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An Analysis of the Euro Area Business Cycle

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The views expressed in the present dissertation are those of the author and do not necessarily reflect those of the European Central Bank.

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I hope the completion of the PhD dissertation will not mark the end of my time as a researcher, but only the beginning. After all, I tend to agree with the wise man who once said that "A life without investigation is not worth living" (Plato, *Apology*, 38a). The challenge, from now on, will be to broaden the questions addressed.

Preface

Analyzing business cycles means neither more nor less than analyzing the economic process of the capitalist era. (...) Cycles are not like tonsils, separate things that might be treated by themselves, but are, like the beat of the heart, of the essence of the organism that displays them.

Schumpeter (1939, Preface, p.V)

Economic crises are recurrent phenomena in most if not all countries of the world and, although at varying degree, affect negatively the majority of families and individuals. Even richer, capitalist, economies are not immune from at least some type of recurrent economic crises: recessions, which, if particularly severe, can lead to depressions. The negative material and psychological consequences of recessions, ranging from an increase of unemployment, rising poverty especially among the more vulnerable groups of people and a general impoverishment of the whole population, cannot but lead to the conclusion that society would greatly benefit if these crises could be avoided or at least their impact reduced. For this purpose, it is necessary first to understand the determinants and intrinsic dynamics of business cycles, such that the most appropriate measures and economic policies can be adopted to minimize its negative consequences.

The process of European economic integration, which started in the 1950s, is an essential part of the more general process of political integration, aimed at ensuring lasting peace and cooperation in Europe. Important steps in the economic integration path were the progressive dismantlement of barriers to trade of goods and capital and the movement of labour within Europe starting from the Rome Treaty of 1957 which led to the creation of a single market, the adoption of a common European Monetary System in 1979, the creation of European Economic and Monetary Union (EMU) along the path designed in the Maastricht Treaty in 1991 leading to the adoption of a common currency, the euro, and the creation of the European System of Central Banks headed by the European Central Bank (ECB), with the task of conducting a single monetary policy for the whole euro area. These factors have gradually made possible the emergence of an economic area with some common fundamental economic features, such that it has already become common to refer to the economies which adopted the euro as a single economic entity, the euro area or euro zone.

Until recently, it was largely agreed that the only natural economic reference areas in Europe were the single states. However, particularly since the delegation of a common monetary policy to a super-national entity in the euro area, it can be argued that for at least some analytical purposes, it is useful to adopt a euro area aggregate perspective. For business cycle analysis, closely linked to monetary policy analysis, there are some very good reasons, which will be discussed at length in chapter 1 of this dissertation, to assume such a perspective. Thus, it becomes necessary to undertake a broad and thorough analysis of the euro area business cycle from a new point of view. Despite the publication of a several studies on euro area aggregate fluctuations[1] since the pioneering work of Mike Artis and Wenda Zhang on the European business cycle in the mid-1990s and more recently also thanks to the creation of the Euro Area Business Cycle Network in 2002, a systematic and satisfactory analysis of the main characteristics of the euro area cycle is still missing. The present investigation aims at contributing to fill this gap by carrying out a broad analysis of euro area fluctuations over the past four decades combining statistical, econometric, historical and economic information and methods.

A number of preliminary conceptual and measurement issues need to be addressed before undertaking a detailed analysis of any business cycle. First, a discussion of what is meant by business cycle must be clarified, in order to avoid confusion. Second, the abstract concept of the cycle must be translated into practical measures which can become the object of analysis. Third, it is necessary to identify which specific concepts and measures of the business cycle are of interest from a macroeconomic perspective. These three questions will be addressed shortly in the introductory chapter.

A general question which is specific to the analysis of the present study is to which extent it makes sense to refer to an aggregate euro area business cycle. This issue will be discussed in chapter 1. It is shown that there are some good economic reasons to adopt

[1] In the remainder of the dissertation we will refer to "the business cycle", "macroeconomic fluctuations" and "aggregate fluctuations" as synonyms.

an aggregate perspective when analyzing business cycles of the euro area and robust empirical evidence that supports such an approach. More precisely, chapter 1 provides evidence on the existence of a common cycle among euro area countries by adopting an analytical approach which tries to overcome some basic limitations which characterise the existing literature. The findings suggest that there is clear evidence of a region-specific euro area business cycle, which started to emerge more forcefully since the 1980s.

Once the above-mentioned questions have been addressed, investigators can undertake what is more properly the analysis of the business cycle. A thorough understanding of the business cycle requires a detailed analysis along several dimensions, both from a theoretical and empirical perspective. Despite the importance (but also the complexity) of the phenomenon under study, as synthesised by Schumpeter in the quotation reported above, and the fact that several theories have been proposed to explain business cycle fluctuations, it still presents several unexplained features such that most analysts in the profession still regard it largely as a puzzle.[2] Nevertheless, the profession seems to have reached a broad agreement from a methodological point of view on how to proceed to the analysis of business cycles. The mainstream research strategy starts from the identification of the facts that characterize business cycles, and that therefore need to be explained, and then moves to testing the alternative theories. If a theory is found to outperform the alternatives and reaches a minimum set of criteria, varyingly defined, then it is used as a framework for policy analysis. The present study follows this strategy by first identifying a broad set of stylised facts characterising the euro area business cycle (chapter 2) and subsequently by drawing some inference on the relative importance of various sources of the cycle (chapter 3). In particular, the purpose of chapter 2 is to identify and discuss the main stylised facts of euro area fluctuations since 1960. These include the basic stylised facts about the cycle such as average duration and amplitude, structural breaks and turning points, and the main properties (variability, persistence, correlation with GDP, etc.) of a set of key macroeconomic variables, from expenditure components to labour market variables and prices. All these properties are compared to the corresponding ones for the US cycle. Chapter 3 identifies the main sources of euro

[2] This view is summarised in the title of the recent note by Christiano and Fitzgerald (1999): "The business cycle: it's still a puzzle".

area fluctuations since 1980 using structural VAR analysis and compares them to the corresponding one for the US. Identification is achieved by imposing sign restrictions on impulse responses based on basic aggregate demand-aggregate supply models. The results of chapter 3, in additions to be interesting for policy purposes, can also provide some key indications on the explanatory power of the main theories for euro area fluctuations.

It is important to stress that the current investigation represents only a starting point for a more comprehensive analysis of the euro area business cycle. Most aspects mentioned in this study deserve a more detailed analysis, and no attempt is made to construct a theoretical model of euro area fluctuations, tasks which can only be undertaken in a long-term research program. Nevertheless, the results of the present study can represent a reference point on various important issues which can be useful to guide further efforts to analyse the euro area business cycle.

Introduction

This introductory chapter provides a discussion of a number of preliminary conceptual and measurement issues which need to be addressed before undertaking a detailed analysis of the euro area business cycle: first, what is the business cycle; second, which concept of the business cycle is more relevant for different analytical purposes; and, third, how the business cycle should be measured. This chapter also introduces the main modelling approach used to extract the cycle used in the subsequent chapters of the thesis, i.e. the structural time series, or unobserved components model, approach.

I. What is the business cycle?

I. 1. General definitions of the business cycle

Before analysing any phenomenon, it is necessary to state at least a general definition of it as a starting point, in order to avoid confusion and misunderstandings of different types. In the case under discussion this initial step is even more important because different concepts of the business cycle have been proposed, each one leading to a different measurement method, with the risk that different analysts disagree on the assessment of fluctuations simply because they refer to alternative concepts of the cycle.

It is worth starting our discussion by reporting and dissecting the most widely quoted definition of the business cycle, which is the one provided by Burns and Mitchell (1946):[3]

> "*Business cycles are a type of fluctuations found in the aggregate economic activity of nations that organise their work mainly in business enterprises: a cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals which merge into the expansion phase of the next cycle; this sequence of changes is recurrent but not periodic; in duration business cycles vary from more than one year to ten or twelve years; they are not divisible into shorter cycles of similar character with amplitudes approximating their own.*" (p. 3)

[3] A very similar definition can be found in Mitchell (1927).

This general definition, which encompasses various more precise concepts of the business cycle which will be discussed below,[4] represents a useful starting point as it highlights the fundamental aspects of business cycles. Essential elements in this definition are:

- diffusion or pervasiveness: the co-movement of several sectors and economic activities, i.e. production, employment, income and trade;
- the alternation of different phases, separated by turning points, in a recurring order;
- delimitation of duration: between one and twelve years. Thus, implicitly also persistence is assumed to be an important feature of cyclical phases.

It can be noted that, in contrast to the delimitation of duration of cycles, no mention is made of a minimum or a maximum amplitude that should characterise the different phases.[5] This fact can be explained by the fact that for example both production and employment were implicitly assumed to be relevant, but these are measured in different units, thus making it difficult to delimit quantitatively amplitude. In addition, there was a perception that the average amplitude of cycles was changing over time, and that therefore a minimum amplitude limit (for example, one for each reference series in terms of percentage) could become soon obsolete.[6] However, the same criticism applies to the delimitation of the duration. Moreover, a reference specification is necessary in order to differentiate contiguous regimes such as recessions and contractions or revivals and expansions. In addition, there is no reason why fixed rules should be adopted, both in terms of duration and amplitude. For the latter, a criterion based on some multiple or fraction of standard deviations, even if changing over time, could be useful not only to classify regimes but also to identify cycles (by setting minimum standards). It should also be observed that the upper and lower bounds which Burns and Mitchell establish to identify business cycles duration are derived from the observation of several US

[4] This definition has been refined by the same and other authors and, for example, the cycle has been dissected into several (up to nine) phases. See for example Niemira and Klein (1994).

[5] At the same time it should be recognised that while Burns and Mitchell do not mention amplitude limits in their definition of the cycle, they discuss this aspect of cycles at length in their monograph.

[6] Mintz in 1972 for example noted that "should not a minimum amplitude be stipulated in some fashion? The reason for not setting such rule [is] … mainly the difficulty of setting standards suitable for a future different from the past. With the declining trend of amplitudes …a lower limit set today may easily be obsolete tomorrow (quotation from Haywood, 1973, p.32).

macroeconomic time series over the previous decades but there is no reason for this limits to be the constant over time or the same across countries.

The complexity of the definition of Burns and Mitchell emerges from the fact that the broad delimitation of the duration of cycles allows for different fluctuations to contribute to the phenomenon under study, including Kitchin (or inventory) cycles, lasting about 40 months on average, and Juglar (or fixed investment) cycles, of duration between seven and eleven years. By contrast, seasonal cycles, lasting less than one year; agricultural (or cobweb) cycles, also of relatively short but variable duration; Kuznets (or building) cycles of 16 years or more duration; and Kondratieff (or long waves) cycles lasting between 45 and 60 years, are assumed to be different phenomena which require a separate explanation. An alternative view was advanced by Schumpeter in his 1939 monumental investigation on the business cycle, based on the idea that all (or most of) these cycles should be analysed in conjunction with one another in order to derive a complete explanation of the dynamic evolution of capitalist systems. Other economists subscribed to this view, but the resulting complexity of the problem convinced most people in the profession that a more viable approach is to separate at least in the initial stage of research the medium-term concept of the business cycle from the short-term seasonal fluctuations and the long-term growth dynamics.

Overall, the definition of Burns and Mitchell (excluding the part proposing a quantitative delimitation of duration of cycles) can be accepted as a starting point. However, from an operational point of view a set of more detailed criteria is necessary in order to identify and classify cycles. The latter aspect will be discussed at length in the following sections.

I. 2. A basic distinction: classical business cycles versus deviation cycles

Within the empirical literature on the business cycle, there exists a basic distinction between two different, although related, concepts of the cycle. The first, which was the concept of the business cycle initially introduced and was the main focus of the studies in the National Bureau of Economic Research (NBER) tradition, refers to absolute declines and increases in economic activity and is known as the "classical business cycle", or simply "business cycle."[7] This was also the concept Burns and Mitchell had in mind, as becomes clear when they define a contraction as an "absolute fall in aggregate economic activity". Within this framework, the analysis of the cycle proceeds by first identifying a set of turning points for the different regimes and then by reporting and discussing the statistical properties of the resulting isolated different phases, including average duration and amplitude, and comparing the turning points across series, by computing leads and lags in timing. The general approach of the NBER was heavily criticised by Koopmans (1947) in a review of Burns and Mitchell's book *Measuring Business Cycles*, still considered the main methodological contribution of the NBER tradition. Koopmans argued that this approach was "measurement without theory", in the sense that the choice of variables examined and the facts or properties to be reported were not guided by economic theory. In addition, he also stressed that explicit assumptions about the probability distributions of the variables were missing, while a structural system of equations is needed as an organising principle. Thus, he concluded, the NBER approach was an "enormously wasteful undertaking". The Koopmans criticisms were very influential in the profession and as a consequence the approach advocated by the NBER, starting from the collection of data and computation of what Kaldor called "stylised facts" to be explained by economic theory, was largely abandoned for three decades (until it was advocated again by real business cycle researchers, starting from Prescott (1986) in the 1980s as a useful starting point for business cycle analysis).

The second concept of macroeconomic fluctuations, which has become the main reference in the academic literature since Lucas' definition of the cycle as recurrent movements of output about trend, is the "<u>growth cycle</u>" or "<u>deviation cycle</u>" notion.[8] Lucas (1977) defined the business cycle as "repeated fluctuations about trend, all of essentially the same character" (p.7), specifying that the latter qualification refers to the "regularities which are observed (…) in the co-movements among different aggregate

[7] See for example Niemira and Klein (1994, p4): "When business activity declines in absolute levels and then rebounds, this is called a "classical business cycle", more frequently it is simply referred to as a "business cycle"".

[8] See Lucas (1977). It should be noted that the concept of growth cycles was introduced much earlier. The first systematic study of deviations cycles was carried out by Mintz (1969) in her study of German post-WWII cycles, as she didn't find evidence of a classical business cycle in West German data over the 1950s and 1960s. However, the concept was popularised in the academic world by Lucas in 1977.

time series (p.9)"[9]. The subsequent work of Kydland and Prescott (1982, 1990), which has been no less influential in shaping the path of large part of business cycle research over the last two decades starts from the same definition. As a matter of fact, Kydland and Prescott (1990) explicitly state that they "follow Lucas in defining business cycles as the deviations of aggregate real output from trend" (p.4) and "in viewing the business cycle facts as the statistical properties of the comovements of deviations from trend of various economic aggregates with those of real output" (p.9). Hence, most business cycle researchers started again the analysis of fluctuations by computing stylised facts but with reference to the deviation cycle rather than the classical cycle as was done mainly before. Another related definition is that by Sargent (1987), who defined and identified the cycle on the basis of spectral analysis,[10] but his definition of the cycle in the frequency domain largely corresponds to Lucas' definition in the time domain, with particular stress on the co-movements (or coherences, in spectral analysis terms) among variables.

II. Is the business cycle of economic interest?

II. 1. The welfare costs of business cycles and the benefits of stabilization policies

There is no doubt that recessions are costly: employment falls, production stagnates and typically also poverty increases at least among the more vulnerable segments of society. However, recessions may also have a positive role. For example, Schumpeter identified in the process of "creative destruction" one of the main forces of capitalist dynamics, including business cycles.[11] Within his theory recessions are the natural consequence of the recurrent waves of innovations which force the most unproductive techniques and less profitable products out of the market making resources free for more productive

[9] It is worth noting that Lucas (1977) refers, among other sources, to the work of Burns and Mitchell (1946) for the identification of these regularities and lists as the first one the feature that "output movements across broadly defined sectors move together" (p.9).

[10] "The business cycle is the phenomenon of a number of important economic aggregates (such as GNP, unemployment, and layoffs) being characterized by high pair wise coherences at the low business cycle frequencies, the same frequencies at which most aggregates have most of their spectral power if they have "typical" spectral shapes" (p.282).

[11] See for example Schumpeter (1939).

uses. Thus, recessions are a time of cleansing.[12] Unfortunately the quantitative relevance of this phenomenon has not yet been established empirically and therefore it is difficult to conclude whether from this perspective recessions should be fully eliminated.

That macroeconomic fluctuations, and in particular recessions, imply a significant cost to society was for a long time taken for granted. However, traditional macroeconomic analysis of this issue was not rigorous, at least not according to the criteria widely adopted nowadays. In particular, traditional macroeconomic models, which were not based on optimizing economic principles, did not allow for a formal welfare analysis to be carried out.

That business cycles were costly was questioned forcefully by Lucas (1987). On the basis of simple but rigorous theoretical considerations, he derived some estimates of fraction of total consumption that optimizing agents would be willing to give up in order to avoid fluctuations. Since his estimates suggested that this fraction was not more than one tenth of one percent of private consumption, he concluded that the welfare costs of business cycle are negligible. Subsequent studies addressed the same question using similar frameworks (that is, dynamic stochastic general equilibrium models) but relaxing in turn the various restricting assumptions made by Lucas. While the results often point in different directions and there is no generally agreed upon conclusion, most recent investigations suggest that welfare costs of fluctuations are much larger than suggested by Lucas and are in fact often quite significant.[13] Moreover, even if some studies find that on average the welfare costs of fluctuations are modest, major slowdowns may imply large welfare losses, thus providing some support for the desirability of stabilisation policies.[14]

Even if the case for stabilisation policy is, at least under certain conditions, accepted, the question emerges to what extent the various stabilisation policies may be effective. The rational expectations revolution seemed to question the possibility of undertaking effective stabilisation policy.[15] However, once macroeconomic imperfections are taken

[12] See also Caballero and Hammour (1994).
[13] For a recent review of this large and growing literature see Barlevy (2005).
[14] See for example Gali et al. (2003).
[15] See for example Lucas and Sargent (1979).

into account, and even under rational expectations, it has been shown that both monetary policy and fiscal policy can be effective to some extent for stabilisation purposes.[16] At the same time, it has been recognized that both the desirability and the efficacy of stabilisation policy depends on the nature of the shock that give rise to fluctuations. In particular, in the presence of permanent supply shocks (such as long-lasting oil price increases) the scope of stabilisation policy seems to be limited.

Thus, the most recent literature on the cost of fluctuations and the desirability and effectiveness of stabilisation policy seems to provide a strong justification for a thorough analysis of the business cycle to be undertaken.

II. 2. On the relevance of the different concepts of the business cycle

While traditional analysis tended to focus on classical business cycles, modern macroeconomics has been mainly directed to analyse deviation cycles. Thus, the discussion in the previous section provides a strong case for the importance of deviation cycles, while the question of the relevance of classical cycles remains open. It is true that classical recessions, which imply a contraction of production and most often a significant increase in the unemployment rate, are more costly than the average deviation cycle slowdown. However, the former can be seen as a subset of the latter. Thus, analysing deviation cycles does not imply that recessions are disregarded. Other arguments which have been advanced to support the relevance of the classical business cycle concept are also not convincing. For example, it has sometimes been pointed out that the classical business cycle is the concept of the cycle historically introduced, that it is what people have in mind and it is what politicians are interested in:[17] these considerations are, of course, irrelevant from an economic perspective. In our view, there is some support for the view that the concept of the classical cycle is relevant if it is recognized that there is no fundamental reason that indicates that long-run growth and medium-run fluctuations are determined by entirely different forces.[18] Thus, the analysis of the business cycle may

[16] For a recent perspective on the role of monetary policy and fiscal policy see Yellen and Akerlof (2004) and Gali (2004) respectively.

[17] See for example Harding and Pagan (2000).

[18] To state it in Hicks (1965) words: "The distinction between trend and fluctuation is a statistical distinction; it is an unquestionably useful device for statistical summarizing. (...) We have no right to

be more fruitful if the focus is on classical cycles, and also long-run growth is taken into account. However, a widely accepted all-encompassing framework is not yet available.[19] Thus, given the current state of macroeconomics, we follow the approach typically adopted in the profession and focus on the analysis of the deviation cycle.

III. How should the business cycle be measured?

"The essential idea of trend is that it should be smooth..."

Kendall (1973)

"There is no fundamental reason, though, why a trend should be smooth..."

Harvey (2001)

III. 1. Alternative approaches to trend-cycle decomposition

Given the general definitions of the business cycle and the discussion of the reasons supporting an interest in the business cycle discussed in the previous sections, the question emerges of how to operationalyse the business cycle, and more precisely the deviation cycle. In other words, how should deviation cycles be measured or estimated? This step is a necessary phase for the empirical analysis and assessment of the cycle.

Deviation cycles are defined as deviations from trend. Typically, it is also assumed implicitly that the reference series has been seasonally adjusted and purged of irregular movements. Thus, the identification of the deviation cycle is equivalent to isolating the cyclical component from the other components. The question of which empirical method should be applied to estimate the cyclical component of a macroeconomic time series is controversial and no conclusion universally agreed upon has been reached in the literature. The most controversial step is probably the estimation of the trend, as no general operational definition of trend has been generally accepted in the literature largely due to the fact that economic theory does not provide practical indications on how the

conclude, from the mere existence of the statistical device, that the economic forces making for trend and for fluctuation are any different, so that they have to be analysed in different ways" (p. 4).

[19] Models of the growth cycle have been proposed, including Evans et al (1998) or Matsuyama (1999). However, these frameworks rely on some restrictive assumptions such that their general explanatory power seems to be rather limited.

trend should be computed. For example, contrasting views such as those of Kendall and Harvey in the quotation reported above still are present in the profession. This controversy is rather unfortunate because it has been shown, for example by Canova (1994, 1998, 1999), that business cycle stylised facts vary significantly across detrending method.

The empirical methods applied to decompose macroeconomic time series range from non-parametric methods, or ad hoc filters, to model-based approaches (i.e. parametric methods). The former include deterministic detrending, the Whittaker-Henderson filter advocated by Hodrick and Prescott (1997), frequency domain-based filters such as the band-pass filters suggested by Baxter and King (1999) and Christiano and Fitzgerald (1998), moving average detrending, and phase trend averaging among others. All these ad hoc methods tend to exhibit a fundamental limitation: they may produce spurious cycles, in the sense that they may extract a cycle from series which *de facto* have none (this is the so-called Yule-Slutsky effect). These distortionary effects are documented by Nelson and Kang (1981) for linear detrending, by King and Rebelo (1993), Harvey and Jäger (1993) and Cogley and Nason (1995) for the Hodrick-Prescott filter[20], by Benati (2002) and Murray (2003) for the band-pass filter, by Osborn (1995) for moving average detrending. As a result, it has been argued that stylised facts identified with these filters may de facto be largely "stylised artifacts", i.e. properties induced by the filter rather than present in the data. It has to be recognized that the danger of creating distortions arises mainly from the mechanical application of these filters, while ways to adapt somewhat the filters to the series have been proposed.[21] However, it can be argued that only within a model-based framework can the dangers of extracting spurious cycles be avoided.

Thus, we choose to estimate the cyclical component of the reference macroeconomic series within a model-based framework, and more precisely the unobserved components (UC), or structural time series, model advocated by Harvey (1989) and, more specifically

[20] Despite the claim of Prescott (1998) that the filter he advocates provides an operational definition of the business cycle, and therefore cannot be qualified as either right or wrong, it cannot be ignored that this filter distorts the evidence on co-movements among detrended series, a fundamental characteristic of fluctuations even in the definition of the cycle he adopts.

[21] For example, Ravn and Uhlig (2002) and Marcet and Ravn (2001) propose ways to adjust the Hodrick-Prescott filter to different frequencies of data and for cross-country comparisons, respectively.

for the purpose of business cycle stylised facts identification, by Harvey and Jäger (1993). It should be observed that UC models are not the only alternative parametric approach. Alternatives are represented by structural VAR models à la Blanchard and Quah (1989), cointegrated-VAR based methods and the Beveridge-Nelson approach.[22] However, as regards the former it should be recognized that the identification scheme, although having the advantage of being rooted in economic theory, is not unique and despite recent advances there is still no general agreement on which identification restrictions are more acceptable in the literature.[23] Moreover, it has been shown that long-run restrictions are rarely robust with the relatively short sample sizes available.[24] Cointegrated VAR approaches are more difficult to compare to the UC model approach, due to the very different underlying modelling philosophies involved. However, cointegration analysis is based on the presence of unit roots in macroeconomic time series. This represents a drawback as available tests have low power in discriminating this hypothesis with respect to the alternative of deterministic trends subject to breaks.[25] By contrast, UC models do not depend on the presence of unit roots for the purpose of business cycle identification.[26] As regards the Beveridge-Nelson decomposition, it has the counterintuitive implication that often the estimated trend component is more volatile than the actual series itself. Overall, UC models are formulated in terms of components which have a natural interpretation in terms of business cycle analysis and are immune from some important drawbacks which affect alternative model-based approaches. Thus, the UC approach will be the one adopted for the purpose of extracting and analysing business cycles in the present study.

One approach which sometimes has been advocated to reduce the specific impact of detrending methods and check the robustness of stylised facts is to take an "agnostic" position and to apply several alternative detrending methods, and testing then whether results are significantly different across method. Such an approach is flawed if it is taken to an extreme: there is no point in comparing stylised facts obtained with methods which

[22] See Proietti (1997).
[23] See for example the overview by Stock and Watson (2001).
[24] See Faust and Leeper (1997) and Cooley and Dwyer (1998).
[25] For a discussion of this issue see Maddala and Kim (1998).
[26] On the relative merits of UC models and VAR models see also Harvey and Koopman (1997), including the comments that follow, especially by Lütkepohl, and the reply.

may produce spurious cycles to those derived from (well-specified) model-based approaches. Such an extreme attitude is likely to lead to the fake conclusion that results should be classified as "non-robust". However, it is a valid approach if only model-based approaches and plausible specifications are considered.

The previous discussion refers to the analysis of the cycle which proceeds by identifying stylised facts which then will need to be explained. Different considerations concern forecasting, which will not be discussed in this dissertation. If for example, the objective is to find the measure of the cycle with best predictive ability for inflation, then it is probably worthwhile to consider a wider set of measures and simply compare them empirically, without necessarily excluding methods such as ad hoc filters which are less appropriate for causation studies.

III. 2. The basic structural time series, or unobserved components, model

UC models have a long history in econometric analysis, as they can be rooted in the conceptualisation of Persons (1919).[27] In general, structural time series models are set up in terms of components which have a direct interpretation. For example, it is often assumed that the time series of interest is composed of a trend, a seasonal component and an irregular term. We will consider the more general form which also includes a cycle as reference framework. Thus, structural time series models, rather than being aimed mainly at representing the underlying data generating process of the data, as in the case of the typical users of the cointegrated VAR methodology, can be interpreted as being instrumental in identifying a set of stylised facts of a time series in terms of its components, which can be attributed a direct intuitive economic interpretation in terms of long-run growth, business cycle, seasonal movements and irregular changes.

The statistical formulation is as follows. The macroeconomic time series of interest, y_t, is assumed to be composed of a trend, μ_t, a cycle, ψ_t, a seasonal component, γ_t, and an irregular term, ε_t:

$$y_t = \mu_t + \psi_t + \gamma_t + \varepsilon_t \qquad \varepsilon_t \sim NID(0, \sigma_\varepsilon^2) \qquad (1)$$

[27] See Nerlove et al. (1995) and Harvey (1989) for a historical overview of these models.

All four components are stochastic and the disturbances driving them are assumed to be mutually uncorrelated. The stochastic trend is modelled as a *local linear trend*:

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t \qquad \eta_t \sim NID(0,\sigma^2_\eta) \qquad (2)$$

$$\beta_t = \beta_{t-1} + \zeta_t \qquad \zeta_t \sim NID(0,\sigma^2_\zeta) \qquad (3)$$

where β_t is the slope, and the error terms η_t and ζ_t are mutually uncorrelated. The *stochastic cycle* is specified as

$$\begin{bmatrix}\psi_t\\ \psi^*_t\end{bmatrix} = \rho\begin{bmatrix}\cos\lambda_c & \sin\lambda_c\\ -\sin\lambda_c & \cos\lambda_c\end{bmatrix}\begin{bmatrix}\psi_{t-1}\\ \psi^*_{t-1}\end{bmatrix} + \begin{bmatrix}\kappa_t\\ \kappa^*_t\end{bmatrix}, \quad \begin{bmatrix}\kappa_t\\ \kappa^*_t\end{bmatrix} \sim NID\left(\begin{pmatrix}0\\0\end{pmatrix}, \begin{pmatrix}\sigma^2_\kappa & 0\\ 0 & \sigma^2_\kappa\end{pmatrix}\right) \qquad (4)$$

where λ_t is the angular frequency measured in radiants ($0<\lambda_t<\pi$) and ρ is a damping factor ($0<\rho<1$). As shown by Harvey (1989), the stochastic cycle becomes a first-order autoregressive process if the frequency is 0 or π. Finally, the seasonal component can be modelled as a stochastic trigonometric seasonal:

$$\gamma_t = \sum_{j=1}^{s/2}\gamma_{jt}, \quad \begin{bmatrix}\gamma_{j,t}\\ \gamma^*_{j,t}\end{bmatrix} = \begin{bmatrix}\cos\lambda_j & \sin\lambda_j\\ -\sin\lambda_j & \cos\lambda_j\end{bmatrix}\begin{bmatrix}\gamma_{j,t-1}\\ \gamma^*_{j,t-1}\end{bmatrix} + \begin{bmatrix}\omega_{j,t}\\ \omega^*_{j,t}\end{bmatrix}, \quad \begin{bmatrix}\omega_{j,t}\\ \omega^*_{j,t}\end{bmatrix} \sim NID\left(\begin{pmatrix}0\\0\end{pmatrix}, \begin{pmatrix}\sigma^2_\omega & 0\\ 0 & \sigma^2_\omega\end{pmatrix}\right) \qquad (5)$$

where s is the number of seasons in the year and the seasonal frequencies $\lambda_j = 2\pi j/s$, with j=1, …, (s/2). Note that both ψ^*_t and γ^*_t appear as a result of the construction of the processes and have no particularly important interpretation.

The statistical treatment of UC models is based on the corresponding state space form and the application of the Kalman filter and associated smoothing algorithms, which allow the likelihood function to be recovered and thus permit estimation of the parameters (λ_t and ρ), the variances and the various unobserved components.[28]

The main advantages of the UC model-based approach to estimate the deviation cycle is that it is possible to estimate the various components of the reference time series in a unified coherent statistical framework, which allows a set of statistical tests to be carried out to assess the goodness of specification. As a result, if these tests are used rigorously spurious cycles can be avoided. Moreover, it offers a general and flexible framework,

[28] See for example Proietti (2002) and references therein for the details of the statistical treatment. Except for few cases specified, all computations have been carried out with STAMP 6.01 (see Koopman et al., 2000) and Ox 2.00 (see Doornik, 1998).

which for example also encompasses the Hodrick-Prescott filter. Within UC models it is also relatively easy to detect and deal with structural breaks and outliers, advantages which are not always present in alternative approaches.

Chapter 1 - Evidence on the existence of the euro area business cycle

I. Introduction

The European countries which in the aftermath of the Second World War decided to undertake a process of economic integration, as part of a more general plan of political integration, chose from the start a gradualist approach. Although slow and not always smooth, the process of European economic integration, started in the 1950s, has reached a remarkably advanced stage. The progressive dismantlement of barriers to trade of goods, services and capital and to the movement of labour was initiated by six member countries in 1957 with the ratification of the Treaty of Rome and has given rise to a single market within the European Union (EU), achieved in 1993 during Stage I of Economic and Monetary Union (EMU). Monetary cooperation, started with the creation of a European Payments Union in 1950, made substantial progress after 1979 with the introduction of the European Monetary System and culminated in 1999 with the adoption of a common currency, the euro, and the transfer of the responsibility of a common monetary policy to a supranational institution, the European Central Bank. National fiscal policies of most EMU member countries have significantly converged during the 1990s, largely as a result of the budgetary convergence criteria of the Maastricht Treaty which came into effect in 1993, and are now disciplined by a set of common rules and regulations contained in the Stability and Growth Pact approved in 1997. These events have gradually made possible the emergence of an economic area in Europe with some common fundamental economic features, normally referred to as the euro area (or, sometimes, as euro zone or Euroland).

Despite the progress in economic integration and the increased economic policy convergence recorded among euro area countries in the past five decades, the question emerges as to whether a common euro area business cycle exists, and if it does since when. In other words, over which period do the common features prevail over the idiosyncratic characteristics such that it makes sense to refer to a common euro area business cycle? To what extent does it makes sense to refer to an aggregate euro area cycle prior to the creation of EMU or the inception of the EMS? These questions are important for institutions such as the ECB, which, for the purpose of maintaining price stability in the euro area, has necessarily to focus its attention on medium term developments at aggregate level. Thus, the ECB monitors constantly a wide range of euro area business cycle indicators, but in analyzing them it is necessary to know to what extent they depart from the historical regularities of euro area fluctuations. These questions are also important for national governments, which in setting fiscal policies (intended in the most general terms to include the determination of the characteristics of automatic stabilizers) need to know to what extent the business cycle dynamics conform to those of the other member countries.

Several studies have appeared in recent years which, directly or indirectly, attempt to identify the common features among euro area business cycles, with mixed results. As a result several analysts are still sceptical about the adequacy of adopting a euro area aggregate perspective in analyzing fluctuations in the euro area and, therefore, the existence of the euro area business cycle is still an open question. The literature will be discussed in the next section, but we anticipate that in our opinion most studies suffer from some important limitation such that most results are not fully reliable for the purpose of establishing whether a euro area business cycle exists.

This chapter attempts to provide an answer to the question of the existence of euro area aggregate fluctuations by adopting an analytical approach which does not suffer from the limitations of most of the studies in the literature. We proceed by applying those methods which we think are most adequate and robust to analyse cross-country cyclical comovements and convergence, with more attention to statistical inference than typically is done in the literature.

Overall, it is found that the business cycle association among euro area countries from 1960 to 2003 is positive and highly significant. Moreover, affiliations of business cycles within the euro area have become stronger, relatively more than those with other economies, notably the US economy, especially since the late 1980s. While euro area cycles are clearly also associated with those of other OECD countries, the evidence suggests that the common cyclical developments in the euro area can hardly be described as resulting from a world cycle led by the US or more generally deriving from the process of globalization, other than for very limited sub-periods and for few specific episodes and countries. In sum, these findings suggest that there is clear evidence of a region-specific euro area business cycle, which started to emerge more forcefully since the late 1980s.

The chapter is organized as follows. Section 2 summarises and discusses the existing related literature. Section 3 describes the methods and data used in the empirical analysis, the results of which are reported section 4. Section 5 draws the conclusions from the whole analysis.

II. The related literature: results and shortcomings

II. 1. An overview of the related literature

The Delors Report of 1989, which proposed a set of concrete stages that would lead to EMU and that were largely adopted in the Maastricht Treaty, provoked a debate among economists on the desirability of EMU from an economic point of view. The main theoretical framework which represented the background for most analytical contributions was the Optimum Currency Area (OCA) theory, formulated by Mundell (1961) and later refined among others by McKinnon (1963) and Kenen (1969). In a nutshell, the basic OCA theory suggests that two countries should form a currency union if the savings in transaction costs, which are higher the higher the degree of openness, exceed the rise in adjustment costs, which result from relinquishing the national monetary and exchange rate policy and which are higher the more frequent are large asymmetric shocks and the lower is labour flexibility. Operationalisations of the OCA theory and applications to the case of EMU often focused on the symmetry of shocks criterion. In this respect, an influential contribution was that of Bayoumi and Eichengreen (1993), who used structural VAR analysis and the Blanchard-Quah identification scheme to examine whether aggregate supply and aggregate demand shocks were asymmetric among the EU countries. They found some evidence of a "core" subset of EU countries with highly correlated disturbances with those of Germany (Austria, Belgium, Denmark, France, Luxembourg and the Netherlands), taken as the centre country, while the other EU countries constituted a periphery set of countries from this point of view. Subsequent studies, which also took into consideration the other criteria suggested by OCA theory, generally confirmed the evidence for a core and a periphery among EU countries.[29] However, the assessment of EMU on the basis of the empirical implementation of the OCA approach is not immune from problems. First, it is very difficult to quantify all criteria suggested, needed to establish whether the net benefit in forming a monetary union is positive or negative. Second, for each single OCA criterion such as the symmetry of shocks one it is difficult to select a method which is not arbitrary and there is no obvious metric on the basis of which to conclude when the quantifications are "close enough" to some ideal reference point.[30] This problem explains why studies aimed at answering the question as to whether Europe is an OCA have not always led to the same conclusions.[31]

A parallel literature emerged on the degree of business cycle synchronisation among European countries, more directly related to our analysis. The basic motivation of these studies was to establish whether cycles were sufficiently synchronised to ensure that the adoption of a common monetary policy would not be destabilising for some countries. The idea is similar to the symmetry of shocks criterion of OCA theory, assuming that short-run dynamics (i.e. business cycles) are mainly related to demand shocks and that monetary policy is more relevant in the short-run. However, this alternative perspective does not attempt to disentangle shocks and propagation mechanisms, a task which is very difficult and not strictly needed as both impulse and propagation mechanisms are relevant. The conclusion most often reached by the studies on co-movement and convergence among euro area business cycles was that, while euro area business cycles are less synchronised than US states or regions, there is some evidence of an increase in cyclical convergence among euro area countries, especially since the adoption of the ERM. More precisely, among those studies which examine cyclical co-movements among euro area cycles (either deviation cycles or classical cycles) in the various sub-periods of

[29] See for example Artis (2003) and Mongelli (2002) and the literature cited therein.

[30] This problem seems to concern also the US, as some recent studies concluded that also in the US asymmetric shocks are significant and that the US does not meet the requirements of an Optimum Currency Area, see for example Kouparitsas (2001) and Del Negro (2002).

[31] Examples are Eichengreen (1990), Caporale (1993), de Grauwe and Vanhaverbeke (1993) and Bofinger (1994).

the post-war era a majority found that it has increased,[32] while some found that is has remained broadly stable[33] and few that is has decreased.[34] These contrasting conclusions largely reflect the different methodologies used. Appendix 1 provides schematic summaries of the main published relevant studies.

II. 2. Shortcomings of the literature

While it is difficult to assess which approach is more credible in all respects, in our opinion most studies suffer from some important limitation which undermine the reliability of the conclusions that can be drawn in relation to the main question addressed: whether it can be concluded that a common euro area business cycle exists (and if so, since when). These shortcomings could be classified into three groups:

1) Data used:

A) Frequency: several studies adopt as reference series to summarise the cycle some series (typically real GDP or total employment) at annual frequency. The problem of this approach is of course that using annual data implies that much of the business cycle dynamics is lost;[35]

B) Sectoral data: most often industrial (or manufacturing) production series are used as reference series to summarise the cycle. This approach has the advantages that these data is available for longer time period compared to other time series such as real GDP or employment and it is relatively highly harmonised across country. However, the industrial sector not only represents just about a fourth (or, for some countries, about a third) of total value added but it is also particularly affected by international developments (the industrial sector being mostly formed by tradable sectors) such that the evidence on interdependence is likely to be distorted upwards

[32] See for example Artis and Zhang (1997), Fatás (1997), Artis and Zhang (1999), Wynne and Koo (2000), Krolzig (2001), Vijselaar and Albers (2001) and Artis (2004).

[33] See for example Döpke (1999), Clark and van Wincoop (2001) and Artis (2004, Siebert ed).

[34] See for example Mills and Holmes (1999) and Inklaar and den Haan (2001).

[35] In relation to this point we agree with the view of Cooper (1998) that "it was agreed long ago that the causal dynamics of business cycles could not be discerned by inspecting annual data, however carefully. Quarterly and preferably monthly data are needed." (p. 118).

(or, in fact, the evidence should be interpreted as relating to so-called industrial cycles rather than economy-wide business cycles);[36]

C) Sample size: in some studies the data set tends to be too small, either in terms of number of economies considered (with relatively few euro area countries, or a lack of other European or OECD economies which should be used as reference to assess euro area specificities) or in terms of time period, such that it is difficult to reach conclusions on the existence of a common euro area (or European) business cycle and not all relevant questions can be addressed.

