D S E
Dipartimento Scienze Economiche

Working Paper

Department of Economics

Ca' Foscari University of Venice

Jacques Anas
Monica Billio
Laurent Ferrara
Marco Lo Duca

A turning point chronology for the Euro-zone

ISSN: 1827/336X
No. 33/WP/2007

Working Papers
Department of Economics
Ca' Foscari University of Venice
No. 33/WP/2007
ISSN 1827-3580

A turning point chronology for the Euro-zone[1]

Jacques Anas
Coe-Rexecode, Paris

Monica Billio
University of Venice

Laurent Ferrara
Banque de France

Marco Lo Duca
European Central Bank

Abstract
We propose a dating process for the business and growth Euro-zone cycles. This process is a result of a non parametric algorithm and diverse criteria assessment (duration, deepness, diffusion, synchronisation), as well as of "expert judgments" based on a combination of the following principles: a comparison of direct and indirect dating; an objective of coherence between growth cycle and business cycle turning points (ABCD approach); an objective of coherence between industrial and GDP cycles. As a complement to the traditional direct approach based on the study of Euro-zone aggregates, the main contribution of this paper is to measure the degree of diffusion and synchronisation of the cycles among the countries.

Keywords
Economic cycles, Turning point, Chronology, Non parametric approach, Euro-zone

JEL Codes
C50, C32, E32

Address for correspondence:
Monica Billio
Department of Economics
Ca' Foscari University of Venice
Cannaregio 873, Fondamenta S.Giobbe
30121 Venezia - Italy
Phone: (++39) 041 2349170
Fax: (++39) 041 2349176
e-mail: billio@unive.it

1 This research has been sponsored by the Eurostat project on "Short-terms indicators of the Euro-zone". We are grateful to Gian Luigi Mazzi and to all the participants of the project for their helpful comments.

The Working Paper Series
is availble only on line
(www.dse.unive.it/pubblicazioni)
For editorial correspondence, please contact:
wp.dse@unive.it

Department of Economics
Ca' Foscari University of Venice
Cannaregio 873, Fondamenta San Giobbe
30121 Venice Italy
Fax: ++39 041 2349210

I Introduction: Why, what and when dating?

We first point out some concepts relevant to the construction of a reference turning point chronology.

I.1 Why dating?

The need for a cycle turning point chronology is now widely recognised by experts and practitioners of economic analysis. As an example of application, it may help to compare the cycles between nations or to point out links between the cycles and diverse economic aggregates. However, it turns out that the most important use of the turning point chronology consists in establishing a reference cycle dating for a given country or economic area. Indeed, this reference cycle is often used in empirical studies either to classify economic series according to their advance (leading, coincident or lagging) or to validate real-time detection and forecasting methods. While there is a reference chronology for the US business cycle, maintained by the Dating Committee of the NBER[1], there is no such chronology as regards the Euro-zone economy.

It is obvious that dating is an *ex post* exercise. In this respect, accuracy is a more important criterion than timeliness. Because of the lack of timeliness, dating may not be useful for economic decision-making. As a matter of fact, governments and central banks are very sensitive to indicators showing signs of deterioration in growth to allow them to adjust their policies sufficiently in advance, avoiding more deterioration or a recession. In this respect, timing is important and the earlier the signal, the better. This issue is linked to the "real-time detection" concept. However, to validate their methods of real-time detection, researchers need a reference turning point chronology.

I.2 What dating?

As our aim is to date cycle turning points, a turning point has to be clearly defined. In this paper, we define a turning point as a peak or a trough in the economic cycle. This definition in turn implies precision of what we call the economic cycle. In economic literature, two kinds of cycles are generally considered: the *classical business cycle* and the *growth cycle*. The classical business cycle refers to fluctuations in the level of the series while the growth cycle is the deviation to the long-term trend. It should be emphasised that academic literature has focused mainly on the analysis of the classical business cycle. For instance, the NBER gives only a reference chronology for this kind of cycle. In this paper, we refer to the ABCD approach of both classical and growth cycles proposed in Anas and Ferrara (2002b) and we call A the peak of the growth cycle, B the peak of the classical cycle, C the trough of the classical cycle and D the trough of the growth cycle. This approach implies that point A is always before point B and similarly point C is always before point D. This will be a constraint in the construction of the business and growth cycles dating chronologies. A third type of economic cycle is often analysed by practitioners, namely the growth rate cycle. Indeed, some economists talk about a recovery when the GDP growth rate has reached a local minimum. However, the growth rate cycle is subject to erratic movements as well as to very short-term fluctuations due to transitory events (for instance strikes) making the peaks of this cycle extremely difficult to date, which removes any practical interest for the signal. For this reason, we only focus on the classical and growth cycles of the Euro-zone economy in this paper.

If dating the classical business cycle is not so easy, then dating the growth cycle is even more difficult since the series must first be de-trended. Several growth cycle extraction methods have been proposed in statistical literature, ranging from filtering techniques (Baxter-King, Hodrick-Prescott, Christiano-Fitzgerald…) to parametric modelling (mainly based on state-space models and Markov-Switching models). However, each method possesses its own advantages and drawbacks and, up to now, it is not very clear which method should be used by practitioners. This supplementary step in the growth cycle dating methodology adds some noise to the signal, since dating depends on the chosen filter (Canova, 1994).

I.3 When dating?

There is a substantial delay before announcing the cycle turning points dates in the United States. For example, the July 1990 peak in the classical US cycle was announced by the NBER in April 1991 and the March 1991 trough only in December 1992. Concerning the last classical cycle, the March 2001 peak was announced in November 2001 and the November 2001 trough was announced just after the Dating Committee meeting of July 2003. This delay is certainly due to the idea that the dating should not be revised. In this respect, dating must be as accurate as possible.

One issue with the dating process lies in the degree of revision of raw data on which the dating method is applied. We should wait for the last revision of the data, which may be disturbing in the case of GDP. Indeed, GDP figures are constantly revised because of new available surveys and methodological innovations (we refer, for example, to Fischer chain-linked price series in the case of the United States or to the recent revision of national accounts in Japan). Using series other than

[1] www.nber.org/cycles

GDP may reduce this drawback. But in this case, the availability and the homogeneity of these series over a long period of time are necessary to provide consistent dating through time.

II Some issues in the choice of the dating methods

The construction of a reference turning point chronology raises some issues related to the choice of methods to be used. For instance, starting from a single time series, two different dating procedures can lead to distinct dating results. It may therefore happen that different estimates are available on the market. There is increasing literature relevant to this specific topic, based on comparisons between the results computed by authors and a reference dating chronology. Unfortunately, this literature is specific to the American economy and not the Euro-zone, mainly because of the lack of reference chronology. Usually, when a researcher develops a method to estimate the turning point chronology of a given country, the ultimate criteria to assess this method is to compare the resulting dating with a benchmark. However, in our case, we want to construct this reference dating chronology! Therefore, the assessment of diverse dating methods is not obvious. Some properties can help us to compare the methods:

(i) Transparency: the dating method must be replicable to every one.
(ii) Adaptability of the method to different series and countries.
(iii) Robustness to extreme values and to the sample.
(iv) The chronology must not be revised through time.

In this section, we present first a review of the various existing chronologies, then we discuss in detail the most important issues concerning the choice of the dating methods.

II.1 A review of dating chronologies for the Euro-zone

Although an official dating chronology is not yet available, some studies have tried to provide one for the Euro-zone cycles.

Classical business cycle

Regarding the business cycle, most of the authors have constructed their chronology based on the Euro-zone GDP, either aggregated or country-specific. This is the reason why the proposed chronologies are generally quarterly (except Anas, 2000, and Harding and Pagan, 2001a, who consider a set of monthly series). The turning points are either estimated non-parametrically (Anas, 2000, Lommatzsch and Stephan, 2001, or Harding and Pagan, 2001a) or parametrically (Artis, Krolzig and Toro, 1999, Krolzig, 2001, 2003, and Anas and Ferrara, 2002c). Krolzig (2001, 2003) has used both a univariate Markov-Switching model (MS-AR hereafter) and a multivariate Markov-Switching model (MS-VAR hereafter). Very recently, the Centre for Economic Policy Research (CEPR, 2003) has formed a dating committee of eight experts to set the dates of the Euro-zone business cycle, based on the NBER experience. They consider GDP and other economic variables, like investment, employment and industrial production, at the Euro-zone level and at a geographical disaggregated level. They provide a quarterly chronology by assessing the depth, duration and severity of the recession, but without describing in detail their methodology. The various dating chronologies are presented in the following table 1. Note also that some other papers deal only with the industrial business cycle (see for instance Artis *et al.*, 2003, or Krolzig, 2003) .

Table 1: Business cycle dating for the Euro-zone over the period 1974 – 2000

	Lommatzsch Stephan (2001)(*)	Anas (2000)	Anas Ferrara (2002)	Artis, Krolzig and Toro (1999)	CEPR (2003)	Krolzig (MS-AR) (2001)	Krolzig (MS-VAR) (2001)	Krolzig (MS-AR) (2003)	Krolzig (MS-VAR) (2003)(**)	Harding Pagan (2001a)
Peak B		M2 1974		Q1 1974	Q3 1974				Q2 1974	M9 1974
Trough C		M3 1975		Q2 1975	Q1 1975				Q1 1975	M3 1975
Peak B	Q1 1980	M2 1980		Q1 1980	Q1 1980	Q1 1980	Q1 1980	Q1 1980	Q4 1979	M3 1980
Trough C	Q4 1980	M11 1980		-	-	Q1 1981	Q1 1981	-	Q3 1981	M3 1981
Peak B	Q3 1981	M3 1982		-	-	-	-	-	Q4 1981	M6 1982
Trough C	Q4 1982	M9 1982	Q4 1982	Q4 1982	Q3 1982	-	-	Q1 1983	Q4 1982	M12 1982
Peak B	Q1 1992	M2 1992	Q1 1992	Q2 1992	Q1 1992	Q1 1992	Q2 1992	Q1 1990	Q2 1992	M3 1992
Trough C	Q1 1993	M3 1993	Q2 1993	Q2 1993	Q3 1993	Q1 1993	Q3 1993	Q1 1993	Q3 1993	M3 1993

(*) Lommatzsch and Stephan (2001) propose several dating depending on the seasonal adjustment method. We retain the most frequently quoted dating.

(**) Krolzig (2003) dates also a surprising business cycle between 1986 and 1987 (peak in Q2 1986 and trough in Q1 1987).

Most of these chronologies start in 1980 and are quarterly because based on the GDP. As regards all the dates of peaks and troughs provided by these studies, the results appear to be more or less coherent. The 1974-75 recession due to the first oil shock seems to be clear. Generally, from 1980, three recessions periods are detected: 1980-81, 1982 and 1992-93. While the 1992-93 period has been underlined by all the studies with the same accuracy (especially the peak), there is an issue as regards the 1980-81 and 1982 periods. Indeed, both recessions of 1980-81 and 1982 can be seen as a single recession phase with a double dip, as did by Artis, Krolzig and Toro (1999), Krolzig (2003) and CEPR (2003). It is noteworthy that other studies have also considered the issue of business cycle dating, but only for separate countries and not for the aggregate Euro-zone economy. We refer for instance to Rabault (1993) or to the Economic Cycle Research Institute[2].

Growth cycle

The Euro-zone growth cycle has been studied much less often compared to the classical cycle. It is perhaps due to the de-trending problem and to the lack of popularity of this concept. Most of the time, the estimates are based on the Euro-zone GDP series (only the OECD prefers their CLI index, see Arnaud, 2000 and Arnaud and Hyong, 2001) and the papers differ mainly according to the cycle extraction method. The Hodrick-Prescott filter is used in Vanhaelan *et al.* (2000), the PAT procedure is used by OECD and Harding and Pagan (2001a) remove a linear deterministic trend from the Euro-zone GDP. In Anas (2000), an empirical comparison of the Hodrick-Prescott and Baxter-King filters with an unobservable components model, developed by Harvey (1989), is undertaken. It is worth saying that all these studies have used a non-parametric dating procedure, based on the Bry and Boschan algorithm adapted for quarterly series. On the contrary, Peersman and Smets (2001) have proposed a parametric dating of the growth cycle based on a MS-VAR model applied to the de-trended industrial production index of a set of European countries. The dating results are presented in the following table 2.

The results are not easily comparable because they do not take the same period of study into account. However, as concerns the common sample period, the results appear also to be coherent.

[2] www.businesscycle.com

Table 2 : Review of growth cycle dating for the Euro-zone over the period 1963 – 2000

	OECD (2001)	Harding Pagan (2001a)	Anas (2000)	Vanhaelan *et al.* (2000) (*)	Peersman Smets (2001)
Peak A	M3 1963				
Trough D	M1 1964				
Peak A	M1 1974	M3 1974	M11 1973		
Trough D	M7 1975	M6 1975	M8 1975		
Peak A	M1 1977	M12 1976	M11 1976		
Trough D	M3 1978	M9 1977	M11 1977		
Peak A	M3 1980	M3 1980	M12 1979		Q4 1979
Trough D	M12 1982	M9 1983	M1 1983		Q1 1983
Peak A	M4 1986	M3 1984	M10 1985		Q4 1985
Trough D	M1 1987	M3 1987	M4 1987	Q1 1987	Q1 1987
Peak A	M1 1991	M3 1990	M8 1991	Q1 1990	Q1 1990
Trough D	M7 1993	M12 1993	M8 1993	Q1 1993	Q3 1992
Peak A	M12 1994	M12 1994	M2 1995	Q1 1995	Q2 1995
Trough D	M12 1996	M6 1997	M1 1997	Q1 1996	Q1 1996
Peak A	M3 1998		M5 1998	Q2 1998	
Trough D	M5 1999		M6 1999	Q4 1998	

(*)Vanhaelan *et al.* (2000) date another minor cycle whose peak is located in Q1 1990 and trough in Q1 1991.

II.2 Univariate *vs.* multivariate

In their seminal work on business cycles, Burns and Mitchell (1946) pointed out two main stylised facts of the economic cycle, namely co-movement and non-linearity. Non-linearity refers to the fact that the behaviour of the series describing the cycle depends on the phase in which it evolves (contraction or expansion), while co-movement refers to the fact that most of macroeconomic time series evolve together along the cycle. The question is how to measure these co-movements accurately?

First, it is possible to assume that a single time series is able to describe the business cycle and/or the growth cycle. In this respect, the quarterly GDP series seems to be the more appropriate univariate time series to be used. One of the drawbacks is that GDP is sampled on a quarterly basis;

a monthly dating is more accurate. Moreover, it is often difficult to get a long historical record of GDPs at the desired frequency and some statistical procedures, such as back-calculations, are needed. Some other series are also often used to assess both classical and growth cycles such as, for example, the industrial production index (IPI) or employment. However, these series partly reflect fluctuations in the whole economy; the industrial production especially measures a declining part of the economy in the Euro-zone. Note also that, concerning the Euro-zone aggregate, the IPI series is available on a monthly basis while employment is only calculated quarterly.

