 as a signal of recession we can date the peaks and troughs of the IPI series in a very clear way, with the probabilities of being in each state close to 1 or 0. In particular, Table 4 contains the NBER turning points and the corresponding dates obtained from the MS model applied to the IPI. The agreement between the two is very high. The MS model captures each of peaks and troughs obtained applying the NBER procedure to the sample.

The dating of the business cycle with MS seems reasonable and in concordance with other dating popular in the profession. As pointed out in the introduction, there is an advantage of the dating coming from this methodology. It allows a real-time dating of the cycle, without having to wait a number of months after period "t" to know the state of the economy in that period.

Table 4: Business Cycles Dates of IPI. NBER and MS model estimated over full sample, 1980-2003.

Note: P=Peak; T=Trough.

	IPI	
	MS	NBER
P	80/5	
T	83/2	82/12
P	92/6	91/11
T	93/7	93/7
P	2001/6	2000/12
T	2002/2	2001/11
P		2002/9

On the other hand, a major inconvenience comes from the use of the IPI series. The series is published with some delay. The information about the IPI in period  $t$  is not known until 2 months later. The problems associated with the statistical delay can be clearly shown in an out of sample exercise. We try the following exercise: We estimate recursively the model from 1992.7 (to capture at least part the recession of the 1990s and to allow for a sufficient number of observations) to 2003.12 and we do a 3 periods ahead forecast for each of the estimations (a 3 periods ahead forecast will be the probability of being in a recession in period  $t+1$  with the information available in period  $t$ , which is dated in  $t-2$ ). This is the probability of interest for us, namely the probability that somebody doing the exercise in period  $t$  would assign to having a recession in  $t+1$ <sup>10</sup>. We plot those series in Figure 7 together with in-sample probabilities shown in Figure 6.

As we can observe, the model predicts systematically late. Even if the model is correct and perfectly describes the states of the economy the filter is useless for prediction because it predicts very late the future state. Therefore, the statistical delay matters and matters a lot when the purpose is more than just describing the past of the series.

In addition, the IPI series are subject to some revisions. Just using the last three years of real time data, for some periods of time the growth rate has gone from a preliminary estimation of negative to a final one which is (we consider final as the last one available) positive<sup>11</sup>. Out of these inconveniences it seems useful to use a more up to date series, not subject to such revisions. As we previously explained, a good candidate is the ICI.

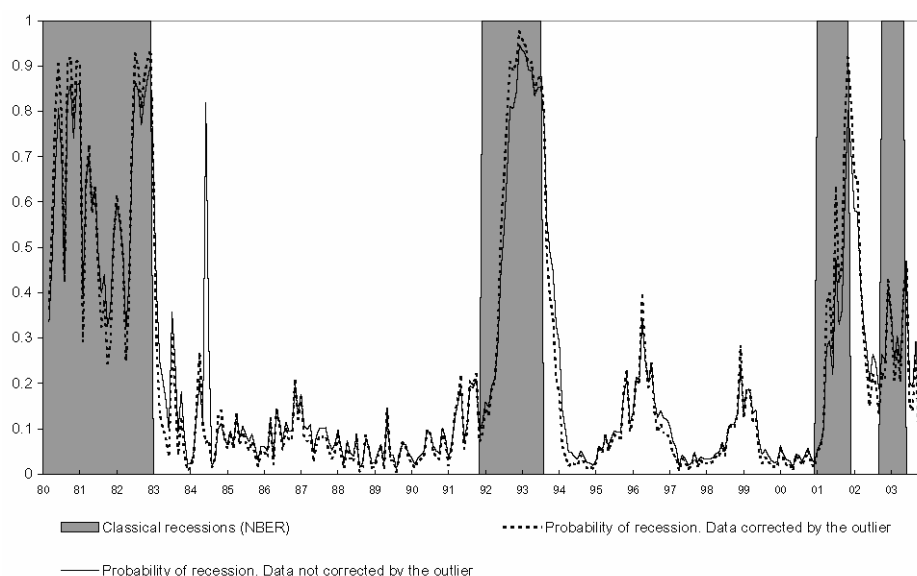


Figure 6: Filtered Probabilities of recession. Univariate Markov switching model for the IPI. The solid line represents the estimation when the data are not corrected by the 84.6 outlier. The dotted line represents the estimation when that observation has been omitted and the shaded areas represents classical business cycle recessions of the IPI, 1980-2003.