2) Methods:

A) Cycle extraction: in most studies business cycles are extracted with methods which include one or more among deterministic detrending, the Whittaker-Henderson filter advocated by Hodrick and Prescott (1997), frequency domain-based filters such as the band-pass filters suggested by Baxter and King (1999) and Christiano and Fitzgerald (1998), moving average detrending, and phase trend averaging among others. All these ad hoc methods tend to exhibit a fundamental limitation: they may produce spurious cycles, in the sense that they may extract a cycle from series which *de facto* have none (this is the so-called Yule-Slutsky effect).[37] While the danger of creating distortions arises mainly from the mechanical application of these filters, it can be argued that only within a model-based framework can the dangers of extracting spurious cycles be avoided.[38]

B) Measures of association: the assessment of co-movement is often carried out only on the basis of correlation indices. However, this index provides a measure only for linear relationships, while non-linear relationships can also be relevant. Moreover, not only synchronisation measures such as the correlation index are of interest, but also measures of the degree of dispersion, which however are often ignored. To

[36] In addition to the studies summarised in Appendix 1, other studies, such as Camacho et al (2005), use industrial production.

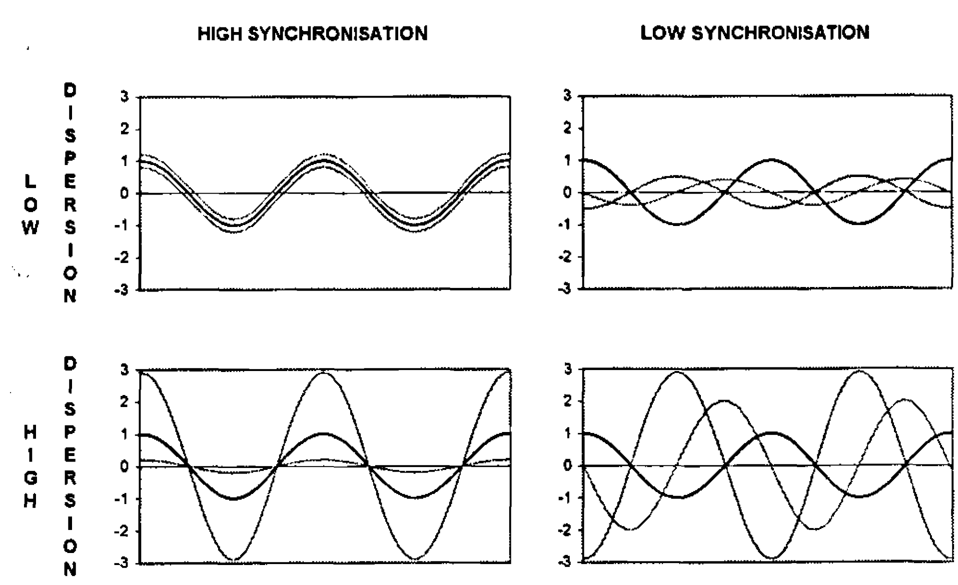
[37] These distortionary effects are documented by Nelson and Kang (1981) for linear detrending, by King and Rebelo (1993), Harvey and Jäger (1993) and Cogley and Nason (1995) for the Hodrick-Prescott filter[37], by Benati (2002) and Murray (2003) for the band-pass filter, by Osborn (1995) for moving average detrending.

[38] In addition to the studies summarised in Appendix 1, other studies, such as Perez et al (2003), use filters such as the Baxter and King band pass filter and the Hodrick and Prescott filter.

illustrate in a simple fashion how both measures are relevant, Figure 1 below shows different possible combinations of synchronisation and dispersion. Both measures are clearly relevant: for example, from a stabilisation policy point of view, it is important to know whether the cycles of the economies for which a common policy measure is chosen move in the same direction and are all above or below trend, but also whether the distance from the trend is similar or varies to a large extent.

C) Standard errors: most often no standard errors to the measures of association are reported, and even more rarely are robust, or heteroskedasticity and autocorrelation consistent (HAC), standard errors computed, which are particularly important for macroeconomic time series. Thus, most often it is not possible to conclude whether synchronisation or dispersion is significant, whether it significantly increased over time or whether the association within the euro area are significantly higher than for example with respect to the US.[39]

Figure 1 – Combinations of synchronisation and dispersion



[39] The danger of spurious cycles and the need of standard errors in relation to business cycle stylised facts identification were forcefully shown by Harvey and Jäger (1993), who conclude that "the danger of finding large sample cross-correlations between independent but spurious HP cycles is not negligible" and that "research on stylised business cycle facts should report standard errors in addition to point estimates of cross-correlations." (p. 245).

3) Questions addressed:

A) Comparison with other economic areas: several papers examine the degree of business cycle association among a group of countries to assess the existence of a common cycle, for example European countries to address the issue of the existence of a European cycle; however, often none or very few economies from other areas are included, thus not allowing to assess the possibility of a common cycle which is de facto not specific to the main group of countries examined. For example, if a number of other OECD economies are not considered, it is not possible to assess whether a high synchronisation among euro area cycles is specific to this economic area, and can therefore lead to the conclusion that a euro area specific cycle exists, or whether in fact this co-movement is part of a world business cycle either led by the US or resulting from the ongoing process of globalisation.

B) Comparison over time: the comparison over time is often carried out on the basis of a selection of sub-periods which is done informally (say, by decade) or on the basis of some criterion which, however, tends to be questionable. For example, often sub-periods are chosen on the basis of the prevailing exchange rate regime, but the international transmission of shocks also depends on factors other than the exchange rate system, as will be discussed more in detail.

An important criticism that has been put forward to both literatures, suggested by Frankel and Rose (1997, 1998), is that OCA criteria are endogenous, i.e. entry into a currency union affects structural economic developments in such a way to make the member country more suitable for participation ex post than ex ante. Some evidence seems to suggest that entry into a monetary union raises trade linkages and increases the similarity of shocks and cycles with the other member countries.[40] However, apart from the fact that the available evidence cannot be considered as conclusive, it is anyway of interest to establish the degree of synchronization before entering EMU, as for example it will affect the speed of ex post adjustment.

[40] See for example Frankel and Rose (1997, 1998), Rose (2000), Rose and Wincoop (2001) and Barro et al. (2002). For an overview of this literature in relation to EMU see also de Grauwe and Mongelli (2005).

This chapter aims at reporting and assessing evidence on the emergence of a common euro area business cycle in such a way as to avoid as much as possible the above-mentioned problems.

III. Data and Methods

III. 1. Data

We consider quarterly, seasonally-adjusted, real GDP time series from the OECD database spanning from 1960:1 to 2003:4 for 15 countries. The latter include seven euro area countries (Germany, France, Italy, Spain, the Netherlands, Belgium and Finland) producing more than 90% of the total output of the euro area.[41] The other euro area economies are not considered, either because the sample size is too short or because the respective data were assessed to be of low quality. In addition, also three other European economies (the United Kingdom, Sweden and Norway), and five other OECD countries (the United States, Japan, Canada, Mexico and Australia) are included. Thus, countries producing almost 90% of the total output of the OECD area are included in the sample. All series were assessed against comparable ones from other sources and in a two of cases the older data were either replaced or complemented so as to have a balanced sample size. [42] While all data are the result of the combination of different data sources and methods, such that the dataset is not perfectly harmonized neither across country nor across time, these data probably represent the most harmonized data set available for such a long time period.

The available data, sample periods and sources are shown in Table 1. The main source is OECD's Economic Outlook (OEO) database, but some series have been complemented or corrected using data from the OECD Main Economic Indicators (MEI) database. All series have been checked against the main official national sources (Eurostat in the case of European data), and the corresponding series from databases of the Bank for

[41] More precisely, using Eurostat ESA 95 annual data, the average actual exchange real-GDP weight of these countries from 1991 to 2003 was 92%. Results are qualitatively identical if OECD weights based on 2000 GDP and PPPs are used.

[42] Data for France before 1963 has been taken from a 2002 vintage of MEI estimates as the most recent MEI release starts in 1978. Similarly, data for Canada from 1960 to the first quarter of 1962 has also been taken from a 2002 vintage of MEI estimates for similar reasons.

International Settlements (BIS) and the IMF (IFS database). German data refer to unified Germany since January 1991 and has been extended backwards by scaling up the series of the former West Germany to the new German series using the ratio of the two series on the unification period. All data correspond to estimates as of 31 January 2005.[43]

Table 1 – Available series

country	ISO code	Sample Period	Source	EA weight[1)]	OECD weight[2)]
Germany	DEU	1960:1-2003:4	OEO (1960:1-2003:4)	34.1	7.6
France	FRA	1960:1-2003:4	MEI (1960:1-1963:1), OEO (1963:1-2003:4)	22.1	5.7
Italy	ITA	1960:1-2003:4	OEO (1960:1-2003:4)	15.3	5.3
Spain	ESP	1960:1-2003:4	OEO (1960:1-2003:4)	8.6	3.0
Netherlands	NLD	1960:1-2003:4	OEO (1960:1-2003:4)	6	1.6
Belgium	BEL	1960:1-2003:4	OEO (1960:1-2003:4)	3.9	1.0
Finland	FIN	1960:1-2003:4	OEO (1960:1-2003:4)	1.9	0.5
				91.9	
UK	GBR	1960:1-2003:4	OEO (1960:1-2003:4)		5.5
Sweden	SWE	1960:1-2003:4	OEO (1960:1-2003:4)		0.9
Norway	NOR	1960:1-2003:4	OEO (1960:1-2003:4)		0.6
US	USA	1960:1-2003:4	OEO (1960:1-2003:4)		36.4
Japan	JPN	1960:1-2003:4	OEO (1960:1-2003:4)		12.2
Canada	CAN	1960:1-2003:4	MEI (1960:1-1962:1), OEO (1962:1-2003:4)		3.3
Mexico	MEX	1960:1-2003:4	OEO (1960:1-2003:4)		3.3
Australia	AUS	1960:1-2003:4	OEO (1960:1-2003:4)		1.8
					38.5

Source: Eurostat and OECD.
1) 1991-2003 average of actual exchange rates GDP-weights (Eurostat annual national accounts data).
2) OECD weights based on 2000 GDP and PPPs.
Note: OEO: OECD Economic Outlook database. MEI: OECD Main Economic Indicators database.

Euro area aggregates were constructed using (fixed) actual exchange rate real GDP weights computed on the basis of the annual national accounts data of Eurostat, and correspond to the average weights from 1991 to 2003. The euro area main aggregate, constructed using the seven euro area cycles considered, is almost identical to aggregates constructed using also other euro area economies (for the sub-periods for which they are

[43] For more details on how each real GDP series is constructed by the OECD see *Sources & Methods of the OECD Economic Outlook* (available online at http://www.oecd.org/dataoecd/29/23/25501352.pdf) and in particular the *Economic Outlook Database Inventory (EO76 December 2004 version)*, available at http://www.oecd.org/dataoecd/47/9/2742733.pdf.

available) as well as the OECD aggregate (available starting from 1963). In addition, seven other euro area aggregates were computed, each excluding in turn one of the seven euro area economies considered. These partial euro area aggregates are used to assess developments of the country excluded compared to the euro area, as it can be shown that assessing the co-movement of one indicator with one of its components can potentially lead to biased results.[44] As will be shown, this approach leads to significantly different indications for at least one case (Germany).

III. 2. Estimation of the deviation cycles

In order to estimate the deviation cycle for each country and the euro area aggregates a univariate unobserved components model was applied to each real GDP series in levels after taking natural logarithms. The modelling strategy was based on the diagnostics tests, residual graphics and auxiliary residual graphics, following the procedure suggested by Harvey and Koopman (1992) and Harvey (2001). More precisely, for each quarterly real GDP series, expressed as natural log-levels of the index (with base 1960:1=100), a so-called basic structural time series model (that is, stochastic level and slope trend, trigonometric seasonal component and irregular component) augmented with a stochastic cycle has been estimated. Once convergence was ensured (if necessary by increasing the number of iterations), the well-specification of the basic general model was checked and possible outliers and breaks was tested using the auxiliary residuals, the significance of the variance of each component was tested and if found not different from zero (implying a deterministic component) the significance of that component was tested. A reduction of the general model was undertaken in steps, always checking for possible residual serial correlation and other signs of mis-specification via the available diagnostic tests (available in STAMP, such as the Box-Ljung Q-statistic). Table 2 reports the details of the final models estimated for each country. In all cases, the seasonal component was found to be insignificant, signalling the absence of residual seasonality after the seasonal-adjustment implemented by the OECD. Also in all cases the "*smooth trend*" representation (i.e. fixed level and stochastic slope) was found acceptable. Outliers, detected via auxiliary residuals,

[44] This point has for example been noted by Christiano and Fitzgerald (1999). They observe that the correlation between one aggregate (for example aggregate hours worked) and its components (hours worked in the various sectors) can be significant even if there is no correlation among components.

were found and corrected for by inserting dummies. The estimated cycles are plotted in figures 2 to 4. Note that this procedure takes into account the possibility of breaks in the variance and mean of each of the component. Thus, the possibility of breaks in the variability of growth found for some economies, which can affect business cycle association, is allowed for a tested in the current framework.[45]

Table 2 – Specifications of unobserved components models

country	trend	cycle	seasonal	irregular	outliers	breaks
Germany	smooth trend[1)]	stochastic (period 12)	no	no	70:1	
France	smooth trend[1)]	AR (1)	no	no	63:1, 68:2	
Italy	smooth trend[1)]	AR (1)	no	no	69:4	
Spain	smooth trend[1)]	stochastic (period 20)	no	no	86:2, 88:4, 90:4	
Netherlands	smooth trend[1)]	stochastic (period 20)	no	no	79:1	
Belgium	smooth trend[1)]	stochastic (period 12)	no	yes	80:1	
Finland	smooth trend[1)]	stochastic (period 12)	no	yes		slope (75:1)
Euro area[2)]	smooth trend[1)]	stochastic (period 12)	no	yes	68:2	
Euro area ex. Germany	smooth trend[1)]	stochastic (period 12)	no	yes	68:2	
Euro area ex. France	smooth trend[1)]	stochastic (period 12)	no	no		
Euro area ex. Italy	smooth trend[1)]	stochastic (period 12)	no	yes	68:2	
Euro area ex. Spain	smooth trend[1)]	stochastic (period 12)	no	no	68:2	
Euro area ex. Netherlands	smooth trend[1)]	stochastic (period 12)	no	yes	68:2	
Euro area ex. Belgium	smooth trend[1)]	stochastic (period 12)	no	yes	68:2	
Euro area ex. Finland	smooth trend[1)]	stochastic (period 12)	no	yes	68:2	
UK	smooth trend[1)]	stochastic (period 20)	no	yes	73:1,2; 74:1; 79:2	
Sweden	smooth trend[1)]	stochastic (period 20)	no	yes	66:3, 68:1, 80:2	
Norway	smooth trend[1)]	stochastic (period 20)	no	yes	70:1, 75:1	
US	smooth trend[1)]	stochastic (period 20)	no	no		
Japan	smooth trend[1)]	AR (1)	no	no	68:4, 73:4, 89:1	
Canada	smooth trend[1)]	stochastic (period 12)	no	no		
Mexico	smooth trend[1)]	stochastic (period 20)	no	no	86:2; 87:2; 94:4; 95:2,3	
Australia	smooth trend[1)]	AR (1)	no	no		

Source: Own computations.
1) Fixed level and stochastic slope.
2) Aggregate using the seven euro area countries considered.
Note: the period of the stochastic cycle corresponds to $2\Pi/\lambda$.

45 See Stock and Watson (2003) for a review of the evidence on breaks in the variability of growth for the G7 economies.

Figure 2 – Euro area country cycles *(percentage deviations from trend)*

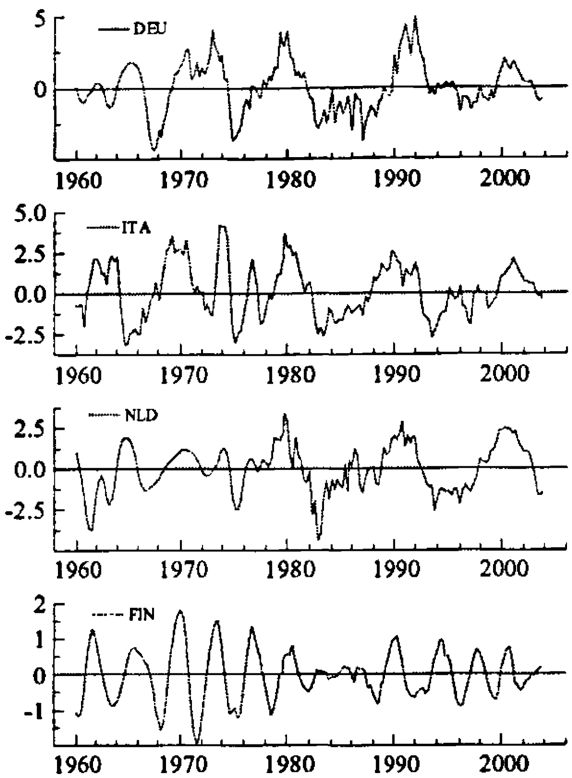


Figure 3 – Euro area aggregate cycles *(percentage deviations from trend)*

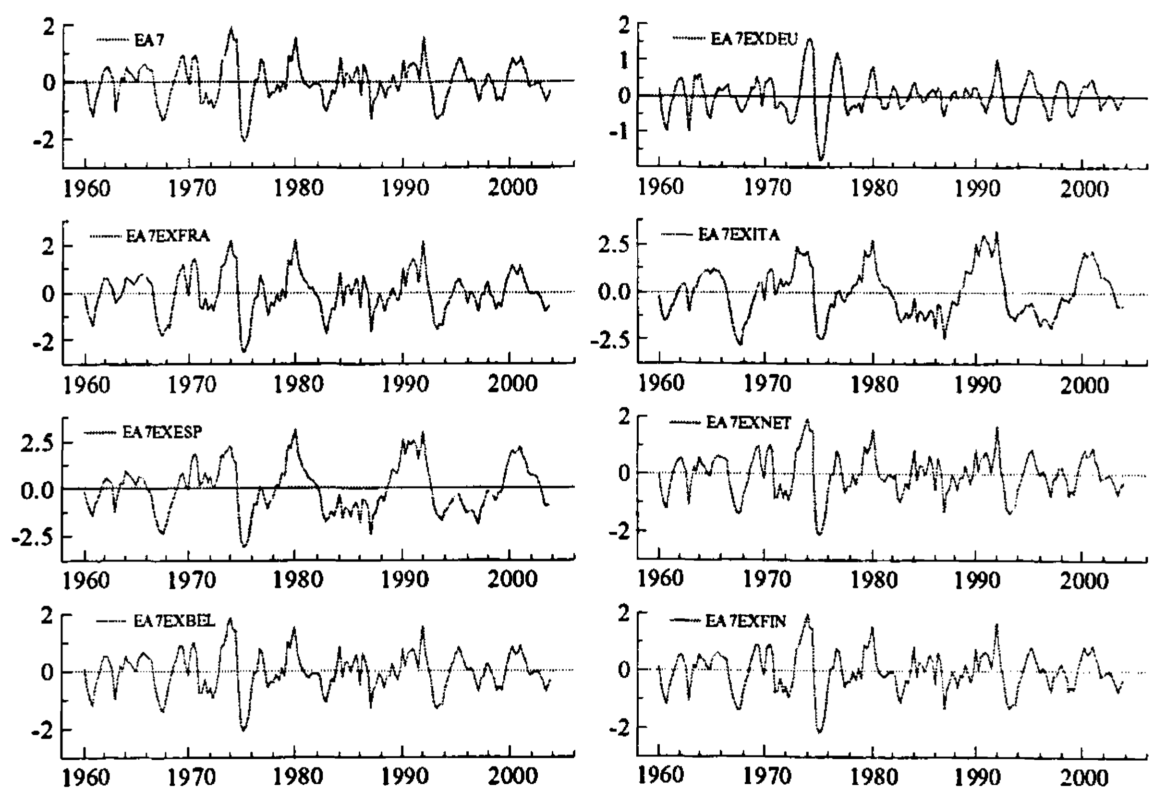
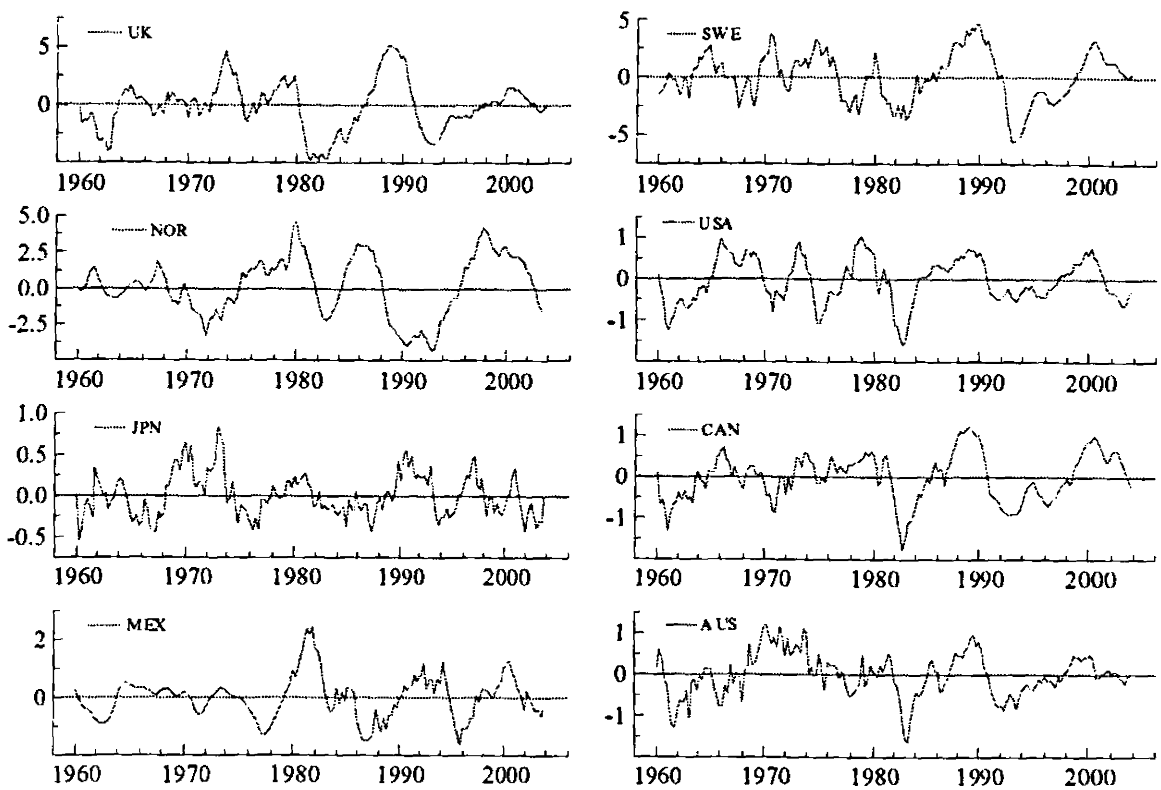


Figure 4 – Other OECD cycles *(percentage deviations from trend)*



III. 3. Measures of association

Association among cycles is assessed using two sets of measures, one relating to synchronisation and another describing dispersion.

As regards synchronisation, two indices are taken into account. First, as is usually done, correlation indices are computed. These describe the linear association between pairs of cycles. Robust standard errors for correlations are computed using the Newey-West heteroskedasticity and autocorrelation consistent method suggested by Newey and West (1987) with the automatic lag selection procedure proposed by Newey and West (1994).[46]

Second, concordance indices are computed. The latter measure essentially how frequently two series are in the same cyclical phase. They are based on (0-1) binary series for each

[46] We thank W. den Haan for kindly making available his Win-Rats codes for the computation of business cycle statistics robust standard errors; an adapted version was used for this chapter.

country, with ones signalling periods of expansion (above-trend) and zeros otherwise (below-trend), and for each pair represent the percentage of time units spent in the same phase of the cycle. Concordance indices have been advocated by Harding and Pagan (2002) and since then have become increasingly used as complements of correlation indices.[47] The advantage of also considering concordance indices is that they are robust to at least some forms of nonlinear relationships between cycles. In order to assess the degree of statistical significance of these indices, also the standardised concordance indices proposed by Artis et al (2004) were computed. The latter are computed using a Newey-West estimator (hence leading to heteroskedasticity and autocorrelation consistent standard errors) and can be easily interpreted as t-statistics. Binary series, needed to compute the concordance indices, were obtained using the algorithm proposed by Artis et al (2004) applied to each of the cycles (expressed as percentage deviations from trend). This algorithm, based on the theory of Markov chains, consists of a set of rules, including minimum requirements in terms of duration and amplitude of business cycle phases. They can be seen as an extension to quarterly data of the Bry-Boschan algorithm, with the advantage of being more flexible, for example by allowing the imposition of restrictions also in terms of minimum amplitude. The later, however, is to some extent an arbitrary step, as no specific threshold is commonly accepted in the literature. Thus, we compute two sets of binary indices, for two different minimum amplitude thresholds. More precisely, we have imposed the following restrictions: 1) peaks and troughs must alternate; 2) each phase must last at least two quarters; 3) each cycle must last at least five quarters; 4) a trough can be located only among quarters of negative (below-trend) values of the cycle and a peaks only among positive (above-trend) values; 5) a turning point can only be located among points where the cycle has a minimum magnitude (or distance from the trend): the two alternative thresholds chosen in terms of percentage deviations from trend are plus and minus 0.1% and 0.2%. Note that rules 2 and 3 are selected as they correspond to the minimum requirements imposed for monthly data in the Bry-Boschan

[47] As observed by Artis et al. (2004), concordance indices were already well-known in the statistical literature as *simple matching similarity coefficients*.

algorithm, which is the most widely diffused algorithm used to locate turning points with monthly data. Rule 5 is imposed simply in order to isolate only major fluctuations. [48]

To assess the evolution of synchronisation over time, rolling correlations and concordance indices will be computed. These show the measures for shifting sub-period, with a length (or "window") corresponding to the average duration of cycles. While these measures are computed for pairs of cycles, they can be aggregated for certain groups, as a convenient way to summarise the evidence for specific areas. The main reference aggregation will be carried out using the relative real output weights, as it can be argued that idiosyncratic patterns by larger economies can have a significantly more important implications.

As regards dispersion measures, standard deviations and diffusion indices are computed. The former are calculated with reference to the cycles expressed as percentage deviations from trend, while the latter are computed with reference to the binary series and represent the percentage of series which are in the same business phase. Diffusion indices can be computed either with reference to a specific cyclical phase (say, the percentage of cycles that in each period are in an expansion) or with reference to one series (for example, for each quarter the percentage of euro area cycles which are in the same phase as the euro area aggregate). The latter option was chosen in the present study, taking as reference the euro area aggregate cycle, the German cycle and the US cycle in turn. Both standard deviations and diffusion indices measures yield a value of dispersion for each moment in time among a set of cycles. In both cases, also weighted measures can be computed by multiplying each index by the relative weight within the set considered. The weighted measures can be more relevant in several contexts as for example, among the euro area economies, deviations of a given magnitude of the German or French cycles from the (weighted) average may have stronger implications than deviations of the same magnitude of the Finnish or Belgian cycles. Thus, weighted averages will be given more importance in the present study, but also simple averages will be reported for reference.

[48] I thank Tommaso Proietti for kindly making available his Ox codes for the computation of the standardised concordance indices as well as the AMP algorithm.

III. 4. Breaks

In order to delimit possible sub-periods over which to assess the evolution of cyclical association, tests for multiple breaks are carried out. The basic test applied is the multiple breaks test proposed by Bai and Perron (1998).[49] This test has several advantages compared to other existing tests, namely it allows for testing of multiple structural breaks (of unknown timing) in a consistent framework, it allows taking into account possible serial correlation and heteroskedasticity in the data and it not only locates the date of the break but also provides confidence intervals around the date. The width of the confidence interval can be interpreted as a measure of the degree of abruptness of the break.[50] The form of the test we use is relatively simple and is based on the regression

$$y_t = \delta_j + \sum_{i=1}^{k} \beta_i y_{t-i} + u_t$$

where $j=1,\ldots, m+1$ (with m being the number of breaks), $t = T_{j-1}+1,\ldots,T_j$, and y_t is measure of association (which is represented by rolling correlations and rolling concordance time series in the case of synchronisation measures and standard deviations and diffusion time series for the case of dispersion measures). The test amounts to testing for breaks in δ_j. In the absence of lagged values in the dependent variable, the test would allow to identify abrupt breaks, while by including one or more lag ($k\geq1$) it would detect more gradual changes. As discussed in Bai and Perron (2003a), the alternative procedures they propose –a sequential procedure and various information criterion procedures- have different advantages. For example, the procedure based on the Bayesian Information Criterion (BIC) appears to work particularly well if breaks are present under the null, and if serial correlation is present. However, the sequential procedure can also take into account potential heterogeneity across segments. Thus, we consider the results of both the sequential procedure and the BIC procedure, applied to both the case of no lags in y_t and one lag.[51] We allow up to five breaks in each series but each regime (isolated by the

[49] See also Bai and Perron (2003a) for some empirical applications of their test.

[50] See also Hansen (2001) and Banerjee and Urga (2005) for a discussion of the advantages of this test compared to alternative ones.

[51] Since including two or three lags didn't produce results significantly different from the case of just one lag, only the results of the latter case are taken into account.

breaks) must last at least 15% of the observations. Standard errors are computed according to the procedure of Bai and Perron (2003b).[52]

IV. Results

IV. 1. What is the degree of association among euro area cycles over the whole sample period?

A positive and significant degree of association among euro area business cycles is a necessary condition for the existence of a common euro area business cycle. Cyclical association can be assessed in several different ways, but it can be argued that synchronisation and dispersion are the most important aspects of it.

As regards synchronisation, Table 3 reports the two measures considered, correlation and concordance statistics, for all business cycles considered with respect to the euro area aggregate cycle (for the case of the individual euro area economies these indices are computed with respect to euro area aggregates excluding the respective country). All correlation indices of the seven euro area cycles with respect to the euro area are positive and strongly significant. Moreover, in all cases the contemporaneous correlation coefficient coincides with the maximum correlation (among those computed by shifting the national cycles series from minus 12 to plus 12 quarters), except for Finland for which the maximum correlation is however not significantly different from the contemporaneous one. Concordance indices provide similar indications, with two exceptions. Contemporaneous concordance statistics are not significant for Italy and Finland. The maximum concordance index for Italy is strongly significant, but is found for Italy leading the euro area (excluding Italy) aggregate by three years. For Finland neither the contemporaneous nor the maximum concordance coefficients are significantly different from zero. While at first glance these two cases are not easy to interpret, it will become easier to understand them the association among cycles over different subperiods will be analysed, as in the next section.

[52] For the test we use the GAUSS code (2004 revision) kindly provided by Pierre Perron in his webpage.

Taking as reference the euro area aggregates excluding each euro area economy in turn does not seem to lead to significantly different results, except for the case of Germany (see Tables A1 to A3 in Appendix 2). More precisely, the degree of association of the German cycle with the euro area excluding Germany aggregate is significantly lower, though still significantly positive, compared to that with respect to the euro area aggregate (including Germany). This applies to both correlation and concordance indices. It can also be observed that results are very similar across binary indices considered (that is, those derived by applying a 1% or a 2% amplitude minimum threshold in the AMP algorithm). As shown in Appendix 2, the association among euro area aggregates is very high (see Table A4).

Table 3 – Measures of synchronisation with respect to the euro area

	correlation indices								concordance indices							
	contemporaneous			maximum (if different)				max	contemporaneous			maximum (if different)				max
	value	st error		value	st error	shift		diff?	index	st conc		value	st conc	shift		diff?
Germany	0.33	(0.13)	*			=			0.64	(2.65)	*			=		
France	0.61	(0.12)	*			=			0.69	(3.29)	*			=		
Italy	0.54	(0.15)	*			=			0.51	(0.10)	ns	0.74	(3.45)	+12	*	YES
Spain	0.33	(0.13)	*			=			0.64	(2.31)	*			=		
Netherlands	0.49	(0.14)	*			=			0.70	(3.33)	*			=		
Belgium	0.69	(0.09)	*			=			0.68	(3.22)	*			=		
Finland	0.44	(0.10)	*	0.47	(0.10)	+1	*	NO	0.57	(1.39)	ns	0.60	(1.83)	+2	ns	NO
average EA	0.49			0.50					0.63			0.67				
UK	0.28	(0.14)	*	0.30	(0.12)	+1	*	NO	0.59	(1.29)	ns	0.61	(1.75)	-1	ns	NO
Sweden	0.29	(0.12)	*			=			0.64	(2.23)	*			=		
Norway	0.05	(0.13)	ns	0.07	(0.13)	+12	ns	NO	0.55	(0.87)	ns			=		
average EUR	0.41			0.41					0.62			0.65				
US	0.32	(0.12)	*	0.35	(0.11)	+1	*	NO	0.58	(1.21)	ns			=		
Japan	0.36	(0.07)	*			=			0.60	(1.59)	ns	0.65	(2.51)	-2	*	YES
Canada	0.28	(0.11)	*	0.28	(0.11)	+1	*	NO	0.61	(1.75)	ns	0.62	(1.9)	-1	ns	NO
average G-7	0.39			0.40					0.60			0.65				
Mexico	0.16	(0.10)	ns	0.23	(0.14)	-8	ns	NO	0.59	(1.42)	ns	0.61	(1.92)	-2	ns	NO
Australia	0.10	(0.12)	ns	0.13	(0.11)	+2	ns	NO	0.53	(0.46)	ns	0.56	(0.97)	+2	ns	NO
average all	0.35			0.37					0.61			0.63				

Note: The euro area aggregate is based on the seven euro area countries. The "shift" column reports the lead (+) and lag(-) at which the maximum association is found. For example, according to the maximum concordance index, Italy leads the euro area aggregate (excluding Italy) by 12 quarters. The "max diff? " column reports results of testing for the difference between the contemporaneous and maximum synchronisation value.

It could be argued that it is questionable to assess the degree of association of euro area cycles with euro area aggregates, which may reflect heterogeneous developments over such a long period. To evaluate whether such claim could drive the results, similar computations can be done with respect to the cycle of the German economy, which often played the most influential economic role in continental Europe. As shown in Table 4, results for euro area cycles with respect to the German one are similar: in most cases both correlation and concordance coefficients are significantly positive and the maximum and contemporaneous indices coincide, with the exception of the concordance indices for Italy and Finland. However, with respect to Germany also for Spain country specific cyclical developments seem to emerge. For Spain the correlation coefficient is not significantly positive and the concordance coefficient at one lag is marginally significant.

The assessment of dispersion is more easily undertaken by comparing the corresponding measures across different areas, and therefore will be discussed in the next sub-section.

Table 4 – Measures of synchronisation with respect to Germany

	correlation indices								concordance indices							
	contemporaneous			maximum (if different)				max	contemporaneous			maximum (if different)				max
	value	st error		value	st error	shift		diff?	index	st conc		value	st conc	shift		diff?
France	0.61	(0.11)	*			=			0.72	(3.54)	*	0.75	(3.96)	-1	*	NO
Italy	0.39	(0.14)	*			=			0.57	(0.96)	ns	0.72	(3.34)	+10	*	YES
Spain	0.24	(0.12)	ns			=			0.61	(1.93)	ns	0.62	(1.98)	-1	*	NO
Netherlands	0.62	(0.13)	*	0.63	(0.12)	+1	*	NO	0.69	(2.82)	*			=		
Belgium	0.38	(0.09)	*			=			0.63	(2.17)	*	0.67	(2.90)	+12	*	NO
Finland	0.31	(0.13)	*			=			0.58	(1.44)	ns	0.60	(1.73)	-2	ns	NO
average EA	0.43			0.43					0.63			0.67				
											ns					
UK	0.19	(0.15)	ns	0.35	(0.18)	+6	ns	NO	0.59	(1.25)	ns	0.61	(1.52)	+2	ns	NO
Sweden	0.21	(0.14)	ns	0.24	(0.16)	+4	ns	NO	0.61	(1.56)	ns	0.63	(1.87)	+1	ns	NO
Norway	-0.21	(0.19)	ns	0.06	(0.14)	+12	ns	NO	0.51	(0.17)	ns	0.59	(1.38)	+12	ns	NO
average EUR	0.31			0.36					0.61			0.65				
US	0.20	(0.15)	ns	0.25	(0.18)	+2	ns	NO	0.62	(1.70)	ns			=		
Japan	0.52	(0.12)	*	0.55	(0.11)	+1	*	NO	0.73	(3.52)	*	0.74	(3.76)	+1	*	NO
Canada	0.16	(0.15)	ns	0.20	(0.14)	+2	ns	NO	0.60	(1.28)	ns			=		
average G-7	0.35			0.39					0.64			0.67				
Mexico	0.33	(0.13)	*	0.42	(0.18)	-7	*		0.63	(1.90)	ns	0.65	(2.18)	-8	*	NO
Australia	0.17	(0.14)	ns	0.32	(0.15)	+6	*		0.56	(0.85)	ns	0.61	(1.50)	+5	ns	NO
average all	0.29			0.35					0.62			0.65				

Note: The euro area aggregate is based on the seven euro area countries. The "shift" column reports the lead (+) and lag(-) at which the maximum association is found. For example, according to the maximum concordance index, Italy leads the euro area aggregate (excluding Italy) by 12 quarters. The "max diff?" column reports results of testing for the difference between the contemporaneous and maximum synchronisation value.

Overall, there are indications of a positive cyclical association among euro area cycles from 1960 to 2003. However, some idiosyncratic developments can also be detected. The latter largely reflect changing common patterns over time, as will be shown in the next section, suggesting that the time dimension is essential is assessing whether a common euro area business cycle exists.

IV. 2. How does the degree of association among euro area cycles compare with that among all European and OECD countries over the whole sample period?

The degree of synchronisation of the cycles of the other OECD economies with respect to both the euro area and Germany appears to be on average lower than that recorded for the euro area cycles. This applies to both the other European economies (UK, Sweden and Norway) and, even more so, the non-European economies. For example, in most cases correlation coefficients are lower and concordance statistics are not significant. A notable exception, already found in previous studies such as Artis and Zhang (1999, 2001), is represented by Japan, which seems to exhibit a relatively high degree of synchronisation with both the euro area and Germany. As regards the other European economies, the Norwegian one seems to be the most idiosyncratic one. Given the key role that oil price developments played in shaping the business cycle dynamics of the advanced economies since the 1970s, this idiosyncracy possibly reflects in large part the fact that Norway, in contrast to most other OECD economies, is a net oil-exporting country. The evidence for the UK is mixed: with respect to the euro area aggregate correlation statistics are relatively low but significant and concordance statistics are non-significant, while no significant statistic is found with respect to Germany. The case of Sweden is also puzzling to some extent, as it exhibits positive and significant synchronisation with respect to the euro area (for both measures) but the opposite is found with respect to Germany.

As regards dispersion, the two (weighted) measures considered give mixed indications (see Table 5). On the one hand, the average standard deviation among euro area cycles is higher than that among all European economies as well as, and even more, than that among all OECD economies. Thus, it would seem that heterogeneity is cyclical developments is particularly marked among euro area economies. However, the average diffusion with respect to both the euro area and Germany is higher for the euro area cycles, suggesting the opposite conclusion. While in part this can be explained by some specific euro area country heterogeneous pattern (possibly of some large country, as for example indicated by the fact that the average unweighted standard deviation for the euro area is lower compared to all Europe or all OECD, see Table A5 in Appendix 2), this also reflects the high dispersion recorded in the initial part of the sample, as will be illustrated in the next section.

Table 5 – Measures of dispersion

	Average Standard Deviation	Average Diffusion with respect to		
		Euro Area	Germany	United States
Euro area	0.43	72.3	65.0	61.2
Europe	0.36	68.6	62.6	64.2
OECD	0.22	62.0	63.6	73.2

Note: Weighted measures. The euro area aggregate is based on the seven euro area countries.

Overall, while there are clear indications that synchronisation among euro area cycles tends to be higher than that between euro area cycles and the cycles of the other advanced economies, dispersion measures provide more ambiguous indications. Thus, to some extent it is questionable whether it is possible to conclude that a specific euro area cycle can be detected for the whole sample period under consideration.

IV. 3. How does the degree of association of euro area cycles with the euro area aggregate (or Germany) compare to that with the US over the whole sample period?

A relevant question is whether the relatively high degree of association recorded for the euro area cycles does not in fact result from the fact that all or most of these economies lag the US one, implying that rather than a euro area region specific cycle it would be more appropriate to talk about a US-lead cycle.