However, there is no single measure of aggregate economic activity. Since the beginning of the nineties, theoretical and empirical business cycle research has revived interest in the extraction of a coincident index describing the evolution of the whole economy. In their pioneer works, Stock and Watson (1989) introduced a dynamic factor model in order to extract a common factor summarising the co-movements from a small number of indicators. Recently, taking the growing available economic information into account, some authors (for instance, Forni *et al.*, 1999 and Watson, 2000) have proposed "big data" dynamic factor models to construct coincident indexes, with roughly 500 series spanning 500 months. For instance, regarding the Euro-zone, a recent coincident index called EuroCOIN[3] has been developed by the CEPR (see Altissimo *et al.* 2001), based on a set of 951 series related to the Euro-zone economy. These approaches afford coincident univariate indexes, which can be used in turn to establish a turning point chronology by applying a given parametric or non-parametric procedure (see for instance Diebold and Rudebusch, 1996). In this paper, we refer to these approaches as "two-step" multivariate methodologies.

Lastly, the direct use of a set of macroeconomic data to assess the turning point chronology may be preferred. For instance, the NBER's dating committee studied four macroeconomic series simultaneously to date with non-parametric techniques the classical cycle of the American economy: employment, personal income less transfer payments, volume of sales in the manufacturing and wholesale-retail sectors and industrial production. A classical statistical approach in a multivariate framework is the use of a multivariate parametric model. In this respect, the multivariate extension of the Hamilton's (1989) Markov-Switching model proposed by Krolzig (1997) has been often used to get dating results (see next subsection). We refer to these approaches as "one-step" multivariate methodologies.

II.3 Non-parametric *vs.* parametric

There have been many attempts to establish turning point dates by translating the graphical inspection approach into a procedure, either parametric or non-parametric. An important feature is that all these procedures must be flexible enough to take into account certain non-linearities of the cycle such as different duration, amplitudes and cumulative movements of its phases.

The first non-parametric procedure consists in examining the relevant time series to locate the peaks and troughs visually (graphical approach). Although not sufficient, this naive procedure can sometimes lead to fruitful results and can be seen as a primary filter anyway. For the most part, non-parametric procedures in turning point dating are based on recognition pattern algorithms. According the business cycle classical definition of Burns and Mitchell (1946), two regimes are imposed: a recession regime and an expansion one. Thus, the classical meaning of the business cycle refers to the alternation of regimes when the economic activity at aggregate level decreases (recessions) and increases (expansions). In this respect, the recognition pattern algorithms try to identify these regimes. The most famous one is the Bry and Boschan (1971) procedure, still used in many countries and in academic works when estimating business cycle turning points. Another class of non-parametric dating procedure consists in *ad hoc* rules and experts claims. For instance, the Conference Board refers to the 3D's rule to date turning points (diffusion, deepness, duration). However, this class of procedure suffers under a lack of transparency. It is indeed a hard task to reproduce the results provided by such procedures. Lastly, it is worth noting that in the multivariate framework, non-parametric procedures are more difficult to adapt. Indeed, the difficulty lies in summarising the diverse dates obtained. This can be done after checking for the degree of synchronisation through a concordance test. An algorithm has been proposed by D. Harding (2002) to cluster various turning points after defining a distance between turning points and a function which measures the centre of tendency of turning points in a cluster. We will use a version of this methodology in section 4.

Apart from these non-parametric approaches, a great number of parametric models have been developed lately to date turning points in the classical business cycle, based mainly on the Markov-Switching model popularised in economics by James Hamilton (1989, 1990) in order to take into account a certain type of non-stationarity inherent to some economic or financial time series that cannot be caught by classical linear models. In the univariate and multivariate framework, many

---

[3] www.cepr.org/Data/Eurocoin

attempts have been undertaken to provide a Euro-zone dating chronology of the business cycle through the MS-AR model and its multivariate generalisation (MS-VAR process introduced by Krolzig, 1997), especially by applying the model to GDP (see the review in this section).

As usual when dealing with parametric modelling, the issues of specification, parameter estimation and validation are raised. As regards the parameter estimation, it seems that the EM algorithm with adequate starting value works quite well. The issue of specification is more tricky and can be done *a priori* or by using a data-driven approach. Several data-driven approach have been proposed in the literature but they are computationally demanding and difficult to use in the case of highly parameterised models (see Hansen 1992, 1996, Hamilton, 1996, Krolzig, 1997, and Garcia 1998). Another possible approach is to start from economic considerations and to define *a priori* the structure of the MS-AR model. Therefore, we can define *a priori* the number of regimes and eventually impose some constraints on the parameters of the model to take into account some specific business cycle features. In economics, the unobservable variable describing the regimes, denoted S_t, is often supposed to represent the current state of the economy. Thus, a 2-state Markov chain model is generally used in applications, that is, for all t, the time series S_t takes value 1 when the economy is in contraction and value 2 when the economy is in expansion. Several authors also find evidence in favour of a three or more regime model for the business cycle (Sichel, 1994, Boldin, 1996, Krolzig and Toro, 2001, Layton and Smith, 2000 or Ferrara, 2003). However, this constraint does not guarantee that recessions in classical meaning will be found, because these regimes usually differ in terms of average growth rates and/or growth volatilities but they may not be characterised by negative growth events, *i.e.* the change in regime does not always produce recessions in classical meaning. In many cases the MS approach properly detects recessions, but not necessarily: anyway, it always indicates some differentiation of the growth rate of the economy. It is impossible to expect a perfect coincidence between the chronologies produced by the non-parametric method and those produced by the parametric one: the two procedures deal with different events (see Anas and Ferrara, 2002c).

Regarding the validation stage, it can be shown that a statistically significant model does not necessarily provides a good description of the business cycle. This is the reason why authors have proposed validation tests of the model based on the comparison between the known and the estimated stylised facts of the business cycle through numerical simulations (see for example Breunig and Pagan, 2002).

To conclude we argue that, in order to establish a reference chronology, it seems advisable to have an expert analysis based on non-parametric procedure, at least for the business cycle. This is due to the necessary calibration of parametric models on dating. However, regarding real-time detection, those parametric models may be very competitive and should benefit from the new co-movement extraction tools, on small or big data sets. Those models will have the purpose to detect in the most efficient way the turning points without necessarily replicating other stylized facts.

II.4 Direct *vs.* indirect

This issue is specific to large economic areas including several national economies. In order to provide a turning point chronology, is it more appropriate to analyse the economies of each country of the zone (indirect approach) or the whole economy of the zone directly (direct approach)?

Regarding the indirect approach, the most difficult part is how to aggregate the multivariate information. Once we get a turning point chronology for each country of the Euro-zone, first of all it is necessary to evaluate whether there is sufficient diffusion of the cyclical movements across countries and whether there is synchronisation among these countries. If there is evidence of diffusion and synchronisation, then it is necessary to define a way to aggregate those information to provide a chronology for the Euro-zone. In practice, this is not so clear how to measure independently the diffusion and the synchronisation of the cycles. Several non parametric measures have been proposed in the literature but they provide simultaneously an evaluation of diffusion and synchronisation.

The simplest one is to calculate a diffusion index measuring the percentage of countries that exhibit the same regime (for example a recession) at a certain time *t*. Indicating with S_{it}, the binary variable that represent the phase of the cycle for the country *i,* the index can be expressed in this way:

$$D_t = \frac{1}{N}\sum_{i=1}^{N} S_{it} \quad , \quad t=1, \ldots, T \tag{2.1}$$

where *N* is the number of countries. Another possible method, used by many authors (see for example Krolzig and Toro (2001), Harding and Pagan (2002), Artis *et al*. (2002)), is to compute a concordance index which measures the fraction of time that the cycles of different series are in the same phase (recession or expansion). In the bivariate case, for the two countries *i* and *j*, the concordance index can be expressed in this way:

$$\hat{I} = \frac{1}{T}\left\{\sum_{t=1}^{T} S_{it}S_{jt} + \sum_{t=1}^{T}(1-S_{it})(1-S_{jt})\right\}. \qquad (2.2)$$

This concordance index is equal to 1 when $S_i = S_j$ at each date *t*, and to 0 when S_i=(1-S_j) at each date *t*. Anyway, it could be misleading because, even if the correlation between S_i and S_j is zero, *I* is equal to 0.5 only if the mean of S_i and S_j are both equal to 0.5. It is possible to demonstrate that the expectation of the concordance index depends on the unconditional probabilities of S_i and S_j (see Harding and Pagan, 2002, and Artis *et al*., 2002). In particular, in the case of independence between S_i and S_j, it is equal to:

$$1\text{-}P(S_i)\text{-}P(S_j)+2P(S_i)P(S_j)=E(I) \qquad (2.3)$$

It is therefore possible to test the null hypothesis of independence between the cycles of two countries by comparing the expected value of *I* in the case of independence and the estimated one. Moreover, since the concordance index depends on the correlation it could be useful also to look at this measure. The use of the correlation matrix permits to test the hypothesis of independence in a multivariate framework in a more simple way than with the concordance index, but it needs the normality assumption.

In the parametric MS-AR approach, for example, the information about the common cycle is represented by the vector containing the smoothed probabilities of each country of being in a given regime. It is then possible to evaluate the synchronisation of cycles looking at the correlation between these probabilities. Once evidence of synchronisation is found, then we need to aggregate the information to find out the common cycle. The question is how to translate them into an algorithm to provide a unique chronology. Some criteria have been proposed in literature. For instance, Krolzig and Toro (2001) argue that Europe is considered to be in recession if at least half of the countries are in recession, so they use a diffusion index to get the signal. However, it seems that this criterion is rather arbitrary and is not based on any economic rationale and a better approach would be certainly to weight the information of each country by a measure representing

its economic importance in the whole Euro-zone. Obviously, an objective measure of the spatial diffusion and of the synchronisation must take the weights of the countries into account. Indeed, an industrial recession in Germany (33.1 % of the industrial production of the Euro-zone) cannot have the same impact that one in Greece (1.1 % of the industrial production of the Euro-zone).
Another possible approach could be to weight the information of each country by a measure representing the importance of its economy in the whole Euro-zone: for example, we could use the proportion of the Euro-zone gross product to weight the smoothed probabilities of this country in order to obtain the smoothed probabilities for the Euro-zone. In the parametric framework, another solution could be found in a multivariate MS-VAR approach. In fact a multivariate MS-VAR model should be useful in the indirect method because it provides us with some information about the relationship among the business cycles of different countries. We refer to the paper of Anas, Billio, Ferrara and LoDuca (2003) for an example of application.

II.5 Importance of the pretreatment of raw series : seasonal adjustment, smoothing and filtering

II.5.1 Direct *vs.* Indirect seasonal adjustment

Eurostat is still engaged in the process of harmonising the production of statistics throughout EU but this will take some time. Progress has been achieved regarding for example surveys, prices and national accounts. But national methodologies and practices are still variable throughout Europe in many different fields. This is the case of seasonal adjustment (SA) which is of concern for the present work.
The objective of getting a Euro-zone cyclical dating is not only facing the issue of diversity in national practices but also the issue of lack of additivity in the SA process. At the national level, the additivity issue is quite well-known and to face it, the indirect approach is used. For example, the SA IIP (index of industrial production) is calculated as the sum of SA sub-indices (2-digits of NACE) in France. But when there are different ways of disagreggating the index, this may arise a question. For example, trade statistics may be broken down by type of products or by country of origin. Therefore the sum of SA sub-indices may be done in two different ways, resulting maybe in two different SA aggregated series. This is the same question when re-basing national accounts. The new GDP growth rate may result from adding new constant values on the demand side or on the supply side. Generally the supply side in chosen as priority and the discrepancy on the demand side may be put in stock variation.

A feasible practice for a European aggregate of industrial production or GDP would seem an indirect approach by adding up SA national series. A decentralised process through national institutes may be more efficient. This is the choice which has been done by Eurostat as concerns the Euro GDP. But because of the variability of methodological practices, this method is under criticism (because of this methodological diversity, this method is called "mixed indirect approach"). On the contrary, for the industrial production, a direct approach has been adopted by Eurostat. But the direct approach is based on a partially pre-adjusted series. In other words, the partial adjustment (working-days adjustment) is made at the national level.

What are the consequences for dating ?

The Euro-zone dating will depend clearly on the way series are constructed at the Euro-zone level. There is the issue of comparing national dating and the Euro-zone dating. At least, we need an "internal constancy" in the dating procedure. To reach this "internal consistency", it is needed to have an "internal constancy" in the way *TC* series are estimated. The indirect approach seems to be the best way to get this "internal consistency". However the national practices are not the same today, therefore the indirect approach is rather a "mixed indirect approach" which is not totally satisfactory. The direct approach, as we saw before, is neither a satisfactory approach. Therefore neither of these two approaches (direct approach for industrial product and mixed indirect approach for GDP) will provide an "internal constancy" explaining why among other reasons the comparison of direct and indirect approaches for dating made in this report will be imperfect.

II.5.2 Dating made on Trend-Cycle (*TC*) series

The business and growth cycles turning points dating should be based on monthly series which evolution must not be distorted by irregular and seasonal effects. The irregular component includes a deterministic part due to the working day effect (including holiday effect with special emphasis on Easter effect) and outliers (additive outliers, transitory and level shift outliers). Any observed time series Y may be written as follows:

$$Y = TC + I + S,$$

where TC is the trend-cycle component, I is the irregular component and S is the seasonal component. The component $TC + I$ is the seasonal adjusted series (SA series) and I includes additive and transitory outliers. The TC component (and therefore SA) includes level shifts. The Tramo-Seats program provides a direct model-based estimate of TC, by applying a classical SARIMA process. On the contrary, the estimate by Census X12 is done through filtering in a non-parametric way.

Traditionally, SA series are used for cyclical analysis because only those series are available in economic databases. In order to deal with *TC* series, the user should process himself the Tramo-Seats seasonal adjustment which is time consuming and difficult. Therefore, *TC* series are not used for cyclical analysis because they are not available. Generally, the SA series is smoothed out by applying some sort of standard smoothing, as for example the commonly used 3-terms centered moving-average. However, this may not be efficient. First, this sort of smoothing is totally arbitrary. Second, there is a risk of smoothing out additive or transitory outliers which may create a distortion of the *TC* series and impact on the dating if this outlier is an exceptional event (for example a strike or a rigorous winter) which should be ignored for cyclical dating. Therefore, *TC* series seem to be the ideal series on which the dating should be made. Of course, it will depend crucially on the way outliers have been defined. Sometimes, in the process of seasonal adjustment, the user may impose the date of fixed outliers. For example, the social movement at the end of 1995 in France may be considered as an outlier. The SARIMA model should be well specified and the outliers correctly defined.