<sup>10</sup>. The best exercise to do would be a real-time information exercise, i.e, with the IPI series available at that period of time. We only have that information for the last three years, therefore, so far, in the Euro-area that exercise is impossible to do. Efforts are being made in the Eurosystem to construct real-time databases but that is still work in progress.

<sup>11</sup>. For example for the period 2002.05, the preliminary estimate was -.06 and the final estimate is .45

In order for the ICI to be useful to describe the properties of the IPI series, movements of the ICI, in particular, the non linear movements of the ICI have to be a good predictor of the dating of the IPI. However, we must consider that the non-linear movements of the ICI do not necessarily implies correlation of the dating of the ICI and the IPI. For example, suppose that the ICI never gets above of .5 in the probabilities of recession. However, it increases when the IPI has a recession. In this case, the "dating" of both series would be uncorrelated but the ICI would be a good predictor of the changes in the dating of the IPI.

At the same time, the probabilities of recession for these two series, could have a non-linear relationship. Therefore, to consider, as it is commonly done in the literature, that the fact that the correlation is high or low as a good way of testing how appropriate one variable is to predict the non-linear changes of the other might not be the most adequate approach.

We propose the following criteria. The ICI will be useful to predict IPI changes of regime if the probabilities of these changes are affected by the movements of the ICI. There are two ways of specifying this type of dependence. The one that is the most popular in the literature implies to use the ICI index as a explanatory variable for the transition probabilities of the IPI and, with this predictive power over these transition probabilities, try, once the data for the ICI are published, to estimate the most likely state for the IPI variable in the current month. However, this was not a successful strategy with our series, perhaps because of the high volatility of our left-hand side variable, the IPI.

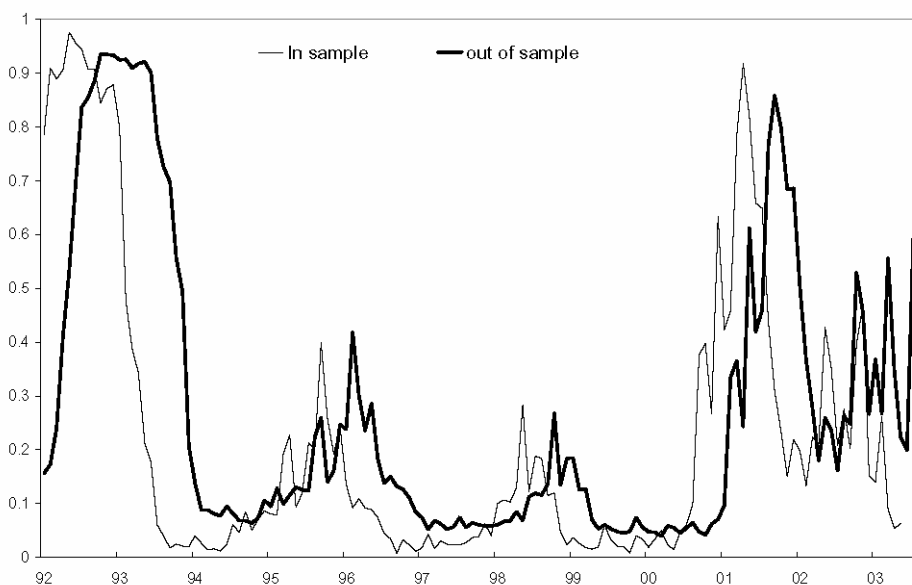


Figure 7: Probability of recession. Univariate Model (MS)