This can be assessed by comparing synchronisation and dispersion measures of the euro area economies with respect to the US cycle. As regards the former, while most euro area economies tend to lag the US one, it can be observed that euro area cycles are in general more closely related to the euro area aggregate or Germany than to the US cycle, even taking into account the possible time shift (by comparing the maximum correlation and concordance statistics, see Table 6). By contrast, for the other economies, including all of the other three European ones, the opposite seems to be the case. The main exception is represented by Japan, which is clearly more closely associated with the euro area and Germany than with the US. The case of Mexico is more clear-cut: the magnitude of the maximum concordance with respect to the US is very similar to that with respect to Germany (but higher than that with respect to the euro area), but the maximum correlation coefficient is higher with respect to Germany. The maximum correlation coefficients for Mexico, however, are significant but relatively low, possibly reflecting frequent country specific crises.

Table 6 – Measures of synchronisation with respect to the United States

	correlation indices									concordance indices							
	contemporaneous			maximum (if different)				max diff?		contemporaneous			maximum (if different)				max diff?
	value	st error		value	st error	shift				index	st conc		value	st conc	shift		
Germany	0.20	(0.18)	ns	0.25	(0.15)	-2	ns	NO		0.62	(1.70)	ns			=		
France	0.31	(0.12)	*	0.37	(0.14)	-2	*	NO		0.55	(0.66)	ns	0.61	(1.63)	-2	ns	NO
Italy	0.20	(0.14)	ns	0.47	(0.15)	-4	*	YES		0.69	(2.77)	*	0.76	(3.81)	-3	*	NO
Spain	0.20	(0.09)	*			=				0.61	(1.78)	ns			=		
Netherlands	0.54	(0.12)	*	0.60	(0.13)	-1	*	NO		0.70	(2.92)	*	0.74	(3.42)	-2	*	NO
Belgium	0.17	(0.10)	ns	0.23	(0.11)	-2	*	NO		0.57	(1.21)	ns	0.62	(1.92)	+12	ns	NO
Finland	0.16	(0.13)	ns	0.17	(0.14)	-2	ns	NO		0.47	(-0.46)	ns	0.53	(0.56)	+12	ns	NO
average EA	0.25			0.33						0.60			0.64				
UK	0.64	(0.12)	*			=				0.77	(3.89)	*	0.78	(4.13)	-1	*	NO
Sweden	0.28	(0.16)	ns	0.41	(0.15)	-5	*	YES		0.58	(1.04)	ns	0.69	(2.66)	-5	*	YES
Norway	0.25	(0.15)	ns	0.26	(0.14)	+1	ns	NO		0.64	(2.13)	*	0.66	(2.45)	+3	*	NO
average EUR	0.29			0.36						0.62			0.66				
Japan	0.17	(0.12)	ns	0.23	(0.13)	-8	ns	NO		0.53	(0.32)	ns			=		
Canada	0.75	(0.11)	*	0.76	(0.13)	-1	*	NO		0.89	(5.79)	*			=		
average G-7	0.38			0.45						0.67			0.70				
Mexico	0.02	(0.15)	ns	0.30	(0.15)	-7	*	YES		0.60	(1.38)	ns	0.65	(2.19)	-3	*	YES
Australia	0.41	(0.15)	*	0.51	(0.15)	-2	*	NO		0.59	(1.21)	ns	0.64	(1.99)	-2	*	YES
average all	0.31			0.37						0.63			0.67				

Note: The euro area aggregate is based on the seven euro area countries. The "shift" column reports the lead (+) and lag(-) at which the maximum association is found. For example, according to the maximum concordance index, Italy leads the euro area aggregate (excluding Italy) by 12 quarters. The "max diff?" column reports results of testing for the difference between the contemporaneous and maximum synchronisation value.

As regards dispersion measures, the average diffusion with respect to the US seems to be higher for the all European economies and even more so for the overall OECD than for the euro area, providing some indication of region specific developments in the euro area (see Table 5). This is the case for both weighted and unweighted diffusion measures (see Table A5 in Appendix 2).

Overall, the hypothesis of a euro area common cycle driven by the US does not seem to be strongly supported by the evidence.

IV.4. Did the degree of association among euro area cycles increase over time?

The period from 1960 to 2003 was characterised by several important macroeconomic changes. For example, various exchange rate regimes were adopted by most European countries over this period, from the Bretton Woods system to the ERM of the EMS and finally monetary union (EMU). Moreover, trade of goods, services and capital was gradually liberalised. Other events had also an important impact on business cycle developments and cross-country linkages, including common shocks such as the two major oil shocks of the 1970s and region-specific shocks such as German unification in 1990. Thus, it would not be surprising to find that the degree of association among cycles of the advanced economies changed significantly over time.

Evidence supporting the non-constancy of (hypothesis of changing) cyclical association can be derived by observing the various measures of synchronisation and dispersion over time. As regards synchronisation, a visual inspection of rolling correlation and rolling concordance indices (both computed with reference to shifting five-year periods-corresponding to the average duration of the business cycles) seems to confirm this hypothesis in most cases (see Figures 5 and 6). Most often there is evidence of increased synchronisation. For example, the weighted average of the rolling correlations of the euro area cycles with respect to the euro area aggregate (excluding the corresponding euro area cycle) gradually increased over time, as shown in the upper left-hand chart of Figure 5. Similar evidence is found for the euro area cycles with respect to Germany, while no clear trend is found with respect to the US (see the mid and lower left-hand charts of Figure 5 respectively). By contrast, all concordance measures of euro area cycles seem to have increased over time, with respect to euro area, Germany and the US (see left-had column charts of Figure 6).

Figure 5 – Rolling Correlation *(5 years window, weighted, centred)*

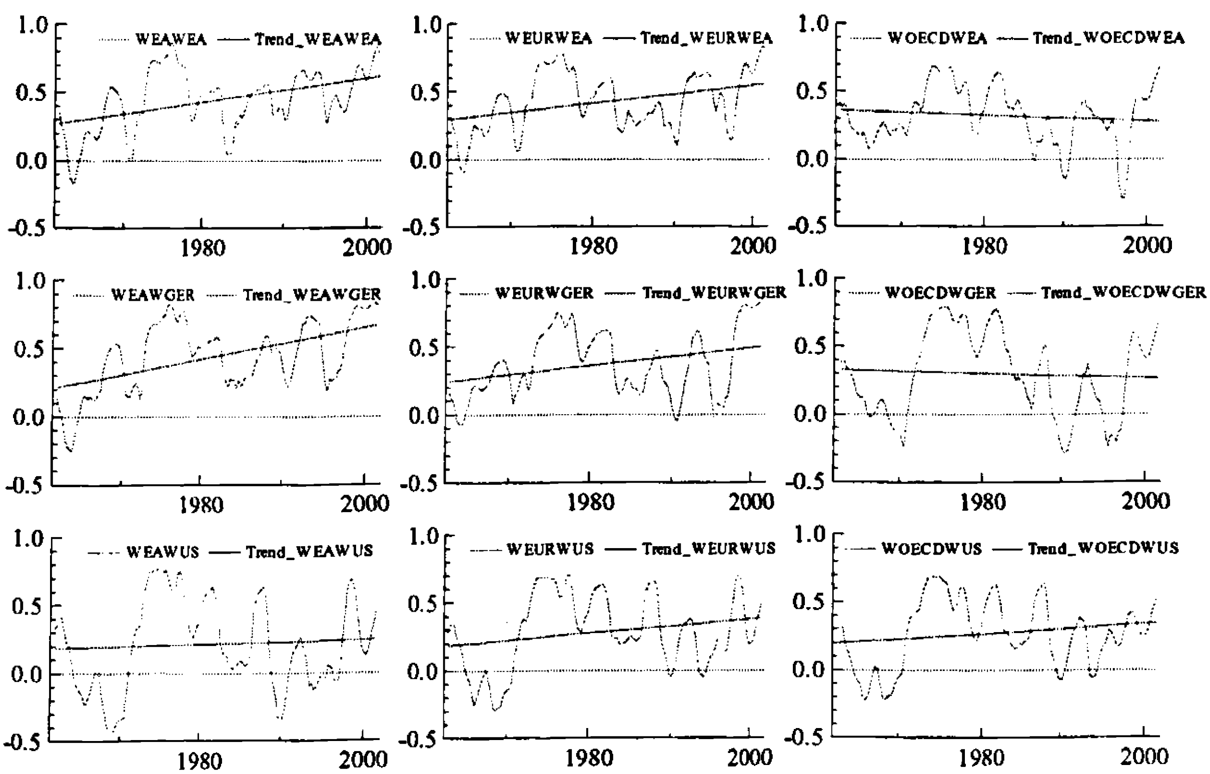
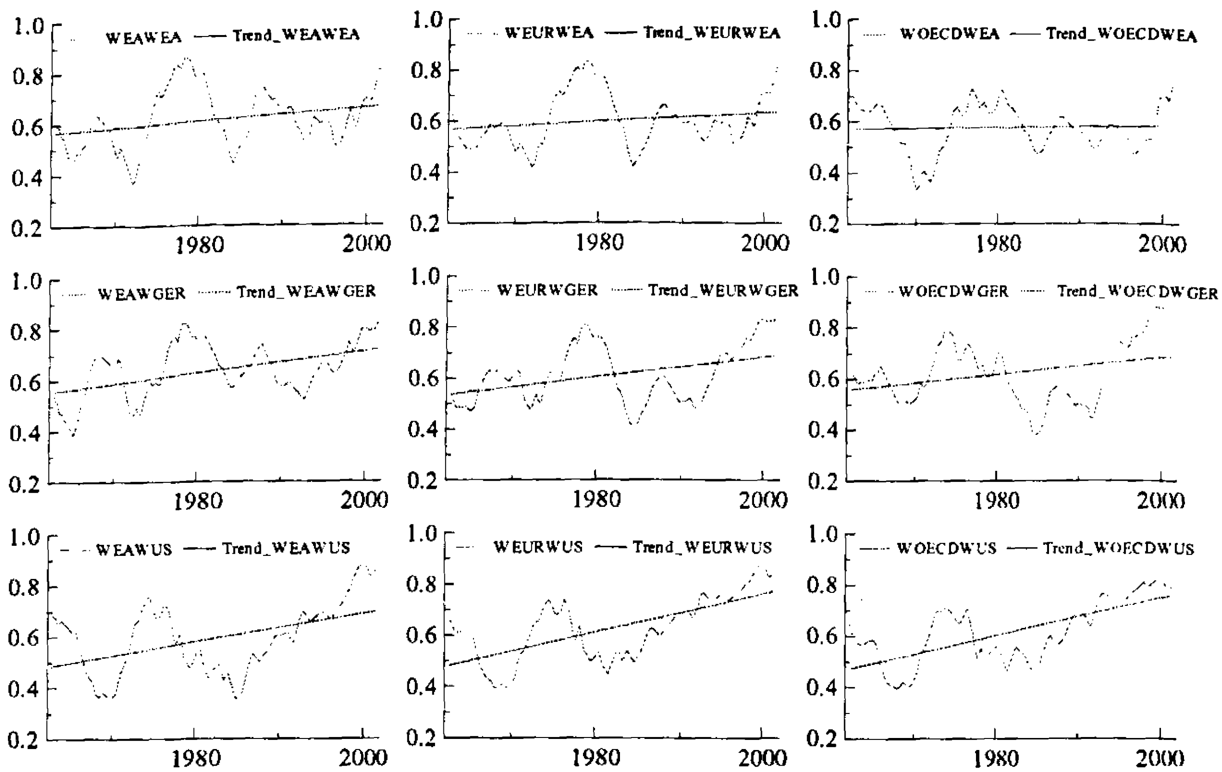


Figure 6 – Rolling Concordance *(5 years window, weighted, centred)*



As regards dispersion measures, the evolution of the (weighted) standard deviation of euro area cycles, which tended to gradually decrease, also provides support for the hypothesis of increased association of cycles within the euro area (see Figure 7). For example, the general trend, as captured by a linear trend, is clearly declining, with a value at the end of the sample which is about half that at the beginning of the sample (similar evidence is found for the simple, or unweighted, standard deviation measure, except that the latter is significantly higher, see Figure A1 in Appendix 2). By contrast, the evolution of the diffusion measures provides more mixed evidence. While the percentage of euro area cycles which are found to be in the same cyclical phase as the euro area aggregate cycle (ex) does not exhibit any clear changing trend, it tended to increase both with respect to Germany and the US (see left-hand column charts of Figure 8). Similar findings are obtained with reference to simple, or unweighted, measures (see Figure A2 in Appendix 2, although the increasing trend with respect to Germany is less marked).

Figure 7 – Weighted Standard Deviation

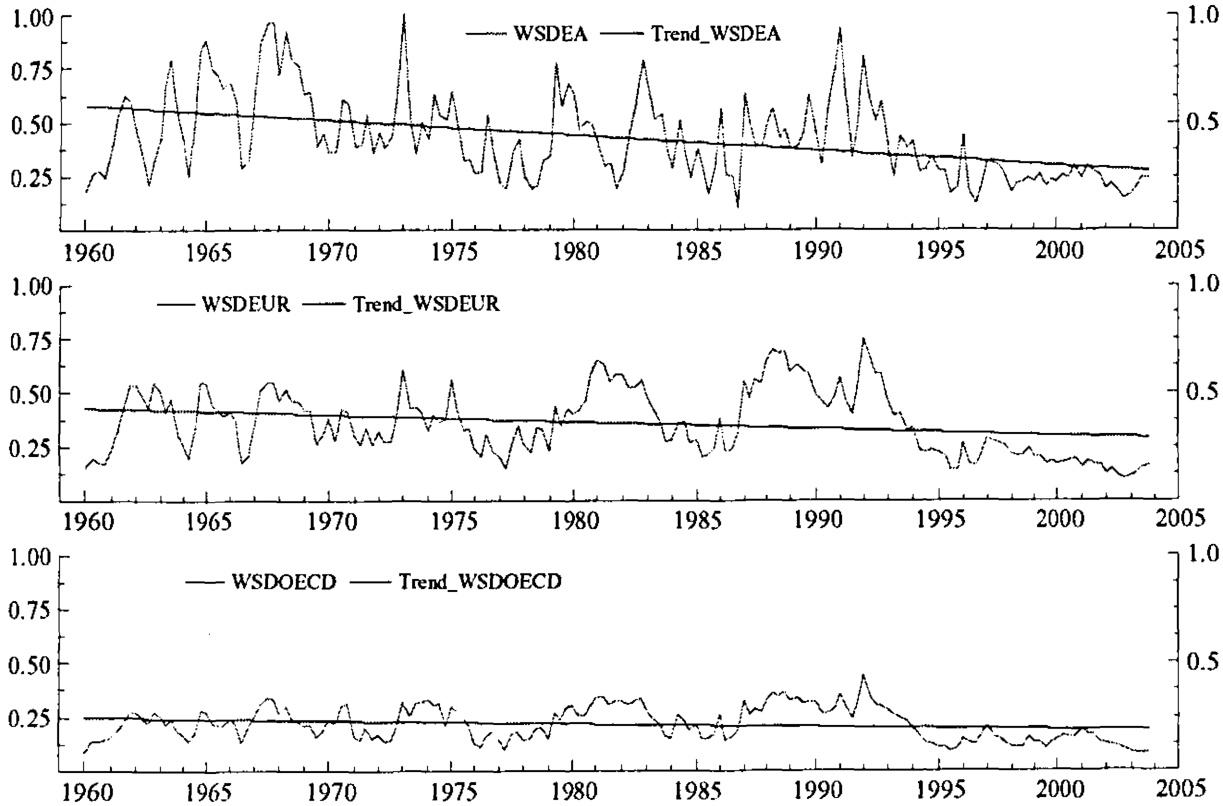
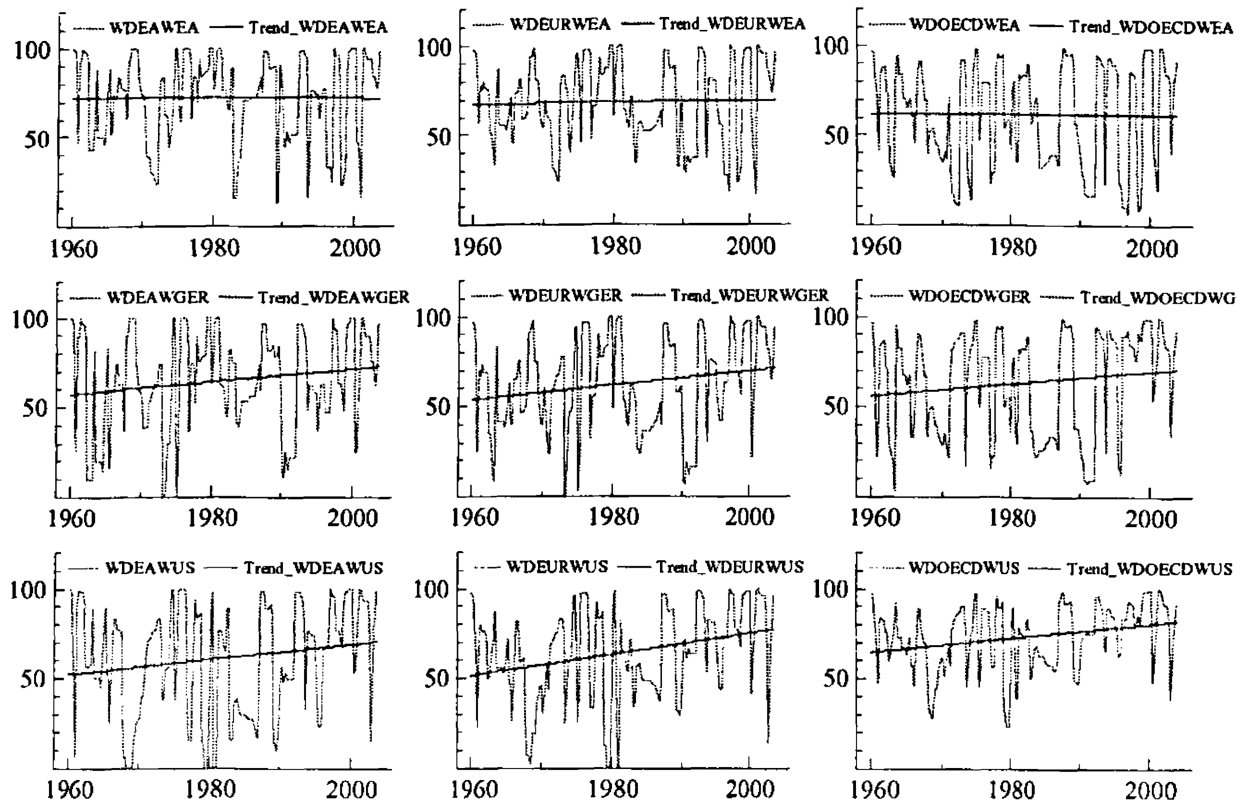


Figure 8 – Weighted Diffusion



Overall, clear evidence of changing cyclical associations can be found. However, to some extent the evidence is mixed, as for example not all measures suggest clearly that both synchronisation increased and dispersion decreased over time. This possibly reflects changing trends over time. To assess the latter possibility and identify periods for which clearer general tendencies can be found, it can be useful to compute the various measures of synchronisation and (average) dispersion over sub-periods. For this purpose, as already mentioned, various approaches can be used. Some approaches, including a division of the overall period by decade or half-decade, are arbitrary both economically and statistically. Other approaches, such as the one often used of dividing the overall period by sub-periods during which a different exchange rate regime prevailed, have an economic content but are problematic from at least two perspectives. First, what is more relevant is a *de facto* classification of exchange rate regimes (i.e., a classification based on actual policies followed) rather than a *de jure* classification (i.e., a classification based on official or announced policy of governments). These two may not coincide and the former is much more difficult to define.[53] Second, other factors play also an important role in determining business cycle linkages and frictions affecting them have changed over time. For example, barriers to trade in goods and services have been gradually been dismantled among advanced economies in most sectors.[54] In addition to trade and financial flows also other channels of international transmission have changed over time, including the increased speed and amount of information which flows internationally, which implies and increased interdependence of confidence and a higher rate of transfer of technological know how. Finally, other channels are less easy to isolate and describe, such as those which take place through multinational firms.[55] Thus, since several channels affect international business cycle association, and each of these may have changed over time significantly, the best approach which can be adopted to identify sub-periods of significantly different cyclical association is to apply statistical breaks tests to the various measures of synchronisation and dispersion. This approach has been adopted also in other studies, but so far not in a very flexible way. For example, Stock and Watson (2004) only consider the case of one break in the comovement of the G7 economies, and Doyle and Faust (2004) consider at most three breaks (also for the G7).

In the present study a more general approach is adopted by testing for multiple breaks using the Bai and Perron (1998) test in all measures of association allowing for up to five breaks. Thus, for each measure of synchronisation (rolling correlation and rolling concordance for each cycle with respect to the euro area aggregate, Germany and the US) and dispersion (weighted standard deviation among euro area, European and OECD groups and diffusion of each of these three groups with respect to the euro area aggregate, Germany and the US) two tests are run: one for abrupt breaks and one for gradual breaks and the results of two alternative procedures are considered (the sequential procedure and the BIC-based procedure, as explained in the previous section). It is

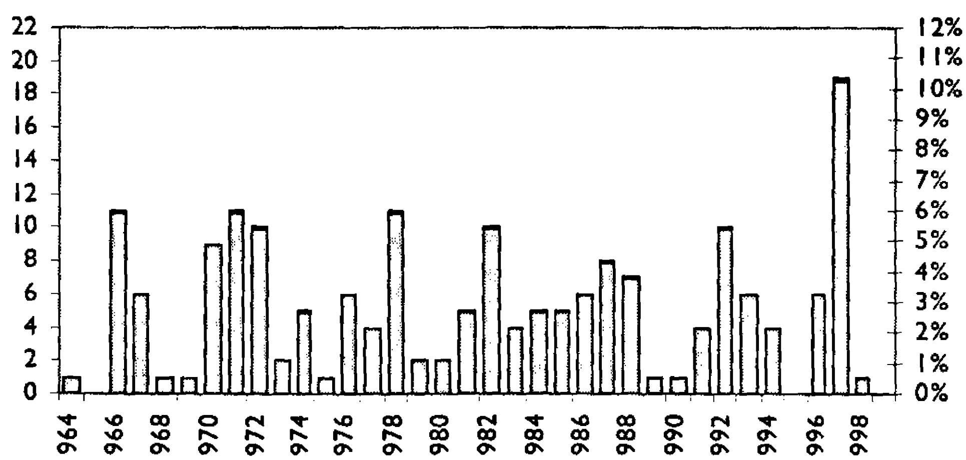
[53] See for example the two recent contributions by Reinhart and Rogoff (2004) and Levy-Yeyati and Sturzenegger (2005).

[54] For evidence on the importance of bilateral trade flows in determining business cycle affiliations see Frankel and Rose (1998) and Baxter and Kouparitsas (2005).

[55] See for example the discussion by Hanson and Slaughter (2004) and the evidence on international rent sharing within multinational firms reported by Budd and Slaughter (2004) and Budd et al (2005).

imposed that each subperiod must contain at least 10% of the observations, implying that the first possible break can be detected in 1964:3 for the dispersion measures and 1966:2 for the synchronisation measures, and the last possible break can be detected in 1999:4 and 1997:4 respectively. This amounts to 120 tests, of which 58 (i.e. about 48%) of the cases suggest the presence of one or more breaks. The total amount of breaks found is 185, and the distribution over time is shown in Figure 9. For more detailed results see similar figures for sub-groups of tests in Appendix 2 (Figures A3 and A4). It is interesting to note that the year with the highest number of breaks found was 1997, with 19 breaks (or 10% of the total). Most of the latter set of breaks was found to be abrupt breaks, with reference to measures of synchronisation and mainly with respect to the euro area (and Germany).

Figure 9 – Breaks



On the basis of these tests results, it was decided to divide the whole sample period into sub-periods delimited by a relatively high number of breaks concentrated in specific years. Imposing a minimum duration of five years for each sub-period (coinciding with the average duration of cycles) and taking as threshold periods the years in which at least 8 breaks (or 4% of the total) could be found, the following classification was chosen: 1) 1960 to 1966; 2) 1966 to 1971; 3) 1971 to 1978; 4) 1978 to 1982; 5) 1982 to 1987; 6) 1987 to 1992; 7) 1992 to 1997; 8) 1997 to 2003.

The picture that emerges from the correlation and concordance measures over these sub-sample periods is that of possibly three waves of synchronisation patterns. First, in the initial sub-periods through the 1970s synchronisation among euro area cycles tends on average to increase (see Table 5 as well as the upper left-hand side charts of Figures 10 and 11). Subsequently, throughout the 1980s sub-periods synchronisation tends mostly to decrease, and from the late 1980s onwards there is a clear increase in the degree of co-movement. This can be concluded by both observing the average correlation and concordance values for the euro area cycles, as well as by counting the number of significant indices among the euro area group. Similar findings for the euro area can be detected with respect to Germany (see Table 6 as well as the mid left-hand side charts of Figures 10 and 11).

Table 7- Measures of synchronisation with respect to the Euro area for sub-periods

	contemporaneous correlation															
	index	st error	index	st error	index	st error	index	st error	index	st error	index	st error	index	st error	index	st error
	1960-1966		1966-1971		1971-1978		1978-1982		1982-1987		1987-1992		1992-1997		1997-2003	
Germany	0.17	(0.19) ns	0.52	(0.17) *	0.43	(0.23) ns	0.47	(0.28) ns	0.71	(0.10) *	0.40	(0.33) ns	0.52	(0.13) *	0.49	(0.16) *
France	0.66	(0.25) *	0.34	(0.22) ns	0.92	(0.06) *	0.46	(0.26) ns	-0.11	(0.28) ns	0.69	(0.19) *	0.73	(0.19) *	0.74	(0.22) *
Italy	-0.23	(0.21) ns	0.24	(0.25) ns	0.66	(0.19) *	0.83	(0.13) *	0.48	(0.17) *	0.64	(0.21) *	0.61	(0.28) *	0.86	(0.10) *
Spain	0.24	(0.27) ns	0.21	(0.26) ns	0.58	(0.29) *	-0.12	(0.19) ns	0.04	(0.18) ns	0.10	(0.28) ns	0.64	(0.29) *	0.48	(0.15) *
Netherlands	0.25	(0.08) *	0.46	(0.24) ns	0.70	(0.20) *	0.72	(0.18) *	0.47	(0.08) *	0.76	(0.17) *	0.49	(0.19) *	0.72	(0.16) *
Belgium	0.55	(0.22) *	0.51	(0.14) *	0.87	(0.15) *	0.28	(0.24) ns	0.65	(0.06) *	0.68	(0.17) *	0.77	(0.17) *	0.65	(0.14) *
Finland	0.41	(0.13) *	0.59	(0.13) *	0.64	(0.19) *	0.44	(0.22) ns	-0.03	(0.15) ns	-0.02	(0.21) ns	-0.08	(0.19) ns	0.43	(0.14) *
average EA	0.29		0.41		0.69		0.44		0.32		0.46		0.53		0.62	
UK	0.31	(0.23) *	0.49	(0.19) ns	0.77	(0.16) *	0.52	(0.26) *	0.05	(0.26) *	-0.34	(0.20) ns	0.33	(0.29) ns	0.84	(0.10) ns
Sweden	0.36	(0.20) ns	0.48	(0.23) *	-0.02	(0.23) ns	0.83	(0.15) *	0.24	(0.25) ns	-0.06	(0.19) *	0.88	(0.11) ns	0.62	(0.24) ns
Norway	0.06	(0.14) *	-0.32	(0.34) ns	-0.10	(0.23) *	0.80	(0.18) *	0.35	(0.21) ns	-0.64	(0.18) ns	0.17	(0.28) ns	0.32	(0.15) *
average EUR	0.28		0.35		0.55		0.52		0.29		0.22		0.51		0.62	
US	0.52	(0.16) ns	0.05	(0.24) ns	0.55	(0.22) ns	0.53	(0.24) ns	0.43	(0.18) ns	-0.43	(0.16) ns	0.04	(0.25) ns	0.46	(0.23) ns
Japan	0.34	(0.20) ns	0.60	(0.19) *	0.30	(0.19) ns	0.58	(0.26) *	0.19	(0.20) ns	0.68	(0.17) *	0.03	(0.27) ns	0.31	(0.28) ns
Canada	0.56	(0.15) *	0.11	(0.21) ns	0.64	(0.26) *	0.63	(0.22) *	0.31	(0.25) ns	-0.37	(0.20) ns	0.42	(0.26) ns	0.61	(0.21) *
average G-7	0.33		0.33		0.61		0.57		0.30		0.18		0.38		0.61	
Mexico	0.30	(0.17) ns	0.24	(0.14) ns	0.22	(0.27) ns	-0.05	(0.16) ns	0.07	(0.24) ns	0.73	(0.09) *	-0.18	(0.23) ns	0.81	(0.11) *
Australia	-0.27	(0.19) ns	0.16	(0.25) ns	0.20	(0.20) ns	0.40	(0.25) ns	0.29	(0.18) ns	-0.32	(0.19) ns	0.10	(0.33) ns	0.15	(0.23) ns
average all	0.28		0.31		0.49		0.49		0.28		0.17		0.36		0.57	

	contemporaneous concordance															
	index	st conc	index	st conc	index	st conc	index	st conc	index	st conc	index	st conc	index	st conc	index	st conc
	1960-1966		1966-1971		1971-1978		1978-1982		1982-1987		1987-1992		1992-1997		1997-2003	
Germany	0.57	(0.54) ns	0.42	(-0.23) ns	0.56	(0.45) ns	0.85	(2.31) *	0.54	(1.27) ns	0.83	(2.51) *	0.79	(2.20) *	0.71	(1.51) ns
France	0.64	(1.09) ns	0.75	(1.52) ns	0.66	(1.22) ns	0.75	(2.00) *	0.71	(1.08) ns	0.67	(1.62) ns	0.63	(1.37) ns	0.82	(2.68) *
Italy	0.46	(-0.50) ns	0.25	(-1.58) ns	0.50	(0.20) ns	0.95	(2.25) *	0.38	(0.73) ns	0.58	(0.79) ns	0.38	(0.15) ns	0.75	(1.93) ns
Spain	0.54	(0.55) ns	0.63	(0.96) ns	0.81	(1.97) *	0.50	(-0.04) ns	0.58	(1.17) ns	0.50	(0.57) ns	0.67	(1.72) ns	0.71	(1.41) ns
Netherlands	0.64	(1.06) ns	0.83	(2.07) *	0.81	(2.44) *	0.95	(2.25) *	0.63	(1.62) ns	0.71	(1.42) ns	0.58	(0.59) ns	0.71	(1.56) ns
Belgium	0.71	(1.88) ns	0.83	(2.12) *	0.72	(1.80) ns	0.65	(0.91) ns	0.50	(0.45) ns	0.79	(2.59) *	0.67	(1.27) ns	0.61	(0.70) ns
Finland	0.75	(1.96) ns	0.75	(1.70) ns	0.69	(1.62) ns	0.60	(0.66) ns	0.38	(-1.31) ns	0.25	(-1.93) ns	0.42	(-0.62) ns	0.57	(0.50) ns
average EA	0.62		0.64		0.68		0.75		0.53		0.62		0.59		0.70	
UK	0.61	(1.29) ns	0.50	(-0.50) ns	0.66	(1.17) ns	0.65	(1.04) ns	0.33	(0.89) ns	0.50	(0.82) ns	0.67	(1.30) ns	0.79	(2.09) *
Sweden	0.57	(0.61) ns	1.00	(3.00) *	0.56	(0.66) ns	0.85	(2.00) *	0.46	(0.49) ns	0.54	(0.19) ns	0.67	(1.30) ns	0.68	(1.29) ns
Norway	0.61	(0.86) ns	0.33	(-1.46) ns	0.69	(1.71) ns	1.00	(2.48) *	0.58	(0.60) ns	0.25	(0.12) ns	0.63	(1.04) ns	0.54	(0.87) ns
average EUR	0.61		0.63		0.67		0.78		0.51		0.56		0.61		0.69	
US	0.82	(2.36) *	0.29	(-1.72) ns	0.59	(0.56) ns	0.65	(0.94) ns	0.50	(1.08) ns	0.54	(1.00) ns	0.63	(0.92) ns	0.71	(1.53) ns
Japan	0.61	(1.12) ns	0.71	(1.54) ns	0.41	(-0.78) ns	0.80	(1.67) ns	0.75	(1.68) ns	0.63	(0.98) ns	0.46	(-0.29) ns	0.57	(0.36) ns
Canada	0.79	(2.12) *	0.42	(-0.67) ns	0.69	(1.59) ns	0.80	(1.88) ns	0.50	(1.08) ns	0.54	(1.00) ns	0.58	(0.77) ns	0.68	(1.29) ns
average G-7	0.64		0.48		0.58		0.78		0.53		0.61		0.59		0.72	
Mexico	0.57	(0.89) ns	0.46	(-1.03) ns	0.66	(1.37) ns	0.65	(1.26) ns	0.63	(0.81) ns	0.75	(1.74) ns	0.42	(-0.66) ns	0.75	(1.82) ns
Australia	0.50	(-0.19) ns	0.75	(1.66) ns	0.53	(1.18) ns	0.65	(1.06) ns	0.54	(0.64) ns	0.38	(-1.36) ns	0.50	(0.00) ns	0.64	(1.06) ns
average all	0.63		0.59		0.64		0.75		0.53		0.56		0.58		0.68	

Table 8- Measures of synchronisation with respect to the Germany for sub-periods

	contemporaneous correlation															
	index	st error	index	st error	index	st error	index	st error	index	st error	index	st error	index	st error	index	st error
	1960-1966		1966-1971		1971-1978		1978-1982		1982-1987		1987-1992		1992-1997		1997-2003	
France	0.29	(0.24) ns	0.52	(0.21) *	0.82	(0.17) *	0.55	(0.25) *	0.28	(0.21) ns	0.66	(0.20) *	0.87	(0.16) *	0.91	(0.11) *
Italy	-0.59	(0.22) ns	0.26	(0.26) ns	0.48	(0.20) *	0.82	(0.14) *	0.43	(0.15) *	0.37	(0.24) ns	0.47	(0.31) ns	0.88	(0.12) *
Spain	-0.07	(0.32) ns	0.27	(0.27) ns	0.44	(0.26) ns	-0.07	(0.17) ns	-0.04	(0.18) ns	0.18	(0.27) ns	0.49	(0.31) ns	0.51	(0.17) *
Netherlands	0.67	(0.23) *	0.72	(0.22) *	0.65	(0.15) *	0.86	(0.07) *	0.39	(0.06) *	0.74	(0.14) *	0.80	(0.19) *	0.88	(0.17) *
Belgium	0.68	(0.12) *	0.42	(0.24) ns	0.44	(0.22) ns	0.18	(0.25) ns	0.48	(0.07) *	0.47	(0.21) *	0.37	(0.29) ns	0.36	(0.21) ns
Finland	0.50	(0.20) *	0.41	(0.27) ns	0.38	(0.30) ns	0.34	(0.21) ns	-0.22	(0.13) ns	-0.01	(0.24) ns	-0.23	(0.29) ns	0.05	(0.22) ns
average EA	0.25		0.43		0.53		0.45		0.22		0.40		0.46		0.60	
UK	0.51	(0.23) *	0.08	(0.20) ns	0.63	(0.20) *	0.64	(0.26) *	-0.01	(0.21) ns	-0.62	(0.15) ns	-0.56	(0.27) ns	0.90	(0.11) *
Sweden	0.52	(0.15) *	0.732	(0.19) *	-0.26	(0.27) ns	0.816	(0.21) *	0.134	(0.20) ns	-0.37	(0.17) ns	0.212	(0.28) ns	0.883	(0.14) *
Norway	0.23	(0.26) ns	-0.67	(0.20) ns	-0.51	(0.23) ns	0.89	(0.10) *	0.17	(0.15) ns	-0.77	(0.16) ns	-0.62	(0.27) ns	0.09	(0.25) ns
average EUR	0.30		0.30		0.34		0.56		0.18		0.07		0.20		0.61	
US	0.55	(0.20) *	-0.50	(0.23) ns	0.75	(0.24) *	0.77	(0.20) *	0.19	(0.16) ns	-0.69	(0.15) ns	-0.34	(0.22) ns	0.38	(0.23) ns
Japan	-0.04	(0.20) ns	0.58	(0.20) *	0.76	(0.19) *	0.70	(0.23) *	0.24	(0.21) ns	0.78	(0.17) *	0.07	(0.25) ns	0.03	(0.30) ns
Canada	0.57	(0.18) *	-0.21	(0.23) ns	0.24	(0.23) ns	0.84	(0.14) *	0.18	(0.17) ns	-0.66	(0.15) ns	-0.38	(0.26) ns	0.87	(0.11) *
average G-7	0.21		0.12		0.61		0.72		0.22		-0.03		0.02		0.66	
Mexico	0.62	(0.24) *	-0.37	(0.19) ns	0.21	(0.25) ns	-0.19	(0.17) ns	0.21	(0.18) ns	0.90	(0.04) *	0.51	(0.27) ns	0.77	(0.12) *
Australia	0.08	(0.21) ns	0.47	(0.29) ns	0.43	(0.22) *	0.50	(0.24) *	0.23	(0.14) ns	-0.57	(0.16) ns	-0.71	(0.27) ns	0.30	(0.27) ns
average all	0.32		0.19		0.39		0.55		0.19		0.03		0.07		0.56	

	contemporaneous concordance															
	index	st conc	index	st conc	index	st conc	index	st conc	index	st conc	index	st conc	index	st conc	index	st conc
	1960-1966		1966-1971		1971-1978		1978-1982		1982-1987		1987-1992		1992-1997		1997-2003	
France	0.54	(0.27) ns	0.96	(2.47) *	0.69	(1.04) ns	0.75	(2.00) *	0.92	(2.75) *	0.67	(1.62) ns	0.54	(1.16) ns	0.89	(2.48) *
Italy	0.43	(-0.67) ns	0.29	(-1.45) ns	0.59	(0.98) ns	0.95	(2.25) *	0.38	(0.73) ns	0.58	(0.79) ns	0.79	(1.92) ns	0.68	(1.26) ns
Spain	0.50	(-0.06) ns	0.63	(0.96) ns	0.56	(-0.06) ns	0.50	(-0.04) ns	0.58	(1.17) ns	0.50	(0.57) ns	0.75	(1.83) ns	0.86	(2.43) *
Netherlands	0.68	(1.29) ns	0.63	(0.60) ns	0.47	(-0.58) ns	0.95	(2.25) *	0.42	(0.88) ns	0.79	(2.12) *	0.83	(2.19) *	0.96	(2.79) *
Belgium	0.86	(2.79) *	0.63	(1.31) ns	0.50	(0.08) ns	0.65	(0.91) ns	0.46	(0.96) ns	0.71	(2.03) *	0.75	(1.84) ns	0.50	(-0.30) ns
Finland	0.75	(1.88) ns	0.63	(1.41) ns	0.66	(1.49) ns	0.60	(0.66) ns	0.50	(-1.06) ns	0.33	(-1.14) ns	0.50	(-0.21) ns	0.46	(-0.40) ns
average EA	0.63		0.63		0.58		0.73		0.54		0.60		0.69		0.73	
UK	0.61	(0.98) ns	0.54	(0.34) ns	0.75	(1.62) ns	0.65	(1.04) ns	0.13	(0.59) ns	0.42	(0.28) ns	0.75	(1.64) ns	0.96	(2.81) *
Sweden	0.64	(1.07) ns	0.79	(1.86) ns	0.22	(-1.97) ns	0.85	(2.00) *	0.33	(0.65) ns	0.63	(0.93) ns	0.75	(1.64) ns	0.86	(2.05) *
Norway	0.75	(1.94) ns	0.13	(-2.23) ns	0.53	(-1.05) ns	1.00	(2.48) *	0.38	(-1.27) ns	0.17	(-1.60) ns	0.71	(1.36) ns	0.57	(1.33) ns
average EUR	0.64		0.58		0.55		0.77		0.45		0.53		0.71		0.75	
US	0.68	(1.34) ns	0.42	(0.34) ns	0.88	(2.71) *	0.65	(0.94) ns	0.29	(0.58) ns	0.46	(0.41) ns	0.79	(1.92) ns	0.96	(2.82) *
Japan	0.68	(1.49) ns	0.92	(2.32) *	0.69	(1.36) ns	0.80	(1.67) ns	0.96	(3.15) *	0.71	(1.78) ns	0.71	(1.40) ns	0.54	(-0.08) ns
Canada	0.64	(1.09) ns	0.46	(0.25) ns	0.78	(1.98) *	0.80	(1.88) ns	0.29	(0.58) ns	0.46	(0.41) ns	0.67	(1.05) ns	0.86	(2.05) *
average G-7	0.60		0.60		0.73		0.77		0.49		0.55		0.71		0.82	
Mexico	0.57	(0.65) ns	0.33	(0.66) ns	0.63	(1.25) ns	0.65	(1.26) ns	0.67	(1.44) ns	0.83	(1.60) ns	0.50	(-0.33) ns	0.93	(2.55) *
Australia	0.50	(-0.06) ns	0.54	(-0.20) ns	0.44	(0.94) ns	0.65	(1.06) ns	0.50	(1.04) ns	0.46	(-0.68) ns	0.58	(0.20) ns	0.89	(2.30) *
average all	0.63		0.56		0.60		0.75		0.49		0.55		0.69		0.78	