In conclusion, the Tramo-Seats program, which is recommended by Eurostat, will be used for seasonal adjustment end the resulting *TC* series will be used for the dating process of monthly series in the present study. In the case of quarterly series, the question is more delicate and we prefer to use the SA series directly to produce a dating chronology.

II.5.3 Growth cycle extraction with filters

The growth cycle extraction is well known by practitioners as an intricate issue. Since the introduction of the growth cycle concept by Ilse Mintz of the NBER in 1969, the literature has been very extensive on this topic, but up to now there is no clear recommendation.

Several methods have been proposed ranging from the simple linear de-trending method (see for instance Harding, 2002) to the unobserved components approach (Harvey, 1989). One of the most used approach is the PAT methodology, still in used by the OECD for example (see Zarnowitz and Ozyildirim, 2002). However, most of the recent methods involve band-pass filters which aim at retaining unaltered the cycle stylised facts while removing high and low frequency components. Generally, the movements with a period lower than 1.5 years and greater than 6 or 8 years are disregarded in the spectral domain. The most popular filters, often found in empirical applications, are the Beveridge and Nelson filter (1981), the Baxter-King and the Hodrick-Prescott filters (respectively BK and HP hereafter) and the Christiano-Fitzgerald (1999) filter. These filters differ only in the way they approximate the ideal band-pass filter. Preliminary results (not presented in this paper) have shown that the Euro aggregated IPI growth cycles extracted by using the BK and HP filters were quite similar and the BK filter provides more or less the same turning points dating than the HP filter. However, the growth cycle extracted from the HP filter has to be smoothed to extract the irregular component (for example by using a centred moving average) while the growth cycle extracted from the BK filter has not.

In the classical HP filter approach, the estimated stochastic trend minimises the penalised least-square criterion and the smoothness parameter λ governs the trade-off between fidelity to the original series and roughness. In other words, the extracted trend is a compromise between the original series and a linear trend and λ is a sort of measure of the stability (linearity) of the produced trend: the lower is λ the closer is the trend to the original series. Usually the choice of λ is rather arbitrary (for example for quarterly data, λ is usually set to 1600, but this rule is often generalised to any frequency of observation, so $\lambda=100s^2$ where s is the data frequency). As shown by Artis *et al.* (2002), the HP filter can be seen as a kind of low-pass filter: it means that it has an implicit cut-off frequency, denoted ϖ_c. This cut-off frequency depends on λ according to the following equation :

$$\varpi_c = Arccos(1- 0.5\ \lambda^{-1/2}). \tag{2.4}$$

By using the following relationship, it is possible to switch from the frequency domain to the time domain:

$$\varpi_c = \frac{2\pi}{\bar{p}s}, \tag{2.5}$$

where s is the data frequency and $\bar{p}$ is the cut off in terms of years. Hence, it is possible to select the cut-off frequency by selecting λ: the series obtained by applying this filter contains only the frequencies lower than ϖ_c. It is then possible to design a band-pass filter as the difference of two HP de-trending filters, the first one working on higher frequencies (for example 1.5 years) and the second one on lower frequencies (for example 6 years). We will consider this filter and refer to it as "two-stages Hodrick-Prescott" (HP2 hereafter, see Artis *et al.,* 2002).

III Methodology

Several studies have shown the existence of a common Euro-zone cycle. Among others, we can quote for instance the paper of Mitchell and Mouratidis (2002) which underlines the common features of the different measures of the growth and business cycles of the Euro-zone. Moreover, they show that the synchronisation between Euro-zone business cycles has increased since the 1980's, which is « coherent with the emergence of a common Euro-zone business cycle ». We can also refer to the paper of Artis, Krolzig and Toro (1999) which points out a "clear evidence of co-movement in output growth among European countries" by using descriptive statistics in the time and frequency domains and by applying different Markov-Switching models. Starting from all these previous studies, we assume in a first time the existence of common Euro-zone business and growth cycles. Therefore, we use the Euro-zone aggregates (GDP, IPI and employment) as proxies for the co-movement.

A clear distinction between business and growth cycles has to be done. As the growth cycle is defined by the deviation to the trend, once the trend has been extracted, the peaks A and troughs D are not so difficult to locate because of the symmetry of the growth cycle. However, the business cycle is non-linear and strongly asymmetric, insofar as expansion and recession periods do not present the same stylised facts as regards, for instance, duration, persistence or volatility (see for example Clements and Krolzig, 2003, for a discussion on business cycle asymmetries). Therefore, points B and C are more difficult to locate: the business cycle asks for further concepts to be measured.

To start with, we assume the description of Burns and Mitchell (1946) of the business cycle into two regimes: expansions and recessions. We assess the occurrence of a Euro-zone recession by measuring the criteria of duration, deepness, diffusion and synchronisation across the countries. Starting from a set of candidate turning points provided by the non-parametric algorithm described below, we will give a measure of these criteria and say that the Euro-zone is in recession if these criteria are simultaneously fulfilled. Duration and deepness are measured starting from the Euro-zone aggregated time series (direct approach), while diffusion and synchronisation are estimated starting from the specific countries (indirect approach). It is noteworthy that our methodology is a general-to-specific one, insofar as we consider all the candidate turning points of the business cycle provided by the non-parametric procedure and we eliminate them progressively when they do not verify one of the criteria.

III.1 A non-parametric algorithm

As noted previously in this paper, we are in favour of non-parametric procedures instead of parametric ones in the framework of turning points dating chronology. Indeed, it has been shown that the model specification step is an intricate issue and can lead to inappropriate results. First, a set of candidate periods of recession has to be selected on the aggregated series. The non-parametric procedure developed in this section to get a dating chronology on a single time series is based on the following algorithm:

1. Outliers are disregarded in the seasonal adjustment step executed by the Demetra software.

2. Irregular movements in the series are excluded in the seasonal adjustment step executed by the Demetra software in the case of monthly data. In the case of GDP quarterly data the SA-WDA series is not smoothed out.

3. Determination of a first candidate set of turning points on the time series of interest (y_t) is determined by using the following rule, which is the heart of the Bry and Boschan (1971) algorithm:

   Peak at t : $\{ y_t > y_{t-k} , y_t > y_{t+k} , k=1,..., K \}$

   Trough at t : $\{ y_t < y_{t-k} , y_t < y_{t+k} , k=1,..., K \}$,

   where $K=2$ for quarterly time series (GDP and employment) and $K=5$ for monthly time series (IPI).

4. Turning points within six months of the beginning or end of the series are disregarded.

5. A procedure for ensuring that peaks and troughs alternate is developed by using the following rule:
   - in the presence of a double through, the lowest value is chosen.
   - in the presence of a double peak, the highest value is chosen.

Regarding the third step of the algorithm, other ways allow the identification of the potential turning points. We present two of the most used ones in practice. First, let us note (y_t) the time series of interest and adopt the following convention, for all date t: $\Delta y_t = y_t - y_{t-1}$ and for each integer k, $\Delta_k y_t$

$= y_t - y_{t-k}$. The best known approach, widely released in the media to detect real time peaks and troughs in the classical cycle is the following:

$$\text{Peak at } t: \quad \{ \Delta y_{t+1} < 0, \Delta y_{t+2} < 0 \}$$

$$\text{Trough at } t: \quad \{ \Delta y_{t+1} > 0, \Delta y_{t+2} > 0 \}.$$

This rule has been attributed to Arthur Okun by Harding and Pagan (1999). It means that a recession involves at least two quarters of negative growth. This rule is generally applied to the quarterly GDP. Another approach can be found in Wecker (1979) and has been used in Pagan (1997):

$$\text{Peak at } t: \quad \{ \Delta y_t > 0, \Delta y_{t+1} < 0, \Delta y_{t+2} < 0 \}$$

$$\text{Trough at } t: \quad \{ \Delta y_{t-1} < 0, \Delta y_t < 0, \Delta y_{t+1} > 0 \}.$$

This second rule is also generally applied to the quarterly GDP to identify peaks and troughs in the classical cycle. All these three approaches are based on a variation in growth rates over a bandwidth in comparison with an *a priori* threshold set to zero. The choice of the threshold value is somewhat natural in this case.

III.2 Deepness and duration assessment

Once the candidate periods have been retained by the non-parametric algorithm on the aggregates, we assess first the criteria of duration and deepness. The duration means that a recession must last "more than a few months", as noted by the NBER in its seminal definition of a recession, but there is no reference minimum duration. Usually, it is often advocated that :

(i) a phase of the cycle must last at least six months,

(ii) a complete cycle must have a minimum duration of fifteen months.

The deepness refers to the amplitude of the recession. Indeed, as noted by the NBER, a recession is a "significant decline in activity". Obviously, the practical difficulty is to assess when the fall of the economy is "significant" enough. To measure this amplitude, we use the following value of deepness, for a recession:

$$Deepness = (X_P - X_T) / X_P, \tag{3.1}$$

where X_P and X_T are respectively the values of the series at the peak and trough of the business cycle to be considered. In the case of normalised indexes, such as the IPI, we simply look at the difference between the values of the series at peak and trough. Moreover, as regards the growth cycle, because of its symmetry, we simply consider the absolute difference for each phase.

To summarise the information on both duration and deepness we assess the measure of, what we call, severity (denoted *S*) of a recession defined by:

$$S = 0.5 \times Deepness \times Duration. \tag{3.2}$$

This measure is in fact the percentage of loss during the phase of the cycle[4]. This severity measure is also referred in the literature to as the *"triangle approximation" to the cumulative movements*, see for example Harding and Pagan (1999). Note that there is a wide literature concerned with the concept of "shape" of the cycle, we refer for example to the recent paper of Clements and Krolzig (2003) for the diverse definitions of the shape.

III.3 Diffusion and synchronisation assessment

Once duration and deepness have been estimated for each candidate recession period through the severity index, we assess now their diffusion and synchronisation over the countries by considering an indirect analysis. The spatial diffusion means that almost all of the countries have to be affected by the exogenous shock in the case of a recession while the concept of synchronisation refers to the timing impact of the exogenous shock which creates leads and lags in cyclical movements of countries. For instance, the industrial growth cycle in 1995 didn't turn into a recession because it was not synchronised (see section 4). Indeed, Italy and Netherlands were in recession later than the other countries. As another example, the 1998 impact of the Asian crisis was not diffused to all the countries in the Euro-zone, only Italy and Belgium were affected by an industrial recession. In this framework, the concept of concordance should perhaps refer to a combination of diffusion and synchronisation aspects.

In this paper, we introduce a version of the simultaneous measure of diffusion and synchronisation between *N* cycles introduced by Boehm and Moore (1984) and revisited in Harding and Pagan (2002). Actually, Boehm and Moore (1984) developed an algorithm which tries to mimic the NBER

[4] In fact, the « real » loss would rather be the surface lying below the trend.

dating procedure by identifying clusters of turning points and applied it to the Australian economy. One of the advantage of this method is to provide as a by-product a dating chronology of the business cycles, that we call in the remaining *indirect dating*.

First, we compute a dating chronology for each country *i*, for $i=1,\dots,N$, according to the method described in the previous subsection. Then, we define τ_{ij}^{P} (respectively τ_{ij}^{T}) as the observation date of the j^{th} peak (respectively trough) in the country *i*. We define $d_i^P(t)$ (respectively $d_i^T(t)$) as the distance in time from *t* to the nearest peak (respectively trough) in the country *i*. That is, for $i=1,\dots,N$ and for $t=1,\dots,T$:

$$d_i^P(t) = \underset{j}{Min}\left|t - \tau_{ij}^P\right|. \tag{3.3}$$

In order to aggregate the information relative to the countries, we consider the following statistics, which are the distances to cycle peaks and troughs for the whole Euro-zone:

$$d^P(t) = \sum_{i=1}^{N} \omega_i d_i^P(t), \tag{3.4}$$

and

$$d^T(t) = \sum_{i=1}^{N} \omega_i d_i^T(t), \tag{3.5}$$

where $(\omega_i)_i$ are the weights of the countries in the Euro-zone according to the a given economic aggregate. We can consider the GDP of the country or the weights given in the national account statistics or in the short term business statistics[5].

Dates at which $d^P(t)$ and $d^T(t)$ achieve their local minima can be assumed to be the dates of the centres of a cluster of, respectively, peaks and troughs for the Euro-zone. Thus, we get a set of dates t_j^P and t_j^T defined as the estimated indirect dates of peaks and troughs for the Euro-zone. Finally, as a measure of the diffusion/synchronisation, we choose the following statistic, for the j^{th} peak (respectively trough):

[5] See for example the Annex 1 of the third progress report on the implementation of the Monetary Committee's report on information requirements in EMU (note EFC/ECFIN/610/02 of 15 January 2003).

$$DS_j = \frac{1}{d^P(t_j^P)} \times 100 . \qquad (3.6)$$

If a local minimum is not present, we set to zero the diffusion measure of the candidate cycle. Thus, when the value of the DS statistic is high we can conclude that the turning point is well diffused and synchronised, when DS is low the turning point is neither diffused nor synchronised and when DS has an intermediate value, it means that the cycle is either not enough diffused or not synchronised.

As we do not know anything about the probability distribution of these measures of severity and diffusion/synchronisation, it is difficult to make statistical inference. In this study, these values serve only as a basis to compare diverse periods of time.

IV Applications

In this section, we propose a dating chronology for both growth and business cycle in the Euro-zone, based on IPI, GDP and employment.

IV.1 A chronology based on the Industrial Production Index

IV.1.1 Data set

The industrial production indices used in this paper are taken from the GRETA database, they represent the total production adjusted by working days (WDA). For Greece, Ireland and Finland, data are not available for the whole period 1970-2002 and therefore will be ignored in the study. The 9 other countries of the Euro-zone are available since 1970. For France, Germany and Spain, a back recalculation had been performed by GRETA:

- From 1985 for France (regression on OECD data)
- From 1978 for Germany (regression on Data from the German National Institute of Statistics)
- From 1980 for Spain (regression on INE data)

Note that the Italian series, available in New Chronos, has been recalculated by the National bank of Italy.