We try a different approach. First, we estimate jointly a Markov switching model for the IPI and the ICI. We estimate the model in first differences. Standard tests accept the hypothesis that the series have a unit root. In addition, economic reasoning is in line with this specification. We have seen that the series in level is correlated with the annual differences of the series of the IPI. Therefore, the level of the ICI series contains information about the past of the IPI series. In order to predict the future, variation of these series will have information about the variation of the IPI series that we want to predict. The estimated model is the following:

$$\begin{pmatrix} y_t \\ x_t \end{pmatrix} = \begin{pmatrix} \mu S_{1t} + \sum_{i=1}^p \phi_i (y_{t-i} - \mu S_{1t-i}) \\ \nu S_{2t} + \sum_{i=1}^k \psi_i (x_{t-i} - \nu S_{2t-i}) \end{pmatrix} + \begin{pmatrix} \epsilon_{1t} \\ \epsilon_{2t} \end{pmatrix} \quad (9)$$

$$\begin{pmatrix} \epsilon_{1t} \\ \epsilon_{2t} \end{pmatrix} \sim N \begin{pmatrix} 0 \\ 0, \Omega \end{pmatrix}$$

where  $y_t$  is the growth rate of the IPI<sup>12</sup> and  $x_t$  is the rate of growth of the ICI (first difference of the series),  $S_{1t}$  has two values, 1 if  $y_t$  is in a recession, 0 if  $y_t$  is in an expansion.  $S_{2t}$  has two values, 1 if  $x_t$  is in a recession, 0 if  $x_t$  is in an expansion. The results of this specification are displayed in the first column of the Table 5.

Table 5: Parameter estimates of four different types of bivariate specifications

Parameter	Model 1		Model 2		Model 3		Model 4	
$\mu_1$	0.25	(0.04)	0.24	(0.05)	0.30	(0.05)	0.32	(0.05)
$\mu_2$	-0.20	(0.09)	-0.23	(0.11)	-0.19	(0.08)	-0.21	(0.09)
$\phi_1$	-0.41	(0.05)	-0.41	(0.05)	-0.43	(0.06)	-0.44	(0.06)
$\sigma_1$	0.64	(0.05)	0.64	(0.06)	0.62	(0.06)	0.60	(0.06)
$p_{11}(S_{1t})$	0.98	(0.34)	0.98	(0.46)	0.95	(0.23)	0.95	(0.24)
$p_{22}(S_{1t})$	0.96	(0.44)	0.93	(0.32)	0.92	(0.23)	0.92	(0.23)
$\nu_1$	0.24	(0.34)	0.26	(0.32)	0.61	(0.20)	0.63	(0.21)
$\nu_2$	-1.77	(0.89)	-1.66	(0.91)	-1.17	(0.24)	-1.18	(0.25)
$\phi_{11}$	0.24	(0.09)	0.24	(0.08)	0.18	(0.07)	0.18	(0.07)
$\phi_{22}$	0.28	(0.07)	0.27	(0.07)	0.24	(0.07)	0.25	(0.07)
$\sigma_{22}$	1.53	(0.23)	1.56	(0.22)	1.47	(0.16)	1.46	(0.16)
$p_{11}(S_{2t})$	0.97	(0.66)						
$p_{22}(S_{2t})$	0.86	(0.34)						
$\sigma_{12}$	0.13	(0.12)	0.13	(0.12)	0.09	(0.11)	0.10	(0.12)
$\delta$							0.27	(0.19)

Notes:

Model 1 presents two independent Markov switching models as the underlying law of motion of the data.

Model 2 presents two independent Markov switching models but sharing the transition probabilities.

Model 3 presents the results assuming that that both series are determined by just one unobserved Markov switching component.