Figure 10 – Rolling Correlations *(5 years window, weighted, centred)*

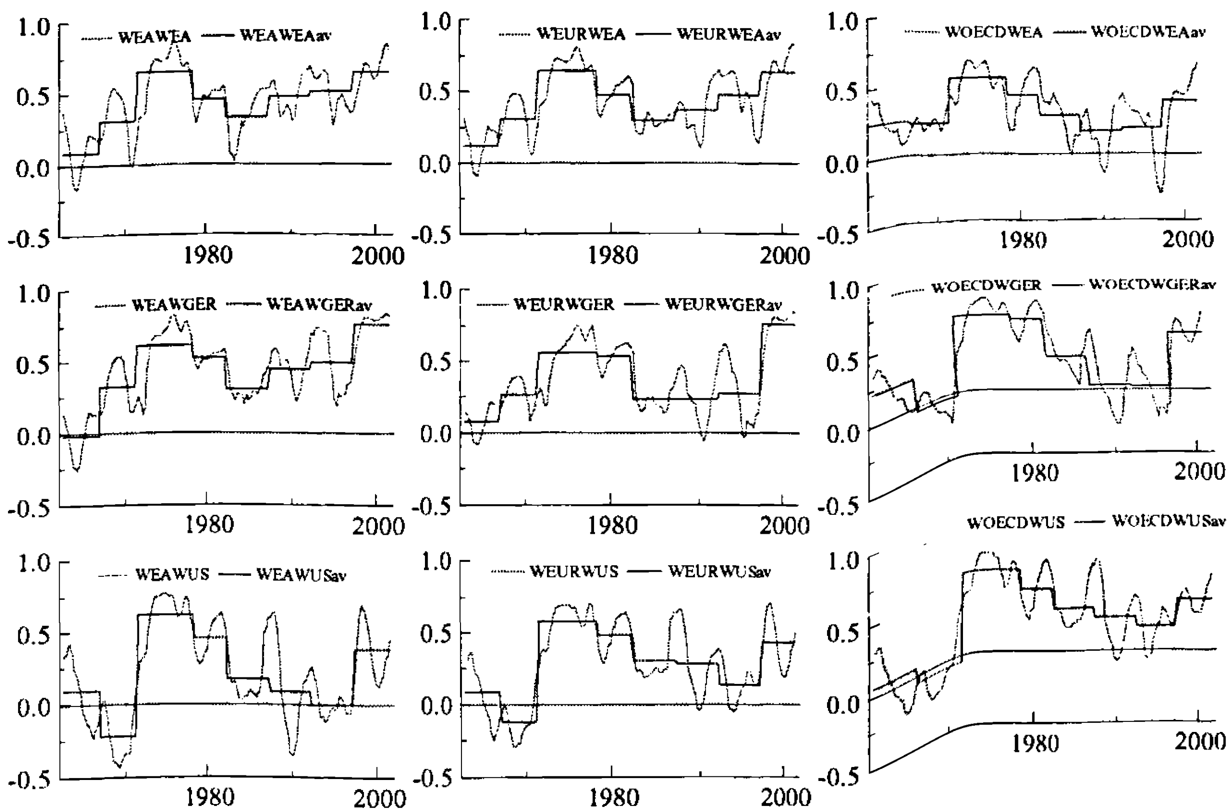
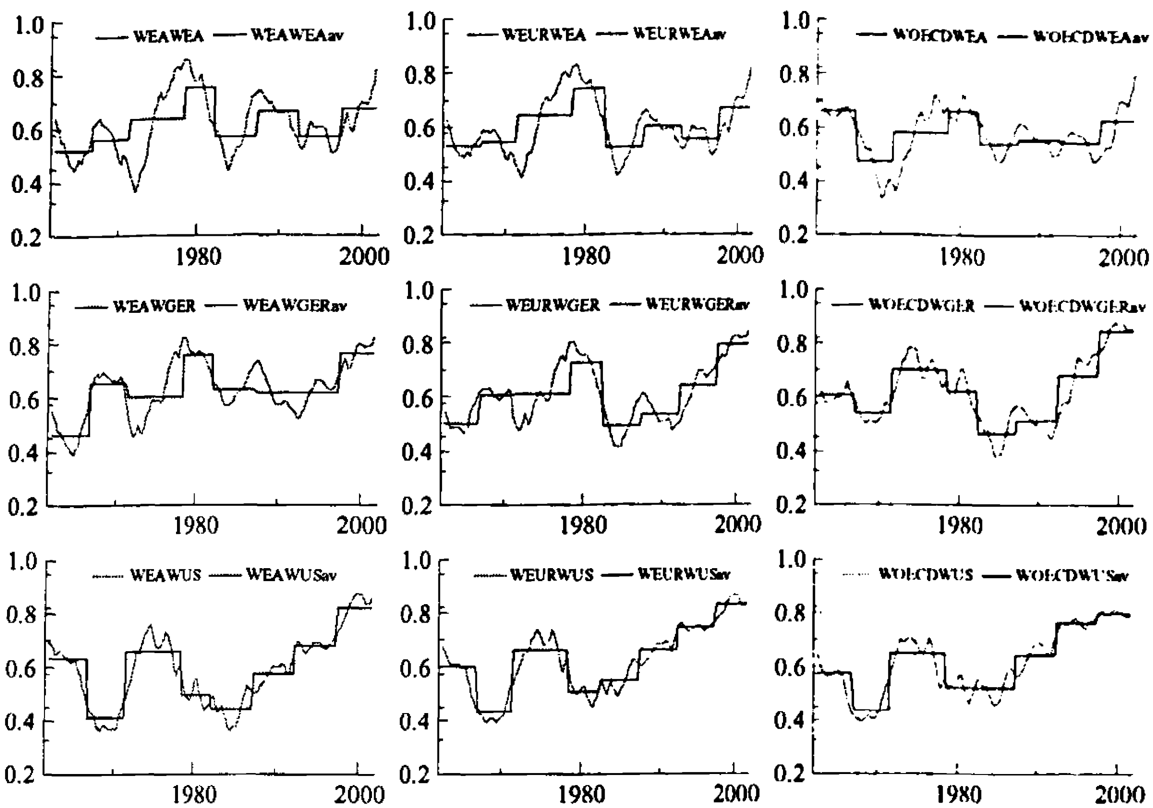


Figure 11 – Rolling Concordances *(5 years window, weighted, centred)*



A complementary approach to assess how the degree of association of business cycles evolved over time is to observe how the time shift at which maximum correlations and concordances are found changed over time. One way of summarising this aspect is to plot how the time shift at which maxima are found evolved over time. Figures 12 and 13 shows how these shifts with respect to the euro area, Germany and the US evolved over time. For example, the upper left-hand side chart of Figure 12 shows, for each quarter, the shift at which the maximum (weighted) average correlation between all euro area cycles with respect to the euro area aggregate cycle (excluding in turn the cycle under consideration) is found among those ranging from minus to plus four quarters. Overall, it can be observed that the maximum association is most often found at contemporaneous time (i.e. no shift), especially with reference to the correlation index. Similar indications result from the euro area cycles with respect to Germany. Thus, the evolution and magnitude if the contemporaneous correlations and concordance tend to be very similar to those or maximum correlations and concordance (see Figure 14 and 15). By contrast, euro area cycles tended most often to lag the US one. Moreover, deviations from these average patterns can be observed but there does not seem to be any tendency for these shifts to gradually change over time.

Figure 12 – Shift of maximum correlation over time

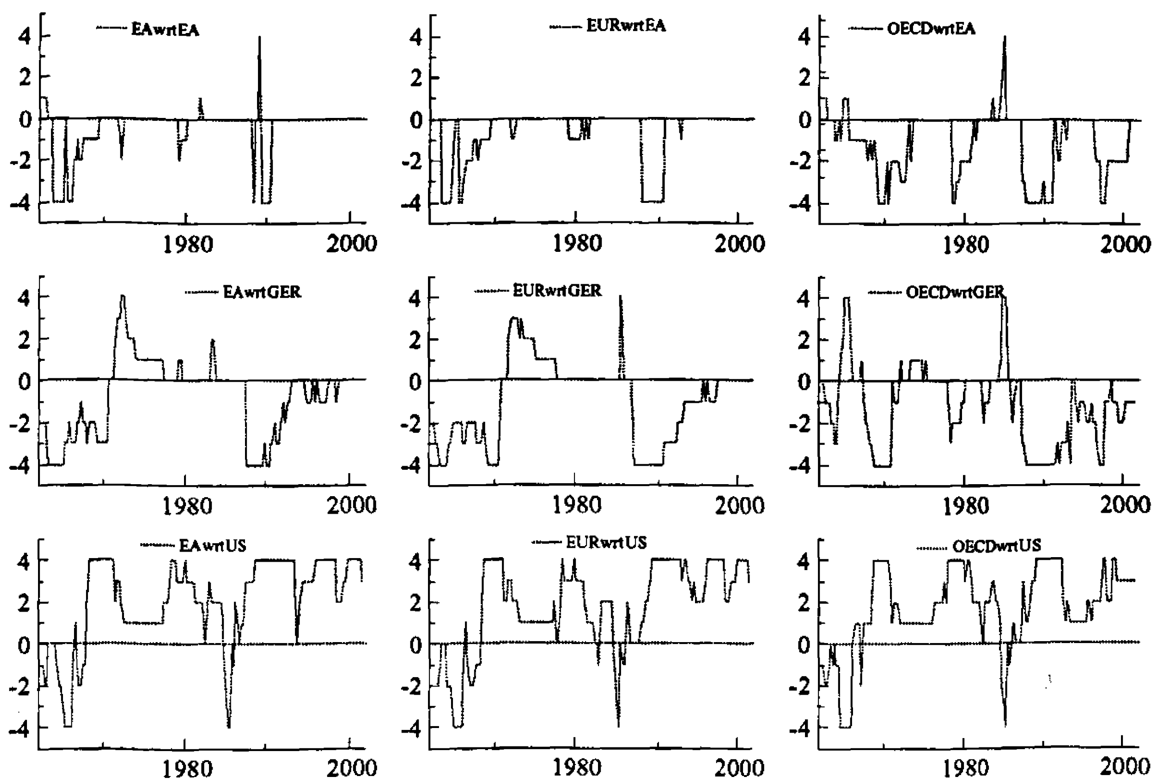


Figure 13 – Shift of maximum concordance over time

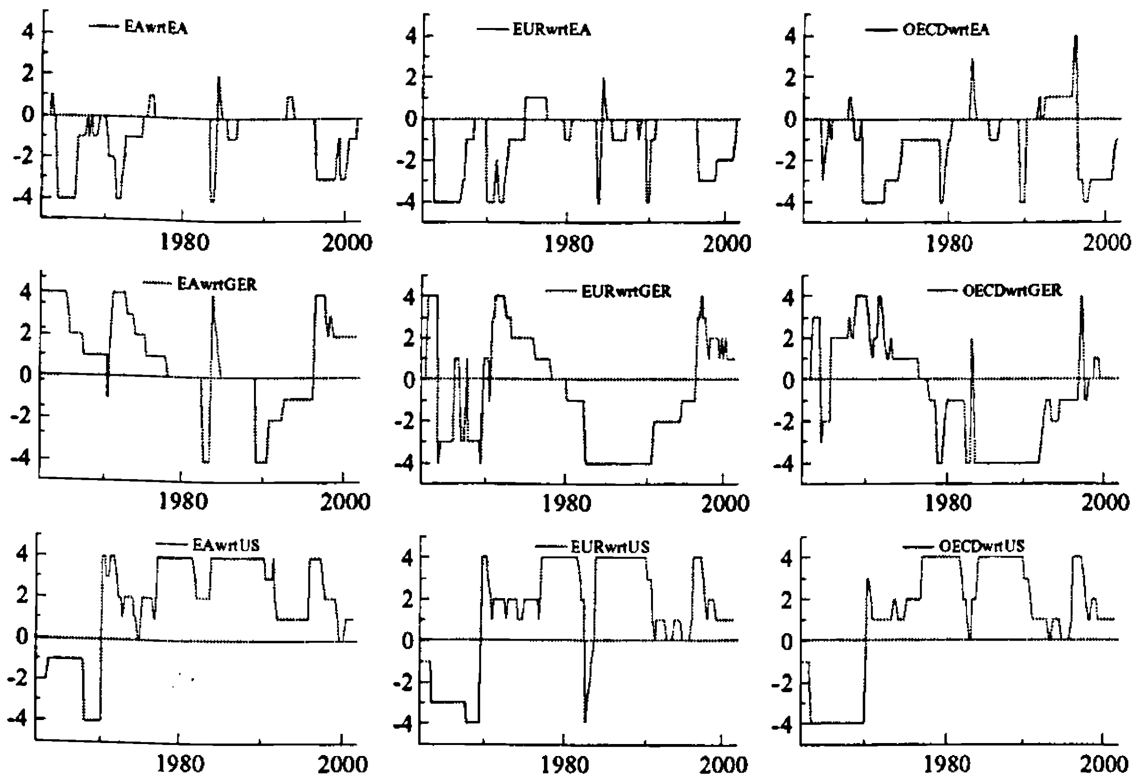


Figure 14 – Values of maximum correlation over time

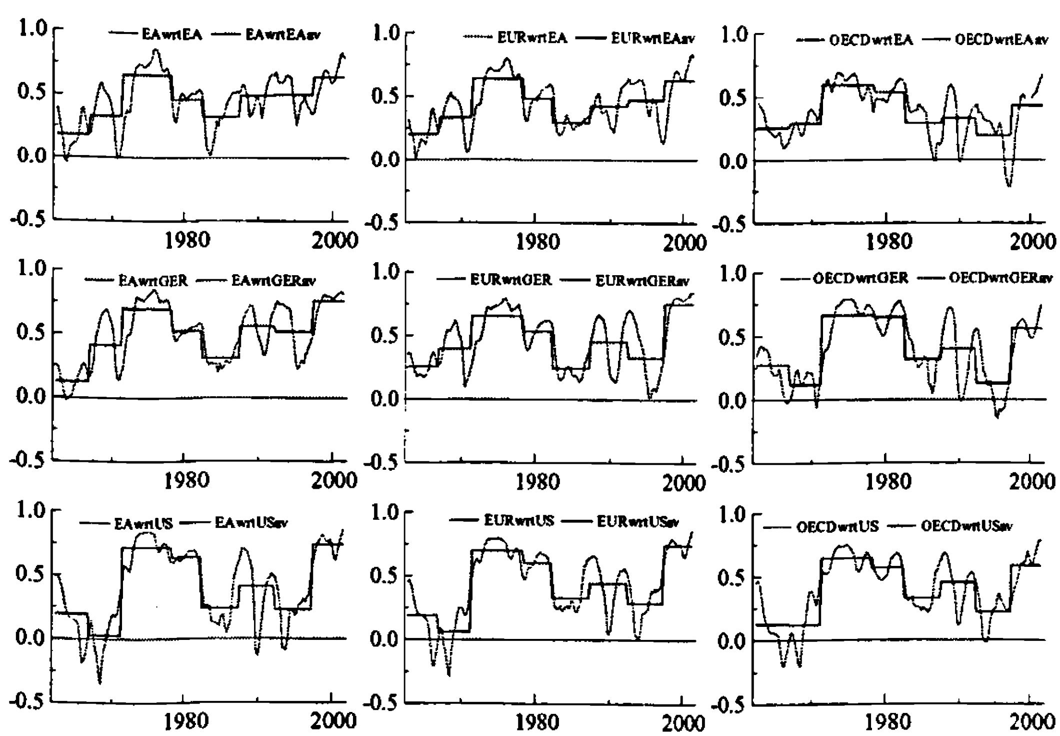
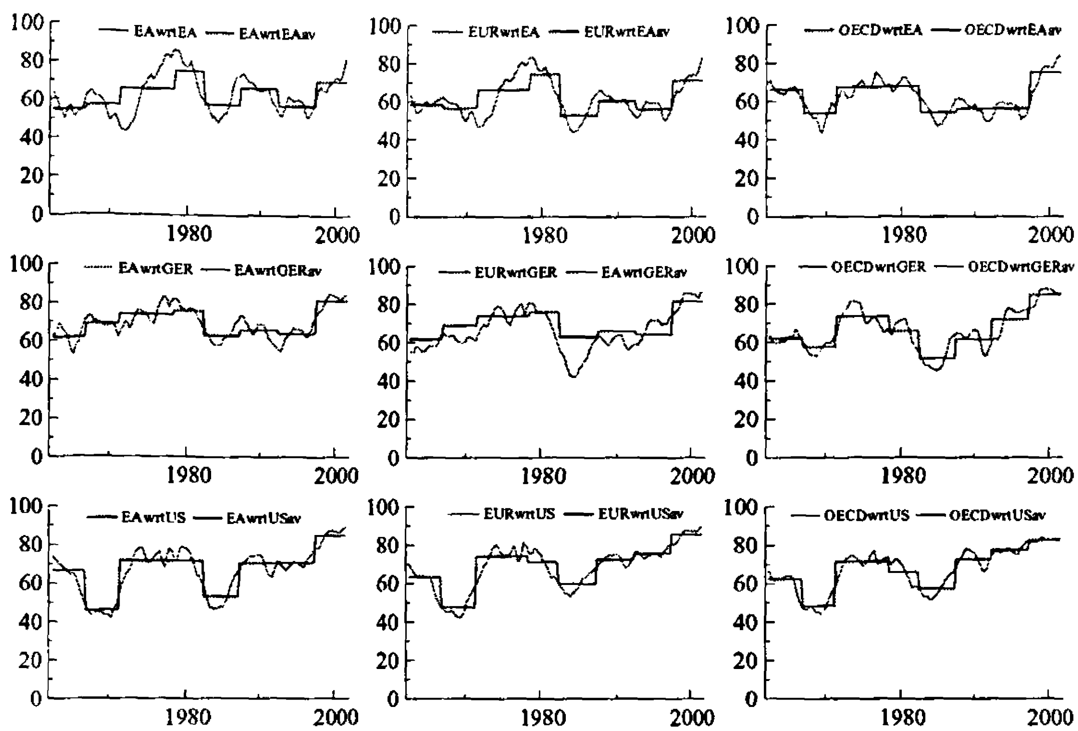


Figure 15 – Values of maximum concordance over time



Regarding dispersion measures, no clear tendency can be detected for the euro area group of cycles except for the 1990s sub-periods, during which evidence of a clear decline in dispersion can be found. For example, the (weighted) average standard deviation among euro area cycles exhibits a gradual tendency to increase during the 1960s, followed by a decline in the early 1970s, a period of broadly constant dispersion up to the mid-1980s, an increase in the late 1980s to early 1990s and a clear decline thereafter (see Table 9 and the upper chart of Figure 16). Similar indications result from diffusion indices, both with respect to the euro area and with respect to Germany (see Table 9 and Figure 17).

Table 9- Dispersion measures by sub-periods

	Average Standard Deviation			Average Diffusion								
				with respect to Euro Area			with respect to Germany			with respect to United States		
period	Euro area	Europe	OECD	Euro area	Europe	OECD	Euro area	Europe	OECD	Euro area	Europe	OECD
1960-1966	0.49	0.37	0.20	72.0	67.9	72.4	54.6	56.0	63.4	68.6	65.3	73.8
1966-1971	0.59	0.38	0.23	71.7	66.5	50.2	66.4	60.5	54.9	41.6	43.8	59.9
1971-1978	0.42	0.33	0.21	70.0	69.5	60.9	60.8	62.2	74.8	71.2	71.0	78.7
1978-1982	0.44	0.45	0.27	85.8	81.4	73.5	77.5	75.6	71.0	55.9	52.9	65.9
1982-1987	0.41	0.38	0.23	67.7	59.7	57.5	62.7	47.9	46.8	44.4	55.5	67.0
1987-1992	0.53	0.57	0.32	70.3	63.5	59.1	62.5	55.9	54.1	63.6	71.2	78.3
1992-1997	0.35	0.33	0.19	69.3	68.7	61.2	68.2	70.9	73.3	71.7	77.7	82.8
1997-2003	0.24	0.18	0.13	77.5	77.2	71.4	79.7	82.8	85.2	84.8	84.4	86.3

Note: Weighted measures. The euro area aggregate is based on the seven euro area countries.

Figure 16 – Weighted Standard Deviation

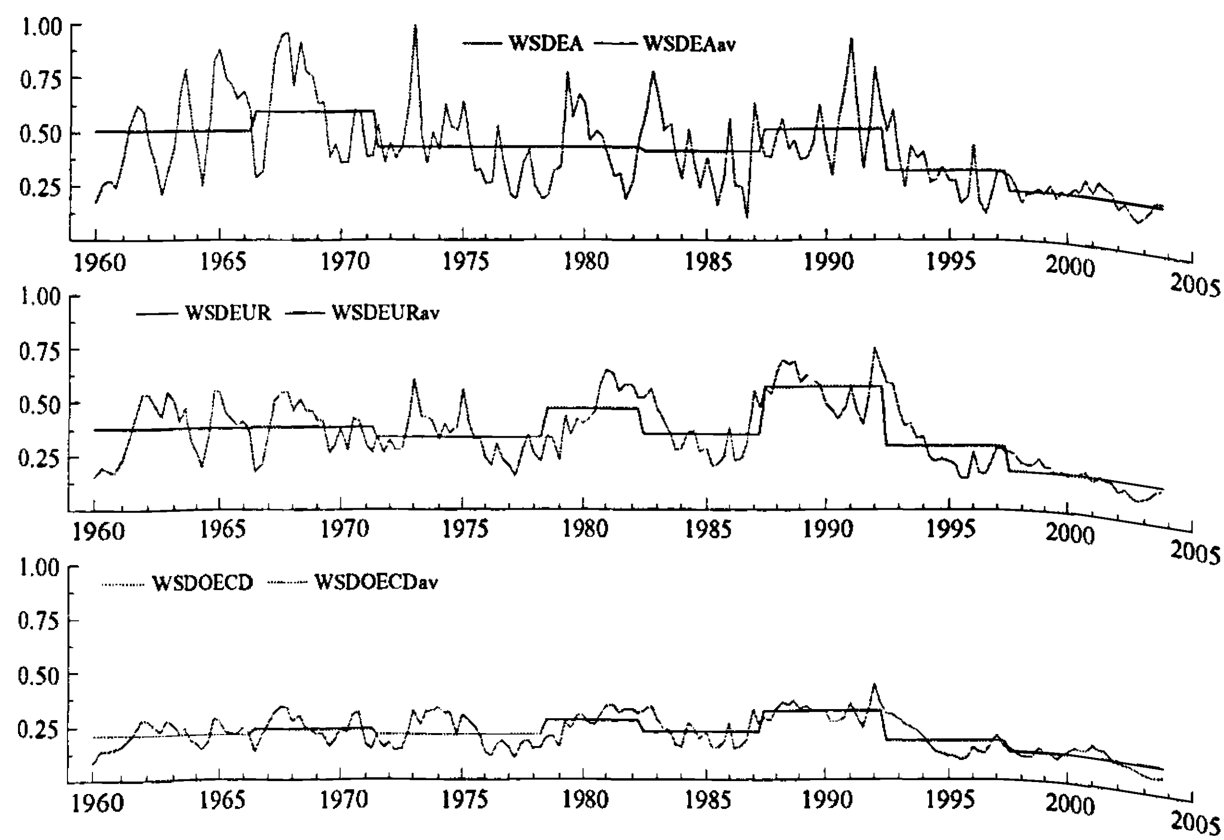
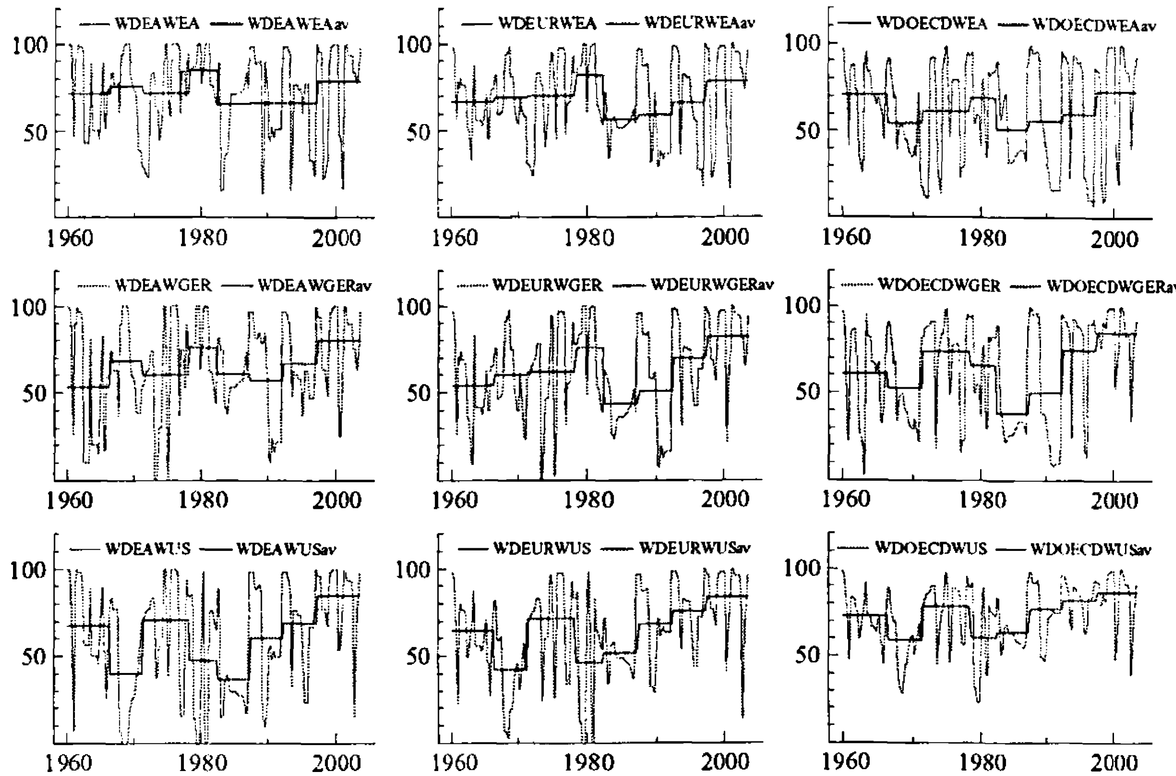


Figure 17 – Weighted Diffusion



IV. 5. Are changes over time specific to euro area cycles or common to other economic areas?

It is important to assess whether the evidence suggesting the emergence of a euro area business cycle is specific to this region or whether in fact it is simply the result either of increased dependency of euro area cycles from the US one or of a more general process of globalisation, i.e. increased interdependence of all OECD economies following gradual liberalisation processes. These different cases have implications for the interpretation of the sources of the common cycle in the euro area as well as for the derivation of optimal policy conclusions.

Focusing on the various measures over the sub-periods identified in the previous sub-section, it can be observed, first of all, that on average correlation indices of euro area cycles tend to be much higher with respect to the euro area (ex) or Germany than with respect to the US (see Tables 7, 8 and 10). By contrast, the evidence from concordance indices is less clear-cut. However, given the evidence of the tendency of euro area cycles to lag the US one (see Figures 12 and 13), it is probably more appropriate to compare maximum correlations and concordances. For the latter, the picture of the association of euro area cycles with respect to the US changes, as they point to a significantly higher degree of synchronisation. However, in general a stronger synchronisation of euro area cycles with euro area (ex) or Germany can still be observed especially from the early 1990s. For concordance indices, no clear area seems to prevail in terms of strength of synchronisation over all or most sub-periods. Although over specific sub-periods specific cases can be highlighted, as for example the particularly high concordance of the Italian cycle with respect to the US from the early 1980s to the early 1990s, no clear persistent deviation from the average can be found among euro area cycles. Thus, the results for the overall period which were highlighted as peculiar seem to be affected in some cases by specific episodes of particularly high association with the US.

The general tendency for (weighted) standard deviation to decrease over the 1990s found for the euro area cycles can also be observed more in general for all European cycles as well as for all OECD cycles (see Figure 16). While the decline for the euro area and Europe is more marked, even for the latest sub-period the standard deviation is lower for the OECD as a whole. This suggest that most of the decline in dispersion over time for the OECD as a whole may be due to a decreasing dispersion among euro area cycles. The evolution of (weighted) diffusion measures point to similar dynamics for the various groups of cycles. More precisely, a general tendency for diffusion to increase from the early 1980s can be observed (see Figure 17). Euro area cycles show a more marked increase with respect to the US over the more recent sub-periods compared to the euro area (ex) or Germany, but except for the very last sub-period, diffusion tends to be lower with respect to the US. The very last sub-period, however, rather than a tendency for euro area cycles to move to a closer association with the US, seems to be affected by a more general trend. More precisely, during this last period a general increase in association (i.e. higher synchronisation and lower dispersion) can be observed across all measures for all groups of countries. Whether this evidence can be interpreted in favour of the hypothesis of recent broad changes reflecting the process of globalisation is an open issue, as it can be found only for the latest sub-period considered, that is from 1997 to 2003, perhaps too short a period for such a conclusion to be drawn.

V. Conclusions

This chapter has provided empirical evidence on the degree of association, based on alternative measures of synchronisation and dispersion, among euro area business cycles from 1960 to 2003. The findings suggest that the degree of association among euro area business cycles is statistically significant for the overall period considered, such that it is possible to conclude that a euro area aggregate business cycle exists. The association among euro area business cycles increased particularly since the late 1980s, such that the specificity of this area emerged most forcefully during the more recent period. A significant association of the euro area cycles can also be found with respect to the cycle of the US, which has tended to lead frequently most euro area cycles. However, the evidence does not suggest that the euro area common cycle is de facto a US-led cycle. Finally, a general tendency for all OECD cycles considered to become more strongly associated can be detected for the most recent sub-period considered, i.e. from the mid-1990s onwards, suggesting that the process of globalisation can be thought of as having exerted some influence. However, the latter seems to have been a possible driving factor for common cyclical developments only for a relatively short period, implying that it can be concluded that the specific euro area common cycle emerged from different forces.

Table 10- Measures of synchronisation with respect to the United States for sub-periods

contemporaneous correlation

	index	st error		index	st error		index	st error		index	st error		index	st error		index	st error		index	st error		index	st error	
	1960-1966			1966-1971			1971-1978			1978-1982			1982-1987			1987-1992			1992-1997			1997-2003		
Germany	0.55	(0.14)	*	-0.5	(0.25)	ns	0.75	(0.13)	*	0.77	(0.16)	*	0.19	(0.23)	ns	-0.69	(0.22)	ns	-0.34	(0.22)	ns	0.38	(0.23)	ns
France	0.39	(0.24)	ns	-0.42	(0.24)	ns	0.61	(0.17)	*	0.46	(0.21)	*	-0.79	(0.18)	ns	-0.03	(0.22)	ns	-0.31	(0.19)	ns	0.19	(0.21)	ns
Italy	-0.57	(0.23)	ns	-0.38	(0.25)	ns	0.29	(0.19)	ns	0.48	(0.26)	ns	0.37	(0.31)	ns	0.24	(0.19)	ns	0.11	(0.28)	ns	0.14	(0.22)	ns
Spain	0.14	(0.22)	ns	0.45	(0.25)	ns	0.59	(0.19)	*	0.11	(0.15)	ns	-0.16	(0.21)	ns	-0.32	(0.21)	ns	0.03	(0.23)	ns	0.49	(0.23)	*
Netherlands	0.51	(0.19)	*	-0.68	(0.2)	ns	0.57	(0.12)	*	0.82	(0.12)	*	0.75	(0.10)	*	-0.23	(0.23)	ns	0.08	(0.24)	ns	0.62	(0.19)	*
Belgium	0.14	(0.14)	ns	-0.22	(0.29)	ns	0.39	(0.15)	*	-0.14	(0.20)	ns	0.28	(0.28)	ns	-0.17	(0.21)	ns	0.32	(0.24)	ns	0.30	(0.26)	ns
Finland	0.16	(0.27)	ns	0.101	(0.31)	ns	0.44	(0.24)	ns	-0.21	(0.24)	ns	0.19	(0.23)	ns	0.44	(0.25)	ns	0.53	(0.24)	*	0.10	(0.26)	ns
average EA	0.19			-0.24			0.52			0.33			0.12			-0.11			0.06			0.32		
UK	0.47	(0.20)	*	0.192	(0.16)	ns	0.71	(0.16)	*	0.83	(0.21)	*	0.79	(0.24)	*	0.94	(0.14)	*	0.64	(0.25)	*	0.65	(0.19)	*
Sweden	0.242	(0.11)	*	-0.53	(0.16)	ns	-0.47	(0.22)	ns	0.44	(0.26)	ns	0.882	(0.18)	*	0.776	(0.23)	*	0.236	(0.25)	ns	0.349	(0.25)	ns
Norway	-0.17	(0.25)	ns	0.602	(0.22)	*	-0.01	(0.29)	ns	0.74	(0.21)	*	0.92	(0.13)	*	0.28	(0.22)	ns	0.70	(0.21)	*	0.69	(0.22)	*
average EUR	0.19			-0.14			0.39			0.43			0.34			0.12			0.20			0.39		
Japan	-0.33	(0.19)	ns	-0.41	(0.19)	ns	0.55	(0.17)	*	0.44	(0.27)	ns	-0.20	(0.15)	ns	-0.32	(0.22)	ns	0.21	(0.17)	ns	0.31	(0.23)	ns
Canada	0.93	(0.09)	*	0.789	(0.1)	*	0.50	(0.20)	*	0.90	(0.13)	*	0.93	(0.11)	*	0.97	(0.11)	*	0.60	(0.27)	*	0.36	(0.25)	ns
average G-7	0.24			-0.12			0.57			0.65			0.22			0.18			0.15			0.34		
Mexico	0.70	(0.26)	*	0.76	(0.14)	*	0.05	(0.25)	ns	-0.54	(0.20)	ns	-0.60	(0.17)	ns	-0.71	(0.22)	ns	0.02	(0.21)	ns	0.78	(0.14)	*
Australia	0.12	(0.17)	ns	-0.79	(0.14)	ns	-0.05	(0.27)	ns	0.36	(0.26)	ns	0.74	(0.13)	*	0.96	(0.09)	*	0.52	(0.28)	ns	0.72	(0.19)	*
average all	0.24			-0.07			0.35			0.39			0.31			0.15			0.24			0.43		

contemporaneous concordance

	index	st conc		index	st conc		index	st conc		index	st conc		index	st conc		index	st conc		index	st conc		index	st conc	
	1960-1966			1966-1971			1971-1978			1978-1982			1982-1987			1987-1992			1992-1997			1997-2003		
Germany	0.68	(1.34)	ns	0.42	(0.34)	ns	0.88	(2.71)	*	0.65	(0.94)	ns	0.29	(0.58)	ns	0.46	(0.41)	ns	0.79	(1.92)	ns	0.96	(2.82)	*
France	0.71	(1.75)	ns	0.46	(0.47)	ns	0.69	(0.35)	ns	0.40	(-0.16)	ns	0.21	(-1.16)	ns	0.79	(1.63)	ns	0.42	(0.80)	ns	0.86	(2.22)	*
Italy	0.68	(0.87)	ns	0.29	(-1.29)	ns	0.53	(0.64)	ns	0.70	(1.17)	ns	0.92	(2.39)	*	0.88	(2.01)	*	1.00	(2.75)	*	0.64	(1.03)	ns
Spain	0.68	(1.13)	ns	0.63	(1.14)	ns	0.69	(0.68)	ns	0.35	(-1.29)	ns	0.38	(-1.29)	ns	0.54	(0.14)	ns	0.63	(0.93)	ns	0.89	(2.69)	*
Netherlands	0.79	(2.11)	*	0.21	(-2.06)	ns	0.59	(0.21)	ns	0.70	(1.17)	ns	0.88	(2.44)	*	0.67	(1.18)	ns	0.96	(2.47)	*	0.93	(2.60)	*
Belgium	0.54	(0.68)	ns	0.46	(-1.22)	ns	0.44	(-0.40)	ns	0.50	(-1.10)	ns	0.83	(2.15)	*	0.67	(1.55)	ns	0.63	(0.78)	ns	0.54	(-0.12)	ns
Finland	0.57	(0.58)	ns	0.54	(-0.51)	ns	0.59	(1.20)	ns	0.25	(-1.71)	ns	0.29	(-1.21)	ns	0.38	(-0.97)	ns	0.46	(-0.81)	ns	0.50	(-0.16)	ns
average EA	0.66			0.43			0.63			0.51			0.54			0.63			0.70			0.76		
UK	0.57	(1.34)	ns	0.54	(0.40)	ns	0.88	(2.36)	*	0.40	(-0.16)	ns	0.83	(0.77)	ns	0.96	(2.42)	*	0.96	(2.53)	*	0.93	(2.58)	*
Sweden	0.39	(-0.71)	ns	0.29	(-1.72)	ns	0.16	(-2.32)	ns	0.50	(-0.63)	ns	0.96	(2.74)	*	0.83	(1.85)	ns	0.96	(2.53)	*	0.82	(1.88)	ns
Norway	0.43	(-0.61)	ns	0.63	(-0.82)	ns	0.66	(-0.71)	ns	0.65	(0.94)	ns	0.67	(1.40)	ns	0.63	(-0.26)	ns	0.92	(2.32)	*	0.54	(1.23)	ns
average EUR	0.60			0.45			0.61			0.51			0.63			0.68			0.77			0.76		
Japan	0.43	(-0.09)	ns	0.33	(0.04)	ns	0.75	(1.84)	ns	0.65	(1.58)	ns	0.25	(0.52)	ns	0.67	(1.03)	ns	0.83	(2.02)	*	0.57	(0.09)	ns
Canada	0.96	(3.28)	*	0.79	(2.00)	*	0.91	(2.69)	*	0.75	(2.05)	*	1.00	(3.24)	*	1.00	(2.63)	*	0.88	(2.12)	*	0.82	(1.88)	ns
average G-7	0.67			0.47			0.77			0.59			0.58			0.79			0.81			0.80		
Mexico	0.61	(1.45)	ns	0.83	(2.00)	*	0.56	(0.99)	ns	0.50	(1.09)	ns	0.63	(1.37)	ns	0.38	(-1.38)	ns	0.46	(-1.10)	ns	0.89	(2.34)	*
Australia	0.61	(0.51)	ns	0.13	(-2.52)	ns	0.31	(0.66)	ns	0.50	(0.65)	ns	0.79	(1.95)	ns	0.83	(1.97)	*	0.79	(1.78)	ns	0.86	(2.15)	*
average all	0.62			0.47			0.62			0.54			0.64			0.69			0.76			0.77		

Appendix 1 – Overview of literature on euro area business cycles co-movement and convergence[56]

Study	Method and data	Countries	Main findings (regarding European economies)
Backus and Kehoe (1992)	• Data: annual output indices, with varying starting year around mid-nineteenth century and end year around mid-1980s; • Method: deviation cycles extracted via Hodrick-Prescott filter; correlation coefficients to measure the strength of association between the deviation cycles.	Australia, Canada, Denmark, Germany, Italy, Japan, Norway, Sweden, the UK and the US	**Overall, most often highest degree of comovements is found during interwar period, and generally higher comovements are detected after World War II than before World War I.** After World War II Germany exhibits a strong comovement only with Italy, and vice versa. Over the same period both euro area countries show also a significant comovement with the UK and Denmark.
Christodoulakis, Dimelis and Kollintzas (1995)	• Data: annual real GDP indices, 1960-1990; • Method: deviation cycles extracted via Hodrick-Prescott filter; correlation coefficients to measure the strength of association between the deviation cycles.	All EU countries except Austria, Finland and Sweden	**Overall, evidence of strong cyclical comovement among a core set of EU countries (Belgium, France, Germany, Luxembourg and the Netherlands).** All EU cycles, with the exception of Denmark and the UK, are highly correlated (i.e. correlation higher than 0.5) with either the German or the French cycles. German and French cycles exhibit very high correlation.
Rubin and Thygesen (1996)	• Data: monthly Industrial Production indices, 1983:6-1994:12; • Method: cointegration and codependence analysis to identify common trends and common cycles.	Austria, Belgium, Finland, France, Germany, Italy, the Netherlands, Sweden and the UK	**Overall, evidence of a substantial degree of business cycle comovement among the nine countries considered, and no clear indications of existence of a core group more closely interdependent.** Evidence is found of a significant long-run co-movement in the series for all nine countries considered. Moreover, the responses to transitory shocks (i.e. cyclical innovations) become coordinated after three months. Results indicate that there is little difference between a presumed "core" group (Austria, Belgium, Finland, France, Germany, the Netherlands) and a "periphery" group (Italy, Sweden and the UK) with regard to coordination of their business cycles.