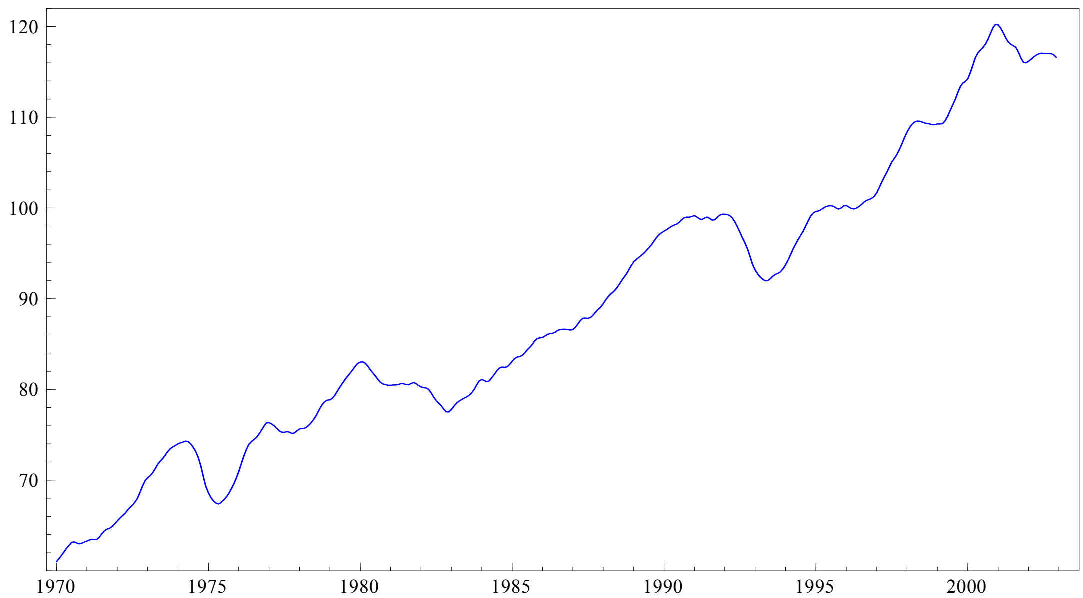
With 9 countries starting in 1970, an Euro9 aggregate is calculated by weighting adequately the 9 indices. Then, a Euro10 aggregate is calculated from 1975 by adding Ireland available since July 1975. A regression is performed to estimate a new Euro10 starting in 1970. Similarly, a Euro11 starting in 1970 is calculated by a regression of Euro11 (available since 1977 by adding Greece) over Euro10. Finally, the Euro12 starting in 1970 is calculated by a regression of the available Euro12 in New-Chronos since 1985 over Euro11. Therefore, the present study is conducted on 8 countries (the 9 countries available since 1970 except Luxembourg) and the Euro-zone aggregate also available since 1970.

Data have been pre-treated by using the TRAMO-SEATS method in Demetra. No trading day adjustment is used since data are already WDA. Sometimes, the airline model was imposed to avoid a non parsimonious model or too avoid too many outliers. Similarly, the critical limit for outliers was sometimes fixed to 3.0 to avoid too many outliers. Generally, we avoided the presence of level shift outliers except obviously in the case of the German series. The only outlier found in the Euro12 series was an additive outlier in June 1984.

IV.1.2 Dating of the Euro-zone industrial business cycle

In this subsection, the methodology is carried out on the Euro-zone aggregated industrial production monthly index presented in figure 1 in order to date the business cycle.

Figure 1 : Euro-zone Industrial Production Index



By applying the non-parametric algorithm on the Euro-zone IPI series over the whole period 1970-2002, we select first 10 candidate recession periods. These candidate periods are presented in table

3. We observe that the main economic events since 1970 are described, namely the first oil shock in 1974-75, the second oil shock and its "double-dip" in 1980-81 and 1981-82, and the 1992-93 recession. Obviously, as no censoring rule is applied, a lot of mini-cycles are also taken into account. For example, the candidate recessions of 1995 and 1996 are only of 3 months (they would therefore not be retained by the usual censoring rule on phase duration), while the most longer candidate recession (16 months) occurred in 1992-1993 (see also table 4 for duration measures). Note also that the usual censoring rule related to the minimum duration of a complete cycle is always respected, excepted between the cycle in 1991 and the one in 1992-93. This means that one of these two candidate recessions should not be retained at the end of the study. Regarding the last candidate recession, there is a peak in June 2002, but it is still to soon to date the through of this industrial recession.

Table 3 : Industrial business cycle candidates for the aggregated Euro-zone IPI

Dates	Peak B	Trough C
1974-75	m4 1974	m5 1975
1977	m1 1977	m10 1977
1980-81	m2 1980	m1 1981
1981-82	m10 1981	m12 1982
1991	m1 1991	m8 1991
1992-93	m1 1992	m5 1993
1995	m7 1995	m10 1995
1996	m1 1996	m4 1996
1998	m5 1998	m11 1998
2000-01	m12 2000	m12 2001
2002-?	m6 2002	

As argued in the previous section, it is important to look simultaneously at the duration and the deepness of each candidate recession, summarised by the severity criteria defined by equation (3.2), to assess the occurrence. Table 4 presents the computed deepness and severity measures for each candidate recession period, as well as their duration.

Table 4 : Duration (in months), deepness and severity of candidate industrial recessions for the aggregated Euro-zone IPI

Dates	Duration	Deepness	Severity
1974-75	13	6.9	45.1
1977	9	1.2	5.3
1980-81	11	2.6	14.2
1981-82	13	3.2	21.1
1991	7	0.5	1.7
1992-93	16	7.3	58.6
1995	3	0.4	0.5
1996	3	0.4	0.6
1998	6	0.4	1.2
2000-01	12	4.2	25.5

First, we observe that the 1991, 1995, 1996 and 1998 candidate recessions are very mild and thus should not be considered as significant recessions. Actually, these short movements are due to a lack of diffusion or synchronisation between countries industrial business cycles (see below). Thus, we note that the impact of the Asian crisis in 1998 on the Euro-zone IPI appears to be very weak, contrary to a common belief in economics. The 1992-1993 industrial recession due to the American recession and the Gulf war is the longest and the deepest, therefore the most intense. The recession due to the first oil shock in 1974-75 is also very strong. Regarding the 1977 recession, we cannot eliminate it, though pretty mild. We will carefully examine its diffusion and synchronisation across the countries.

We assess now the diffusion and the synchronisation of the recessions among the countries through an indirect approach. First, a non-parametric dating procedure is carried out for each of the 8 considered Euro-zone countries. To avoid too many mini-cycles, we impose a minimum duration of 6 months for phases and a minimum duration of 15 months for complete cycles. The results are presented in Appendix (table A1).

The distances to cycle peaks and troughs $d^P(t)$ and $d^T(t)$, defined in equations (3.4) and (3.5) are presented in figures A1 and A2 in Appendix. It is important to observe that the trough of the 1977 recession does not appear as a local minimum. Concerning the dates of peaks and troughs, the indirect approach (see table A.1) provide basically the same dates as the ones of the direct approach presented in table 3. Only the 1977 and the 1995 recessions are not present in this indirect dating procedure. The following table 5 contains the diffusion/synchronisation measures described by the DS statistic presented in equation (3.6).

Table 5 : Diffusion/Synchronisation measures (DS) of candidate industrial recessions for the aggregated Euro-zone IPI

Dates	Peak B	Trough C
1974-75	17.5	52.6
1977	18.9	0
1980-81	52.6	25.0
1981-82	18.5	40.0
1991	0	0
1992-93	31.3	100.0
1995	8.3	9.3
1996	0	0
1998	0	0
2000-01	71.4	10.2

Thus, it appears clearly that, by using the indirect approach, three candidate industrial recession periods should not be considered (in 1991, 1996 and 1998). Moreover, the trough of the 1977 candidate recession is not visible, therefore this period can not be retained. Actually, this candidate recession is not enough diffused across the countries (see table A.1). Indeed, only France, Italy, Netherlands and Belgium were affected at this time. Among the other recessions, the DS value of the 1995 candidate recession is pretty mild. Actually, this recession is well diffused across the Euro-zone, but not synchronised: France, Germany, Spain and Belgium experienced recession before Italy, Netherlands and Portugal. This is the reason why its severity computed previously is so low (the lowest over the 10 candidates). As regards the dates of the other candidate recessions, the indirect dating provides more or less the same dates as the direct dating (see tables 3 and A1). The maximum difference between two dates is of two months. However, sometimes it may induce a change in the corresponding quarter. For example, the direct dating provides a trough in January 1981 (belonging to Q1 1981), while the indirect dating provides a trough in December 1980 (belonging to Q4 1980).

Finally, we retain five industrial recession phases in the Euro-zone. The dating chronology is contained in the following table 6 for the IPI business cycle.

Table 12 : Final industrial business cycle dating chronology for the Euro-zone

Dates	Peak B	Trough C
1974-75	m4 1974	m5 1975
1980-81	m2 1980	m1 1981
1981-82	m10 1981	m12 1982
1992-93	m1 1992	m5 1993
2000-01	m12 2000	m12 2001

IV.1.3 Dating of the Euro-zone industrial growth cycle

In this subsection, the methodology is carried out on the Euro-zone aggregated industrial production index in order to date the growth cycle.

First, the industrial growth cycle is estimated trough the two-step Hodrick-Prescott filter described in section 2, the cut-off frequencies being of 1.5 and 6 years. The following figure 2 presents the estimated growth cycle. The growth cycle appears to be symmetric and the peaks and troughs (respectively points A and D in the ABCD approach) seem easier to locate than the business cycle ones.

Figure 2: Euro-zone Industrial Production Index growth cycle

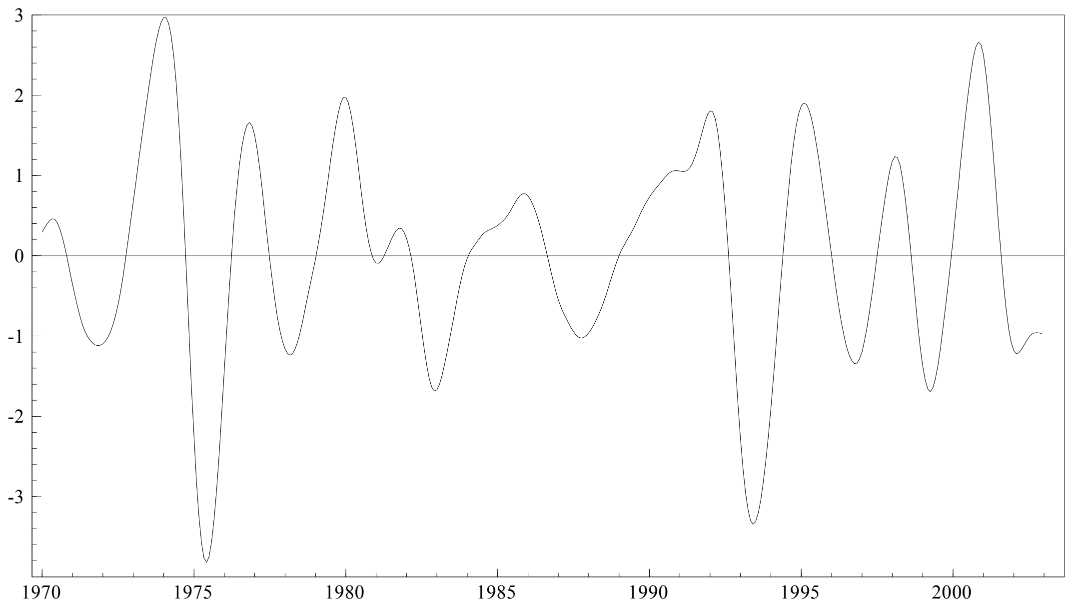


Table 7 presents the dating results from the non-parametric method. The phases of the growth cycle are longer than the business cycle ones, their minimum duration is of 9 months. We get 9 complete candidate growth cycles (from trough to trough).

Table 7: Industrial growth cycle dating for the aggregated Euro-zone

Dates	Peak	Trough
1971-72		m11 1971
1974-75	m1 1974	m6 1975
1976-78	m11 1976	m3 1978
1980-81	m2 1980	m1 1981
1981-82	m10 1981	m12 1982
1985-87	m11 1985	m10 1987
1992-93	m1 1992	m6 1993
1995-96	m2 1995	m10 1996
1998-99	m2 1998	m4 1999
2000-02	m11 2000	m2 2002

We are going to assess simultaneously the duration and deepness of each candidate phase of the growth cycle, summarised by the severity criteria. However, because of the symmetry of the growth cycle, we consider both ascending (from a trough to a peak) and descending phases (from a peak to a through). The results are presented in table 8.

Table 8: Severity measures for the Euro-zone IPI growth cycle

Dates	Peak-Trough	Trough-Peak
1971-72		55.1
1974-75	57.5	46.6
1976-78	23.2	36.2
1980-81	11.0	1.9
1981-82	14.2	43.0
1985-87	20.7	72.2
1992-93	43.8	52.5
1995-96	32.4	20.6
1998-99	20.5	41.3
2000-02	29.1	

The average severity of a descending phase is of 28.1, while of 41.6 for an ascending phase. Among the ascending phases, the severity of the phase from January 1981 to October 1981 is only of 1.9, which appears to be very low in comparison to the others. We are going to examine carefully its DS value.

Now, we assess the diffusion/synchronisation of the growth cycles among the countries. First, we extract the industrial growth cycle of each country by applying a two-step Hodrick-Prescott filter. A non-parametric dating procedure is then carried out for each of the 8 considered countries. Contrary to the business cycle, as all the phases last at least 9 months, it is not necessary to impose a minimum duration for the phases and for the complete cycles. The results are presented in table A2. The distances to cycle peaks and troughs are presented in figures A3 and A4.

Concerning the dates of peaks and troughs, the indirect approach provide again the same dates as the direct approach. The table 9 contains the values of DS statistic. We note that the DS values for troughs are higher than the peaks ones and that the measures are stronger than those computed for the business cycle. Anyway, according to this table, all the candidate peaks and troughs estimated on the aggregated series should be kept. Especially, the indirect approach validate the 1981-82 candidate cycle as a “true” cycle. Indeed, this cycle is diffused to all the countries of the zone and is strongly synchronised, especially the peak.

Table 9: DS statistics for the Euro-zone IPI growth cycle

Dates	Peak	Trough
1971-72		29.4
1974-75	30.3	76.9
1976-78	83.3	37.0
1980-81	76.9	40.0
1981-82	22.7	62.5
1985-87	19.6	40.0
1992-93	66.7	125.0
1995-96	21.3	27.8
1998-99	125	200
2000-02	66.7	31.3

Finally, we decide to keep all the candidate growth cycles for the final dating chronology. Thus, over the period 1970-2002, the Euro-zone experienced 9 industrial growth cycles. Five of them were followed by an industrial business cycle. The growth cycles peaks of 1976, 1985, 1995 and 1998 (points A) were not followed by business cycle peaks (points B).

The following table 10 contains the leads and lags of the growth cycles over the business cycle of the IPI. The average delay between points A and B and between points C and D is less than a month. That is, in case of a industrial recession, the fall is sudden and the recovery is strong.

Table 10: Leads and lags of the industrial growth cycle over the industrial business cycle

Dates	Peak	Trough
1974-75	- 3	+ 1
1980-81	0	0
1981-82	0	0
1992-93	0	+ 1
2000-01	- 1	+ 2

IV.2 A chronology based on the Gross Domestic Product

IV.2.1 Data set

In this report, we have used the raw GDP data for the Euro-zone at a quarterly level in 1995 prices (and in 1995 ESA) calculated by the Greta[6] for the period 1970-2001. This series results from a back-calculation until 1991Q1 linked to the official aggregate produced and published by Eurostat since then. We also used the Greta historical raw data GDP series on 1970-2002 for the 6 following main countries: France, Germany, Italy, Spain, Netherlands (only since 1977) and Belgium (only since 1980). This group of countries accounts for 92% of the total Euro zone GDP. For the period 2002Q1-2003Q2, data have been taken form the Eurostat's Euroindicators database. In order to avoid the bias of possible revisions of the Greta database, applying the variation of the raw data did this update.