Model 4 presents the results assuming that the true data generating process is a mixture of model 2 and 3 with  $\delta$  been the weight of model 3 and  $(1-\delta)$  the weight of model 2.

Standard errors are written in parentheses on the right of the parameters estimates.

The first question that we could address when looking at these results and with the question of comovements could be: can the null hipótesis that the series have the same inertia in terms of probabilities of staying in recession of expansion be accepted? Can these characteristics be shared between these two variables?

<sup>12</sup> In all the bivariate specifications, we use the IPI data corrected by the atypical observation in 1984.6. The results are robust without correcting this observation.

We estimate the model in (9) under the assumption that the two variables share the probability of staying in expansions or recessions. The result is that they do so, the hypothesis is accepted with a p-value of .21. The second column of Table 5 gives the results of this estimation. Out of the previous exercise, we have learned that the two series share the transition probabilities. However, a more restrictive question can be tested. Do these series share the state of the economy in each period of time? In terms of (9) the question can be stated as: Is  $S_{1t} = S_{2t}$  for each  $t$ ? If this is the case, we do not need two Markov process to describe the data because both series move with the same unobserved variable. The model estimated under this assumption is displayed in the third column of Table 5.

The problem is that, given that the two models are not nested, there is no formal way to test this hypothesis, because obviously, the model, even though is very restrictive with respect to the estimated with two independent Markov processes, has the same number of parameters, therefore, none of the formal tests can be applied in this case.

We propose a scheme to test how restrictive the assumption is that the two series share the business cycle. To our knowledge, this scheme is also another contribution of the paper. The method that we propose is the following: We have estimated two different extreme models. On one side we have estimated a model with two independent Markov switching models. In a model like this, for the case of just two states (for presentation purposes we forget about the need of  $2^2$  states although we are careful in the estimation of taking all these technicalities into account), we will have 4 basic states:

$$\begin{aligned} P(S_{1t} = 1, S_{2t} = 1), \\ P(S_{1t} = 0, S_{2t} = 1), \\ P(S_{1t} = 1, S_{2t} = 0), \\ P(S_{1t} = 0, S_{2t} = 0), \end{aligned}$$

with the probability of being in each state equal to the product of the probabilities of being in each of the individual states:

$$\begin{aligned} P(S_{1t} = 1, S_{2t} = 1) &= P(S_{1t} = 1) * P(S_{2t} = 1) \\ P(S_{1t} = 0, S_{2t} = 1) &= P(S_{1t} = 0) * P(S_{2t} = 1) \\ P(S_{1t} = 1, S_{2t} = 0) &= P(S_{1t} = 1) * P(S_{2t} = 0) \\ P(S_{1t} = 0, S_{2t} = 0) &= P(S_{1t} = 0) * P(S_{2t} = 0) \end{aligned}$$

on the other side when they share the state of the economy, we could rewrite the probabilities of each basic state as:

$$\begin{aligned} P(S_{1t} = 1, S_{2t} = 1) &= P(S_{2t} = 1) \\ P(S_{1t} = 0, S_{2t} = 1) &= 0 \\ P(S_{1t} = 1, S_{2t} = 0) &= 0 \\ P(S_{1t} = 0, S_{2t} = 0) &= P(S_{2t} = 0) \end{aligned}$$

Obviously, given that they share the state of the business cycle, it is impossible to be in state 1 for one variable and state 0 for the other or vice versa.