[56] Only published papers are summarised. Moreover, only those parts of these papers related to euro area cross-country co-movements are reported.

Artis, Kontolemis and Osborn (1997)	• Data: monthly Industrial Production indices, 1961:1-1993:12; • Method: Bry-Boschan algorithm to identify classical cycles turning points; contingency coefficients to measure association between binary series representing the cycles.	G-7, Belgium, Ireland, Luxembourg, the Netherlands and Spain	**Overall, evidence of a strong association between classical cycles of continental European economies (with the exception of Spain).** Evidence of a group of "core" European countries with high classical business cycle association: Germany, France, Italy, the Netherlands, Belgium, Ireland and Luxembourg. The cycle of the UK seems to be significantly (albeit not strongly) associated with that of Germany and appears to be independent of the US cycle. The cycle of Spain appears to be strongly associated with the US cycle and almost independent of the German and French ones, but the strongest association is found with the Belgian cycle. Strong association between classical cycles of US and Canada. The Japanese cycle is associated with both the US and German cycles in a similar degree.
Artis and Zhang (1997)	• Data: monthly Industrial Production indices, 1961:1-1993:12; • Method: deviation cycles extracted via phase-average-trend, Hodrick-Prescott filter and linear detrending; correlation coefficients to measure synchronisation degree, phase shift and strength of association between the deviation cycles.	G-7, Belgium, Finland, Ireland, the Netherlands, Norway, Portugal, Spain and Sweden.	**Overall, evidence for the emergence of a group-specific continental European growth cycle in the Exchange Rate Mechanism (ERM) of the EMS period, somewhat independent from the US cycle.** Correlations of cycles of countries members of the ERM suggest that, compared to the pre-ERM period (before 1979:4), cycles of these countries have become more synchronous with the German cycle (and less with the US cycle), more in phase and more strongly linked. By contrast, no significant change over the two exchange rate regimes periods can be observed for the non-ERM countries, which have a stronger association with the US cycle. The exceptions are the UK, a member of the ERM only for a short period (October 1990 to August 1992), and Ireland. The cycles of both countries seem to be more synchronised with the US cycle, with no apparent change in cycle affiliation over time. Results appear robust across filtering method.
Bai, Hall and Shepherd (1997)	• Data: quarterly real GDP indices, samples start between 1965 and 1972 and end in 1989:4; • Method: quarterly growth rates, cointegration and common features analysis to identify common trends and common cycles.	Austria, France, Germany, Italy, Spain and the UK	**Overall, evidence of a common cycle in real GDP growth for each country with respect to Germany, but no evidence of long-run convergence with respect to Germany.** Common business cycle features in real GDP growth found for each country with respect to Germany, of a pro-cyclical form. However, common features tests based only on sub-sample 1980:1-1989:4. Using longer samples and bivariate models no evidence of cointegration in real GDP growth between Germany and other countries.

Fatás (1997)	• Data: annual employment indices, 1966-1992; • Method: annual growth rates; correlation coefficients to measure strength of association between growth rate cycles.	All euro area countries except Austria and Finland, plus Denmark and the UK. 38 regions of France, Germany, Italy and the UK.	**Overall, evidence of increased correlations during ERM period compared to pre-ERM period.** Country correlations with a European aggregate increase for all countries during the ERM period compared to pre-ERM period, except for Greece and Denmark. Comovement of regions with a European aggregate has increased over time comparing the ERM and pre-ERM periods, while cross-regional comovements within countries has decreased.
Bergman, Bordo, Jonung (1998)	• Data: annual real GDP indices, 1880-1995; • Method: deviation cycles extracted via Baxter-King band-pass filter; correlation coefficients to measure the strength of association between the deviation cycles.	G-7 countries, plus Belgium, Denmark, Finland, the Netherlands, Norway and Sweden	**Overall, evidence of an increase in comovements over time, comparing pre-WWI period, with interwar and post-WWII periods. However, no clear distinct pattern of euro area cycles can be found.** Comparing the Bretton Woods period with the post-Bretton Woods years, most correlations among euro area cycles increase significantly, but this tendency can be detected also with other countries.
Dickerson, Gibson and Tsakalotos (1998)	• Data: annual real GDP indices, 1960-1993; • Method: deviation cycles extracted via Hodrick-Prescott filter; correlation coefficients to measure the strength of association between the deviation cycles.	15 EU countries, plus Australia, Canada, Iceland, New Zealand, Norway, Switzerland, the UK and the US	**Overall, evidence of strong comovements among a core group of EU countries (Austria, Benelux, France and Germany), not shared by all other EU countries. Little evidence of cyclical convergence over decades.** Over whole sample period all euro area countries exhibit significant correlation with both French and German cycles, except Ireland and Finland, for which it is significant only for one of the two. Only Japan and Switzerland have also a significant correlation with both Germany and France among extra-euro area countries.
Artis and Zhang (1999)	• Data: monthly Industrial Production indices, 1961:1-1995:10; • Method: deviation cycles extracted via phase-average-trend; correlation coefficients to measure synchronisation degree, phase shift	G-7, Austria, Belgium, Finland, Greece, Ireland, Luxembourg,	**Overall, results of Artis and Zhang (1997) are confirmed and evidence that the synchronisation of business cycles is linked to lower exchange rate volatility.** Evidence that ERM membership has promoted a shift in business cycle affiliation to that of the German cycle (the anchor country in the system) and away from the US cycle. This pattern appears to be associated with lower exchange rate volatility

	and strength of association between the deviation cycles; a non-parametric rank correlation approach to examine relationship between business cycle affiliation and exchange rate volatility.	the Netherlands, Norway, Portugal, Spain, Sweden and Switzerland.	among ERM members.
Döpke (1999)	• Data: quarterly Manufacturing Production indices, 1980:1-1997:4; • Method: deviation cycles extracted via Hodrick-Prescott filter; growth rate cycles via year-on-year growth rates; correlation coefficients to measure strength of association between the cycles.	All euro area countries except Greece	**Overall, evidence of very high cross-correlations but not clear evidence of increasing comovement.** Cross-correlations of deviation cycles and year-on-year growth rates suggest high degree of comovement in most cases, especially with respect to either the German or the French cycles. Rolling correlations suggest that for almost half of the countries comovement with the rest of the euro area increased over the 1990s compared to the 1980s, while for the rest it remained broadly constant.
Mills and Holmes (1999)	• Data: monthly Industrial Production indices, 1960:1-1971:08 and 1979:03-1994:12; • Method: cointegration and common features analysis to identify common trends and common cycles.	Belgium, France, Germany, Italy, the Netherlands and the UK	**Overall, compared to the Bretton Woods period, there are indications of long-run convergence but short-run divergence during the ERM period.** Evidence is found that the ERM period, compared with the Bretton Woods period, has been associated with increased long-run convergence (i.e. fewer common trends are detected). However, during the ERM period signs of short-run divergence of output among the countries considered (i.e. absence of common cycles) are found. The UK is found to have the highest degree of independence.
Artis and Toro (2000)	• Data: monthly Industrial Production indices, 1970:1-1997:9; • Method: Bry-Boschan algorithm to identify classical cycles turning points; contingency and concordance coefficients to measure association between binary series representing the cycles; common cycle test in the frequency domain.	Austria, Belgium, France, Germany, Italy, the Netherlands, Spain and the UK	**Overall, evidence of a core group of countries with high (classical) cyclical association and evidence of a common cycle component.** Evidence of high degree of cyclical concordance among Austria, Belgium, France and Germany. However, low concordance values with respect to other cycles found for Italy, the Netherlands, Spain and the UK. A frequency domain test based on the classical cycle binary indices suggests the existence of a common component in the turning points chronologies, apparently corresponding to short recessionary periods.
Wynne and Koo (2000)	• Data: annual total output (1963-1992), and total employment (1960-1996) indices; • Method: deviation cycles extracted via	All EU countries and 12 Federal Reserve	**Overall, over whole sample cycles appear to be more correlated in the US than in the EU, but the dispersion among euro area output cycles seems to be decreasing over time and during the 1980s was similar than in the US.** As regards total output, all EU countries exhibit a very strong positive correlation

	Baxter-King band-pass filter; correlation coefficients to measure the strength of association between the deviation cycles.	Districts of the US	with either the German or the French cycles, with the exception of Portugal (which is significantly correlated with the French cycle) and Sweden. Only the UK, among the EU 15, appears to be more correlated with the US than with either France or Germany. The average volatility in the EU is very similar to that of the US districts. The cyclical dispersion among euro area cycles (as well as among EU cycles) appears to be decreasing over decades, while that of US district is slightly higher in the 1980s than previously. Over the 1980s the dispersion is similar in the euro area than in the US. Correlation among employment cycles in the EU is much lower than among US districts and is rarely significant. The dispersion of employment cycles in the EU is higher than in the US and does not appear to be decreasing but the average volatility of employment cycles in the EU is significantly lower than in the US.
Breitung and Candelon (2001)	• Data: monthly Industrial Production indices, 1975:1-1997:4; • Method: comparison of deviation cycles extracted via Baxter-King band-pass filter; common cycle test in the frequency domain on growth rate cycles via year-on-year growth rates. •	Austria, France, Germany, the Netherlands and the UK	**Overall, some evidence of a common cycle is found for the four euro area countries but not for the UK.** Strong indications of a common cycle between Germany and Austria are found, but only weak between these two countries and France and the Netherlands. The common cycle hypothesis is clearly rejected for the UK.
Clark and van Wincoop (2001)	• Data: annual total output and employment for US regions and EU countries (1963-1997), total employment for EU regions (1970-1992) and total output for EU regions (1982-96) indices; • Method: annual growth rates; correlation coefficients to measure the strength of association between the growth rate cycles.	All EU countries except Luxembourg, 8 French regions, 8 German regions and 9 US Census regions.	**Overall, evidence that US regions are substantially more synchronised than EU countries. Also evidence of a border effect in the EU: within-country correlation is higher than cross- country correlation.** Correlations across EU countries do not seem significantly different comparing the 1960s and 1970s to the 1980s and 1990s. Indications that border effect can be largely attributed to the lower level of trade between EU countries in comparison to US regions. Border effect is smaller for output than employment, as average cross-country correlation is larger for output. Authors claim that results do not change significantly using deviation cycles extracted via Baxter-King or Hodrick-Prescott filters.
Croux, Forni and Reichlin (2001)	• Data: annual GDP indices for Europe and personal income indices for the US, 1962-1997;	All EU countries, plus Norway, Switzerland	**Overall, business cycle comovements are significantly stronger among US states than among euro area countries, but at lower frequencies (i.e. for cycles longer than four years) the comovement is similar.** Cross-country business cycle comovement within euro area countries is higher

	Method: annual growth rates, a measure of dynamic comovement between multiple time series in the frequency domain.	and US (by state and BEA eight regions).	than between euro area countries and US states, but differences disappear in the longer run. Evidence of border effect: comovements tend to be higher with neighbouring countries/states than with other countries countries/states, both in the short and long run, more in the US than in Europe.
Forni and Reichlin (2001)	• Data: annual total output for US regions (1969-1993) and EU regions (1977-1993) indices; • Method: dynamic factor model to extract common and idiosyncratic components of series.	138 regions of 9 EU countries (Belgium, France, Germany, Greece, Italy, the Netherlands, Portugal, Spain and the UK) and 3075 US counties.	**Overall, considering the fraction of the total variance explained by the common (EU-wide and US-wide, respectively) component, it is concluded that the EU is as much integrated as the US.** The more disaggregated analysis confirms this general result for all EU countries except for the UK and Greece. A European core of regions with a large common component can be identified, but the boundaries of this core are not national, and all countries have some regions inside and outside the core. Overall, in the EU the national component does not appear to be important, while the European and local components seem to be the relevant ones in explaining fluctuations.
Krolzig (2001)	• Data: quarterly real GDP indices, 1970:3-1995:4; • Method: Markov-switching VAR (three regimes, regime-dependent intercepts and variances) to extract common cycle component.	Austria, France, Germany, Italy, Spain and the UK	**Overall, evidence of a common European business cycle.** One regime in the common European cycle appears to correspond to a period of catching-up in growth during the 1970s of the southern European countries considered. Subsequently, evidence is found of convergence in the growth pattern over the cycle, suggesting the notion of a European business cycle. There are signs of relatively weaker affiliation of the UK cycle to this common cycle.
Inklaar and de Haan (2001)	• Data: monthly Industrial Production indices, 1960:1-1997:12; • Method: deviation cycles extracted via Hodrick-Prescott filter; correlation coefficients with respect to German series to measure synchronisation degree, phase shift and strength of association between the deviation cycles.	G-7, Austria, Belgium, Finland, Greece, Ireland, Luxembourg, the Netherlands, Norway, Spain, Sweden and Switzerland.	**Overall, findings of Artis and Zhang (1997, 1999) not confirmed if sample data is divided in four periods (1960-1971, 1971-1979, 1979-1987, 1987-1997) instead of two periods (pre-ERM period up to 1979 and ERM period from 1979).** The cycles of most ERM members show an increase in correlation with German cycle from 1960s to 1970s, but a decrease from 1971-1979 to the 1979-1987 period. No systematic relationship between cycle correlation and exchange rate stability with Germany.

Vijselaar and Albers (2001)	• Data: monthly Manufacturing Production (1973:1-1996:2) and quarterly real GDP (1979:1-1996:1) indices; • Method: deviation cycles extracted via Baxter-King band-pass filter, segmented linear trend detrending and Hodrick-Prescott filter; correlation coefficients to measure degree of synchronisation, phase shift and strength of association between the deviation cycles.	All 15 EU countries plus US	**Overall, evidence of high correlation of all euro area cycles with euro area aggregate cycle and indications of increasing convergence during 1990s.** All euro area cycles are strongly correlated with the euro area aggregate over the whole sample period. Comparing the 1979-1986 period to the 1987-1996 period, most euro area cycles become more correlated with the euro area aggregate and more in phase. A notable exception is Germany, whose cycle exhibits an opposite trend both as regards strength of association and phase shift. Results appear robust across filtering method.
Agresti and Mojon (2003)	• Data: quarterly real GDP (1970-2000) indices; • Method: deviation cycles extracted via Baxter-King band-pass filter; correlation coefficients to measure degree of synchronisation, phase shift and strength of association between the deviation cycles.	All euro area except Lux. and Ireland, plus US	**Overall, evidence of high correlation of euro area cycles with euro area aggregate, on average stronger than with respect to the US.** In all cases highest correlation is found at contemporaneous level (or at plus or minus one quarter shift, but values seem statistically not different from contemporaneous).
Artis, Krolzig and Toro (2004)	• Data: industrial production (1970-1996) indices; • Method: deviation cycles proxied by smoothed probabilities of recession regimes estimated via Markov-switching models, and binary indices derived from the same probabilities; correlation coefficients and contingency indices to measure degree of synchronisation.	All euro area except Greece, Finland, Lux. and Ireland, plus UK	**Overall, relatively high correlation and contingency values among euro area countries, while UK exhibits weak association with all other countries (except possibly Spain).**
Artis, Marcellino and Proietti (2004)	• Data: quarterly real GDP (1970-2002) indices; • Method: binary series computed by applying the AMP algorithm to	Euro area aggregate, Germany, France, Italy,	**Overall, cyclical association found to be significant among all five economies, especially so among euro area countries.** In all case the hypothesis of independence is rejected.

	deviation cycles extracted via a band-pass filter (double low frequency Hodrick-Prescott filter); standardised concordance indices to measure degree of synchronisation and a HAC test of cyclical independence	UK and US	
Artis (2004)	• Data: quarterly real GDP (1970:1-2001:4) indices; • Method: deviation cycles extracted via a band-pass filter (double low frequency Hodrick-Prescott filter); correlation coefficients to measure degree of synchronisation, graphical techniques to detect patterns.	All 15 EU countries plus US	**Overall, evidence of high correlation of all euro area cycles with euro area aggregate cycle and indications of increasing convergence during 1990s.** All euro area cycles are strongly correlated with the euro area aggregate over the whole sample period. Comparing the 1979-1986 period to the 1987-1996 period, most euro area cycles become more correlated with the euro area aggregate and more in phase. A notable exception is Germany, whose cycle exhibits an opposite trend both as regards strength of association and phase shift. Results appear robust across filtering method.
Massman and Mitchell (2004)	• Data: industrial production (1960:1-2001:8) indices; • Method: deviation cycles extracted alternatively via three parametric methods and four non-parametric methods; correlation coefficients and relative robust standard errors to measure degree of synchronisation, including a test of convergence based on these.	All euro area countries	**Overall, results tend to depend on the measure of the cycle, but some common results can be found.** In particular, periods of convergence alternate to periods of divergence. Rolling correlations suggest that for the most recent periods the degree of association is positive and significant, and has risen from the trough found in the early 1990s. Some evidence that over the past 20 years correlations on average tended to increase.

Appendix 2 – Further Results

Table A1 – All bivariate correlations

	EA	EAex	DEU	FRA	ITA	ESP	NLD	BEL	FIN	UK	SWE	NOR	USA	JPN	CAN	MEX	AUS
EA	1.00		0.67	0.62	0.58	0.56	0.52	0.72	0.46	0.28	0.29	0.05	0.32	0.36	0.28	0.16	0.10
EAex		1.00	0.33	0.61	0.54	0.33	0.49	0.69	0.44								
DEU			1.00	0.61	0.39	0.24	0.62	0.38	0.31	0.19	0.21	-0.21	0.20	0.52	0.16	0.33	0.17
FRA				1.00	0.61	0.36	0.60	0.39	0.13	0.46	0.41	-0.31	0.31	0.41	0.40	0.25	0.29
ITA					1.00	0.43	0.43	0.44	0.22	0.32	0.35	-0.02	0.20	0.46	0.33	0.09	0.36
ESP						1.00	0.08	0.43	0.40	0.15	0.08	-0.03	0.20	0.26	0.17	0.00	-0.12
NLD							1.00	0.37	0.09	0.48	0.47	0.10	0.54	0.31	0.58	0.26	0.47
BEL								1.00	0.48	0.17	0.24	0.09	0.17	0.14	0.21	0.21	0.13
FIN									1.00	0.11	0.12	0.09	0.16	0.22	0.13	0.09	0.04
UK										1.00	0.67	0.03	0.64	0.19	0.74	-0.29	0.55
SWE											1.00	0.02	0.28	0.12	0.59	-0.11	0.51
NOR												1.00	0.25	-0.27	0.25	-0.07	0.02
USA													1.00	0.17	0.75	0.02	0.41
JPN														1.00	0.02	0.15	0.27
CAN															1.00	-0.01	0.54
MEX																1.00	0.06
AUS																	1.00

Note: The euro area aggregate EA is based on the seven euro area countries.

Table A2 – All bivariate concordances

	EA	EAex	DEU	FRA	ITA	ESP	NLD	BEL	FIN	UK	SWE	NOR	USA	JPN	CAN	MEX	AUS
EA	1.00		0.80	0.69	0.65	0.68	0.70	0.68	0.57	0.59	0.64	0.55	0.58	0.60	0.61	0.59	0.53
EAex		1.00	0.64	0.69	0.51	0.64	0.70	0.68	0.57								
DEU	0.80	0.65	1.00	0.72	0.57	0.61	0.69	0.63	0.58	0.59	0.61	0.51	0.62	0.73	0.60	0.63	0.56
FRA	0.70	0.69	0.73	1.00	0.59	0.65	0.63	0.54	0.55	0.56	0.55	0.41	0.55	0.63	0.57	0.55	0.50
ITA	0.66	0.51	0.55	0.58	1.00	0.55	0.74	0.59	0.50	0.66	0.65	0.60	0.69	0.53	0.74	0.51	0.69
ESP	0.66	0.64	0.63	0.67	0.55	1.00	0.55	0.59	0.53	0.57	0.46	0.53	0.61	0.48	0.61	0.48	0.40
NLD	0.72	0.70	0.70	0.64	0.74	0.55	1.00	0.62	0.49	0.76	0.74	0.61	0.70	0.62	0.73	0.60	0.72
BEL	0.68	0.66	0.63	0.54	0.61	0.57	0.64	1.00	0.67	0.57	0.66	0.57	0.57	0.58	0.57	0.56	0.53
FIN	0.61	0.61	0.54	0.51	0.50	0.56	0.52	0.70	1.00	0.49	0.56	0.60	0.47	0.57	0.51	0.60	0.49
UK	0.57		0.61	0.58	0.66	0.57	0.76	0.55	0.51	1.00	0.69	0.64	0.77	0.57	0.78	0.64	0.64
SWE	0.66		0.60	0.55	0.67	0.47	0.77	0.69	0.56	0.72	1.00	0.60	0.58	0.59	0.65	0.61	0.74
NOR	0.53		0.50	0.43	0.62	0.55	0.59	0.53	0.62	0.62	0.57	1.00	0.64	0.45	0.66	0.49	0.49
USA	0.58		0.65	0.57	0.70	0.62	0.72	0.58	0.51	0.78	0.62	0.66	1.00	0.53	0.89	0.60	0.59
JPN	0.59		0.73	0.65	0.53	0.49	0.60	0.59	0.55	0.55	0.56	0.43	0.49	1.00	0.51	0.56	0.57
CAN	0.60		0.60	0.60	0.73	0.62	0.74	0.58	0.51	0.77	0.72	0.73	0.86	0.45	1.00	0.63	0.66
MEX	0.60		0.61	0.55	0.51	0.48	0.60	0.57	0.59	0.64	0.64	0.47	0.59	0.53	0.59	1.00	0.68
AUS	0.56		0.53	0.48	0.72	0.44	0.68	0.51	0.49	0.61	0.72	0.50	0.60	0.52	0.65	0.64	1.00

Note: The euro area aggregate EA is based on the seven euro area countries.

Table A3 – All bivariate standardised concordances

	EA	EAex	DEU	FRA	ITA	ESP	NLD	BEL	FIN	UK	SWE	NOR	USA	JPN	CAN	MEX	AUS
EA			5.21	3.37	2.58	3.17	3.41	3.22	1.39	1.29	2.23	0.87	1.21	1.59	1.75	1.42	0.46
EAex			2.65	3.29	0.10	2.31	3.33	3.22	1.39								
DEU	4.93	2.85		3.54	0.96	1.93	2.82	2.17	1.44	1.25	1.56	0.17	1.70	3.52	1.28	1.90	0.85
FRA	3.33	3.13	3.56		1.33	2.67	1.97	0.69	0.91	0.94	0.67	-1.37	0.66	2.03	1.04	0.77	-0.03
ITA	2.71	0.10	0.64	1.19		0.72	3.74	1.55	0.03	2.34	2.27	1.58	2.77	0.44	3.72	0.13	2.79
ESP	2.92	2.31	2.20	2.92	0.72		0.77	1.65	0.64	1.09	-0.76	0.54	1.78	-0.45	1.78	-0.42	-1.74
NLD	3.51	3.33	2.99	2.14	3.74	0.77		2.03	-0.05	3.77	3.53	1.92	2.92	1.73	3.23	1.42	3.17
BEL	3.21	2.85	2.05	0.63	1.79	1.29	2.23		3.19	1.11	2.82	1.34	1.21	1.35	1.19	0.97	0.43
FIN	1.88	1.88	0.62	0.17	-0.05	1.00	0.20	3.56		-0.16	1.11	1.66	-0.46	1.21	0.16	1.77	-0.07
UK	1.03		1.45	1.14	2.34	1.09	3.77	0.72	0.12		2.71	2.30	3.89	0.93	4.09	2.02	2.00
SWE	2.69		1.38	0.65	2.55	-0.62	4.02	3.15	0.92	3.19		1.59	1.04	1.21	2.07	1.56	3.46
NOR	0.61		0.04	-1.07	1.84	0.89	1.45	0.61	1.97	1.84	1.07		2.13	-0.71	2.67	-0.06	-0.09
USA	1.16		2.06	1.03	2.91	1.96	3.08	1.24	0.04	4.01	1.66	2.29		0.32	5.79	1.38	1.21
JPN	1.38		3.50	2.20	0.48	-0.22	1.42	1.42	0.74	0.63	0.81	-1.04	-0.13		-0.12	0.83	1.04
CAN	1.40		1.21	1.34	3.40	1.95	3.27	1.14	-0.02	3.74	3.18	3.43	5.13	-0.88		1.96	2.24
MEX	1.58		1.59	0.66	0.13	-0.42	1.42	1.23	1.50	2.02	1.97	-0.40	1.20	0.49	1.19		2.57
AUS	0.73		0.27	-0.36	3.24	-1.20	2.49	0.03	-0.17	1.35	3.14	0.05	1.28	0.19	1.79	2.02	

Note: The euro area aggregate EA is based on the seven euro area countries.

Table A4 – Correlations and concordances among euro area aggregates

	corr	se	conc 1	conc 2	st conc 1	st conc 2
EA11	0.91	0.06	0.89	0.87	7.16	6.41
EA7exDEU	0.83	0.06	0.80	0.84	5.62	6.32
EA7exFRA	0.96	0.05	0.97	0.98	8.42	8.53
EA7exITA	0.70	0.13	0.79	0.80	4.93	5.02
EA7exESP	0.76	0.12	0.80	0.81	5.12	5.21
EA7exNET	1.00	0.01	0.99	0.98	9.06	8.75
EA7exBEL	1.00	0.01	1.00	0.98	9.17	8.53
EA7exFIN	1.00	0.01	1.00	1.00	9.17	8.95

Note: All measures are with respect to euro area aggregate is based on the seven euro area countries.

Table A5 – Measures of dispersion

	Average Standard Deviation	Average Diffusion with respect to		
		Euro Area	Germany	United States
Euro area	0.94	68.3	63.3	60.1
Europe	1.32	65.5	61.1	61.9
OECD	1.14	63.0	61.6	62.8

Note: Simple (unweighted) measures. The euro area aggregate is based on the seven euro area countries.

Figure A1 – Simple Standard Deviation

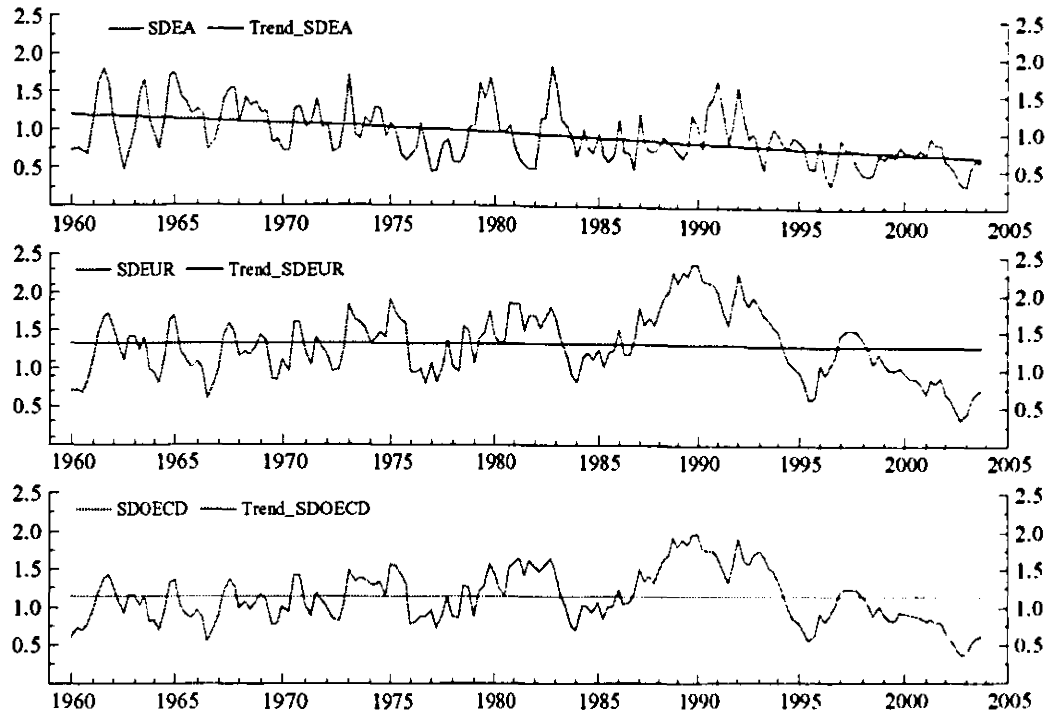


Figure A2 – Simple Diffusion

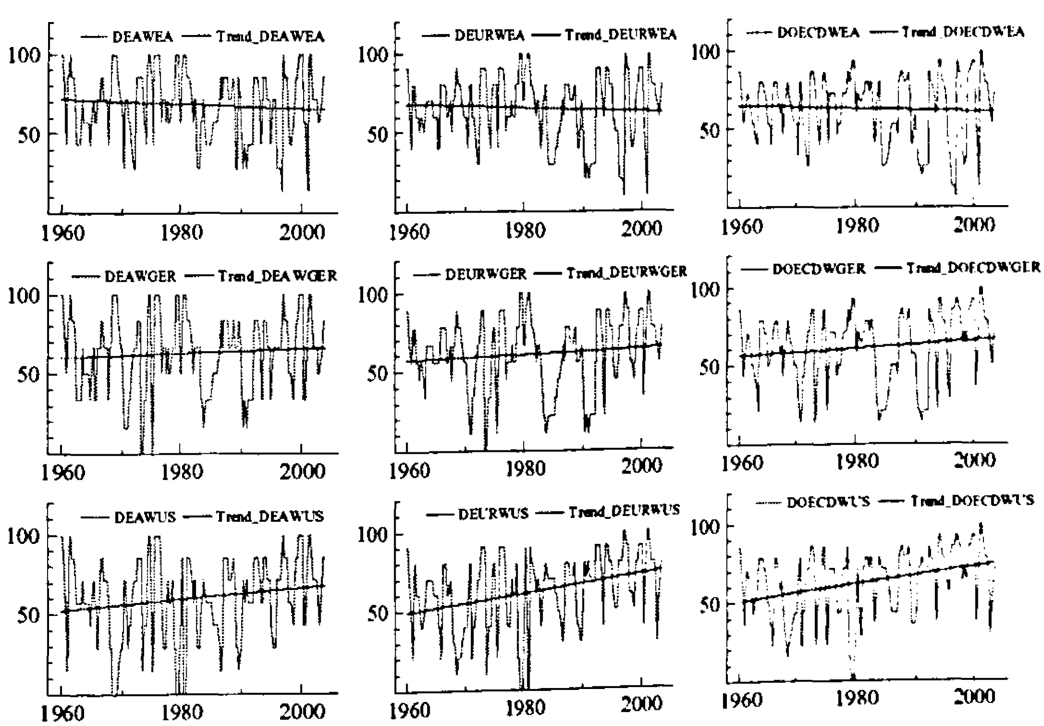


Figure A3 – Breaks tests

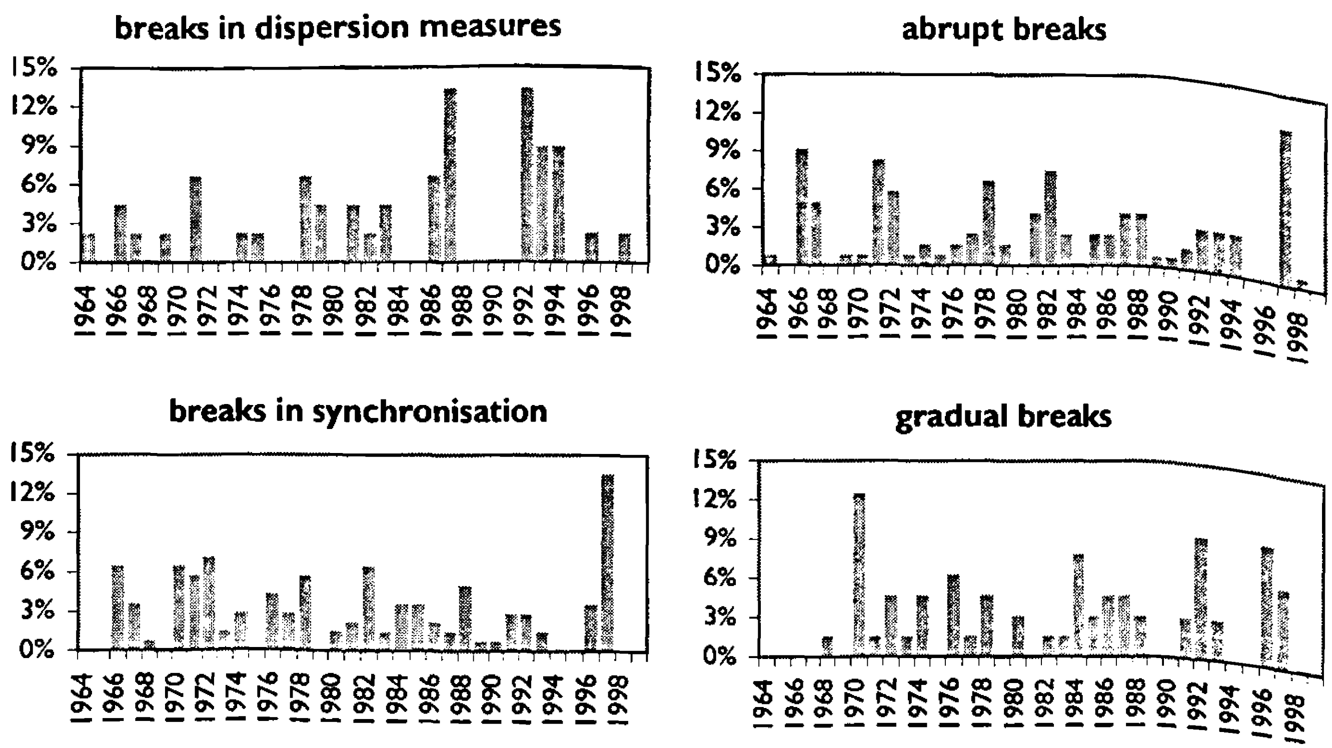


Figure A4 – Breaks tests (by region)

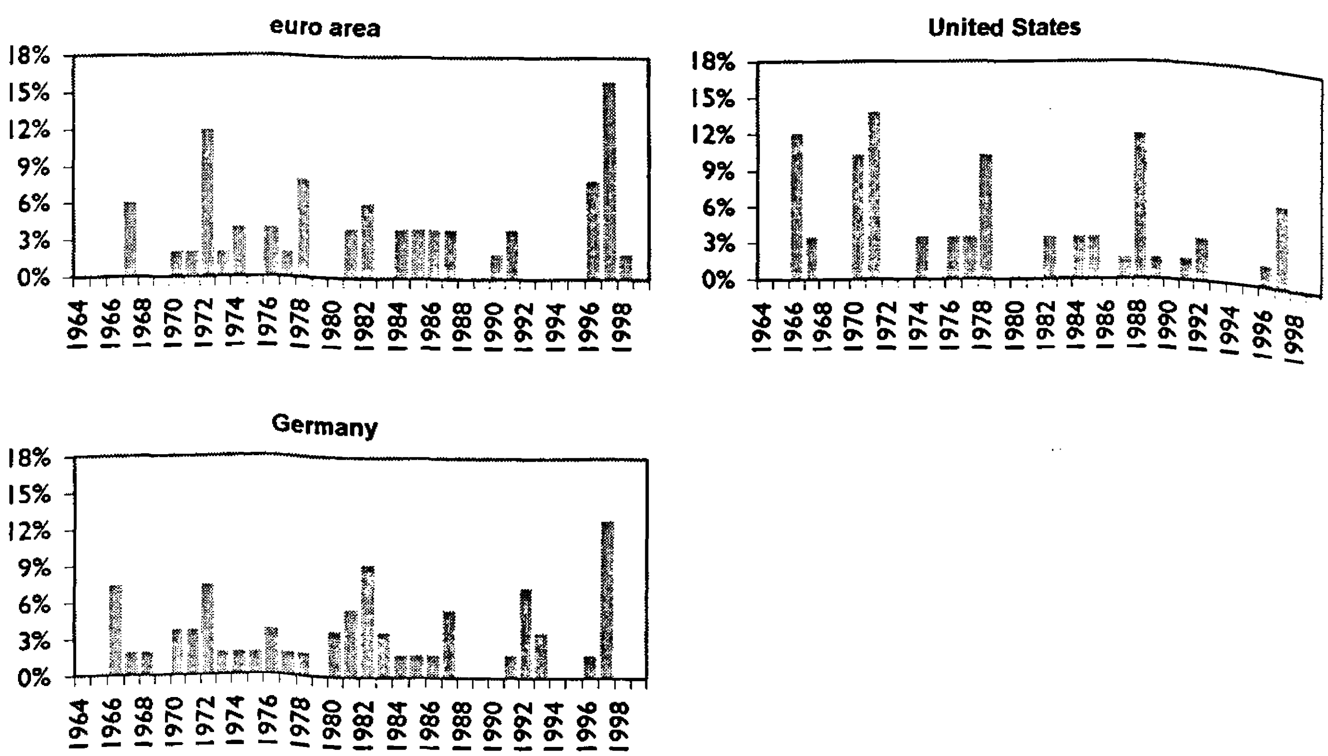


Table A6- Dispersion measures by sub-periods

	Average Standard Deviation			Average Diffusion								
				with respect to Euro Area			with respect to Germany			with respect to United States		
period	Euro area	Europe	OECD	Euro area	Europe	OECD	Euro area	Europe	OECD	Euro area	Europe	OECD
1960-1966	1.13	1.15	0.98	68.9	66.1	66.0	62.5	63.9	63.0	66.3	60.4	61.7
1966-1971	1.14	1.19	1.04	72.0	68.8	63.3	62.5	57.9	56.3	42.9	44.6	46.7
1971-1978	0.91	1.30	1.12	71.4	69.1	65.2	57.8	55.2	59.8	62.9	60.9	61.6
1978-1982	1.00	1.52	1.35	77.1	79.0	76.3	73.3	76.7	74.6	50.7	51.0	53.6
1982-1987	0.92	1.37	1.18	60.1	55.8	56.7	54.2	45.4	48.5	54.2	62.5	63.7
1987-1992	1.03	2.00	1.66	61.9	56.3	56.4	59.7	53.2	55.1	62.5	67.9	69.0
1992-1997	0.81	1.38	1.20	65.5	65.4	60.8	69.4	70.8	68.8	69.6	77.1	76.2
1997-2003	0.67	0.95	0.84	71.9	70.4	69.3	72.6	75.0	78.1	76.0	76.1	76.8

Note: Simple measures. The euro area aggregate is based on the seven euro area countries.