A direct approach is used to estimate the SA. The Tramo-Seats method has been used by means of Demetra. This approach is different from the current practice in Eurostat, which calculates the constant SA GDP indirectly, based on the aggregation of national SA series (mixed indirect

[6] « Methodology for Back-recalculation », Greta, Eurostat project Lot8 task 2.

approach). The advantage of the direct approach is to use the same program to perform the seasonal adjustment. As a result, the direct SA quarterly growth rate we calculate may differ from the official Eurostat growth rate. The 6 raw series of the countries have also been seasonally adjusted by using Demetra, then used for an indirect approach dating of the Euro-zone cycle.

As was stated before, the advantage to work directly on the TC series in order to produce a dating is to avoid the issue of smoothing out series and eliminating or correcting outliers. However, in the present case of quarterly series, we feel that the use of the SA series may be better. The choice is not clear-cut; advantages and disadvantages are balanced.

The issue of outliers is not easy. We have decided to estimate additive (AO), transitory (TO) and level shift (LS) outliers but to keep them only if there is some economic rationale to justify the use of such outliers. For example, we keep the level shift (LS) outlier of 1991Q1 for the Euro-zone and German GDP because it captures the effect of the East Germany integration in the aggregate. Even if it concerns only one country, it is obviously of sufficient size to impact on the global aggregate. In Tramo-Seats, the LS outlier is integrated in the TC series and the SA series but not in the irregular series. But it will be removed from the SA series.

The natural outcome of the Tramo program on the Euro-zone GDP is a SARIMA(1 1 0)(0 1 1) model with acceptance of a Trading day effect, a leap year effect and an Easter effect. Also, the multiplicative model is selected. The regressors are positive for weekdays and negative for weekend days, as expected. There are two detected level shift outliers:

- A level shift in 1991Q1 (+3,6%) which coincides with the integration of East Germany in the global aggregate (estimated at +22,2% at the level of Germany).
- A level shift in 1974Q4 (-2,9%) which may be related to the global change in trend growth.

Only the 1991 level shift will be remained from the SA series since it represents a real definitive change of level

All the diagnostics tests are satisfactory. The Ljung-Box and Box-Pierce tests on residuals and squared residuals do not show any residual serial correlation or dependence. The normality assumption is accepted. For the other countries, the specification of the SARIMA models are the following:

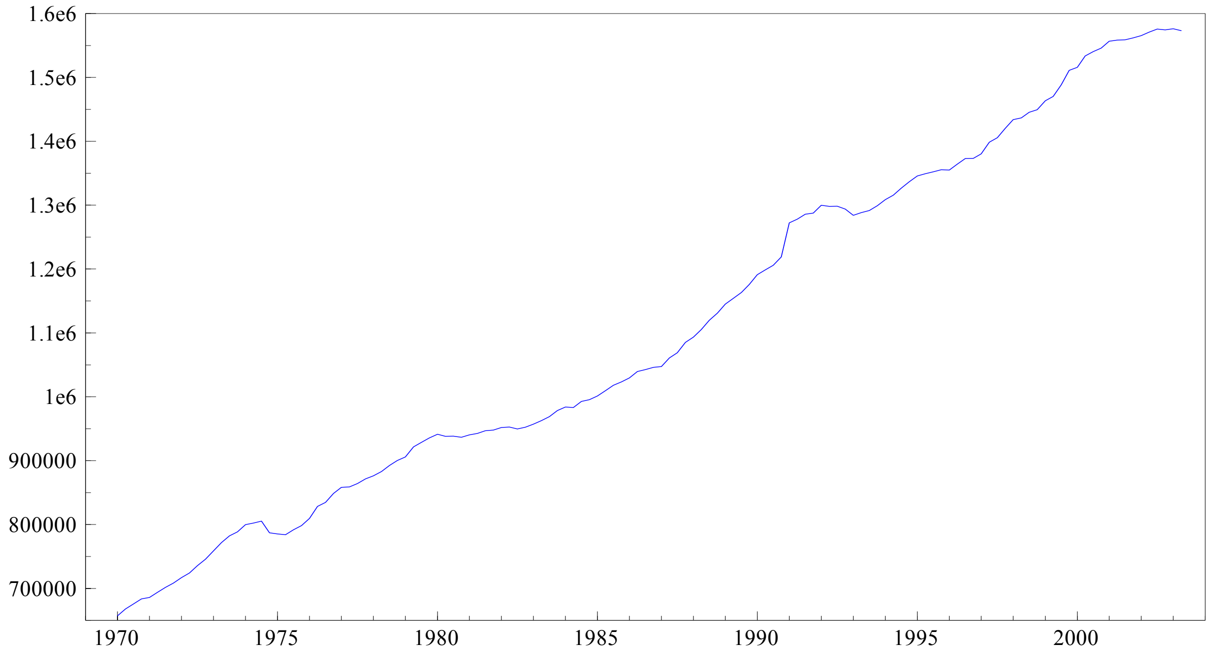
Germany	(0 1 1)(0 1 1)
France	(0 1 0)(0 1 1)
Italy	(2 0 0)(0 1 1)
Spain	(0 1 0)(0 1 1)
Belgium	(0 1 0)(0 1 1)
Netherlands	(1 1 0)(0 1 1)

The outcome for trading day correction is very sensitive to the choice of number of regressors. If one selects the option of two regressors instead of 7 regressors for the pre-adjustment phase, the results in terms of Easter effect identification and outlier detection change quite substantially. The main issue seems to lie on the automatic identification of outlier. It seems reasonable to give an economic interpretation for those outliers. Among the six countries, the trading day effect is very present in Germany, Belgium and Spain but almost not significative in France, the Netherlands and above all Italy.

IV.2.2 Dating of the Euro-zone business cycle

In this subsection, the methodology is carried out on the Euro-zone aggregated GDP presented in figure 3 in order to date the business cycle.

Figure 3 : Euro-zone GDP



By applying the non-parametric algorithm on the Euro-zone GDP series over the whole period 1970Q1-2003Q2, we select first four candidate recessions periods. These candidates periods are presented in table 11. Here again, we observe that the main economic events since 1970 are described, namely the first oil shock in 1974-75, the second oil shock and its “double-dip” in 1980-81 and 1981-82, and the 1992-93 recession. Contrary to the IPI, none mini-cycle appear. In fact, the GDP is less sensitive to short-term economic shocks. Three of the four candidate recessions last at least 3 quarters, only the 1982 recession is of one quarter (see also table 12 for duration measures). As regards the recent period, no peak is detected by the algorithm.

Table 11 : GDP business cycle candidates for the aggregated Euro-zone

Dates	Peak B	Trough C
1974-75	Q3 1974	Q2 1975
1980	Q1 1980	Q4 1980
1982	Q2 1982	Q3 1982
1992-93	Q1 1992	Q1 1993

As previously, we look simultaneously at the duration and the deepness of each candidate recession, summarised by the severity criteria defined by equation (3.2), to assess the occurrence. Table 12 presents the computed deepness and severity measures for each candidate recession period, as well as their duration.

Table 12 : Duration (in quarters), deepness (in percent) and severity of candidate recessions for the aggregated Euro-zone GDP

Dates	Duration	Deepness	Severity
1974-75	3	2.62	3.94
1980	3	0.50	0.75
1982	1	0.32	0.16
1992-93	4	1.21	2.42

The most severe candidate recession is the one due to the first oil shock in 1974-75. In fact, this latter recession is the deepest, its value is twice the 1992-93 one. There is an issue as regards the 1982 candidate recession, because its severity is very low in comparison with the others. We will carefully examine its diffusion and synchronisation across the countries.

We assess now the diffusion and the synchronisation of the recessions among the countries through an indirect approach. First, a non-parametric dating procedure is carried out for each of the 6 considered Euro-zone countries. The dating results for each country are presented in table A3 in Appendix. We consider the four main countries (Germany, France, Italy, Spain) since 1970 and Belgium and Netherlands since 1980. To avoid to mini-cycles, we impose a minimum duration of 2 quarters for each phase of the cycle. The distances to cycle peaks and troughs $d^P(t)$ and $d^T(t)$, defined in equations (3.4) and (3.5) are presented in figures A1 and A2 in Appendix. The computations are done with 4 countries from 1970 to 1979 and with 6 countries from 1980. The following table 13 contains the diffusion/synchronisation measures described by the DS statistic presented in equation (3.6).

Table 13 : Diffusion/Synchronisation measures (DS) of candidate recessions for the aggregated Euro-zone GDP

Dates	Peak B	Trough C
1974-75	115	1053
1980-81	67	52
1981-82	48	48
1992-93	47	46

The DS measures for the peak and trough of the 1974-75 recession are very strong, because we only consider 4 countries. However, the recessions in these countries are diffused to all and extremely synchronised, especially the through. The measures for the other recession candidates are similar. Especially, the 1982 recession candidate is diffused to four countries over six, only France and Spain are not affected by this double-dip. Thus, albeit very mild, this candidate recession cannot be dropped from the final selection. As regards, the 1992-93 recession, the indirect dating provides exactly the same dates. It is noteworthy that a recession in 2001 appears in the indirect dating. However, the DS measure for the trough is very low. Moreover, it seems to be too soon to be able to confirm this recession, because the GDP figures will certainly be revised.

Finally, we retain four recession phases based on the Euro-zone GDP. The dating chronology is contained in the following table 14.

Table 14 : Final business cycle dating chronology for the Euro-zone GDP

Dates	Peak B	Trough C
1974-75	Q2 1974	Q1 1975
1980	Q1 1980	Q4 1980
1982	Q4 1981	Q4 1982
1992-93	Q1 1992	Q1 1993

IV.1.3 Dating of the Euro-zone GDP growth cycle

In this subsection, the methodology is carried out on the Euro-zone aggregated GDP in order to date the growth cycle.

First, the GDP growth cycle is estimated trough the two-step Hodrick-Prescott filter described in section 2, the cut-off frequencies being of 1.5 and 6 years. The following figure 4 presents the estimated growth cycle. Here again, The growth cycle appears to be symmetric and the peaks and troughs (respectively points A and D in the ABCD approach) seem easier to locate than the business cycle ones.

Figure 2: Euro-zone GDP growth cycle

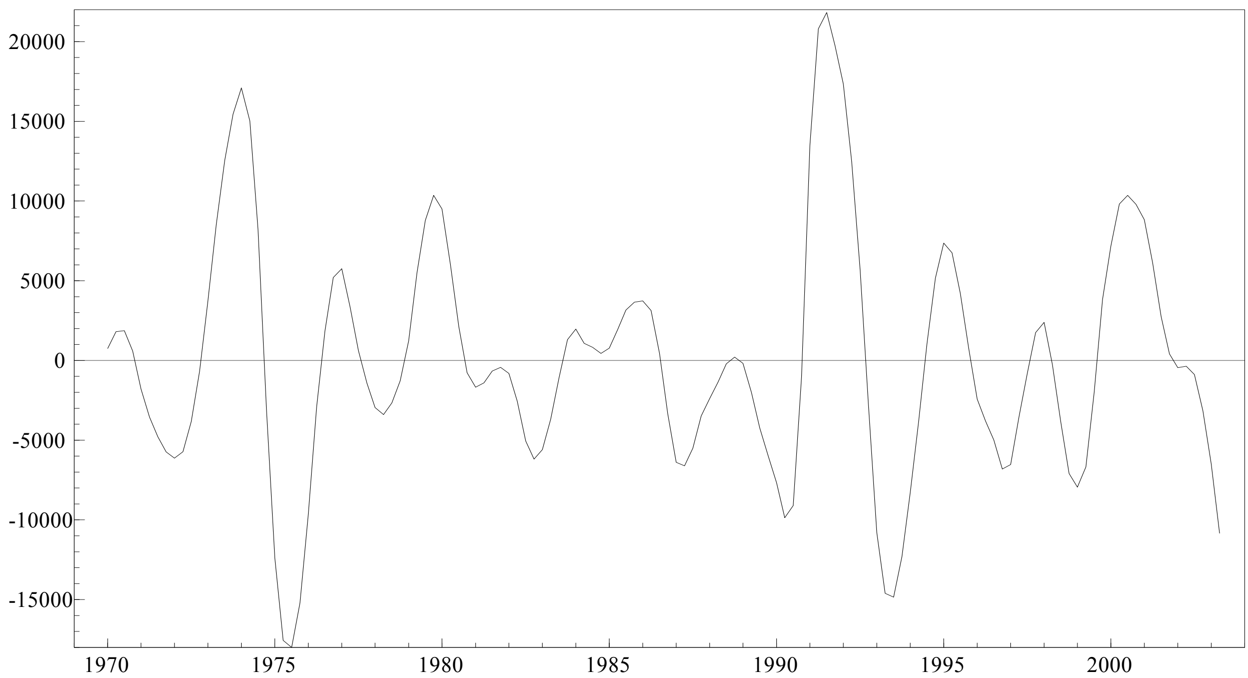


Table 15 presents the dating results from the non-parametric method. The number of GDP growth cycles appears to be higher than IPI growth cycles one. This result is quite surprising and implies that some of these candidate will not be retain as "true" cycle at the end of the study.

Table 15: Candidate growth cycle dating for the aggregated Euro-zone GDP

Dates	Peak	Trough
1971-72		Q1 1972
1974-75	Q1 1974	Q3 1975
1977-78	Q1 1977	Q2 1978
1979-81	Q4 1979	Q1 1981
1981-82	Q4 1981	Q4 1982
1984	Q1 1984	Q4 1984
1986-87	Q1 1986	Q2 1987
1988-90	Q4 1988	Q2 1990
1991-93	Q3 1991	Q3 1993
1995-96	Q1 1995	Q4 1996
1998-99	Q1 1998	Q1 1999
2000-?	Q3 2000	

We are going to assess simultaneously the duration and deepness of each candidate phase of the growth cycle, summarised by the severity criteria. However, because of the symmetry of the growth cycle, we consider here again both ascending (from a trough to a peak) and descending phases (from a peak to a through). The results are presented in table 16.

The average severity for descending and ascending phases are quite similar (respectively 44.5 and 43.7). Among the ascending phases, the severity of the phase from Q1 1981 to Q4 1981 appears to be very low in comparison to the others (as in the IPI case). Although this phase lasts 3 quarters, its deepness is very low. Moreover, the ascending phase from Q4 1984 to Q1 1986 has also a low severity value. Among the descending phases, the severity of the phase from Q1 1984 to Q4 1984 is also very low in comparison to the others. We are going to examine carefully their DS values.