Stated like we did above, we can see that the only difference between sharing or not the state of the economy is localized in the form of the transition probabilities. We do not know which is the best model for the data. Probably, the true data generating process would be a point between these two extremes assumptions. In order to find this intermediate point we propose the following transition process:

$$\begin{pmatrix} P(S_{1t} = 1, S_{2t} = 1) \\ P(S_{1t} = 0, S_{2t} = 1) \\ P(S_{1t} = 1, S_{2t} = 0) \\ P(S_{1t} = 0, S_{2t} = 0) \end{pmatrix} = (1 - \delta) \begin{pmatrix} P(S_{2t} = 1) \\ 0 \\ 0 \\ P(S_{2t} = 0) \end{pmatrix} + \delta \begin{pmatrix} P(S_{1t} = 1) * P(S_{2t} = 1) \\ P(S_{1t} = 0) * P(S_{2t} = 1) \\ P(S_{1t} = 1) * P(S_{2t} = 0) \\ P(S_{1t} = 0) * P(S_{2t} = 0) \end{pmatrix}$$

We estimate a model with this transition probabilities across states. The important parameter is  $\delta$ . If we are closer to the independence of the states, we will expect a  $\delta$  close to 1. If, on the contrary, the assumption of sharing the state of the economy is not restrictive, we will expect a  $\delta$  close to 0. The results are displayed in the fourth column of Table 5 and the probabilities of being in recession for each variable are plotted in Figure 8.

Looking at Table 5, we can see that the  $\delta$  is closer to 0 than to 1. We can even accept the null that  $\delta = 0$ , giving a clear statement that even though the "true" data generating process is in the middle, the assumption that they share the business cycle is closer to reality than the independence of the business cycles.

Figure 8 presents the probabilities of both series being in recession periods. Looking at the figures, it is clear that they do not match with the ones presented in Figure 6. Relating these probabilities with the level of the IPI series, it seems, that these episodes with high probability of recessions are characterized by low, but not negative growth rates of the IPI series. It seems that firms consider recessions, not only periods with negative growth (as the classical definition of recession implies) but also periods with lower than the long term trend rate.

This definition of recession is not new in the literature and has been previously defined as "growth cycle" or "deviation cycle"(Mintz,1969; Zarnowitz,1992).

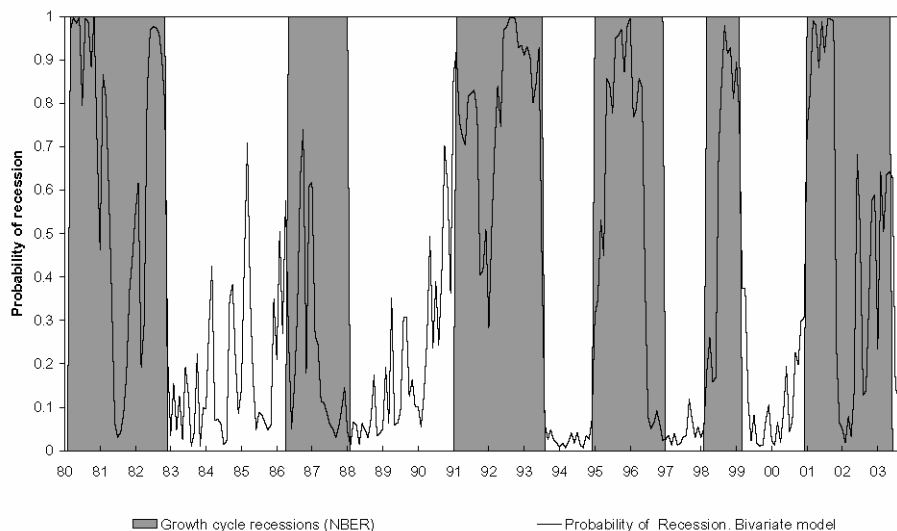


Figure 8: Filtered probabilities of recession in the IPI. Bivariate Markov switching model with a mixture of independent Markov states and the sharing of the state of the economy (Model 4) and growth cycle recessions of IPI.

The shaded areas of Figure 8 represents those periods (calculated with the Bry-Boschan algorithm on the detrended series of IPI) It can be observed the strong concordance

between the dating of the growth cycle of the IPI and the dating obtained from the Markov-switching bivariate model applied to the IPI and ICI. The bivariate (MS) model captures each of the NBER growth cycle recessions in the sample. In addition, the bivariate model does not generate false growth cycle dates. To complete the information about this "growth cycle", figure 9 plots the IPI series with the trend used to obtain the growth cycle, calculated with the Hodrick-Prescott filter (Hodrick and Prescott, 1980).