Chapter 2- Euro area business cycle stylised facts

I. Introduction

The objective of this chapter is to compute a set of stylised facts for the euro area deviation cycle. First, a turning points chronology will be computed from which a basic set of characteristics of fluctuations will be derived, including the average duration and the average amplitude of the different phases of the cycle. Second, the properties over the business cycle of a set of macroeconomic variables will be estimated and compared to similar properties identified for the US in other studies. These stylised facts can represent a benchmark which business cycle models for the euro area should aim at replicating and also represent regularities which can be a reference for conjunctural analysis and forecasting of euro area macroeconomic developments over the medium term.

As is discussed below more in detail, a number of contributions on these questions have been published in recent years. However, all either provide a partial picture of basic characteristics and stylised facts or adopt methods which undermine the reliability of the results. Thus, a full and robust set of regularities of the euro area deviation cycle still has not become available. This chapter aims at filling this gap.

Compared to the literature this chapter attempts to derive more robust results, by using model-based approaches and specification tests to estimate both cyclical components and stylised facts, by computing standard errors for most statistics, and by adopting a comparative perspective.

II. Basic characteristics of the euro area deviation cycle

II. 1. Introduction

The objective of section II is to derive and discuss a set of basic characteristics of the euro area deviation cycle. For this purpose we adopt a long historical perspective, focusing on data from 1960 to 2003. Moreover, all results are compared to corresponding one for the US cycle.

In the past few years a number of studies with a similar purpose to the one of this note have appeared. However, a number of them have a different focus, as they either focus on a broader concept of European business cycle (i.e. often including the UK), as opposite to a euro area cycle, or analyse exclusively the classical cycle (or sometimes the cycle in the growth rate of the reference series), without discussing the deviation cycle[57]. Among those more closely related to the current study, the majority focuses on measures of the deviation cycle, often derived from mechanical filters, which may produce spurious cycle and/or use exclusively industrial production data, thus referring de fact thus to the industrial cycle as opposed to the economy-wide business cycle. [58] Thus, most of the results of the available literature are either not directly relevant for the euro area business cycle or are characterised by a low degree of reliability. One notable exception is represented by Artis, Marcellino and Proietti (2004). However, as regards the parts addressing the questions of the current note, while they consider alternative representations of the deviations cycle, they report the basic characteristics only obtained from a band-pass Hodrick-Prescott filter. Moreover, they focus on a shorter period (starting in 1970), do not provide a comparative perspective with the US and do not discuss the evolution of the basic characteristics over time (limiting the discussion to average characteristics).

[57] For example Krolzig (2001a,b), Krolzig and Toro (2001), Krolzig (2004), Anas and Ferrara (2004a), Altissimo et al (2001), Forni et al (2001), Artis (2004), Artis, Krolzig and Toro (2004) and McAdam (2003). Note also that other studies aim at defining a turning points chronology but do not derive any set of basic characteristics from it (for example, Harding, 2004, Lommatzsch and Stephan, 2001, Mönch and Uhlig, 2004, and Schumacher, 2001).

[58] These include Harding and Pagan (2001), Anas and Ferrara (2004b), Anas and Nguiffo-Boyom (2001), Anas et al (2003), Giannone and Reichlin (2004), Agresti and Mojon (2003), Doepke (1999). Ross and Ubide (2001) consider several alternative measures of the cycle, including some based on unobserved components models. However, all have some shortcoming: apart from filter based methods (already discussed) and survey based indicators (which often relate only vaguely to actual developments), they also consider a production function approach (where however total factor productivity is decomposed via the Hodrick-Prescott filter), the Blanchard-Quah decomposition (which has been shown to be empirically unreliable, see Faust and Leeper, 1997, and Cooley and Dwyer, 1998), an inefficiency wedge measure from Gali, Gertler and Lopez-Salido (2001) (which is not easy to clearly associate to the business cycle, and is probably better suited as a specific measure of households welfare, derived from a specific model), and a number of multivariate unobserved components models, which combine a Phillips-type of relationship and a form of Okun's law (thus, implying that the concept of the cycle under study is the traditional output gap, defined as deviations from the non-inflationary level of output, which is different from the deviation cycle, whose definitions do not include any reference to price developments).

II. 2. Data and methods

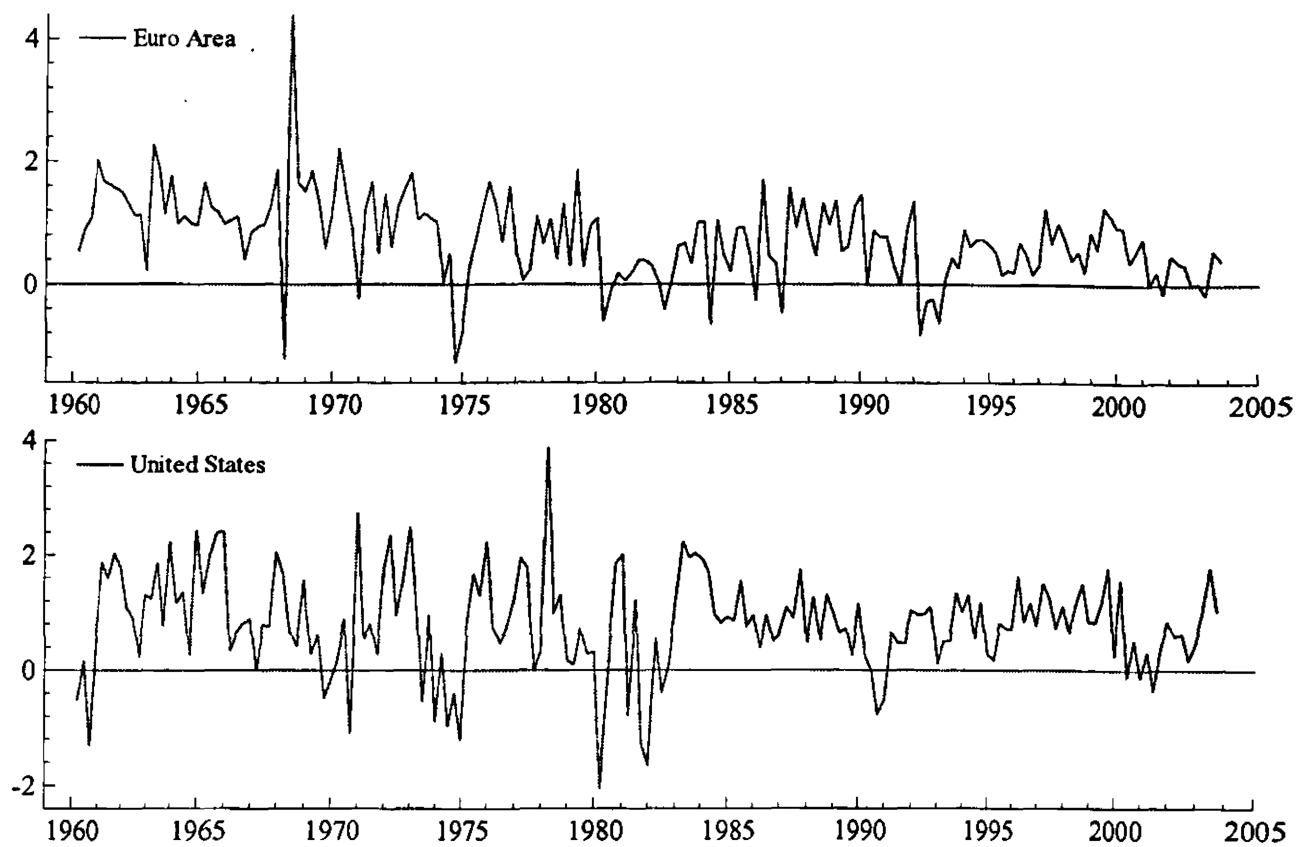
The main reference series from which the deviation cycle is extracted is represented by quarterly real GDP. For the euro area this series is constructed using data from the OECD Economic Outlook database, which spans from 1963:1 to 2003:4, and extending it back using growth rates based on an aggregate constructed using OECD Main Economic Indicators database from 1960:1 to 1963:1.[59] From 1991 these data correspond to the Eurostat ESA 95 official data. For the United States the real GDP data is obtained from the Bureau of Economic Analysis (BEA). The quarterly growth rates of the reference series are shown in Figure 1. Apart from an outlier observation in 1968 (due to a spike in the French data, resulting from the well-known riots and strikes that took place in France during May of that year), the euro area series seems to subject to relatively milder fluctuations compared to the US.

In order to estimate the deviation cycle a univariate unobserved components model was applied to each real GDP series in levels after taking natural logarithms. The modelling strategy was based on the diagnostics tests, residual graphics and auxiliary residual graphics, following the procedure suggested by Harvey and Koopman (1992) and Harvey (2001). More precisely, for both quarterly real GDP series, expressed as natural log-levels of the index (with base 1960:1=100), a so-called basic structural time series model (that is, stochastic level and slope trend, trigonometric seasonal component and irregular component) augmented with a stochastic cycle has been estimated. Once convergence was ensured (if necessary by increasing the number of iterations), the well-specification of the basic general model was checked and possible outliers and breaks was tested using the auxiliary residuals, the significance of the variance of each component was tested and if found not different from zero (implying a deterministic component) the significance of that component was tested. A reduction of the general model was undertaken in steps,

[59] For France, for which data before 1963 is missing, data from an old vintage of the MEI database is used. The aggregate is constructed using real GDP data for all twelve euro area countries (from the OECD Economic Outlook for all except France) and fixed weights corresponding to the average weights from 1991 to 2003 from Eurostat's ESA 95 National Accounts database. Note that the correlation of the growth rates of the series constructed in this way and the OECD Economic Outlook series from 1963 to 2003 is 1.00.

always checking for possible residual serial correlation and other signs of mis-specification via the available diagnostic tests (available in STAMP, such as the Box-Ljung Q-statistic).

Figure 1 – Quarterly growth rates



Source: Eurostat, OECD and own calculations.

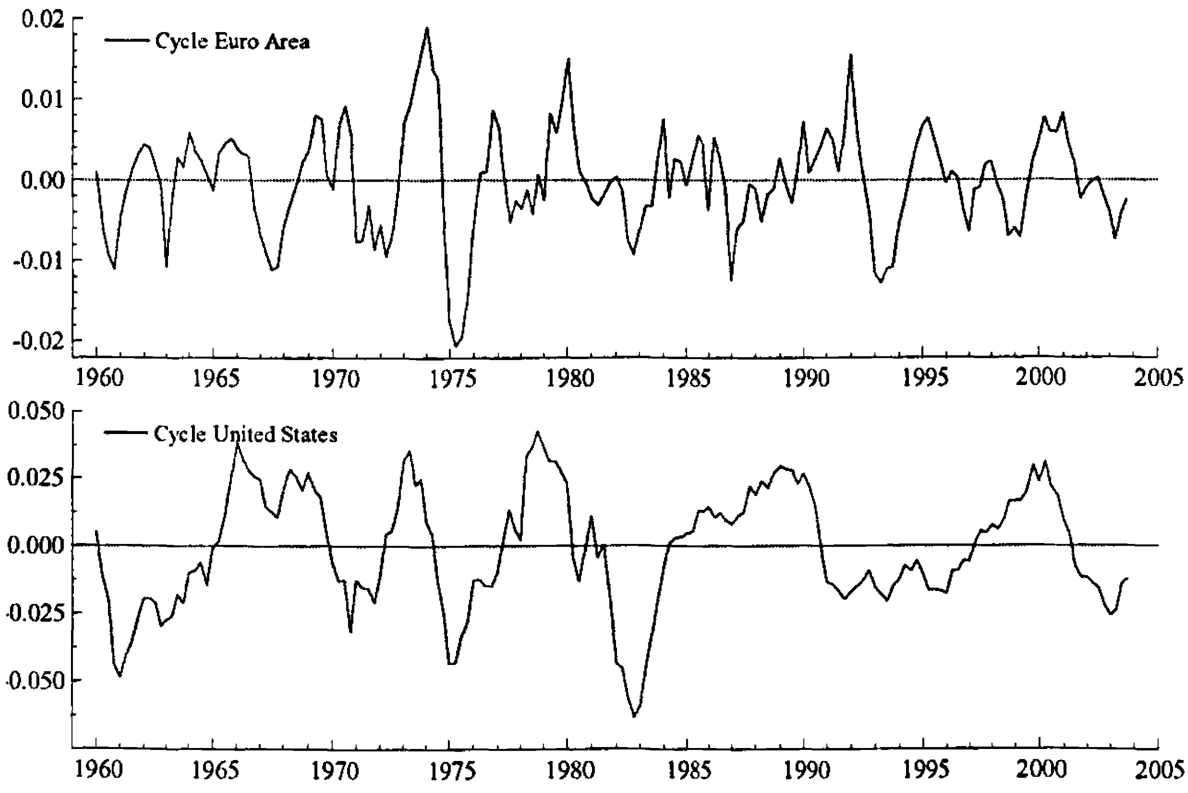
Table 1 reports the details of the final models estimated for each economic area. In all cases, the seasonal component was found to be insignificant, signalling the absence of residual seasonality after the seasonal-adjustment implemented by the OECD. Also in all cases the "*smooth trend*" representation (i.e. fixed level and stochastic slope) was found acceptable. Outliers, detected via auxiliary residuals, were found and corrected for by inserting dummies. The estimated cycles are plotted in Figure 2. Note that this procedure takes into account the possibility of breaks in the variance and mean of each of the component. Thus, the possibility of breaks in the variability of growth found for some economies, which can affect business cycle association, is allowed for a tested in the current framework.[60] It can be observed that, as expected on the basis of the original growth rates series, the deviation cycle of the US exhibits wider fluctuations, although from the mid-1980s the range of fluctuations seems to be similar to the euro area one.

Table 1 – Specifications of unobserved components models

	trend	cycle	seasonal	irregular	outliers	breaks
Euro area	smooth trend[1)]	stochastic (period 20)	no	yes	1968:2	no
US	smooth trend[1)]	stochastic (period 20)	no	no	no	no

Source: Own computations.
[1)] Fixed level and stochastic slope.
Note: the period of the stochastic cycle corresponds to $2\Pi/\lambda$.

Figure 2 – Cycles



Source: Own calculations.

[60] See Stock and Watson (2003) for a review of the evidence on breaks in the variability of growth for the G7 economies.

Some of the basic characteristics that will be discussed are based on a turning points chronology. The corresponding sets of peaks and trough were obtained using the algorithm proposed by Artis et al (2004) applied to each of the cycles (expressed as percentage deviations from trend). This algorithm, based on the theory of Markov chains, consists of a set of rules, including minimum requirements in terms of duration and amplitude of business cycle phases. They can be seen as an extension to quarterly data of the Bry-Boschan algorithm, with the advantage of being more flexible, for example by allowing the imposition of restrictions also in terms of minimum amplitude. More precisely, we have imposed the following restrictions: 1) peaks and troughs must alternate; 2) each phase must last at least two quarters; 3) each cycle must last at least five quarters; 4) a trough can be located only among quarters of negative (below-trend) values of the cycle and peaks only among positive (above-trend) values. Note that rules 2 and 3 are selected as they correspond to the minimum requirements imposed for monthly data in the Bry-Boschan algorithm, which is the most widely diffused algorithm used to locate turning points with monthly data. [61]

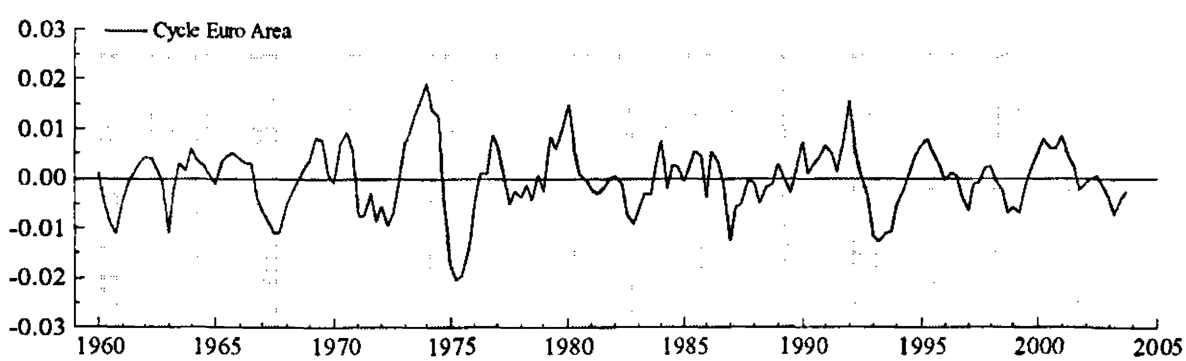
For the main reference series no threshold for the minimum amplitude was imposed, but a robustness analysis was carried out by also deriving alternative sets of turning points. The latter are derived by also imposing that a turning point can only be located among points where the cycle has a minimum magnitude (or distance from the trend), using alternative restrictions from 1% to 5%. This robustness analysis is motivated by the need to assess to which extent minor fluctuations, not all of which may clearly be associated with business cycle fluctuations, may drive the results.

Note that the peaks and troughs are defined as local maxima and minima and the cyclical phases, i.e. upswings and slowdowns, are determined on the basis of these turning points. More precisely, we define upswings as periods starting from the quarter immediately after a trough and ending with the quarter of the subsequent peak, and slowdowns all other remaining periods (or, as those periods starting from the quarter immediately after a peak and ending with the quarter of a trough).

[61] I thank Tommaso Proietti for kindly making available his Ox codes for the computation of the standardised concordance indices as well as the AMP algorithm.

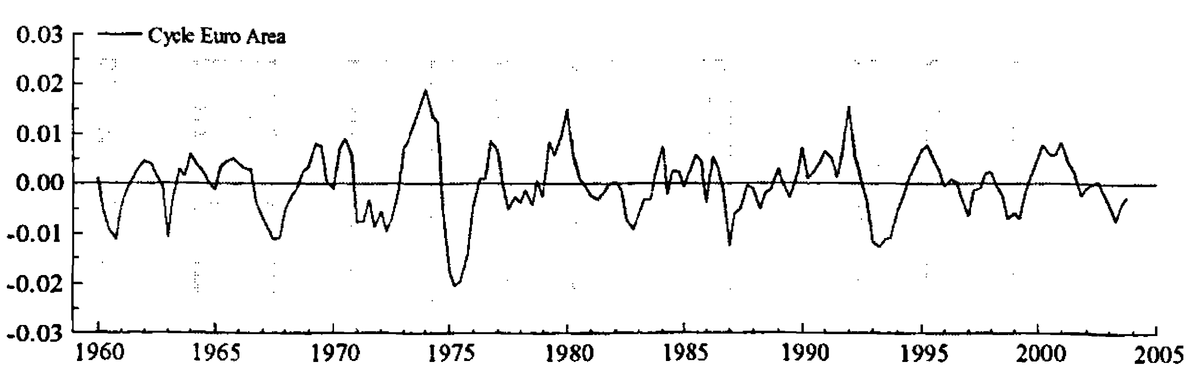
Figures 3 to 5 show the deviation cycle phases for the euro area and the US derived from the sets of turning points discussed. Slowdowns are shown as shaded areas. For the euro area, by imposing the 5% minimum amplitude threshold, various turning points derived from the algorithm without the amplitude criterion disappear. In particular, the 1963/64 and 1989 slowdowns are not classified as such any more and the two slowdowns of the second half of the 1990s are combined into one. By contrast, for the US all alternative rules, with or without the amplitude restrictions (up to 5%) determined the same set of turning points.

Figure 3 – Cyclical phases of the euro area deviation cycle (basic)



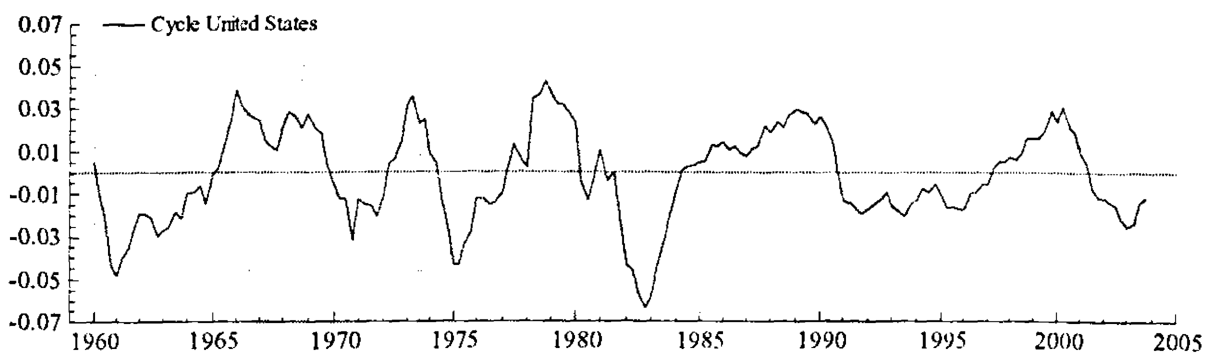
Note: Phases derived without imposing any minimum threshold to cyclical amplitude.

Figure 4 – Cyclical phases of the euro area deviation cycle (alternative)



Note: Phases derived by imposing a 5% minimum threshold to cyclical amplitude.

Figure 5 – Cyclical phases of the US deviation cycle

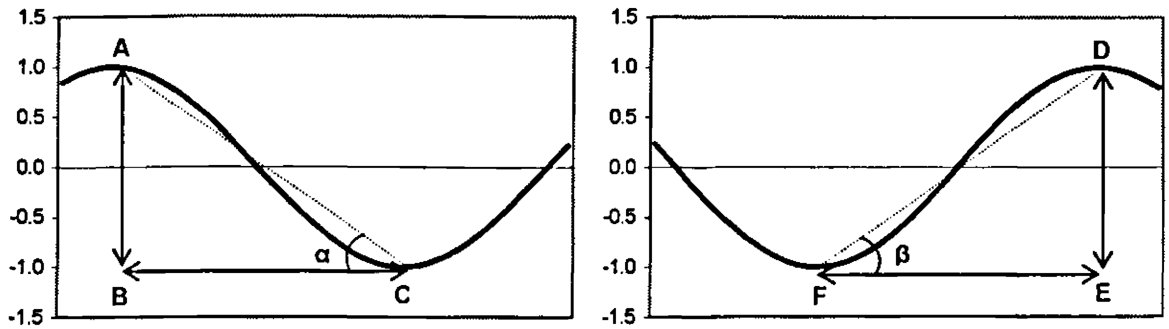


II. 3. Average basic characteristics of the deviation cycle

On the basis of the selected turning points chronology it is possible to compute a set of basic characteristics. These include the average duration, amplitude and steepness of the two main phases of the cycle (i.e. upswings and slowdowns). Amplitude measures are expressed in terms of percentage deviations from trend, and correspond to the distance from the peak to the trough for slowdowns and vice versa for upswings. Steepness measures, following Harding and Pagan (2002a), are derived by dividing amplitude by duration and can be interpreted as the average change (increase for upswings and decrease for slowdown) during the corresponding phase. Figure 6 shows a stylised representation of cyclical phases, from which the basic characteristics can be illustrated. For example, for slowdowns, represented in the left-hand panel, duration would correspond to the segment AC (measured in terms of number of quarters), amplitude to the segment AB (measured in terms of absolute value of the deviations from trend, thus in the picture the value would be about 2%) and steepness would correspond to the tangent of the angle α (obtained by dividing AB by BC).

Figure 6- Stylised representation of cyclical phases

A) Slowdown B) Upswing



Taking as main reference for the euro area the characteristics derived from the turning pints algorithm without amplitude censoring rule (which for simplicity will be called the "basic" reference henceforth), it can be noted that during the sample period considered, the euro area experienced about a dozen cycles, that is twice as many as the US (see Table 2). The alternative classification for the euro area, based on the algorithm including a 5% minimum amplitude restriction (referred to as the "alternative" measures henceforth), implies three fewer cycles compared to the basic one, which still correspond to one third more frequent fluctuations than in the US. As a result, it is not surprising that the average duration of cycles in the euro area (about four years) is much lower than in the US (about seven years).

As regards the various measures of the cyclical phases, it can be observed that for the euro area the cycle seems to be clearly symmetric. In other words, the average duration, amplitude and steepness of upswings is very similar to those of slowdowns. Thus, on average both upswings and slowdowns last two years and are characterised by an overall change of almost two percentage points, with an average change per quarter of about one third of a point. Symmetry also emerges from the alternative chronology for the euro area. At the same time, slowdowns seem to be characterised by wider diversity, as signalled by the larger ranges for all three measures. Also for the US symmetry seems to be broadly a stylised fact, with the possible exception of duration, as slowdowns tend to last on average almost three years, i.e. one year less than upswings.

Table 2 – Basic characteristics

		Euro area basic	US	difference EA v. US	Euro area alternative*	difference EA bas. v. alt.
FREQUENCY				difference		difference
number of cycles (P to P)		11	5	6	8	3
number of cycles (T to T)		12	6	6	9	3
number of upswings		13	7	6	10	3
number of slowdowns		13	7	6	10	3
DURATION (number of quarters)				difference		difference
cycles (P to P)	average	15	28	-13	20	-4
	minimum	9	10	-1	12	-3
	maximum	27	46	-19	33	-6
cycles (T to T)	average	15	29	-14	20	-5
	minimum	10	10	0	10	0
	maximum	22	44	-22	28	-6
upswings	average	7	17	-9	10	-3
	minimum	4	2	2	5	-1
	maximum	12	27	-15	20	-8
slowdowns	average	7	11	-4	9	-2
	minimum	2	7	-5	3	-1
	maximum	14	19	-5	16	-2
AMPLITUDE (percentage)				ratio		ratio
upswings	average	1.9	6.8	0.3	2.2	0.9
	minimum	0.9	2.4	0.4	1.5	0.6
	maximum	2.9	9.3	0.3	2.9	1.0
slowdowns	average	1.8	6.4	0.3	2.1	0.9
	minimum	0.6	5.0	0.1	1.2	0.5
	maximum	4.0	7.9	0.5	4.0	1.0
STEEPNESS (percentage)				ratio		ratio
upswings	average	0.3	0.6	0.5	0.3	1.1
	minimum	0.2	0.2	0.9	0.1	1.3
	maximum	0.5	1.2	0.4	0.5	1.0
slowdowns	average	0.3	0.7	0.5	0.3	1.0
	minimum	0.1	0.3	0.4	0.1	1.3
	maximum	0.8	1.1	0.7	0.8	1.0

Source: Own calculations.
Note: The average and ranges of duration, amplitude and steepness are calculated considering only those phases that fully start and end within the sample.

II. 4. Evolution of the basic characteristics over time

Average developments can potentially conceal broad gradual changes over time, as well as be largely influenced by idiosyncratic episodes. Thus, it is important to complement these basic characteristics with representations of the evolution of the various characteristics over time. One way to approach this aspect is to plot the duration, amplitude and steepness of all phases and assess broad trends by visual inspection. Figures 7 to 10 report the basic characteristics for each cycle and cyclical phase over time for the euro area and the US. The corresponding ones for the alternative euro area classification are shown in

Appendix 1, and provide a similar picture compared to the basic classification in terms of broad developments.

As regards durations of cycles and phases, no clear upward or downward trend can be observed over time, neither for the euro area nor for the US. Taking aside specific episodes such as the particularly long slowdown and (peak-to-peak) cycle of the late 1960s in the euro area, some broad patterns in terms of gradual change can however be observed. More precisely, in the euro area the duration of cycles and phase seems to gradually increase up to the 1980s, and to gradually decrease thereafter (see Figures 7 and 8). By contrast, for the US the opposite gradual changes can be observed. For the US, however, the number of observation is much smaller and therefore it is more difficult to describe these changes as broad (changing) trends.

Figure 7 – Duration of cycles

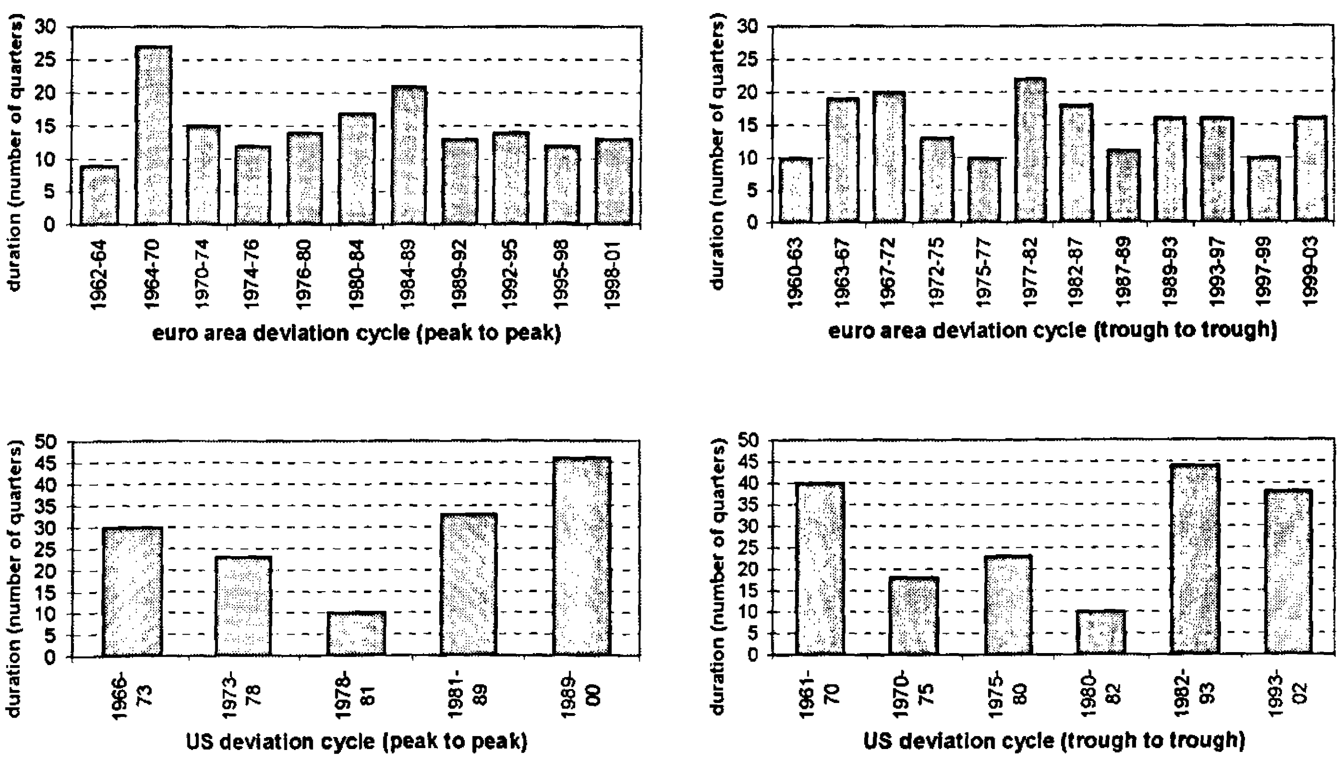
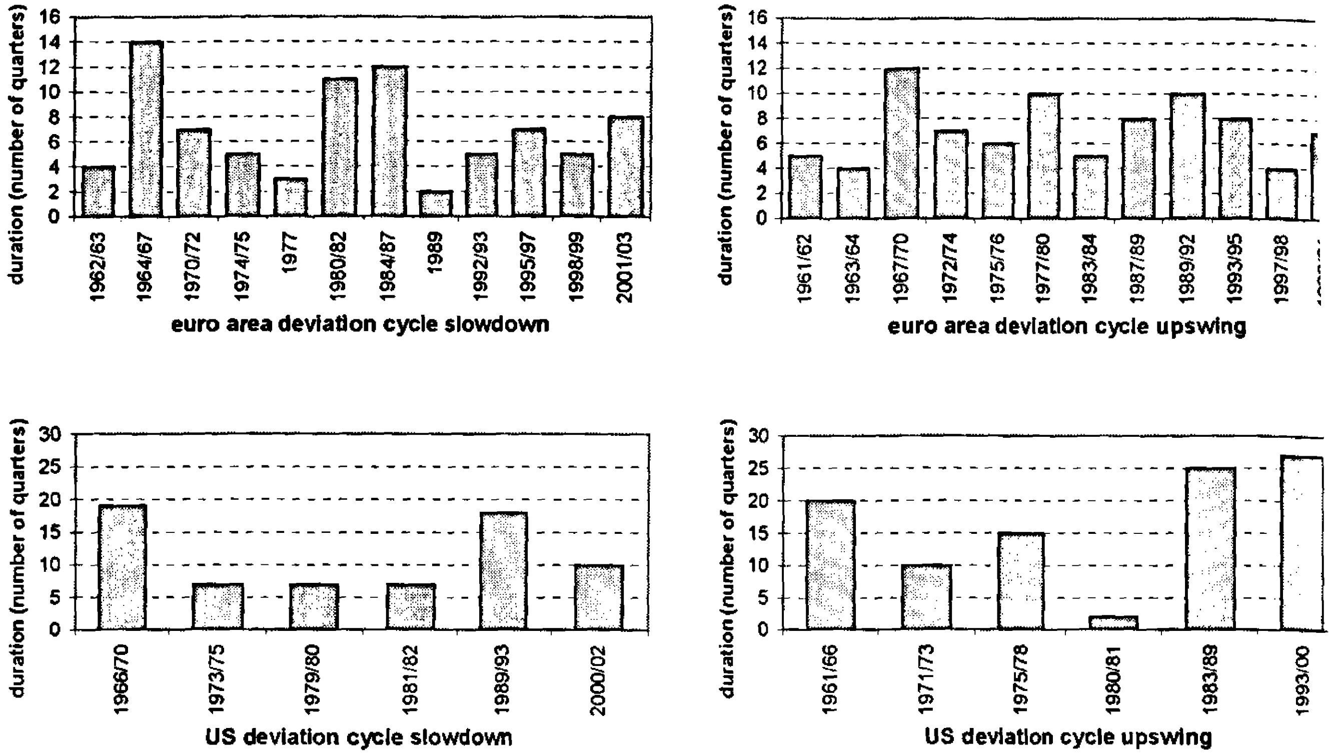


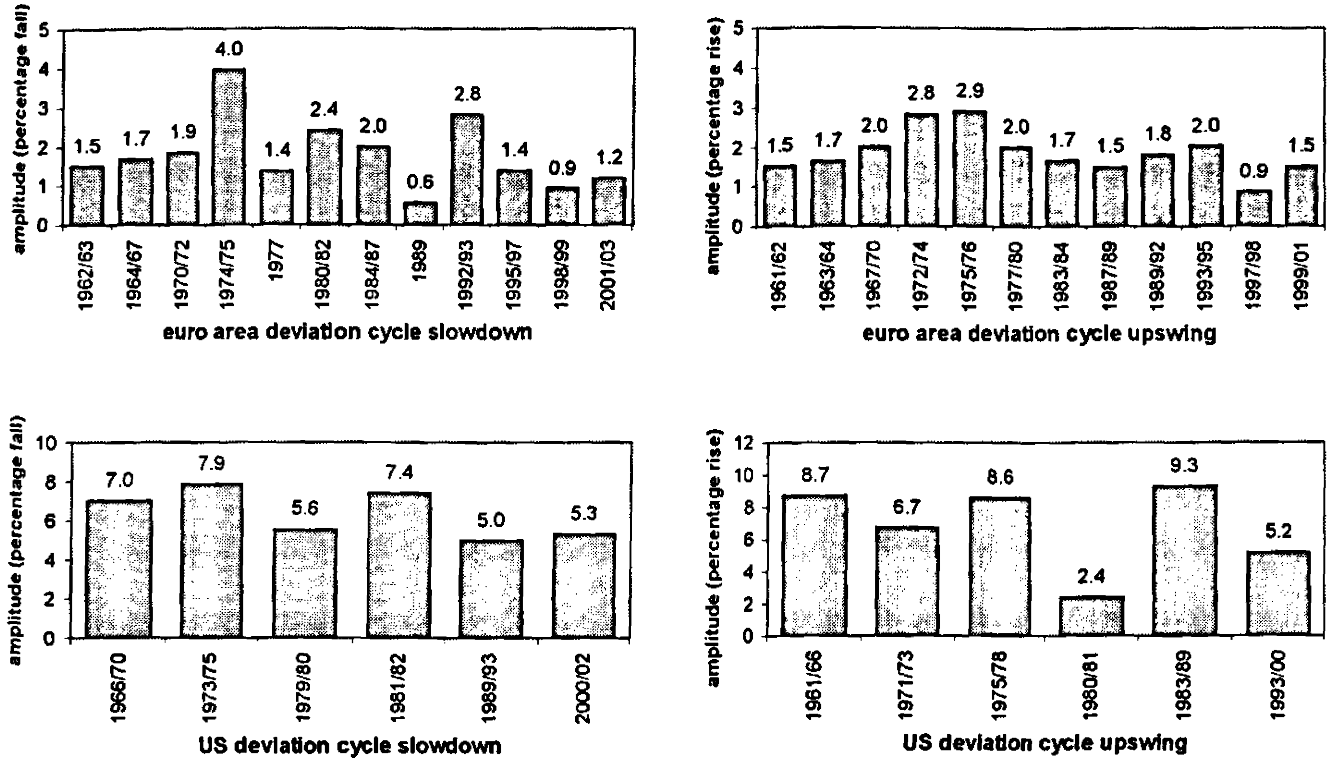
Figure 8 – Duration of phases



Also for amplitude no clear trend can be highlighted for neither economic area (see Figure 9). For the euro area, however, possibly also for this measure a gradual increase up to the late-1970s/mid-1980s and a gradual decrease thereafter can be highlighted. By contrast, for the US no specific gradual change seems to emerge from the data. It should be noted that the amplitude can be seen as an aspect of volatility. However, volatility is characterised also by other aspects. Therefore, this evidence is not necessarily in contrast with the finding of recent studies that the US cycle has become less volatile since the mid-1980s.[62]

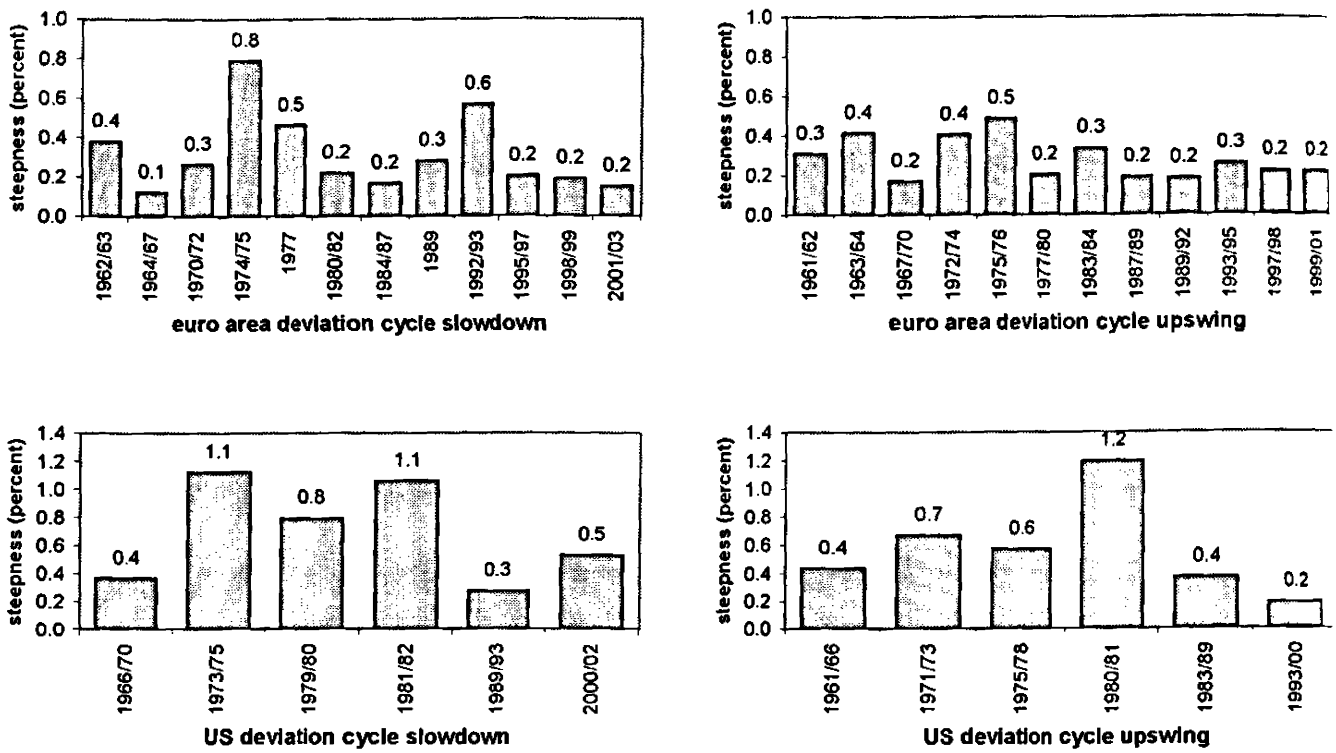
[62] See for example the evidence reported in Stock and Watson (2002).