Table 16: Severity measures for the Euro-zone GDP growth cycle candidate

Dates	Peak-Trough	Trough-Peak
1971-72		92.9
1974-75	105.3	71.3
1977-78	22.9	41.3
1979-81	30.1	1.9
1981-82	11.5	20.4
1984	2.3	8.2
1986-87	25.9	20.5
1988-90	30.2	79.2
1991-93	146.7	66.6
1995-96	49.6	23.0
1998-99	20.7	54.9

Now, we assess the diffusion/synchronisation of the growth cycles among the countries. First, we extract the industrial growth cycle of each country by applying a two-step Hodrick-Prescott filter. A non-parametric dating procedure is then carried out for each of the 6 considered countries. Contrary to the business cycle, it is not necessary to impose a minimum duration for the phases and for the complete cycles. The results are presented in table A4. The distances to cycle peaks and troughs are presented in figures A7 and A8.

Table 17: DS statistics for the Euro-zone GDP growth cycle

Dates	Peak	Trough
1971-72		56
1974-75	103	238
1977-78	143	78
1979-81	244	45
1981-82	37	72
1984	476	99
1986-87	62	104
1991-93	2000	250
1995-96	345	159
1998-99	233	588
2000-02	46	35

The table 17 contains the values of DS statistic. Here again, we observe that peaks and troughs of the growth cycle are more diffused and synchronised that the ones of the business cycle. By comparison with the direct dating, the 1988-90 cycle has not been recognised with this approach because of its lack of diffusion. Regarding the phase from Q1 1984 to Q4 1984, we note that this phase is well diffused and synchronised, especially the peak which has a strong DS value. Therefore, we decide to keep this candidate cycle in the final chronology. Regarding the last growth cycle, it seems that a peak could be identified in Q2 2000 (highly diffused, but not well synchronised). However, it is too soon to date the trough.

Finally, we retain 9 growth cycles over the period 1970-2000 (see table 18), four of them being followed by a business cycle. Indeed, the growth cycles peaks of 1974, 1979, 1981 and 1992 (points A) were followed by business cycle peaks (points B). The delays between points A and points B are less or equal to one quarter, while the delays between points C and points D are less or equal to two quarters.

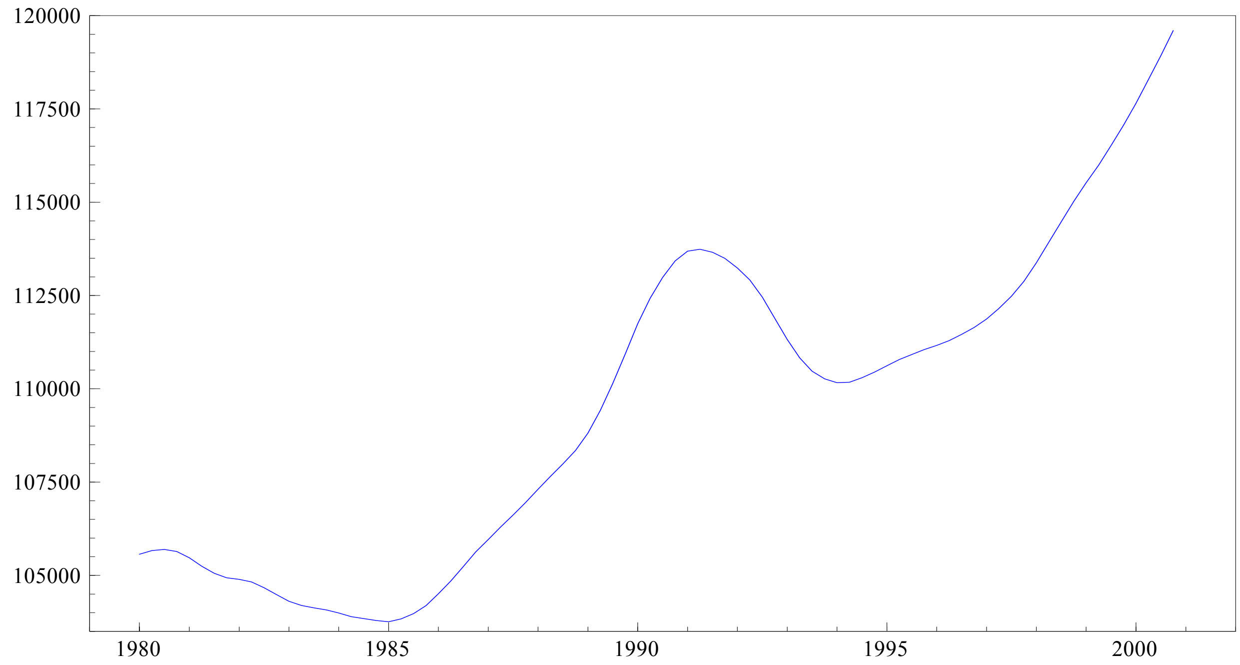
Table 18: Final growth cycle dating for the aggregated Euro-zone GDP

Dates	Peak	Trough
1974-75	Q1 1974	Q3 1975
1977-78	Q1 1977	Q2 1978
1979-81	Q4 1979	Q1 1981
1981-82	Q4 1981	Q4 1982
1984	Q1 1984	Q4 1984
1986-87	Q1 1986	Q2 1987
1991-93	Q1 1992	Q3 1993
1995-96	Q1 1995	Q4 1996
1998-99	Q1 1998	Q1 1999

IV.3 A chronology based on the Employment

In this section, we consider the Euro-zone employment as an indicator of the business cycle. We deal with the quarterly data of total employment in the Euro-zone, back-calculated by GRETA since 1980. These data have been pre-treated by using the TRAMO-SEATS method in Demetra. No trading day adjustment is used and a shift outlier has been included to account for the Germany reunification. The shift has been then removed for the analysis. Note that this series ends in 2001. As we do not possess back-calculated series for the specific countries, we are not able to assess the diffusion and the synchronisation across the whole zone.

Figure 5 : Total employment in the Euro-zone in thousands of persons



We carry out the non-parametric algorithm in order to date the employment cycle. The results are presented in the following table 22.

Table 22: Non parametric employment cycle dating for the Euro-zone aggregated with no censoring rule

	Dates
Peak B	Q3 1980
Trough C	Q1 1985
Peak B	Q2 1991
Trough C	Q1 1994

The non-parametric algorithm allows to identify two recessions periods. The first period begins in Q3 1980 and ends in Q1 1985, that is a duration of 18 quarters. The second period begins in Q2 1991 and ends in Q1 1994, that is a duration of 12 quarters. These duration are quite long to identified these periods as low phases of the business cycle. However, it is interesting to note that the dates of the two peaks are more or less coincident with the dates founded in the previous sections on GDP and IPI. But the dates of troughs are clearly delayed in comparison with the troughs of the business cycles. This phenomenon denotes a kind of asymmetry in the employment behaviour: when a recession occurs, the employment seems to react reasonably quickly, while it is much more persistent when the expansion occurs. This persistence may be linked with the structure of the job market in Europe. As a comparison, the employment or the unemployment rate are useful to date or to detect the cycles in the United-States because of the high flexibility degree in the job market. Because of this persistence, employment seems not to be very efficient to date accurately the Euro-zone business cycle.

Conclusion

In this paper, we are looking for the dates of the business and growth Euro-zone cycles. The dating process we propose here is a result of a non parametric algorithm and diverse criteria assessment (duration, deepness, diffusion, synchronisation), as well as of "expert judgements" based on a combination of the three following principles:

1) a comparison of direct and indirect dating
2) an objective of coherence between growth cycle and business cycle turning points (ABCD approach)
3) an objective of coherence between industrial and GDP cycles.

As a complement to the traditional direct approach based on the study of Euro-zone aggregates, the main contribution of this paper is to measure the degree of diffusion and synchronisation of the cycles among the countries.

From this study, it seems clear that the Euro-zone has experienced four economic recessions since 1970:

- the first oil shock (1974 Q2 – 1975 Q1, 3 quarters)
- the second oil shock double-dip (1980 Q1 – 1980 Q4, 3 quarters, and 1981 Q4 – 1982 Q4, 4 quarters)
- the 1992-93 recession (1992 Q1 – 1993 Q1, 4 quarters).

Recently, it is possible that the Euro-zone experienced another period of recession from 2001 Q1 to 2001 Q4. Of course, because of revision issues, it would seem premature to accept and date accurately this business cycle. Nevertheless, we have dated an industrial recession in 2001. Since we found empirically on the period 1970-2000 a full equivalence between industrial recession and global recession in the Euro-zone, there is a high probability of a global recession in the recent period.

References

Altissimo, F., Bassanetti, A., Cristadoro, R., Forni, M., Hallin, M., Lippi, M., Reichlin, L. and Veronese, G. (2001), EuroCOIN: A real time coincident indicator of the Euro area business cycle , CEPR Discussion Paper No. 3108.

Anas J. (2000), Le cycle économique Européen: datation et détection, in *Les Mutations de l'Economie Mondiale,* C. de Boissieu (ed.), Economica, Paris.

Anas, J. and Ferrara, L. (2002a), "Un indicateur d'entrée et sortie de récession :application aux Etats-Unis", Document de travail No. 58, Centre d'Observation Economique (www.coe.ccip.fr).

Anas, J. and Ferrara, L. (2002b), "Detecting cyclical turning points: the ABCD approach and two probabilistic indicators ", paper presented at the *26th Ciret Conference* in Taiwan, October 2002 (www.coe.ccip.fr).

Anas, J. and Ferrara, L. (2002c), "A comparative assessment of parametric and non-parametric turning points methods: the case of the Euro-zone economy", paper presented at the *Colloquium on Modern Tools for Business Cycle Analysis*, Luxembourg, November 2002 (www.coe.ccip.fr).

Arnaud, B. (2000), The OECD system of leading indicators: recent efforts to meet users needs, paper presented at the 25th CIRET Conference in Paris, October 2000.

Arnaud, B. and Hyong E.-P. (2001), Comparison of compilation methodologies for the composite Leading indicators of Euro area, manuscript OECD.

Artis M. J., Krolzig H. and Toro J. (1999), The European business cycle, *Working paper ECO*, n° 99-24, European University Institute, Florence, to appear in *Oxford Bulletin of Economics and Statistics*.

Artis M. J., Marcellino M., Proietti T. (2002), Dating the Euro area Business Cycle, *Working paper.*

Boehm, E. and Moore, G.H., (1984), New Economic indicators for Australia, 1949-84, *The Australian Economic Review*, 4th Quarter, pp. 34-56.

Boldin M. D. (1996), A check on the robustness of Hamilton's Markov Switching model approach to the economic analysis of the business cycle, *Studies in Nonlinear Dynamics and Econometrics* 1, 35-46.

Breunig R. and Pagan A. (2002), Specification Testing of Markov Switching Models, paper presented at the 13th (EC)² Conference "Model selection and evaluation", Bologna, Italy, November 2002.

Bry G. and Boschan C. (1971), Cyclical analysis of time series: Selected procedures and computer programs, *NBER, Technical Paper*, n° 20.

Burns A. F. and Mitchell W. C. (1946), *Measuring Business Cycles*, NBER, Columbia University Press.

Canova F., (1994), De-trending and Turning Points, *European Economic Review*, 38, pp. 614-623.

CEPR, (2003), *Business Cycle Dating Committee of the Centre for Economic Policy Research*, CEPR, September 2003 (www.cepr.org)

Christiano, L.J. and Fitzgerald, T.J. (1999), The band pass filter, NBER Working paper 7257.

Clements M.P., Krolzig H.M., (2003), Business cycle asymmetries: characterization and testing based on Markov-Switching autoregressions, *Journal of Business and Economic Statistics*, Vol. 21, No. 1, pp. 196-211.

Diebold F. X. and Rudebusch G. D. (1996), Measuring business cycles: a modern perspective, *Review of Economics and Statistics*, vol. 78, n° 1, pp. 67-77, reprinted in : *Business Cycles: Durations, Dynamics and Forecasting*, Princeton University Press, Princeton, 1999.

Forni, R., Hallin, M., Lippi, M. and Reichlin, L. (1999), The generalized dynamic factor model: Identification and estimation , CEPR Discussion Paper No. 2338.

Garcia, R. (1998), Asymptotic null distribution of the likelihood ratio test in Markov switching models, *International Economic Review* 39(3), 763-788.

Hamilton J. D. (1989), A new approach to the economic analysis of non stationary time series and the business cycle, *Econometrica*, vol. 57, n° 2, pp. 357-384.

Hamilton J. D. (1990), Analysis of time series subject to changes in regime, *Journal of Econometrics* 45, 39-70.

Hamilton, J.D. (1996), Specification testing in Markov-Switching Time series Models, January 1996, *Journal of Econometrics*.

Hamilton J.D. (2001), Comment on “A Comparison of Two Business Cycle Dating Methods”, forthcoming in the *Journal of Economic Dynamics and Control*.

Hansen, B.E. (1992), The likelihood ratio test under non-standard conditions: testing Markov switching model of the GNP, *Journal of applied Econometrics*, 7, S61-S82.

Hansen, B.E. (1996), Inference when a nuisance parameter is not identified under the null, *Econometrica*, 64, 414 – 430.

Harding D. (2002), Non-parametric turning point detection, dating rules and the construction of the Euro-zone chronology, paper presented at the Eurostat *Colloquium on modern tools for business cycle analysis* in Luxembourg, November 2002.

Harding D. and Pagan A. (1999), Dissecting the Cycle: A Methodological Investigation, forthcoming, *Journal of Monetary Economics*.

Harding D. and Pagan A. (2001a), Extracting, analysing and using cyclical information, *manuscript, University of Melbourne*, August 2001.

Harding D. and Pagan A. (2001b), A comparison of two business cycle dating methods, *manuscript* University of Melbourne.

Harding D. and Pagan A. (2001c), Comment on a comparison of two business cycle dating methods, forthcoming in the *Journal of Economic Dynamics and Control.*

Harding D. and Pagan A. (2001d), Rejoinder to James Hamilton, forthcoming in the *Journal of Economic Dynamics and Control.*

Harding D. and Pagan A. (2002), Synchronization of cycles. *Working Paper,* Australian National University.

Harvey A. C. (1989), *Forecasting, Structural Time Series Models and the Kalman Filter*, Cambridge University Press, Cambridge.

Krolzig H. M. (1997), *Markov-Switching vector auto-regressions. Modelling, statistical inference and applications to business cycle analysis*, Springer, Berlin.

Krolzig H.M. (2001), Markov-Switching procedures for dating the Euro-zone business cycle, *Quarterly Journal of Economic Research*, vol. 3, pp 339-351.