We have now developed a filter for the joint behavior of the IPI and ICI. Out of this filter we obtain the joint probabilities of recession for these series, and, as stated in the univariate model, the filter implies a statistical definition of recession periods that allows making inference for future periods. This has with an important advantage with respect to the univariate model. In that case, we had to make inference about period  $t+1$  with information up to  $t-2$ . However, in the bivariate specification, there is information about one of the two series that allows updating the probabilities in  $t-1$  and  $t$ . Therefore, we can make inference about  $t+1$  with series dated in period  $t$ . With this model in mind we propose the following scheme for

- In period  $t$ , estimate the bivariate model for the sample for which we have available information for both series. This will imply estimating the model for both variables up to period  $t-2$ .
- With the probabilities of recession and expansion estimated for the last period of the estimation ( $t-2$ ), use the transition probabilities stated above for predicting the probabilities of being in recessions and expansions in  $t-1$ .
- Update those probabilities using the data for the ICI in  $t-1$ .
- With these probabilities, generate, using again the transition probabilities, the probabilities of recession and expansions.
- Update those probabilities using the data for the ICI in " $t$ ". These last probabilities are our proposed best inference about the current state of the economy.

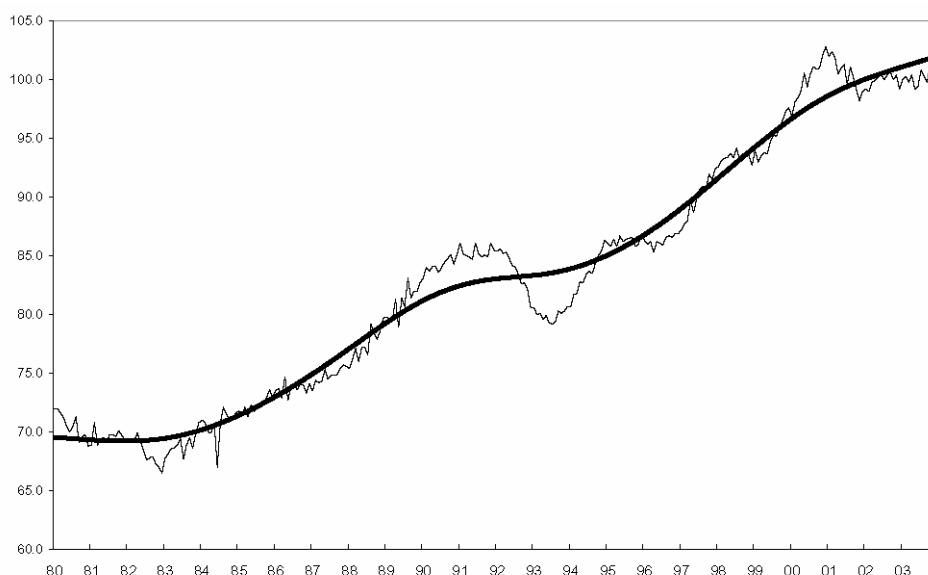


Figure 9: Level and HP trend of the IPI, 1980-2003

In order to address the performance out of sample of this specification we do the same exercise that we did in the univariate case. We estimate the model recursively from 1992.07 to 2003.12 and we keep the out-of-sample forecast using the proposed filter. The

results are plotted in Figure 10, where we plot the in-sample probabilities already plotted in Figure 8 and these out-of-sample estimations. Both series are closer together than the ones presented in Figure 7. The systematic delay has been corrected. However, there is still a marginal delay. Obviously we are forecasting for  $t+1$  with information up to  $t$ . This is the minimum delay possible in forecasting.