Figure 9 – Amplitude of phases



Finally, steepness measures seem to be characterised by a relatively higher dispersion over time, reflecting the specific developments in both duration and amplitude measures (see Figure 10). Thus, for the steepness measure it is difficult to highlight not only any broad trend but also gradual changes over time. A possible common feature of these data is the lower steepness that characterises the most recent cyclical episodes both in the euro area and the US. This can be interpreted as a reduced degree of dynamism, but is also likely to reflect an increased degree of stability of the economies under study.

Figure 10 – Steepness of phases



II. 5. Complementary aspects of the deviation cycle

A relevant complementary aspect of the deviation cycle is represented by the position of the cycle with respect to the trend, and in particular whether the economy is at a higher or lower level compared to trend. For example, from a monetary policy perspective inflationary pressures would emerge largely (but nor only, as for instance also speed limit effects may be relevant) when the economy is above trend. Note that the classification of cyclical phases from this point of view, which would reduce to two states of above and below trend, does not depend on the turning points chronology, as it depends only on the series representing the cycle. However, the classification of the cycles requires a minimal set of rules to delimit the two regimes. For this purpose, we adopt a minimal set of requirements, consisting of each regime lasting at least two quarters, and isolated quarters of above or below trend within prolonged periods of below or above trend not representing interruptions in the regime.

Also from this perspective it can be observed that cycles in the euro area are about twice as frequent as in the US (see Table 3). Thus, the average duration of periods above trend and below trend in the euro area, which is about two years, is about half that recorded for the US. Amplitude, measured as the minimum and maximum points in terms of deviations from trend within the corresponding regime, are on average one percentage point in the euro area, which is three to four times lower than in the US. Moreover, regimes tend to be symmetric in both economic areas, as suggested by all measures. The longer duration and higher amplitude of the US regimes on average imply that the average gain and loss of the two regimes, measures as the cumulated output increase and decrease during the corresponding phase, are much higher n the US, by a factor of about ten. Note that also in this case, no clear trend in the evolution of the two regimes can be observed (see for example Figures 3 to 5).

Table 3 – Additional characteristics

			Euro area	US	EA v US
FREQUENCY					difference
number of periods above trend			12	6	6
number of periods below trend			12	6	6
DURATION (number of quarters)					difference
above trend	average		8	17	-9
	minimum		2	9	-7
	maximum		13	26	-13
below trend	average		7	16	-9
	minimum		3	9	-6
	maximum		12	26	-14
AMPLITUDE (percentage)					ratio
above trend	average		0.9	3.5	0.3
	minimum		0.2	2.9	0.1
	maximum		1.9	4.3	0.4
below trend	average		-1.1	-4.1	0.3
	minimum		-2.0	-6.3	0.3
	maximum		-0.5	-2.1	0.3
GAIN (percentage)					ratio
cumulated output gain when above trend		average	3.7	29.6	0.1
cumulated output gain when above trend		minimum	0.4	15.2	0.0
cumulated output gain when above trend		maximum	9.0	40.6	0.2
LOSS (percentage)					ratio
cumulated output loss when below trend		average	-3.7	-31.3	0.1
cumulated output loss when below trend		minimum	-8.1	-44.7	0.2
cumulated output loss when below trend		maximum	-1.2	-13.8	0.1

Source: Own calculations.
Note: The average and ranges of duration, amplitude and gain/loss are calculated considering only those phases that fully start and end within the sample.

III. Statistical cyclical properties of macroeconomic variables

III. 1. Introduction

The objective of section III is to report and discuss the main stylised facts characterising a set of key euro area macroeconomic variables, and compare them to the corresponding ones for the US.

Various contributions have already provided some basic statistical properties of a set of fundamental macroeconomic variables for the euro area. However, there are several studies for single euro area countries but very few papers attempt to identify regularities for the euro area as an aggregate. One of the first to adopt the euro area aggregate perspective in the analysis of business cycle stylised facts was Döpke (1999), who discusses regularities for a number of euro area macroeconomic time series constructed by the author by aggregating data for the largest five euro area economies and filtered via the Hodrick-Prescott detrending method from 1980 to 1997. His results are not particularly reliable, both due to the questionable quality of the data, the arbitrary aggregation method, the short sample period, the less than optimal representation of the euro area, and especially the ad hoc filtering method used. Agresti and Mojon (2003) carry out a similar exercise with data for 24 euro area macroeconomic variables from 1970 to 2000 with reference to the cyclical components extracted via the Baxter-King filter, and compare the regularities with those of the US[63]. Also the stylised facts identified in the latter study are not fully reliable because the authors apply mechanically the band-pass filter (only calibrating the maximum length of the cyclical component), thus exposing the analysis to the risk of focusing on spurious cycles. Moreover, they do not test for structural breaks in the series before filtering them (nor, of course, in the framework of the filtering process) and they do not examine the stability of the characteristics identified. The latter aspects are relevant, as for example Marcellino (2002) has shown: he finds signs of instability in seven out of the 15 euro area macroeconomic variables he examines (taken from the same database of Agresti and Mojon). Finally, Artis et al. (2004) examine

[63] See also the ECB Monthly Bulletin article in the July 2002 issue on "Characteristics of the euro area business cycle in the 1990s", which focuses on Baxter-King filtered data for the 1990s only.

a set of properties like number of cycles, average duration and amplitude, of a set of twelve macroeconomic variables, ranging from real GDP and expenditure components to four labour market variables (taken from the AWM database, from 1970 to 2001), for both the classical cycle and the deviation cycle (extracted via an extended, or band-pass, Hodrick-Prescott filter). However, they do not examine regularities such as the degree of co-movement with respect to GDP, relative variability and autocorrelations, which are also relevant for business cycle analysis. Compared to these studies, the second part of this chapter adopts a broader approach and provides an analysis which has several advantages compared to the existing literature: we focus on a model-based approach to extract cyclical components (which also tests for possible outliers and breaks in the data), look at a larger set of stylised facts, provide HAC standard errors for the stylised facts, compare all regularities with the corresponding ones for the US, focus on a relatively harmonised and long historical set of data, and also provide an assessment of the stability of regularities over time.

III. 2. Data and methods

Ideally, the choice of variables to examine should be dictated by economic theory, as is done for example by Kydland and Prescott (1990). Unfortunately for the euro area the available data is more limited than for the US economy. Moreover, since we want to adopt a comparative perspective with the US, we need a set of macroeconomic variables for the euro area and the US which is relatively harmonised. For this reason we use mainly the OECD Economic Outlook database and focus, among the variables of interest from a theoretical point of view, on the variables which are defined similarly and are available for both economic areas. Thus, we have to restrict out attention to real GDP, private consumption, gross fixed capital formation (i.e. fixed investment), industrial production (excluding construction), total civilian employment, the unemployment rate, labour productivity (per person, rather than per hour), the GDP deflator and the CPI index. Table 4 provides an overview of the basic characteristics of our dataset. All data is quarterly and is available from 1963q1 to 2003q4, except for euro area labour market variables, which are available only as of 1970q1. Although US variables are available from

1960 or before, we restrict the analysis to the sample period for which also euro area data are available, in order to ensure comparability of results.

Table 4 – Basic properties of the data

	sample period	unit	mean	range		st dev
EURO AREA				min	max	
real GDP	1963q1-2003q4	quarterly growth rate	0.7	-1.3	4.4	0.7
private consumption	1963q1-2003q4	quarterly growth rate	0.8	-1.6	5.6	0.7
fixed investment	1963q1-2003q4	quarterly growth rate	0.6	-2.7	5.4	1.5
GDP deflator inflation	1963q1-2003q4	percentage	1.3	0.1	3.3	0.8
CPI inflation	1963q1-2003q4	percentage	1.3	0.1	3.4	0.8
industrial production	1963q1-2003q4	quarterly growth rate	0.7	-4.5	6.3	1.4
total employment	1970q1-2003q4	quarterly growth rate	0.1	-0.5	0.7	0.3
unemployment rate	1970q1-2003q4	percent of labour force	7.1	2.1	10.8	2.8
labour productivity	1970q1-2003q4	quarterly growth rate	0.4	-3.1	1.9	0.6
US						
real GDP	1963q1-2003q4	quarterly growth rate	0.8	-2.0	3.9	0.9
private consumption	1963q1-2003q4	quarterly growth rate	0.9	-2.3	2.8	0.7
fixed investment	1963q1-2003q4	quarterly growth rate	1.0	-8.3	8.0	2.1
GDP deflator inflation	1963q1-2003q4	percentage	1.0	0.2	2.9	0.6
CPI inflation	1963q1-2003q4	percentage	1.1	-0.5	3.9	0.8
industrial production	1963q1-2003q4	quarterly growth rate	0.8	-6.3	4.3	1.5
total employment	1970q1-2003q4	quarterly growth rate	0.4	-1.4	1.7	0.5
unemployment rate	1970q1-2003q4	percent of labour force	6.3	3.9	10.7	1.4
labour productivity	1970q1-2003q4	quarterly growth rate	0.3	-1.5	2.6	0.7

Source: Eurostat, OECD and own calculations.

Industrial production data were obtained from the OECD Main Economic Indicator database, and for the euro area were extended backwards (before 1980) using an aggregate from harmonized country data from Eurostat. The OECD Economic Outlook data for total employment for the euro area was replaced by Eurostat ESA95 data from 1980 onwards, as the OECD series was not adjusted for German unification and thus exhibits a big spike in 1991.

With the exception of the unemployment rate, the cyclical components of the series were obtained by estimating univariate unobserved components models for each series. The original series were expressed in log-levels, except for the GDP deflator and the CPI which were expressed in terms of quarterly inflation rates (or quarter-on-quarter growth rates). The cyclical components of the unemployment rate for the two economic areas were approximated by the deviations of the unemployment rate from NAIRU estimates. For the US the NAIRU estimates were obtained from the OECD Economic Outlook database while for the euro area (for which the estimates from the OECD Economic Outlook database start in 1978) the NAIRU was estimated using the multivariate unobserved components model of Proietti, Musso and Westermann (2002).[64] Table 5 shows the specifications of the unobserved components models chosen for each variable, following the modelling strategy already used for the previous part of this chapter. All resulting cycles are plotted in Figures 11 and 12.

Table 5 – Specifications of unobserved components models

	trend	cycle	seasonal	irregular	outliers	breaks
EURO AREA						
real GDP	smooth trend[1)]	stochastic (period 20)	no	yes	1968:2	no
private consumption	smooth trend[1)]	stochastic (period 20)	no	yes	1990:3-4	no
fixed investment	smooth trend[1)]	stochastic (period 20)	no	yes	1968:2, 70:1, 79:1, 87:1, 96:1	no
GDP deflator inflation	linear trend	AR (1)	no	yes	1971:1	no
CPI inflation	smooth trend[1)]	stochastic (period 20)	no	yes	no	no
industrial production	smooth trend[1)]	stochastic (period 20)	no	yes	1968:2	no
total employment	smooth trend[1)]	stochastic (period 20)	no	no	1976:3	1991:1 (slope)
labour productivity	smooth trend[1)]	stochastic (period 20)	no	no	1991:1	no
US						
real GDP	smooth trend[1)]	stochastic (period 20)	no	no	no	no
private consumption	smooth trend[1)]	stochastic (period 20)	no	no	1980:2	no
fixed investment	smooth trend[1)]	stochastic (period 20)	no	no	1980:1	no
GDP deflator inflation	smooth trend[1)]	stochastic (period 20)	yes	yes	no	no
CPI inflation	smooth trend[1)]	stochastic (period 20)	no	yes	1980:3, 1986:2	no
industrial production	smooth trend[1)]	stochastic (period 20)	no	no	no	no
total employment	smooth trend[1)]	stochastic (period 20)	no	no	no	no
labour productivity	smooth trend[1)]	stochastic (period 20)	no	yes	1970:4	no

Source: Own computations.
[1] Fixed level and stochastic slope.
Note: the period of the stochastic cycle corresponds to $2\Pi/\lambda$.

[64] More precisely the pseudo-integrated cycles variant of the model, which assumes that the cycles in the labour variables are more persistent, was estimated. See T. Proietti, A. Musso and T. Westermann (2002): "Estimating potential output and the output gap for the euro area: a model-based production function approach", *European University Institute, Florence, Working paper ECO* 2002/09.

Figure 11 – Euro area cyclical components

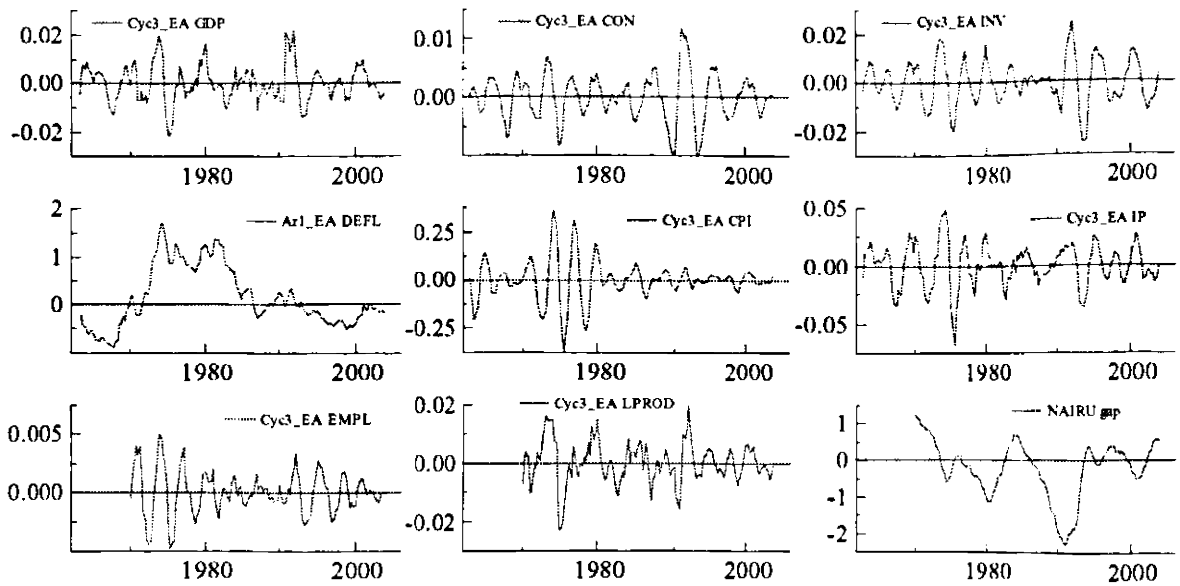
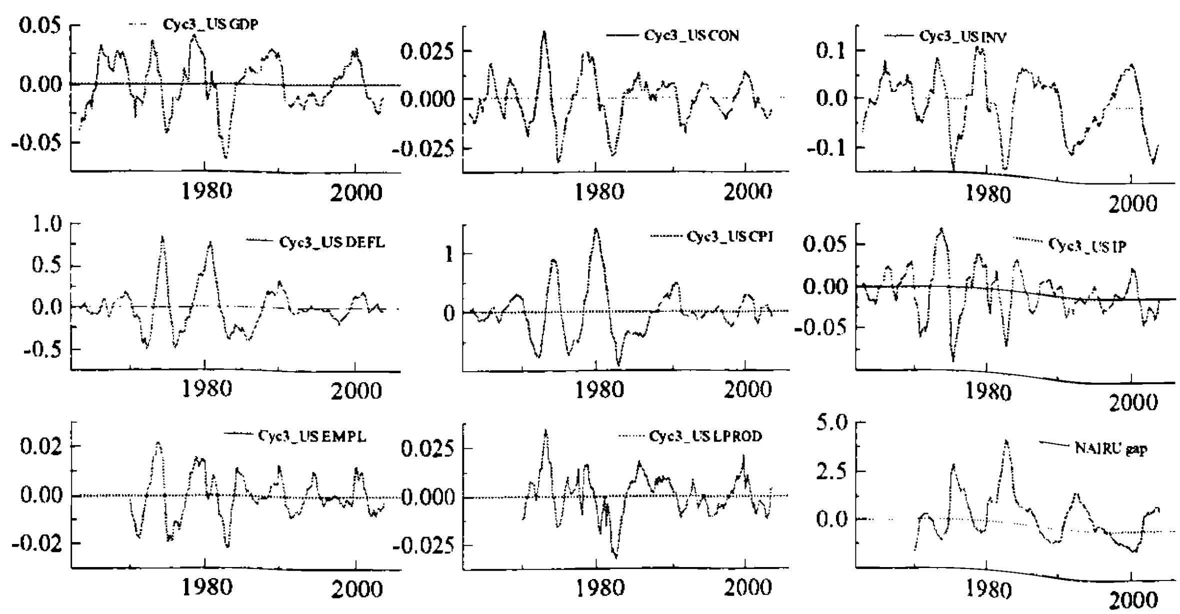


Figure 12 – US cyclical components



III. 3. Stylised facts

The euro area classical cycle stylised facts, shown in Table 6, are discussed in this section mainly by contrasting them with the corresponding ones found for the US, shown in Table 7. The regularities we focus on are the relative volatility of each variable with respect to real GDP (see second column, which shows the relative standard deviations with that of real GDP –indicated in the entry for GDP- as denominator), the type of cyclicality (pro-, counter- or a-cyclicality, found when the maximum correlation between real GDP and the variable is significantly positive, significantly negative and non-statistically significant, respectively), the type of time shift (depending on the quarterly shift where the maximum correlation is found) and the correlation values (maximum and contemporaneous). In brackets are Newey-West heteroskedasticity and autocorrelation consistent standard errors. Appendix 3 provides more details on these statistics.

Most regularities are very similar across economic area and appear to be consistent with the common wisdom. For example, the cyclical component of consumption tends to be smoother than output, consistently with life-cycle and permanent income theories of consumption. By contrast, the cyclical components of investment and industrial production are significantly more volatile, confirming that these expenditure and sectoral components are among the main driving forces of the cycle, despite representing a minor fraction of total value added (about one fifth and one fourth, respectively). Consumption appears to be much more important for fluctuations in the US than in the euro area, confirming that this component of expenditure probably plays a relatively more important role in explaining the North-American deviation cycle than in the euro area, a finding also noted by Angeloni et al. (2003), which relate it to the larger role of this expenditure component to the monetary transmission mechanism in the US.

Inflation rates tend to be procyclical, but relatively less linked to the cycle, as signalled by the lower (although still significant) correlations and the lower standard deviations with respect to the deviation cycle, approximated by the cyclical component of real GDP. A notable difference between the euro area and the US is that these variables tend to be coincident (or exhibiting a short lag of only one quarter on average in the case of the CPI) in the former area, while they are clearly lagging, by about one year, in the latter region.

However, the significantly lower maximum correlations found for these variables in the euro area suggests that the degree of price stickiness is possibly higher than in the US.

Also regarding labour market variables some differences emerge between the two economic areas considered. Despite the fact that the latest upswing has been characterised as a jobless recovery in the US, suggesting that employment may have become more lagging with respect to the cycle, for the overall period the evidence suggests that labour market variables tend to be coincident in the US. This finding can be explained at least in part with the higher flexibility of the North-American labour market, which reacts more and more rapidly to cyclical developments. By contrast, in the euro area, the cyclical components of both employment and unemployment tend to be lagging. In both areas, labour productivity is highly correlated with the cycle and coincident. The cyclical component of latter variable is more volatile and more closely linked to the cycle in the euro area than in the US. This result is possibly also due to the increased importance of the structural component of productivity in the US since the 1990s, related to the so-called "new economy" effects of the higher production and adoption of information and communication technologies.

Table 6 – Euro area stylised facts

	relative standard deviation		contemporaneous correlation		maximum correlation		significantly different?	cyclicality	lead/lag shift
real GDP	0.76	(0.09)							
consumption	0.53	(0.19)	0.65	(0.11)				procyclical	coincident
investment	1.20	(0.07)	0.80	(0.11)				procyclical	coincident
GDP defl	0.82	(0.16)	0.13	(0.15)	0.14	(0.16)	no	procyclical	coincident
CPI	0.14	(1.09)	0.43	(0.14)	0.49	(0.21)	yes	procyclical	lagging (1)
ind prod	2.46	(0.03)	0.84	(0.08)				procyclical	coincident
employment	0.24	(0.45)	0.51	(0.12)	0.67	(0.12)	yes	procyclical	lagging (1/2
lab prod	0.91	(0.07)	0.85	(0.07)				procyclical	coincident
unempl rate	0.97	(0.19)	-0.29	(0.15)	-0.33	(0.14)	yes	countercyclical	lagging (1/2

Table 7 – US stylised facts

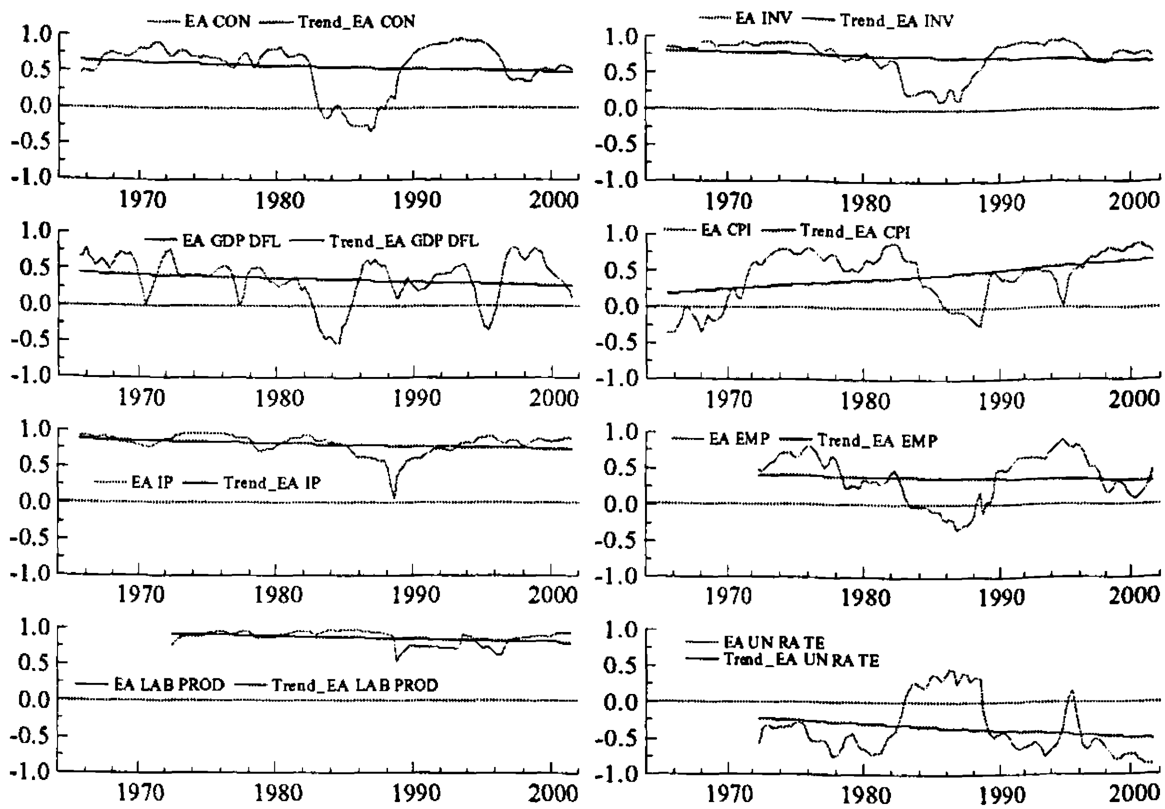
	relative standard deviation		contemporaneous correlation		maximum correlation		significantly different?	cyclicality	lead/lag shift
real GDP	2.18	(0.21)							
consumption	0.54	(0.18)	0.79	(0.11)	0.81	(0.12)	no	procyclical	coincident
investment	2.72	(0.03)	0.88	(0.11)				procyclical	coincident
GDP defl	0.12	(1.37)	0.19	(0.14)	0.65	(0.16)	yes	procyclical	lagging (4/5)
CPI	0.19	(0.85)	0.38	(0.15)	0.67	(0.18)	yes	procyclical	lagging (3/4)
ind prod	1.24	(0.12)	0.71	(0.15)				procyclical	coincident
employment	0.42	(0.27)	0.71	(0.14)	0.75	(0.13)	no	procyclical	coincident
lab prod	0.51	(0.19)	0.76	(0.12)	0.77	0.12	no	procyclical	coincident
unempl rate	0.54	(0.14)	-0.81	(0.10)	-0.83	(0.12)	no	countercyclical	coincident

III. 4. Stability of relationships

Regularities reported in the previous section are average characteristics, which may be the result of unstable relationships. In order to assess the stability of the co-movement relationships over the cycle, we report the rolling correlations for each variable with respect to real GDP. More precisely, we compute centred rolling contemporaneous correlations with a five-year moving window, corresponding to the average duration of cycles (in the euro area), for both the euro area (Figure 13) and the US (Figure 14). Thus, each point reports the correlation over a period spanning from the previous two and a half years to the subsequent two and a half years with output. Although the maximum correlation with output is not always found at contemporaneous level these charts can provide useful indications on major changes.

It can be observed that in most cases occasional episodes of departures from average co-movements. These episodes do not appear to be systematically related to particular phases of the cycle (such as slowdowns). However, in most cases the range of fluctuation of the correlations is limited, thus suggesting that relationships tend to be stable over time. Although some signs of changing trends can be detected, as for the CPI in the euro area or employment for the US, these may be mainly induced by the occasional deviations from the average than being the result of genuine structural changes. Labour productivity per worker appears to exhibit the most stable co-movement with output over time for the euro area, while for the US this is possibly found for the unemployment rate.

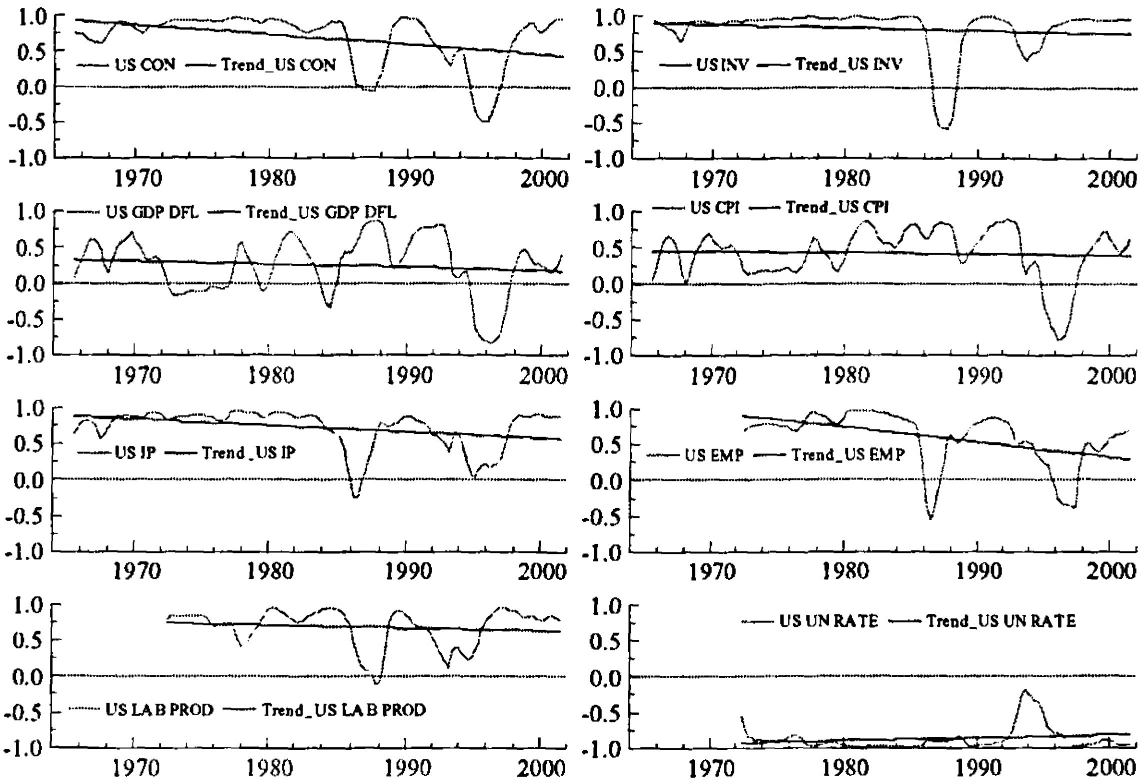
Figure 13 – Rolling (contemporaneous) correlations of euro area variables with real GDP *(five year window, centred)*



In order to test for structural breaks in these relationships, the multiple break test of Bai and Perron was implemented for all the rolling correlation series. In all cases, the sequential procedure did not signal the presence of any break, while the information criteria tended to suggest 3 to 5 breaks for all series. Overall, this evidence is consistent with the presence occasional deviations from the average developments, possibly for prolonged but relatively short periods, but no structural breaks in these regularities.

Figure 14 – Rolling (contemporaneous) correlations of US variables with real GDP

(five year window, centred)



IV. Conclusions

Basic characteristics and stylised facts of the business cycle can represent a useful reference for various purposes, including conjunctural analysis, forecasting and model selection. In this study we have identified a set of basic stylised facts of the euro area deviation cycle from 1960 to 2003, and discussed it in comparative perspective with respect to the US business cycle.

The main findings of the first part of the chapter are the following. First, the deviation cycle appears to be broadly symmetric, in terms of all of the basic characteristics considered, both in the euro area and the US. Second, compared to the US, the euro area seems to be subject to more frequent fluctuations, of shorter duration and milder amplitude. Finally, no clear trends in the evolution of the basic characteristics can be observed over time.

In the second part of the chapter it has been shown that a number of regularities can be detected for the euro area business cycle which are very similar to the corresponding ones for the US. For example, the cyclical component of consumption tends to be smoother than output, while the cyclical components of investment and industrial production are significantly more volatile. However, some notable differences can also be identified. For instance, in the US consumption dynamics seem to be more closely lined to the cycle than in the euro area. Moreover, labour market variables seem to be clearly lagging in the euro area, in contrast to the US where they tend to be coincident. Price developments are relatively less associated to the cycle, and there are signs that they tend to lag the cycle, especially so in the US. Most variables exhibit a relatively stable degree of co-movement with output. Although occasional departures from average co-movements can be observed for most variables, these do not seem to be associated with structural changes.

All these regularities should be taken into account when formulating and assessing models for business cycle analysis.

Appendix 1 – Turning points chronologies

Table – Turning points

	Euro Area	Euro Area	US
	No Amplitude Threshold	5% Amplitude Threshold	
peak			
trough	1960:4	1960:4	1961:1
peak	1962:1		
trough	1963:1		
peak	1964:1	1964:1	1966:1
trough	1967:3	1967:3	1970:4
peak	1970:3	1970:3	
trough	1972:2	1972:2	
peak	1974:1	1974:1	1973:2
trough	1975:2	1975:2	1975:1
peak	1976:4	1976:4	1978:4
trough	1977:3	1977:3	1980:3
peak	1980:1	1980:1	1981:1
trough	1982:4	1982:4	1982:4
peak	1984:1	1984:1	
trough	1987:1	1987:1	
peak	1989:1		1989:1
trough	1989:3		
peak	1992:1	1992:1	
trough	1993:2	1993:2	1993:3
peak	1995:2	1995:2	
trough	1997:1		
peak	1998:1		
trough	1999:2	1999:2	
peak	2001:1	2001:1	2000:2
trough	2003:1	2003:1	2002:4

Appendix 2 – Results for the alternative euro area chronology

Figure A1 – Duration of cycles

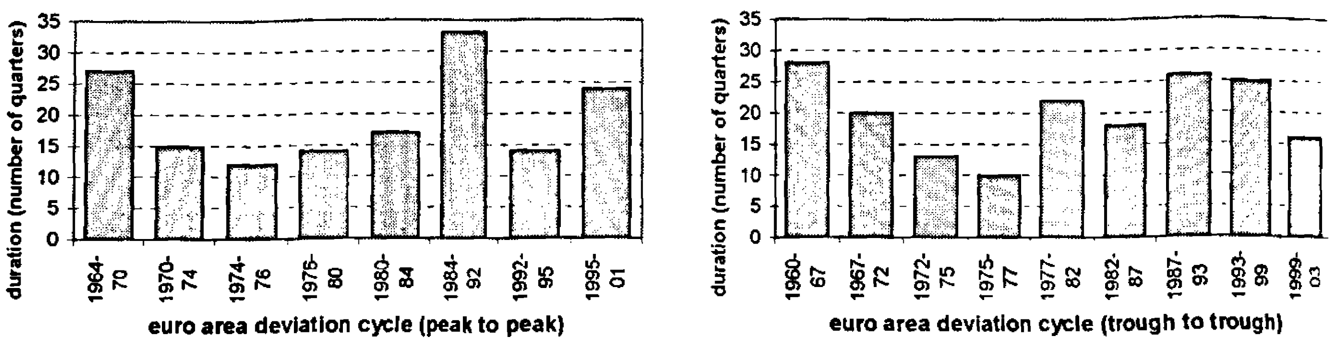


Figure A2 – Duration of phases

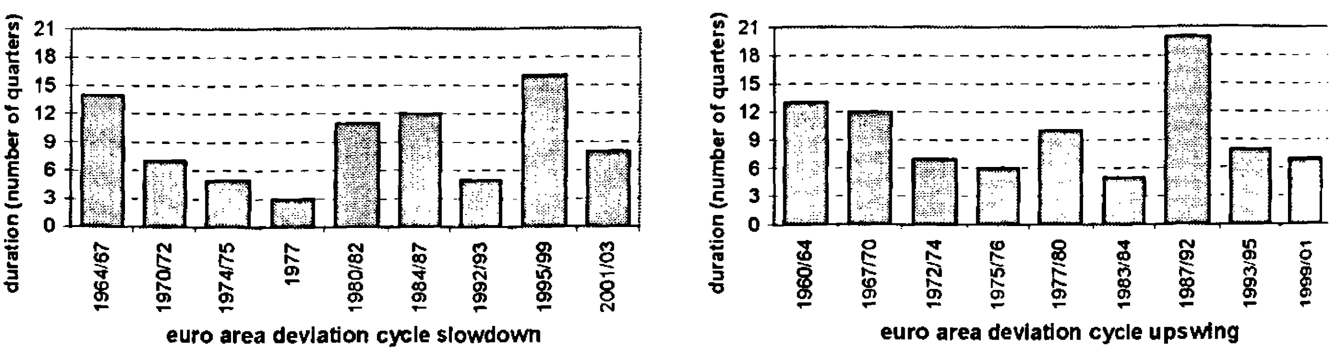


Figure A3 – Amplitude of phases

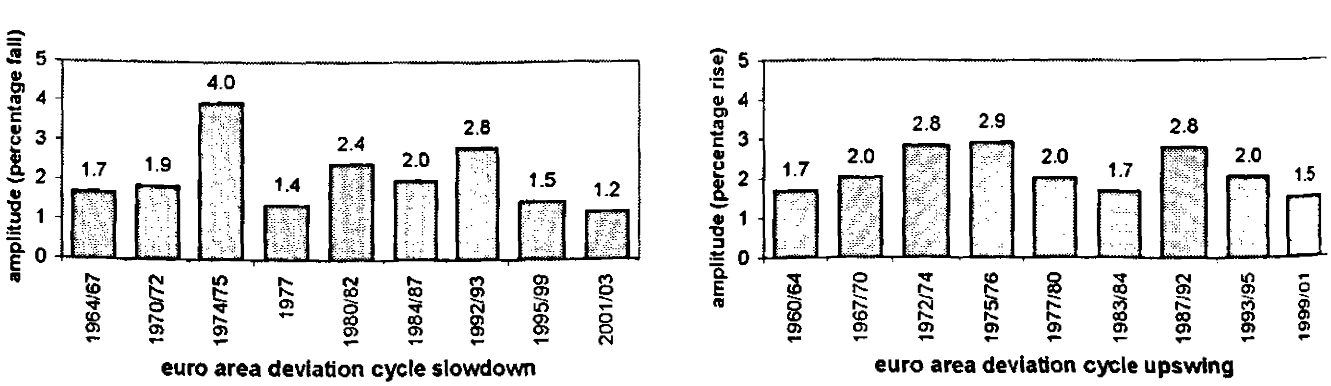
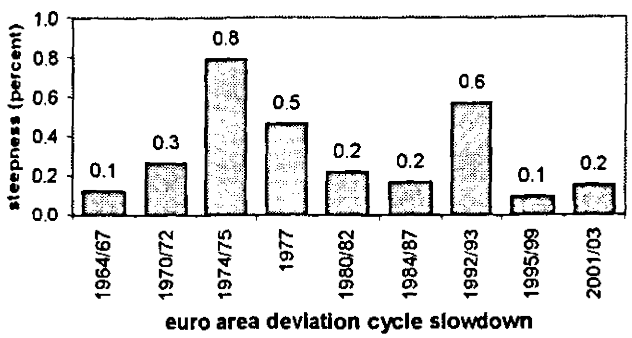
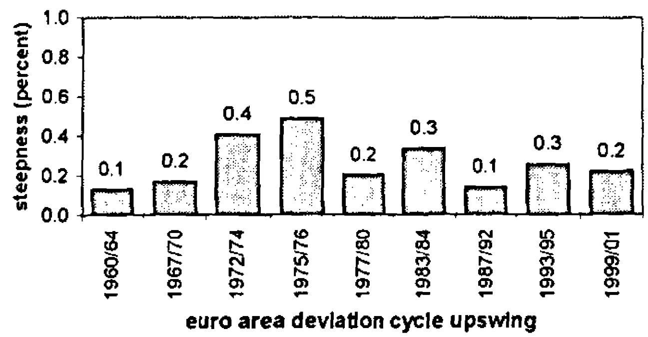


Figure A4 – Steepness of phases





Appendix 3 – Detailed stylised facts

This appendix provides more details on the co-movements and relative standard deviations of euro area and US cyclical components. These include both statistics and the corresponding Newey-West heteroskedasticity and autocorrelation consistent (HAC) standard errors.