Krolzig H.M. (2003), Constructing turning point chronologies with Markov-Switching vector autoregressive models: the Euro-zone business cycle, paper presented at the *Colloquium on Modern Tools for Business Cycle Analysis*, Luxembourg, November 2002

Krolzig H. M. and Toro J. (2001),Classical and modern business cycle measurement: The European case, University of Oxford, Discussion Paper in Economics No. 60.

Layton A.P. and Smith D. (2000), A further note to the three phases of the US business cycle, *Journal of Applied Economics*, 2000, 32, 1133-1143.

Lommatzsch K. and Stephan S. (2001), Seasonal adjustment method and the determination of turning points of the EMU business cycle, *Quarterly Journal of Economic Research*, vol. 3, pp 399-415.

Peersman G. and F. Smets (2001), Are the effects of monetary policy in the Euro area greater in recessions than in booms?, ECB Working Paper, No. 52.

Rabault G. (1993), Une application du modèle de Hamilton à l'estimation des cycles économiques, *Annales d'Economie et de Statistique*, vol. 30, pp. 57-83.

Stock J. H. and Watson M. W. (1989), New indexes of coincident and leading indicators, in: *Macroeconomics Annual*, vol. 4, MIT Press.

Vanhaelen, J.-J., Dresse, L. and DeMulder, J. (2000), The Belgian industrial confidence indicator: leading indicator of economic activity in the Euro area, *Economic Surveys and Data Analysis*, Proceedings of the 25th CIRET Conference in Paris, October 2000, OECD Publications, Paris.

Watson M. (2000), Macroeconomic forecasting using many predictors, paper presented at the World Congress of the Econometric Society, August 2000.

Zarnowitz, V. and Ozyildirim, A. (2002), Time series decomposition and measurement of business cycles, trend and growth cycles, NBER Working Paper 8736.

Appendix

Table A1: IPI business cycle (SA data) - Countries: censoring rule of 6 months for a phase and 15 months for a cycle

	Euro-zone Indirect	France	Germany	Italy	Netherlands	Belgium	Spain	Portugal	Austria
Peak A				M7 1970					
Trough D				M5 1971					
Peak A	M4 1974	M5 1974	M8 1973	M4 1974	M8 1974	M2 1974	M4 1974	M3 1974	M6 1974
Trough D	M5 1975	M5 1975	M2 1975	M5 1975	M8 1975	M9 1975	M1 1975	M4 1975	M7 1975
Peak A		M1 1977		M11 1976	M9 1976	M10 1976			
Trough D		M8 1977		M11 1977	M11 1977	M9 1977			
Peak A	M1 1980	M12 1979	M1 1980	M3 1980	M9 1979	M8 1979	M10 1980	M6 1980	M3 1980
Trough D	M12 1980	M11 1980	M12 1980	M9 1980		M12 1980		M7 1981	
Peak A	M10 1981	M4 1982	M10 1981	M5 1981		M1 1982		M2 1983	
Trough D	M11 1982	M10 1982	M11 1982	M5 1983	M11 1982	M8 1982	M2 1982	M4 1984	M12 1982
Peak A		M2 1984			M8 1984	M11 1985			
Trough D		M12 1984			M7 1985	M5 1986			
Peak A					M9 1986				M3 1986
Trough D					M8 1987				M1 1987
Peak A		M6 1990		M11 1989		M10 1990	M9 1989	M2 1991	M1 1991
Trough D		M7 1991		M4 1991		M8 1991			M10 1991
Peak A	M12 1991	M1 1992	M12 1991	M10 1991	M1 1992	M2 1992			M5 1992
Trough D	M5 1993	M6 1993	M6 1993	M6 1993	M5 1993	M7 1993	M6 1993	M6 1993	M5 1993
Peak A	M11 1994		M11 1994			M5 1995	M6 1995		
Trough D	M11 1995		M11 1995			M2 1996			
Peak A				M9 1995	M2 1996				
Trough D				M10 1996	M3 1997		M4 1996		
Peak A				M12 1997		M6 1998			
Trough D				M4 1999		M2 1999			
Peak A	M12 2000	M12 2000	M1 2001	M11 2000	M3 2001	M12 2000	M5 2000	M8 2001	M11 2000
Trough D	M12 2001	M4 2001	M12 2001		M4 2002	M11 2001	M12 2001		M10 2001
Peak A		M4 2002							M6 2002

Table A2 : IPI growth cycle dating (SA data, cycle extracted by HP2)

	Euro-zone Indirect	France	Germany	Italy	Netherlands	Belgium	Spain	Portugal	Austria
Peak A			M10 1970	M12 1971	M9 1970	M7 1970		M6 1971	M8 1970
Trough D	M11 1971	M5 1971	M11 1971	M7 1972	M3 1972	M11 1971	M6 1971	M3 1972	M12 1971
Peak A	M2 1974	M3 1974	M7 1973	M2 1974	M6 1974	M3 1974	M1 1974	M2 1974	M4 1974
Trough D	M6 1975	M6 1975	M4 1975	M6 1975	M8 1975	M8 1975	M7 1975	M4 1976	M8 1975
Peak A	M10 1976	M11 1976	M9 1976	M10 1976	M10 1976	M10 1976	M2 1977	M10 1977	M1 1977
Trough D	M2 1978	M11 1977	M6 1978	M1 1978	M3 1978	M2 1978	M1 1978	M9 1978	M5 1978
Peak A	M12 1979	M11 1979	M12 1979	M2 1980	M7 1979	M8 1979	M3 1980	M1 1980	M2 1980
Trough D	M1 1981	M1 1981	M1 1981	M1 1981	M5 1980	M1 1981		M8 1981	
Peak A	M10 1981	M2 1982	M10 1981	M7 1981	M1 1981	M1 1982		M1 1983	
Trough D	M12 1982	M11 1982	M12 1982	M2 1983	M10 1982	M12 1982	M4 1982		M12 1982
Peak A		M3 1984		M9 1984	M5 1984	M1 1984	M9 1983		
Trough D		M11 1985		M9 1985	M7 1985	M11 1984	M4 1985	M6 1984	
Peak A	M3 1986	M10 1986	M11 1985	M3 1986	M8 1986	M11 1985	M8 1987	M9 1986	M8 1985
Trough D	M3 1988	M6 1988	M3 1988	M9 1987	M12 1987	M3 1987	M5 1988	M11 1988	M9 1987
Peak A		M2 1989		M10 1989	M9 1989	M8 1988	M8 1989		M8 1988
Trough D		M11 1989			M3 1990	M5 1989			M2 1989
Peak A		M8 1990			M12 1990	M8 1990		M10 1990	M12 1990
Trough D		M4 1991		M2 1991		M7 1991	M11 1990	M9 1991	
Peak A	M1 1992	M2 1992	M1 1992	M1 1992		M3 1992	M12 1991	M4 1992	
Trough D	M7 1993	M7 1993	M6 1993	M8 1993	M6 1993	M6 1993	M6 1993	M10 1993	M7 1993
Peak A	M5 1995	M1 1995	M1 1995	M5 1995	M2 1996	M5 1995	M2 1995	M3 1996	
Trough D	M9 1996	M12 1996	M5 1996	M10 1996	M4 1997	M7 1996	M9 1996	M6 1997	
Peak A	M2 1998	M3 1998	M2 1998	M12 1997	M3 1998	M2 1998	M2 1998	M6 1998	M3 1998
Trough D	M4 1999	M5 1999	M4 1999	M4 1999	M5 1999	M3 1999	M3 1999	M2 2000	M3 1999
Peak A	M11 2000	M12 2000	M11 2000	M10 2000	M2 2001	M10 2000	M5 2000	M8 2001	M9 2000
Trough D	M3 2002	M7 2002	M3 2002	M5 2002	M7 2002	M1 2002	M1 2002		

Table A3: GDP business cycle dating - Countries : censoring rule of 2 quarters for a phase

	Euro-zone indirect	France	Germany	Italy	Spain	Netherlands	Belgium
Peak B	Q3 1974	Q3 1974	Q1 1974	Q2 1974	Q4 1974	NA	NA
Trough C	Q1 1975	Q1 1975	Q1 1975	Q1 1975	Q2 1975	NA	NA
Peak B				Q1 1977	Q3 1978	NA	NA
Trough C				Q3 1977	Q1 1979	NA	NA
Peak B	Q1 1980	Q1 1980	Q1 1980		Q2 1980	Q4 1979	NA
Trough C	Q1 1981	Q1 1981	Q4 1980		Q1 1981	Q3 1980	Q1 1981
Peak B	Q3 1981		Q3 1981	Q2 1981		Q1 1982	Q1 1982
Trough C	Q4 1982		Q4 1982	Q4 1982		Q4 1982	Q1 1983
Peak B	Q1 1992	Q1 1992	Q1 1992	Q1 1992	Q1 1992		Q1 1992
Trough C	Q1 1993	Q1 1993	Q1 1993	Q1 1993	Q1 1993		Q1 1993
Peak B							Q2 1998
Trough C							Q4 1998
Peak B	Q1 2001		Q1 2001	Q2 2001			Q1 2001
Trough C	Q4 2001		Q4 2001	Q1 2002			Q3 2001
Peak B		Q4 2002				Q3 2002	

Table A4: GDP growth cycle dating - Countries : censoring rule of 2 quarters for a phase

	Euro-zone indirect	France	Germany	Italy	Spain	Netherlands	Belgium
Peak A		Q3 1971	Q3 1970			NA	NA
Trough D		Q3 1972	Q4 1971	Q4 1972	Q2 1971	NA	NA
Peak A	Q1 1974	Q1 1974	Q3 1973	Q1 1974	Q2 1974	NA	NA
Trough D	Q2 1975	Q3 1975	Q2 1975	Q2 1975	Q4 1975	NA	NA
Peak A	Q4 1976	Q1 1977	Q4 1976	Q4 1976	Q1 1978	Q2 1978	NA
Trough D	Q2 1978	Q4 1977	Q2 1978	Q4 1977	Q2 1979	Q1 1979	NA
Peak A	Q4 1979	Q4 1979	Q4 1979	Q1 1980	Q2 1980	Q4 1979	NA
Trough D	Q1 1981	Q1 1981	Q1 1981		Q3 1981		Q4 1980
Peak A	Q3 1981	Q2 1982	Q3 1981				Q1 1982
Trough D	Q1 1983	Q3 1983	Q4 1982	Q1 1983		Q4 1982	Q1 1983
Peak A	Q1 1984	Q1 1984	Q1 1984	Q1 1984	Q3 1983	Q1 1984	Q2 1984
Trough D	Q4 1984	Q4 1984	Q1 1985	Q4 1984		Q4 1984	Q4 1984
Peak A	Q1 1986	Q1 1986	Q2 1986	Q3 1985		Q1 1986	Q4 1985
Trough D	Q2 1987	Q2 1987	Q3 1987	Q1 1987	Q3 1986	Q1 1987	Q1 1987
Peak A			Q4 1988		Q1 1988		
Trough D			Q3 1989		Q4 1988		
Peak A		Q1 1990	Q1 1991	Q1 1990	Q4 1991		Q1 1990
Trough D		Q1 1991	Q3 1991	Q4 1990			Q1 1991
Peak A	Q1 1992	Q1 1992	Q1 1992	Q1 1992		Q4 1991	Q1 1992
Trough D	Q3 1993	Q3 1993	Q2 1993	Q2 1993	Q3 1993	Q4 1993	Q2 1993
Peak A	Q1 1995	Q1 1995	Q1 1995	Q2 1995	Q2 1995	Q1 1995	Q1 1995
Trough D	Q1 1997	Q2 1997	Q1 1997	Q4 1996	Q4 1996	Q1 1997	Q2 1996
Peak A	Q4 1997	Q1 1998	Q4 1997	Q4 1997	Q2 1997	Q1 1998	Q4 1997
Trough D	Q1 1999	Q1 1999	Q1 1999	Q1 1999	Q3 1998	Q1 1999	Q1 1999
Peak A	Q2 2000	Q4 2000	Q2 2000	Q1 2001	Q2 2000	Q1 2000	Q4 2000
Trough D	Q1 2002	Q4 2001	Q1 2002		Q3 2002	Q4 2001	Q1 2002
Peak A	Q2 2002	Q2 2002	Q3 2002			Q2 2002	Q3 2002