In order to clarify how the delay has been reduced in the bivariate specification, in Figure 11 we plot the in-sample probabilities in each period for both, the univariate and the bivariate model with the out of sample probabilities lagged only one period. Clearly, we can observe that the delays have been corrected in the bivariate case but not in the univariate model. In the bivariate case we have the minimum delay (one period, due to the nature of any forecasting exercise). In the univariate case the delay is bigger and it is the summation of the forecasting nature plus the statistical information delay.

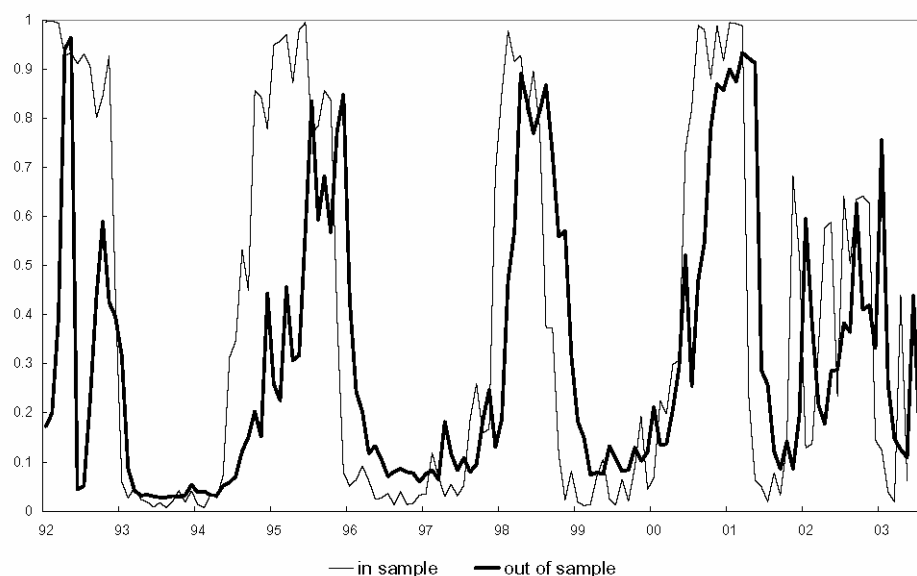


Figure 10: Probability of recession. Bivariate Model (MS)

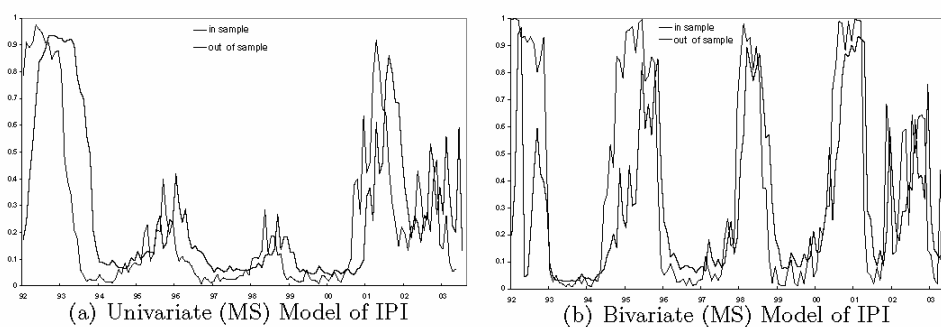


Figure 11: Probability of recession



## 6 Conclusions

We have proposed a new methodology based on Markov switching processes for dating the business cycle in the euro-area economy. We think that our methodology is a useful contribution to the literature because it allows us to make inference about the state of the economy in period " $t$ " with the available information up to that period. For different reasons that go from the need to smooth the data to publication lags, previous methodologies were unable to shed light on the current state.

One of the key variables in our specification is the industrial confidence indicator published by the Commission. We think that these series are helpful for describing recessions and expansions in the past as well as being a key for identifying the current and future states of the economy of the euro area.

## REFERENCES

- [1] ARTIS, M. J. and W. ZHANG (1999), "Further Evidence on the International Business Cycle and the ERM: is there a European Business Cycle?", *Oxford Economic Papers*, 51.
- [2] ARTIS, M. J., H-M. KROLZIG and J. TORO (1999), "The European Business Cycle", *CEPR Discussion Paper No. 3696. EUI Working Papers, Eco No. 99/24*.
- [3] ARTIS, M. J., M. MARCELLINO and T. PROIETTI (2003), "Dating the Euro Area Business Cycle", *CEPR Discussion Paper Series No. 2242, January 2003*.
- [4] BATCHELOR, R. (1999), "Confidence and the macroeconomy: a Harkov switching model", Mimeo. City University Business School, London.
- [5] BRY, G. and C. BOSCHAN (1971), *Cyclical Analysis of Time Series: Selected Procedures and Computer Programs*, New York: NBER.
- [6] BURNS, A. M. and W. C. MITCHELL (1946), *Measuring Business Cycles*, New York: NBER.
- [7] EUROPEAN COMMISSION. Directorate-General For Economic And Financial Affairs (1997), "The Joint Harmonised EU Programme of Business and Consumer Surveys", *European Economy No 6*.
- [8] HAMILTON, J.D. (1989), "A new approach to the analysis of non-stationary time series and the business cycle", *Econometrica No. 57*.
- [9] HAMILTON, J.D. (1994), *Time Series Analysis*. Princeton, N.J.: Princeton University Press A new approach to the analysis.
- [10] HARDING, D. (2002), "Non-parametric turning points detection, dating rules and the construction of the euro-zone chronology", *Paper presented at the Eurostat Colloquium on Modern tools for Business Cycle Analysis, Luxembourg, 28-29 November 2002*.
- [11] HODRICK, R. and PRESCOTT, E. (1980), "Post-war US Business Cycles: An empirical Investigation " *working paper, Carnegie-Mellon Uni*.
- [12] KATONA, G. (1951), *Psychological Analysis of Economic Behaviour*, McGraw-Hill, New York.
- [13] KROLZIG, H-M and J. TORO (2001), "Classical and Modern Business Cycle Measurement: The European Case", University of Oxford, *Discussion Papers in Economics*, 60.
- [14] KROLZIG, H-M (2001), "Markov-Switching Procedures for Dating the Euro-Zone Business Cycle", *Vierteljahrshefte zur Wirtschaftsforschung No. 70. Jahrgang, Heft 3/2001*.
- [15] KROLZIG, H-M (2002), "Constructing turning point chronologies with markov- switching vector autorregressive models: the Euro-Zone business cycle", *Paper presented at the Eurostat Colloquium on Modern tools for Business Cycle Analysis, Luxembourg, 28-29 November 2002*.
- [16] MASSMAN, M and J. MITCHELL (2003), "Reconsidering the Evidence: Are Euro zone Business Cycles converging?", *NIESR Discussion Paper No. 210*.
- [17] MINTZ, I. (1969), *Dating Postwar Business Cycles: Methods and Their Application to Western Germany, 1950-67*, New York: NBER.
- [18] MITCHELL, J. and K. MOURATIDIS (2002), "Is there a common Euro-zone business cycle?", *Paper presented at the Eurostat Colloquium on Modern tools for Business Cycle Analysis, Luxembourg, 28-29 November 2002*.
- [19] MOUROUGANE, A. and M. ROMA (2002), "Can Confidence Indicators be useful to predict short term GDP growth?", ECB, *Working Paper No. 133, March 2002*.
- [20] SANTERO, T. and N. WESTERLUND (1996), "Confidence Indicators And Their Relationship To Changes In Economic Activity", OECD, *Working Paper No. 170, Paris 1996*.
- [21] ZARNOWITZ, V. (1992), *Business Cycles: Theory, History, Indicators and Forecasting*, Chicago: The University of Chicago Press.

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