Figure A1: Distance to cycle peaks for IPI business cycle

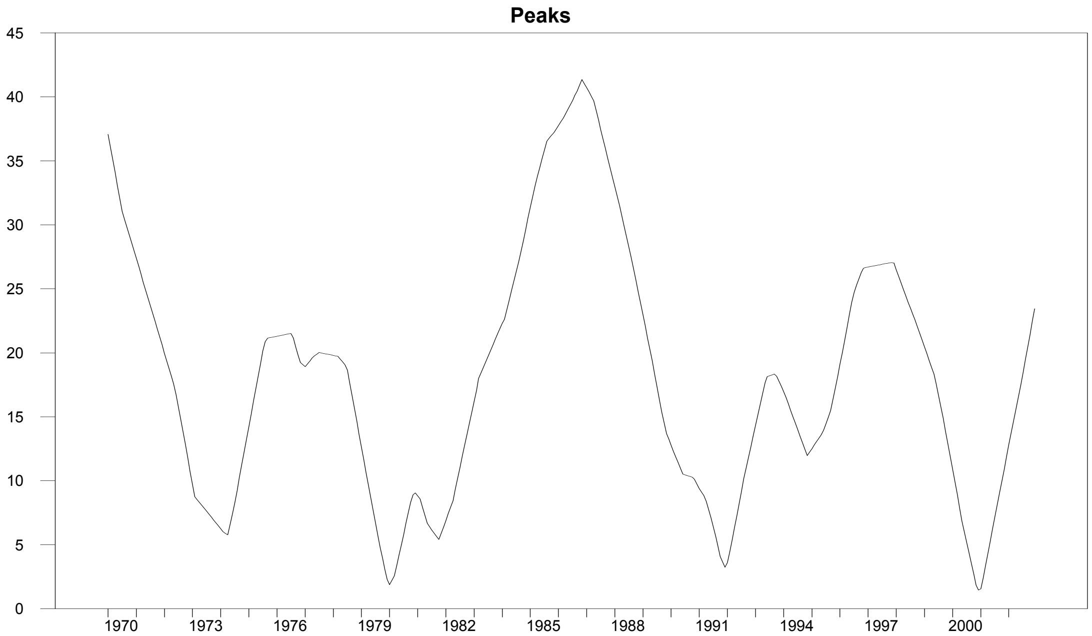


Figure A2: Distance to cycle troughs for IPI business cycle

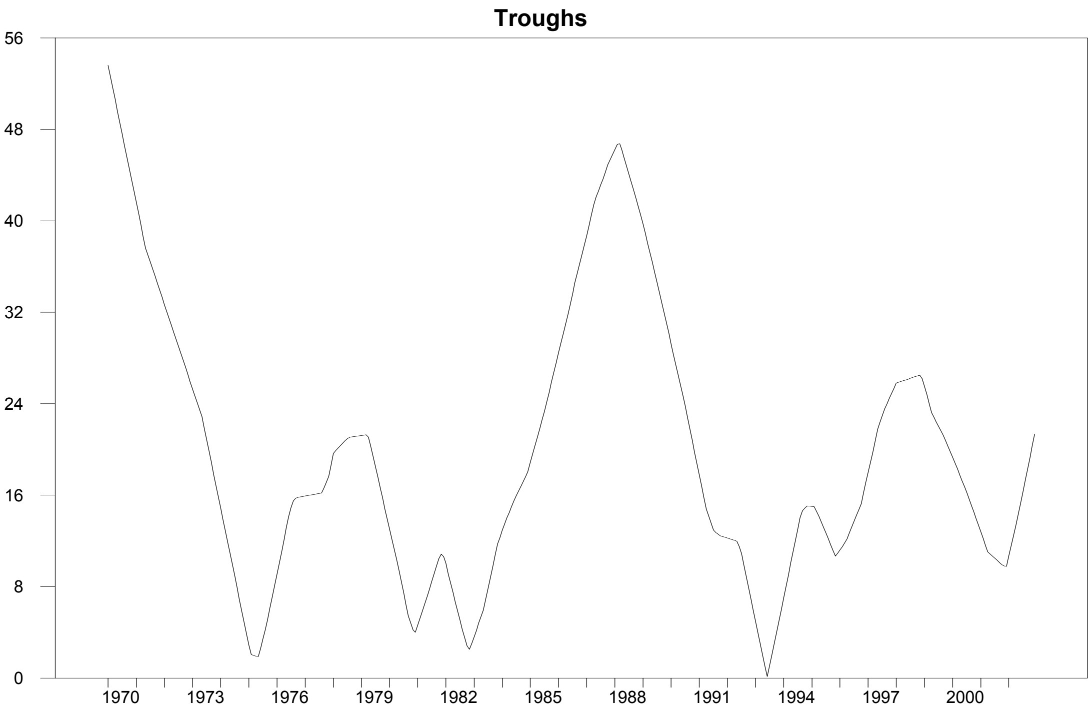


Figure A3: Distance to cycle peaks for IPI growth cycle

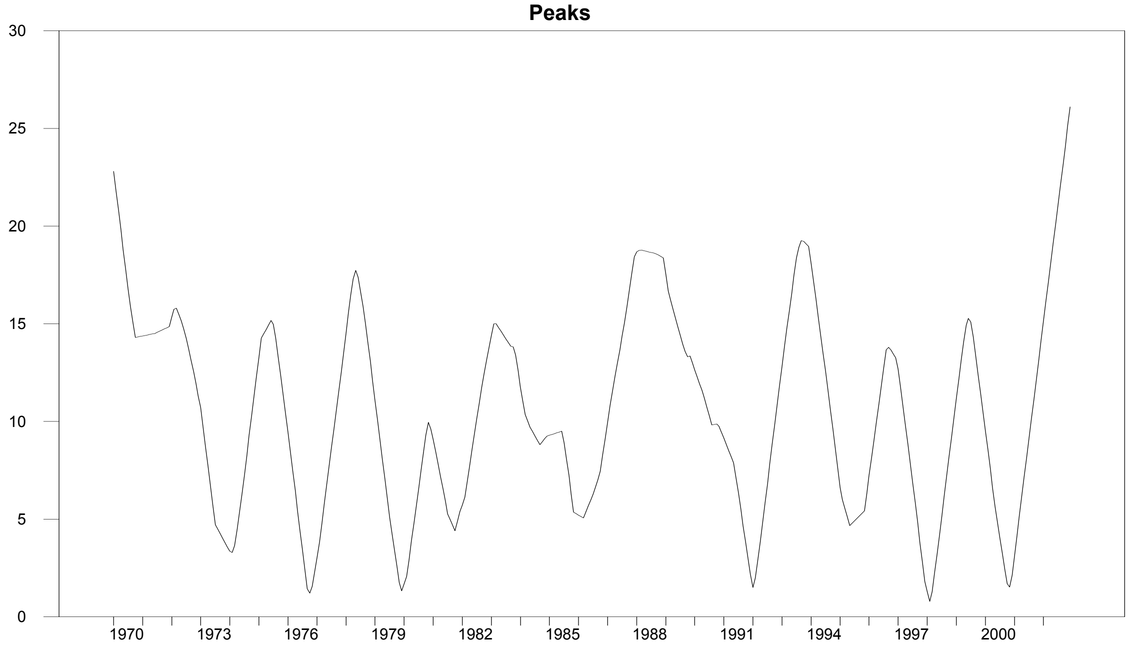


Figure A4: Distance to cycle troughs for IPI growth cycle

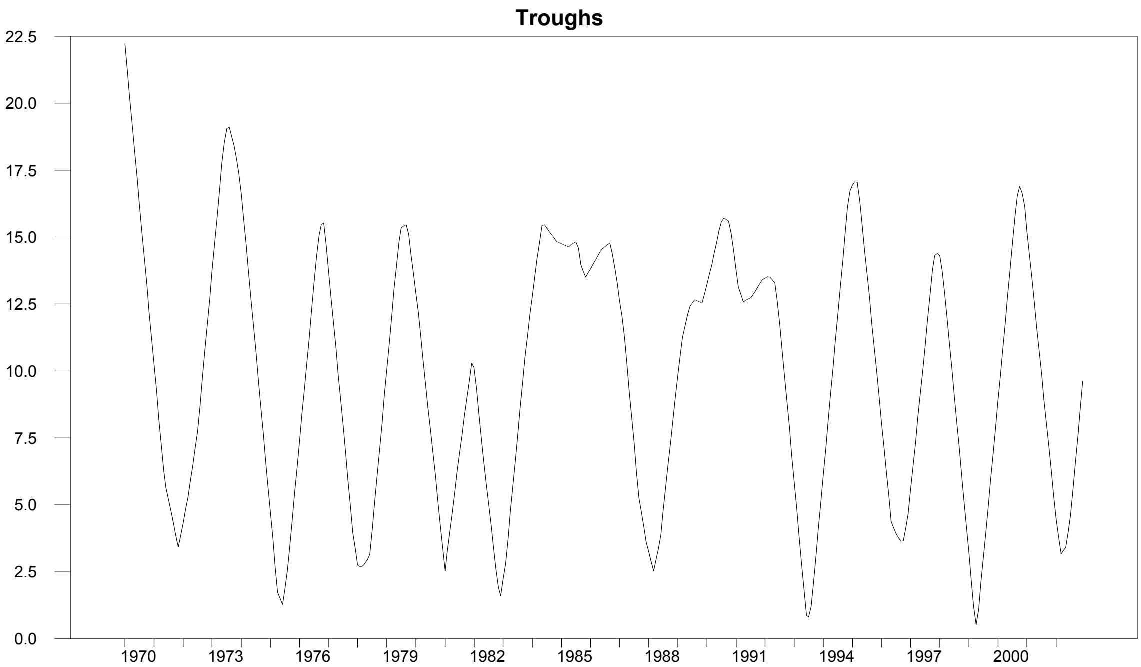


Figure A5: Distance to cycle peaks for GDP business cycle

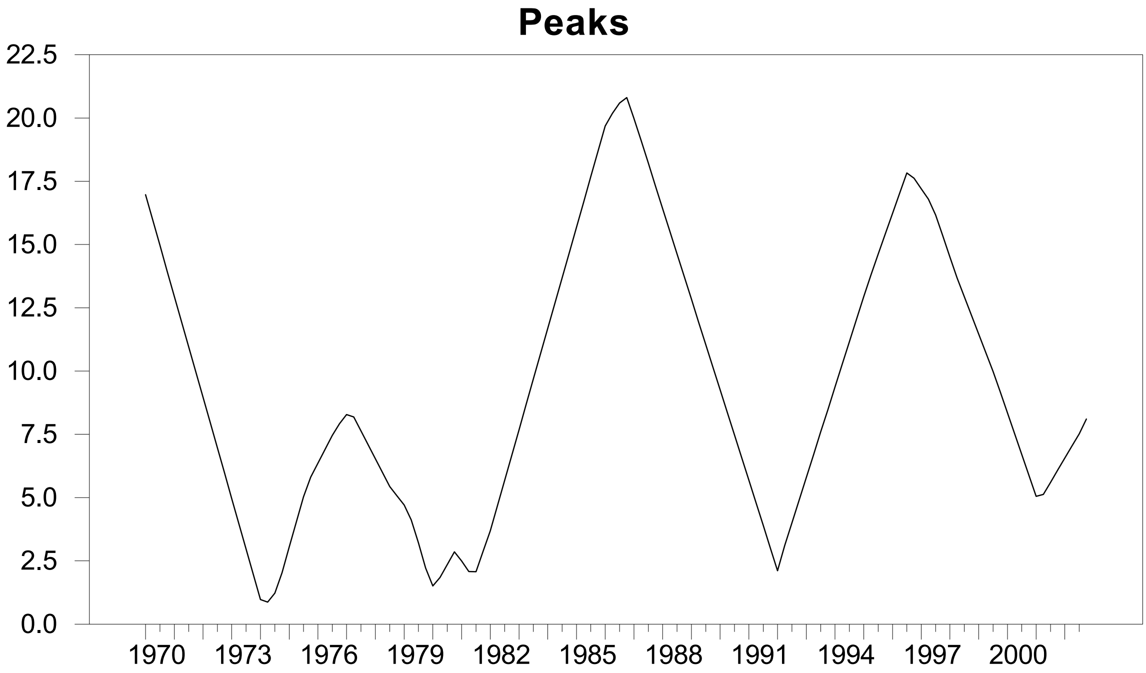


Figure A6: Distance to cycle troughs for GDP business cycle

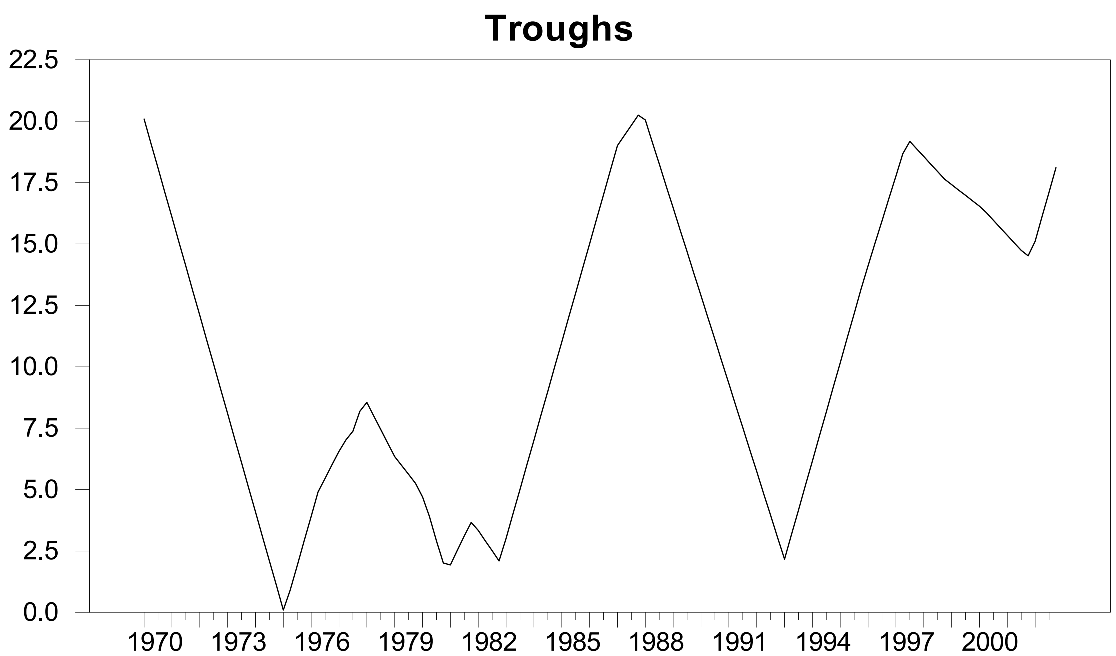


Figure A7: Distance to cycle peaks for GDP growth cycle

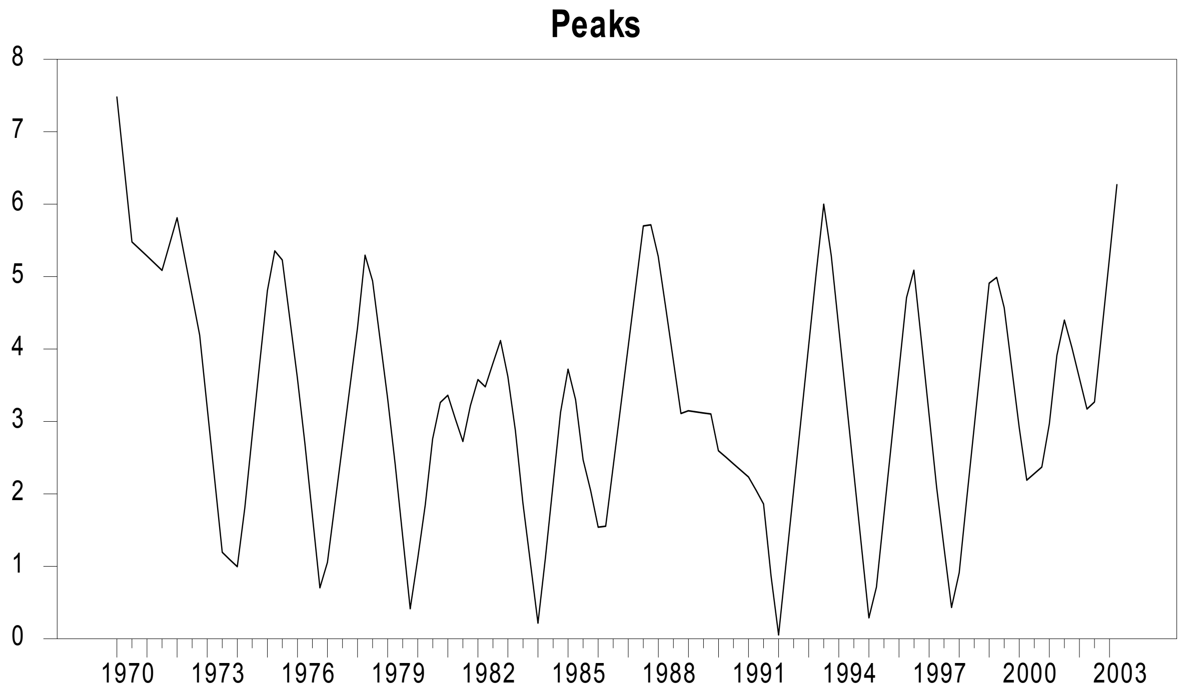


Figure A8: Distance to cycle troughs for GDP growth cycle