Table 1 – Euro area

variable	st dev rel to GDP	cross correlation with real GDP -6	-5	-4	-3	-2	-1	0	1	2	3	4	5	
real GDP	0.8	-0.44	-0.27	-0.02	0.22	0.50	0.78	**1**	0.78	0.50	0.22	-0.02	-0.27	[illegible]
private consumption	0.5	-0.41	-0.21	0.03	0.27	0.48	0.63	**0.65**	0.49	0.29	0.08	-0.12	-0.29	[illegible]
fixed investment	1.2	-0.43	-0.27	-0.02	0.22	0.47	0.69	**0.80**	0.68	0.45	0.17	-0.12	-0.38	[illegible]
GDP deflator inflation	0.8	-0.12	-0.12	-0.09	-0.04	0.03	0.09	0.13	**0.14**	0.12	0.08	0.04	0.00	[illegible]
CPI inflation	0.1	-0.44	-0.47	-0.38	-0.20	0.05	0.28	0.43	**0.49**	0.43	0.27	0.04	-0.18	[illegible]
industrial production	2.5	-0.38	-0.26	-0.04	0.24	0.53	0.75	**0.84**	0.72	0.48	0.16	-0.17	-0.43	[illegible]
total employment	0.2	-0.47	-0.54	-0.48	-0.34	-0.10	0.20	0.51	**0.67**	**0.66**	0.49	0.24	-0.07	[illegible]
labour productivity	0.9	-0.34	-0.20	0.03	0.25	0.47	0.67	**0.85**	0.60	0.30	0.04	-0.18	-0.36	[illegible]
unemployment rate	1.0	0.05	0.01	-0.05	-0.10	-0.15	-0.22	-0.29	**-0.33**	**-0.32**	-0.28	-0.21	-0.11	[illegible]

Newey-West HAC Standard Errors

variable	st dev rel to GDP	cross correlation with real GDP -6	-5	-4	-3	-2	-1	0	1	2	3	4	5	
real GDP	0.09	0.11	0.09	0.06	0.04	0.02	0.06		0.04	0.04	0.04	0.06	0.07	[illegible]
private consumption	0.19	0.11	0.10	0.04	0.05	0.11	0.11	0.11	0.13	0.09	0.13	0.13	0.09	[illegible]
fixed investment	0.07	0.11	0.10	0.04	0.08	0.12	0.10	0.11	0.10	0.11	0.10	0.05	0.05	[illegible]
GDP deflator inflation	0.16	0.14	0.15	0.16	0.16	0.16	0.16	0.15	0.16	0.17	0.17	0.16	0.15	[illegible]
CPI inflation	1.09	0.16	0.19	0.15	0.13	0.06	0.13	0.14	0.21	0.17	0.14	0.12	0.13	[illegible]
industrial production	0.03	0.14	0.11	0.11	0.06	0.08	0.11	0.08	0.11	0.11	0.07	0.05	0.09	[illegible]
total employment	0.45	0.15	0.17	0.15	0.13	0.06	0.07	0.12	0.12	0.12	0.12	0.08	0.07	[illegible]
labour productivity	0.07	0.14	0.15	0.14	0.15	0.15	0.14	0.07	0.07	0.03	0.09	0.13	0.15	[illegible]
unemployment rate	0.19	0.21	0.21	0.21	0.20	0.18	0.16	0.15	0.14	0.14	0.13	0.11	0.10	[illegible]

Table 2 – US

variable	st dev rel to GDP	cross correlation with real GDP												
		-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6
real GDP	2.2	0.17	0.33	0.50	0.66	0.81	0.92	**1**	0.92	0.81	0.66	0.50	0.33	0.17
private consumption	0.5	0.17	0.33	0.50	0.64	0.75	**0.81**	0.79	0.67	0.51	0.33	0.14	-0.03	-0.18
fixed investment	2.7	0.28	0.40	0.53	0.65	0.78	0.86	**0.88**	0.81	0.69	0.54	0.37	0.18	0.00
GDP deflator inflation	0.1	-0.59	-0.52	-0.42	-0.29	-0.13	0.03	0.19	0.34	0.48	0.58	0.64	**0.65**	0.62
CPI inflation	0.2	-0.50	-0.41	-0.28	-0.12	0.05	0.23	0.38	0.51	0.60	0.66	**0.67**	0.64	0.58
industrial production	1.2	-0.12	0.00	0.14	0.30	0.46	0.62	**0.71**	0.68	0.59	0.44	0.26	0.06	-0.10
total employment	0.4	-0.26	-0.13	0.03	0.19	0.39	0.57	0.71	**0.75**	0.70	0.60	0.46	0.30	0.12
labour productivity	0.5	0.35	0.47	0.58	0.68	0.75	**0.77**	0.76	0.57	0.37	0.19	0.04	-0.10	-0.20
unemployment rate	0.5	-0.11	-0.23	-0.35	-0.47	-0.61	-0.73	-0.81	**-0.83**	-0.79	-0.68	-0.55	-0.39	-0.24

Newey-West HAC Standard Errors

variable	st dev rel to GDP	cross correlation with real GDP												
		-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6
real GDP	0.21	0.11	0.10	0.12	0.11	0.08	0.05		0.04	0.08	0.10	0.10	0.11	0.10
private consumption	0.18	0.12	0.10	0.11	0.11	0.11	0.12	0.11	0.11	0.07	0.10	0.06	0.10	0.11
fixed investment	0.03	0.11	0.12	0.10	0.10	0.11	0.10	0.11	0.11	0.11	0.11	0.11	0.11	0.11
GDP deflator inflation	1.37	0.12	0.13	0.14	0.15	0.14	0.13	0.14	0.08	0.11	0.13	0.15	0.16	0.15
CPI inflation	0.85	0.13	0.13	0.14	0.13	0.12	0.12	0.15	0.13	0.15	0.17	0.18	0.17	0.16
industrial production	0.12	0.12	0.12	0.12	0.11	0.11	0.08	0.15	0.15	0.14	0.14	0.08	0.11	0.11
total employment	0.27	0.13	0.13	0.13	0.08	0.12	0.11	0.14	0.13	0.13	0.15	0.15	0.14	0.13
labour productivity	0.19	0.12	0.10	0.10	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.11	0.11	0.11
unemployment rate	0.14	0.13	0.13	0.14	0.14	0.14	0.13	0.10	0.12	0.12	0.13	0.13	0.12	0.12

Chapter 3 - Inference on the sources of the euro area business cycle. A structural VAR analysis

I. Introduction

The objective of this chapter is to draw some inference on the sources of the euro area business cycle based on a structural vector autoregression (SVAR) analysis. The analysis is carried out in a comparative perspective, taking the US economy as reference.

Despite the existence of a vast literature on the sources of the business cycle, there are some basic questions which are still open. One fundamental controversy regards the methodological approach which should be adopted to tackle the issue of what source of the cycle is relatively more important. As a conceptual framework the Frisch-Slutsky impulse-propagation scheme has become the main reference, while the endogenous fluctuations approach has been largely abandoned. However, in more specific terms various alternative approaches consistent with the distinction between shocks and propagation mechanisms have been proposed. For example, some favour a theory-driven approach, such as the calibration and simulation of dynamic stochastic general equilibrium (DSGE) models, while other prefer a data-driven approach, like a-theoretical VAR models, and finally others support methods which combine theory and data in various ways, including the LSE and structural VAR approaches.[65] In part as a result of this methodological controversy, there is no widely accepted conclusion as regards the relative importance of the various potential sources of the cycle. Thus, while a large part of the profession still tends to agree that macroeconomic fluctuations are mainly determined by demand shocks,[66] proponents of the real business cycle paradigm argue that the main driving force of the cycle is represented by supply shocks (i.e. technological changes).[67]

This state of affairs is exemplified by the inconclusive debate on the sources of the 1990/1991 recession in the US: several different explanations have been proposed, each stressing a different driving force, including a fall in aggregate spending (see Walsh, 1993), a negative consumption shock (see Blanchard, 1993), a negative technological shock (see

[65] See for example the debate in the Economic Journal issue of November 1995 on "Business Cycle Empirics: calibration and estimation", with contributions by Gregory and Smith, Eichenbaum, Hendry and Wickens.

[66] See for example Blanchard (1997) and Solow (1997).

[67] See for example Cooley and Prescott (1995).

Hansen and Prescott, 1993), a credit crunch (see Bernanke and Lown, 1992), the oil shock (Hamilton, 1996) and Fed monetary policy (see Dornbusch, 1997, and Romer, 1998).

One difficulty in identifying the source of fluctuations is related to the choice of the relevant economic factor in the chain of events which leads to fluctuations. Using an example of Temin (1998), "OPEC countries raised the price of oil sharply following the Yom Kippur War in the fall of 1973. Prices began to rise in the United States as a result, and the Fed sharply restricted monetary growth. A recession followed (...). Was the recession "caused" by the oil shock or by the monetary policy?" (p.38). The answer to this question is difficult and to some extent inevitably arbitrary, depending among other factors on the model used as reference (i.e. which forces are endogenous and which are exogenous).[68]

In this paper we ask what is the relative importance of aggregate demand (AD) versus aggregate supply (AS) shocks. Each of the two categories of shocks is further decomposed into two more specific categories, which are labelled nominal and real. It is ultimately more desirable to derive quantitative inference on the precise sources of the cycle but given all the problems involved in such an analysis, also related to the high number of specific candidate shocks (including shocks to government fiscal policy, consumption, investment and net exports, unexpected changes to money demand and money supply, and technology and oil price disturbances), it is a useful initial step to focus on the main categories of shocks. Even at this general level of analysis, the policy implications are significant, especially as regards the desirability of stabilisation policy. In the light of the contributions of the literature to solve some of the main problems which are encountered in an analysis with these purposes, we opt for a methodology which attempts to combine inference from data with guidelines from economic theory, which are derived from a general widely accepted economic framework. More precisely, we adopt a structural VAR (SVAR) model with few basic variables which allow to distinguish between nominal and real AD and AS shocks and apply identification restrictions based

[68] On this issue the debate is still on-going and no agreement has been reached, see for example Bernanke et al (1997), the subsequent critique by Hamilton and Herrara (2004) and the reply by Bernanke et al. (2004).

on predictions of the basic aggregate supply/aggregate demand model. The validity of the results of any SVAR depends crucially on the identification restrictions adopted. Thus, ideally restrictions which should be consistent with as many models as possible should be applied. We think that most, if not all, models in the Keynesian tradition properly extended to account for the characteristics of contemporary economies (in particular as regards current monetary policy regimes), which can be represented in the AS/AD framework, fulfil the minimum requirements of descriptive and predictive power such that they can be taken as reference. By contrast, despite some attempts to resurrect them,[69] it is common opinion that, as summarised by Gali (2004), real business cycle models have "not held up to the promise of providing a convincing alternative business cycle interpretation".

A number of studies have used SVAR analysis in a similar way to try to identify the relative importance of the sources of fluctuations. One critical step in this approach is the restrictions which allow to derive the structural shocks assumed to represent to ultimate economic source of the cycle. Various alternative identification schemes have been applied. For example, Blanchard and Quah (1989) have used a bivariate model with output and unemployment imposing the identification restriction that one type of shocks (which they call demand shock) does not have a long run impact on output and find that demand disturbances are the main determinant of the business cycle. Other studies have imposed similar or other long run restrictions, short run restrictions or combinations of both, including Altig and Stockman (1998), Bergman (1996), Blanchard (1989, 1993), Cochrane (1994), Gali (1992, 1999), Karras (1994), King et al. (1991), Robertson and Wickens (1997), Shapiro and Watson (1988), Sims and Zha (1998) and Walsh (1993). Most of these approaches have come under attack from various fronts. For example, Faust and Leeper (1997) and Cooley and Dwyer (1998) show that structural inference under long run restrictions may be empirically unreliable unless some strong restrictions are met (and typically they are not). Moreover, short run restrictions are often criticised for not being consistent with economic theory (see for example Canova and Pina, 1999). Other criticisms of these approaches are summarised in Stock and Watson (2001), who,

[69] See for example King and Rebelo (1999).

after reviewing the state of the art and the main problems of the approaches proposed so far, advocate identifying restrictions which are either based on institutional factors, such as in Blanchard and Perotti (2002), or which are less restrictive, such as those based on the sign of theoretical impulse responses, such as in Faust (1998), Uhlig (2005), or Canova and de Nicolò (2002, 2003). We agree with their analysis and conclusions and adopt the latter approach in the present paper.

Some recent contributions attempt to estimate the relative importance of various types of shocks for euro area business cycle fluctuations. For example, Smets and Wouters (2003) develop and estimate a stochastic dynamic general equilibrium model and use it to investigate the contribution of ten structural shocks to euro area fluctuations from 1970 to 1999. They find that output fluctuations at business cycle frequencies (medium run: 2.5 years) are mainly driven by preference and monetary policy shocks, but also two supply shocks (to productivity and labour supply) are found to be significant determinants. Peersman (2005), the study closest to ours, attempts to identify the main sources of the most recent slowdown in the euro area. He applies SVAR analysis with 1980q1-2002q2 data for the euro area and applies two alternative identification schemes, one based on contemporaneous impact restrictions similar to Gali (1992) and Gerlach and Smets (19995) and the other based on sign restrictions similar to Canova and de Nicolò (2003). He finds that a combination of demand and supply shocks explains both the recent slowdown and the early 1990s recession. However, in our opinion a number of steps in his method, which will be discussed in detail in the methodological section, imply that his results are not fully reliable.

This chapter is organized as follows. Section 1 explains the economic framework and the econometric approach adopted, as well as providing a discussion of the properties of the data used. Results are illustrated and discussed in section 2, which focuses on both average characteristics of the cycle and on specific episodes represented by the early 1990s recessions experienced in the euro area and the US. Finally, section 3 provides a summary of the main conclusions that can be drawn from the analysis.

II. Methods

II. 1. Economic framework

The basic theoretical framework adopted in the present study is the aggregate supply/aggregate demand textbook model. It is shown that various versions of this general model are consistent with the predictions used to identify the various categories of shocks of interest.

II. 1. 1. The categories of shocks

The focus of this study will be on four categories of shocks: nominal AS shocks, real AS shocks, nominal AD shocks and real AD shocks. *Nominal AS shocks* (sometimes also called price or inflation shocks) can be defined as shocks whose main initial impact is on prices. They include shocks to the costs of production (both labour and non-labour) and shocks to the price setting behaviour of firms. *Real AS shocks* (sometimes also called supply shocks) can be defined as shocks whose main initial impact is on production. They include shocks to technology and to the factors of production. It is possible to think of nominal AS shocks as shocks implying shifts in the short-run AS function and of real AS shocks as implying shifts in the long-run AS function. *Nominal AD shocks* (sometimes called money or liquidity shocks or with reference to the IS-LM model as LM shocks) can be defined as shocks to the money market and include shocks to velocity and monetary policy shocks. *Real AD shocks* (sometimes called spending, preferences, taste, or demand shocks or with reference to the IS-LM model as IS shocks) are shocks to the goods and services market. They include fiscal policy shocks and private sector spending shocks.

Appendix 1 proposes a general taxonomy of macroeconomic shocks and provides more details on the different categories of shocks, including examples and a discussion of the links between real world events and structural shocks. Note that the classification is consistent with several AS/AD models. These include the IS-LM-PC model (which combines the IS-LM model with a Phillips curve), the IS-MP-IA model (where the supply side is represented by an inflation adjustment, IA, curve) and several DSGE models.

Specific shocks which have been stressed as important sources of business cycles are: oil price shocks[70], monetary policy shocks[71], technology shocks[72] and private spending shocks[73]. Although the relative importance of each of these shocks is not an issue beyond dispute, it is clear that an analysis of the sources of the business cycle should include all of the main four categories of shocks which we have defined. As stressed for example by Shapiro and Watson (1988), it is important in empirical analyses to include the whole spectrum of possible sources of the cycle in order to avoid biased results due to omitted variables. However, there does not seem to be much agreement on the minimum level of disaggregation that should be adopted in investigations of the sources of fluctuations.[74] For various reasons it could be argued that it is desirable to consider also more specific types of shocks within these categories. However, there are disadvantages in increasing the level of disaggregation. First, the more detailed a category of shocks needs to be identified the more difficult it is to find conditions that are common to various classes of economic models, thus the less credible the analysis. Second, there is a dimensionality issue: the more disaggregate categories of shocks need to be identified the more variables need to be included in the model, but VARs are powerful tools for relatively small sets of variables only. Note that already at this general level of detail the conclusions are of policy relevance. For example, Clarida *et al.* (1999) show that in the new neoclassical synthesis (NNS) framework the optimal reaction of monetary policy differs depending not only on whether the economy experiences an AD or an AS shock, but also on the type of AS shock. In particular, it is only nominal AS shocks (which they call cost-push shocks) that give rise to a short-run trade-off between inflation and output volatility stabilisation, while real AS shocks (defined as a shock to potential output in their framework) should be fully

[70] See for example Hamilton (1983).

[71] See for example the discussion of the large literature by Christiano et al. (1999).

[72] See Prescott (1986) but also the recent controversy exemplified by Galì (1999, 2004) and Christiano et al (2004).

[73] See for example Cochrane (1994) on the role of consumption shocks.

[74] For example Shiller (1987) advocates, and Fair (1988) supports empirically, the view that the cycle is the result of several different sources. By contrast, Cochrane (1994) provides various arguments suggesting that it is enough to focus on a small number of shocks.

accomodated.[75] Classical analyses, carried out within traditional IS-LM or Mundell-Fleming models, also showed that the relative frequency of nominal versus real AD shocks determines both the optimal monetary policy operating procedure[76] and the optimal exchange rate regime.[77] Finally, note that the four categories of shocks considered include the above-mentioned most frequently stressed specific "usual suspects". Thus, assuming that each of these specific shocks represents the main type of shock within each of these classes of shocks, as the empirical literature seem to suggest, focusing on a more specific classification is likely to produce relatively little value added for our purposes.

II. 1. 2. Economic identification

The economic identification of the four types of shocks can be done on the basis of the sign of the responses of a small set of variables over the short run. The variables include output growth, inflation, the real interest rate and the output gap. In particular, it can be shown that within AS/AD models, in response to a negative nominal AS shock, in the short run inflation and the real interest rate will rise and output growth and the output gap will fall; in response to a negative real AS shock, in the short run inflation, the real interest rate and the output gap will rise and output growth will fall; in response to a negative nominal AD shock, in the short run inflation, output growth and the output gap will fall and the real interest rate will rise; finally, in response to a negative real AD shock, in the short run all four variables will fall. These responses are summarised in Table 1.

[75] Note that in their framework, which assumes that the central bank targets the real interest rate as in the macro model presented in Appendix 2, nominal AD shocks include only monetary policy shocks as shocks to money demand only affect the quantity of money to be supplied but are irrelevant for the determination of output, inflation and interest rates.

[76] The classical study is Poole (1970), where nominal AD shocks are represented by velocity shocks. See Friedman (1990) and Woodford (2003, chapter 4) for a critique of Poole's analysis and a reassessment of the relative merits of monetary targeting versus interest rate targeting in more modern frameworks.

[77] Mundell (1963). Devereux and Engel (1998) and Lahiri et al. (2004) provide a discussion of this issue in modern DSGE frameworks and show that the choice of exchange regime should depend also on other factors and under certain conditions the results of Mundell are reversed. However, the relative frequency of the type of AD shock still remains an important element.

Table 1 – Economic identification restrictions

SHOCK	SHORT RUN RESPONSES TO A NEGATIVE SHOCK			
	Output growth	**Inflation**	**Output gap**	**Real interest rate**
AS nominal	↓	↑	↓	↑
AS real	↓	↑	↑	↑
AD nominal	↓	↓	↓	↑
AD real	↓	↓	↓	↓

Thus, over the short run in the presence of a negative output growth response to any negative shock, the response of inflation allows us to identify AS and AD shocks, the response of the output gap allows us to distinguish between nominal and real AS shocks, and the response of real interest rates allows us to differentiate between nominal and real AD shocks.

Most often AS/AD models are analysed either in terms of output growth or in terms of the deviation cycle only. Moreover, in some versions of the basic AS/AD model the difference between nominal and real interest rates is ambiguous. Thus, some of these dynamics may not be obvious. For this reason, Appendix 2 reports the details of the responses of the four basic variables considered to the four types of shocks analysed within a simple macroeconomic model which has become very popular in recent years, the IS-MP-IA model.[78] Overall, it is shown that the short run responses to the four shocks considered will be the same in response to negative permanent and temporary shocks, and are those summarised in Table 1. The IS-MP-IA macroeconomic model has the advantage that, thanks to its simplicity (in addition to its descriptive power, as discussed in Appendix 2), it provides a very clear economic intuition behind these dynamics. However, it should be observed that the responses of Table 1 are also consistent with microeconomic founded (or DSGE) versions of the IS-MP-IA model. For example, Ireland (2004) shows that, within a standard optimisation based New Keynesian model (which consists of the same three basic equations as those used in

[78] See Taylor (2000) and Romer (2000) for a discussion of the characteristics and advantages of this model over traditional macro AS/AD models as well as for further references.

Appendix 2 except that they include some forward looking components), the responses of the four variables to shocks to technology, monetary policy, preferences and cost-push shocks (that is, representative shocks of the four categories under investigation in the present study) are broadly equivalent to those depicted in Table 1.

II. 2. Econometric method

In this section only the intuition behind the econometric methodology will be explained, while the technical aspects are discussed in detail in Appendix 3.

Once a VAR in standard or reduced form is specified and estimated, in order to identify the structural shocks from the reduced form residuals the procedure follows two steps. First, since it is typically assumed that structural shocks are serially and contemporaneously uncorrelated, the idea is to use some results from the statistical literature to construct a set of all possible shocks with such a property. As shown in the appendix, there is an infinite number of decompositions of the variance-covariance matrix of reduced form residuals that can give rise to serially and contemporaneously uncorrelated shocks, but using a scheme proposed by Canova and de Nicoló (2002) (henceforth CdN) it is possible to transform the space of all possible decompositions into a large but countable set. The second step is based on economic theory and requires first of all the derivation of a number of restrictions such as those we have illustrated in the previous section regarding the sign of the impulse responses of the endogenous variables to the structural shocks. The idea is then to search in the space of all desired decompositions defined in step one to detect those that satisfy these restrictions. In practice for each decomposition the impulse responses are computed and their sign is checked over a prespecified number of periods. The search is carried out using an algorithm devised by CdN. If more than one decomposition satisfies all sign restrictions, then by making the restrictions more binding it is possible to reduce their number until one decomposition is selected, which represents the basis for the shock accounting exercise.

Although the basic idea is that of CdN, we deviate from CdN in various respects. First of all, the specific economic restrictions differ somewhat, as for example in order to differentiate nominal from real AD shocks we use restrictions based on the response of the real interest rate instead of real money balances, one of the reasons being that economic theory does not suggest which monetary aggregate should be used and results tend to differ across measures. In addition, we also differentiate nominal from real AS shocks, while CdN only consider AS shocks.[79] Moreover, while CdN impose the restrictions on the sign of the (conditional) correlations of the impulse responses, we apply them to the sign of the cumulative impulse responses. Furthermore, we impose all restrictions specified in Table 2 and make them more binding, if necessary, by increasing the time horizon over which they must hold. For example, if more than one decomposition satisfies all restrictions over the first N quarters after the shock, we impose it over the first N+1 etc until only one decomposition is selected. CdN, by contrast, impose the restriction first on the contemporaneous correlations, then on correlations shifted and lagged by one period and so on. While CdN are not clear on the time horizon over which they impose the restrictions, we choose an economic criterion: the starting horizon is represented by the minimum among the average durations of business cycle phases identified in chapter 2. The reason is that any shock which is a potential source of a cyclical regime should exert its impact typically over a period corresponding to the average phase duration. Since the average duration of phases of fluctuations tends to differ across both regime and concept of the cycle, we choose the minimum of such average durations as starting point. Note that we impose the sign restriction on the cumulative response of each variable to the structural shocks over the time horizon N considered instead of imposing it on the impulse response in all periods from 1 to N. The reason is that the latter choice could be too restrictive, as for example the responses in DSGE models like that of Ireland (2004), while being broadly consistent with our scheme, occasionally show short-lasting deviations (in sign) from the main pattern. For example, the response of output growth to the various shocks conforms

[79] Similarly, we deviate from Peersman (2005) in various respects. In addition to some technical aspects, described in Appendix 3, the classification of shocks is different. As is clear from our taxonomy of shocks, the classification of Peersman of AS shocks is questionable. In particular, his identification restrictions to differentiate oil from non-oil AS shocks is ambiguous: according to his definitions, the difference is that only negative oil shocks imply an increase in the price of oil for four quarters, but there is no reason why also other AS shocks may imply that. Moreover, his classification of AD shocks is restrictive: for example within nominal AD shocks he only considers monetary policy shocks and ignores money demand shocks.

broadly to the pattern of the AS-AD macro model, but in some periods before returning to zero it may change sign (by a relatively small magnitude and typically in the short run only for one period). Thus, our approach is more robust being consistent with a larger class of models.

Note that by using both output growth and the output gap, which are needed in order to disentangle nominal from real AS shocks, our approach allows for an analysis of both classical cycles and deviation cycles.[80]

III. Results

The starting point is a reduced form VAR including four variables: output growth, the output gap, inflation and the real interest rate. Output growth and inflation are expressed as annualised quarter-on-quarter growth rates of real GDP and the consumer price index respectively. Various estimates of the output gap (expressed as percentage deviations from trend) are considered, but since results are qualitatively invariant to the alternative estimates only those based on OECD measures are reported. Real interest rates are measured as ex post short-term real interest rates. All data used are expressed at quarterly frequency. More details on the data set considered are reported in Appendix 4.

The sample period spans from 1980q1 to 2003q4 for both the euro area and the US. This range is chosen for various reasons. First, as regards the euro area the analysis of chapter 1 has indicated that, consistently with large part of the literature, the evidence for the emergence of a euro area business cycle tends to point to the 1980s as a more robust staring period. Second, in several countries the monetary policy regime changed significantly around the late 1970s and early 1980s, including the US with the start of the "Volker regime" in 1979. Third, the data for the euro area are more consistent across euro area countries from about 1980, making the analysis more reliable.[81] Consistent with these arguments, there are clear signs of instability in models estimated using longer time

[80] See also Giordani (2004) for additional reasons pointing to the use of both output and the output gap.

[81] For example, ESA 95 national accounts are still missing for Germany before 1980.

periods, with breaks often located in coincidence with the first and second oil shocks.[82] Note, finally, that the models adopted as basic economic framework are most likely mainly valid for the period starting from 1980, due to the new monetary policy regimes adopted since then, while their validity or completeness for the period before may be questionable. Given the importance of the stability of the VAR for analysis based on impulse responses as ours[83], the choice of 1980 as a starting point should increase the credibility of the results. Thus, the choice of starting the analysis from 1980 allows to avoid, or at least minimise, possible problems related to the Lucas critique.

The specification of the VAR is done following the literature. In particular, as CdN suggest, lag length is chosen on the basis of the Schwarz criterion, which led to the choice of two lags for both the euro area and the US. Given the relatively short sample periods considered and following CdN, we omit the unit root and cointegration analysis of the data on the grounds of the low power of the corresponding tests which may provide misleading indications which would then affect critically the rest of the analysis.[84]

For both the euro area and the US, starting from the imposition of the sign restrictions on the cumulative impulse responses over three quarters (corresponding to the minimum average duration of classical recessions for both economic areas[85]), searching among specifications both with and without a trend (always with a constant term), various combinations of angle and rotations were found to satisfy the restrictions but they all produced essentially identical results. Thus, it was not necessary to increase the duration of the restrictions to four quarters. The impulse responses, together with confidence bands computed using a bootstrap algorithm, resulting from the selected decompositions

[82] See for example Clarida et al. (1998), Bagliano and Favero (1998), Beyer and Farmer (2002) for evidence of breaks related to changes in monetary policy regimes, Bai and Perron (2001a) for evidence on breaks around 1980 in the real interest rate and Stock and Watson (2003) for evidence of breaks in the volatility of growth in the early 1980s.

[83] See for example Ericsson, Hendry and Mizon (1998).

[84] See also Sims, Stock and Watson (1990) on the consistency of estimates of coefficients of VARs in levels with some unit roots.

[85] See Musso (2003) for evidence on the average duration of cyclical phases of the classical cycle in the euro area and the US.

are reported in Appendix 5. Overall, since these impulse responses satisfy the economic restrictions by assumption, they do not require a thorough discussion.

III. 1. What causes business cycles?

The first question we address regards the relative importance of the various shock types to explain fluctuations. An answer to this question can be provided by an analysis of forecast error variance decompositions. The latter represents the percentage of the variance of the error made in forecasting h-step ahead each variable due to the various shocks. The contributions of each shock to the unexpected movements in the four variables considered can be related to the relative importance of the various sources of the cycle.

The forecast error decompositions are reported in Table 2, which shows 68% error bands (i.e. the 16 and 84 percentiles as suggested by Sims and Zha, 1999) at various time horizons: one, two and five years ahead. Note that the relative importance of shocks seems to vary only to a minor extent across time horizon.

Overall, fluctuations seem to be due largely to real AD shocks, consistently with the Keynesian view of business cycles. This seems to be the case for both classical cycles and deviation cycles, both for the euro area and the US. For example, at 8 quarters ahead about 90 percent of fluctuations are due to real AD shocks in the euro area, both for the classical cycle and the deviation cycle. The only other type of shocks which has some influence on the cycle is represented by nominal AD shocks. By contrast, AS shocks do not appear to play any significant role. It should be observed that these results refer to average dynamics. Thus, they are consistent with the possibility that during specific episodes AS shocks play some role, but these episodes would be rare.

Real AD shocks appear to be the main source of fluctuations also for the inflation rate and the real interest rate. For inflation also nominal AS shocks are significant, especially in the short run. For real interest rates nominal AD shocks do not seem to matter significantly. This could be consistent with an interpretation according to which it is mainly the systematic part monetary policy that has exerted an influence in the economies considered since 1980, while the unsystematic part (which would be captured by the nominal AD shocks) has played a minor role.

A note of caution is that only temporary shocks are examined in the current framework. Thus, as CdN also stress, these results are not necessarily in contrast to economic models which assign an important role also to permanent shocks, such as permanent technology shocks or other real AS shocks. Admittedly, the role of real AS shocks is probably understated in the current framework, although from a traditional perspective they are viewed as being particularly important in explaining long term developments rather than business cycle fluctuations.[86]

Table 2 – Forecast error variance decomposition

	euro area (1980:1-2003:3)			US (1980:1-2003:3)			
	Output Gap	Inflation	Interest rates	GDP growth	Output Gap	Inflation	Interest rates
	quarter forecast error variance			4 quarter forecast error variance			
l–0	0–0	4–14	2–6	0–0	0–1	2–5	0–1
)–0	0–0	11–32	0–1	0–0	0–1	11–25	1–2
l–96	82–100	41–79	88–95	97–98	87–95	61–83	93–97
l–6	0-18	3–16	2–7	1–2	4–13	2–10	1–4
	8 quarter forecast error variance			8 quarter forecast error variance			
)–0	0–0	2–9	1–4	0–0	1–2	2–5	0–1
)–0	0–0	6–22	0–1	0–1	1–3	10–25	1–3
l–96	82–100	55–85	89–96	97–98	82–94	61–85	93–98
l–6	0-17	3–17	2–8	1–3	4–14	2–10	1–4
	20 quarter forecast error variance			20 quarter forecast error variance			
0–0	0–0	0–5	0–2	0–0	1–2	2–5	0–2
0–0	0–0	1–10	0–1	0–1	2–6	9–24	2–5
94–96	83–99	66–95	89–96	97–98	82–93	63–96	90–97
4–6	0-17	1–20	2–9	1–3	3–11	2–10	1–4

Notes: Bands are computed using 10000 Monte Carlo replications. 68% error bands are reported.

[86] This view is consistent with mainstream macroeconomics, as summarised for example in the contributions to the sessions on "Is there a core of practical macroeconomics that we should all believe?" AER PP May 1997.

III. 2. Small frequent shocks or large infrequent shocks?

Another interesting question that can be addressed in the current framework is whether fluctuations are mainly due to frequent small shocks or to infrequent large shocks. Following Blanchard and Watson (1986), a shock can be defined as large if its magnitude is larger (in absolute value) than 1.5 times the standard deviation of the corresponding structural shock series.

Figures 1 and 2 show the structural shocks for the euro area and the US, respectively. In each chart also the horizontal lines representing plus and minus 1.5 times the standard deviation of each shocks are plotted.

Overall, the general impression is that infrequent large shocks can be detected for all type of disturbances in both the euro area and the US. Moreover, large shocks tend to be concentrated in particular periods which can be associated with recessions in most cases. For example, most large shocks can be located either in the early 1980s or in the early 1990s. Finally, there seems to be a tendency for large shocks to be followed by other large shocks, often of opposite sign.

These observations are in line with an interpretation of fluctuations according to which most often cyclical developments result from the accumulation of small shocks but occasionally are characterised by recessionary periods which are started and ended by infrequent large shocks. This interpretation can be discussed in detail with reference to specific episodes, as in the next subsection which focuses on the early 1990s recessions.

Figure 1 – Structural shocks for the euro area

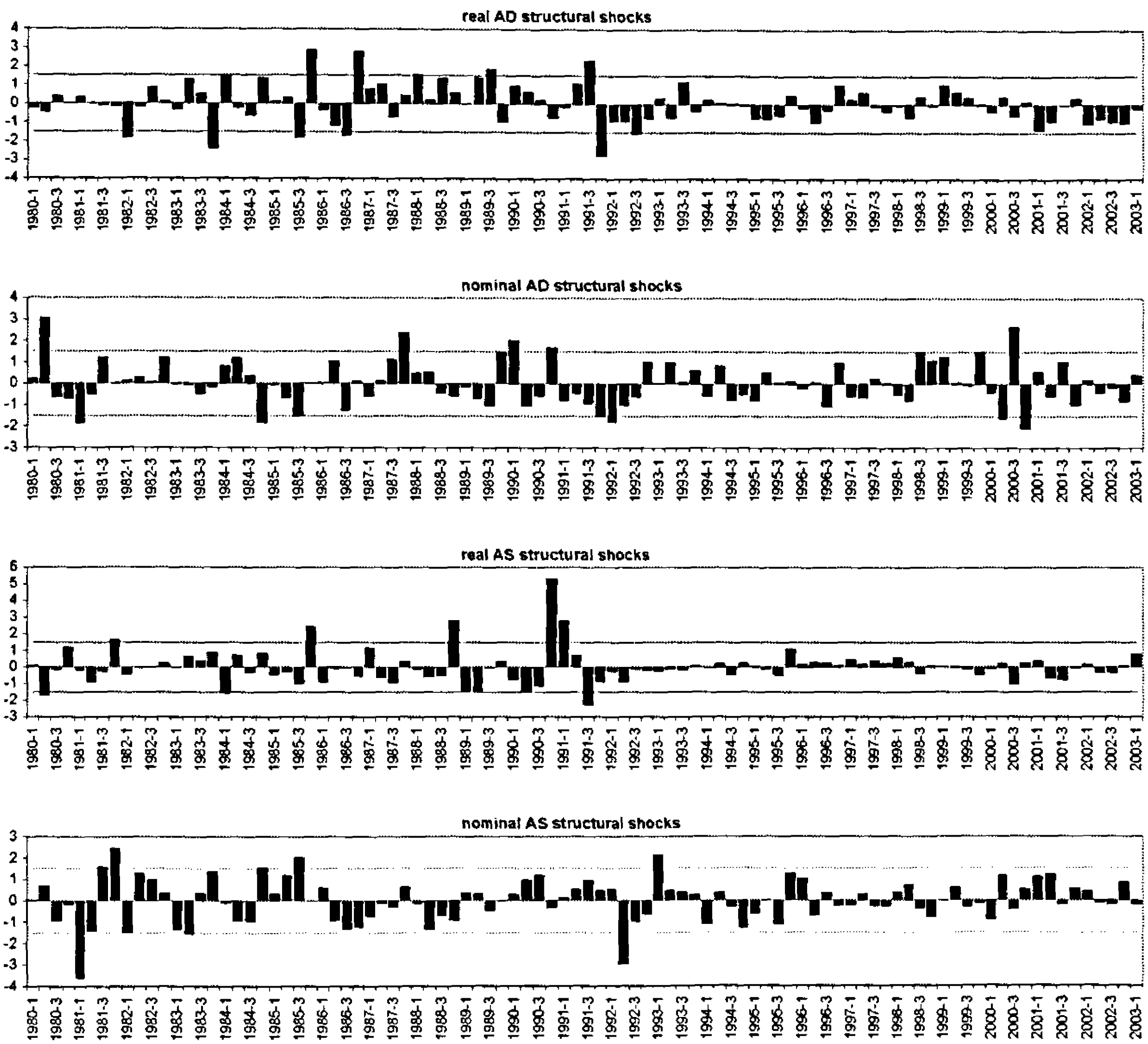
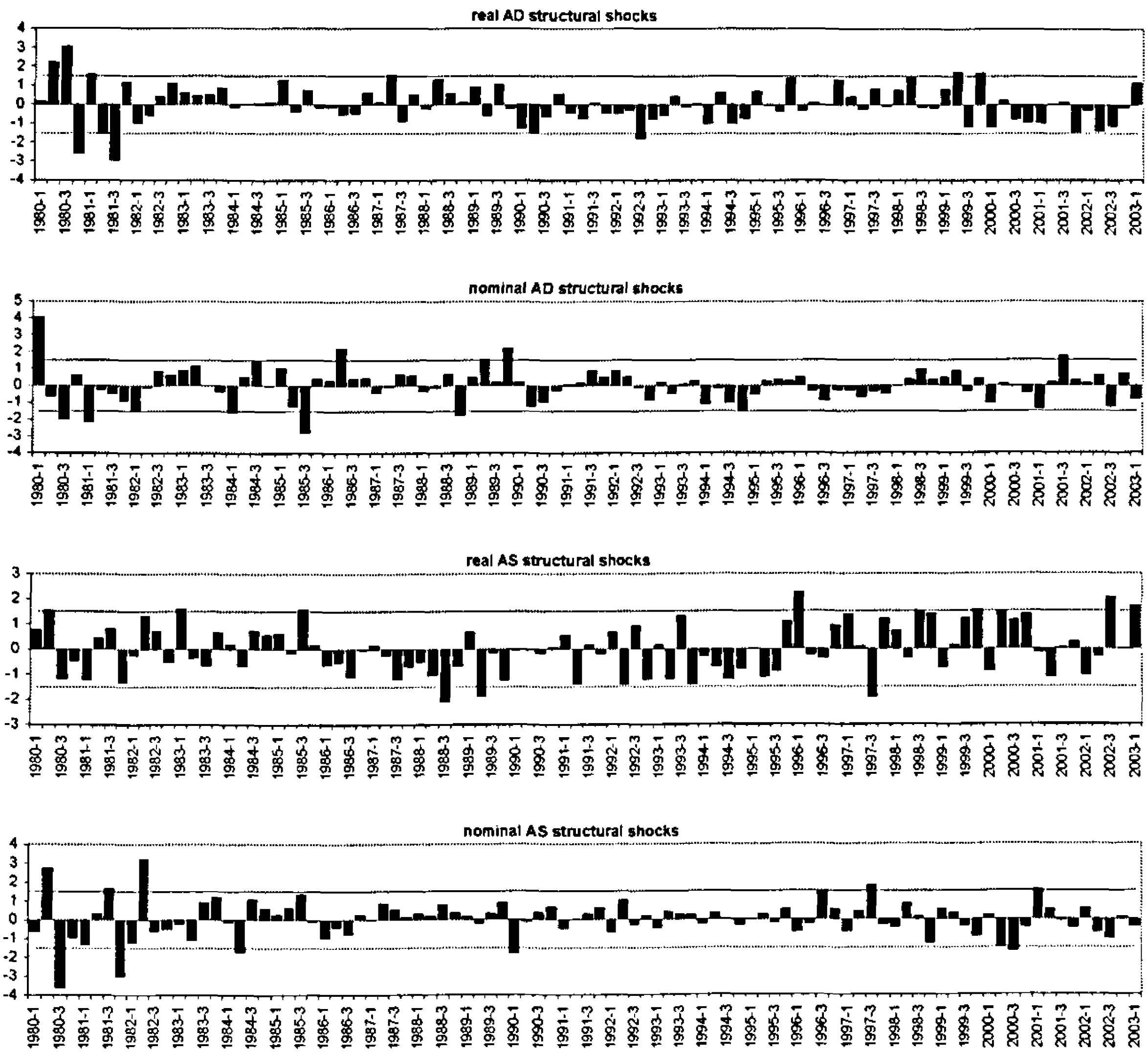


Figure 2 – Structural shocks for the US



III. 3. A case study: the early 1990s recessions

III. 3. 1. Results

It can be interesting to discuss the explanatory power of the current framework also for specific business cycle episodes. Historical decompositions, another standard shock accounting tool proposed by Sims (1980), can be used for this purpose. More specifically, the moving average representation of the structural VAR can be partitioned such that the historical values of all variables can be decomposed into a base projection and the accumulated effects of current and past innovations. The base projection is an unconditional forecast based on a few initial periods of observations.

For the purpose of discussing the recessions of the early 1990s in the euro area and the US it is enough to examine the historical decompositions of real GDP growth from 1990 to 1993. These are shown in Table 3. For both the euro area and the US the first two columns report actual output growth and the baseline projection, while the subsequent four columns show the contributions of each shock type to the deviations of output growth from the base projection. Note that these contributions reflect the accumulated effects of current and past innovations in each quarter. Thus, in a particular period a negative contribution can be recorded from a specific type of shock even if in the same quarter the shock was positive, if the impact of the negative shocks in the previous quarters prevails. These contributions can be used to gauge the relative importance of the various shocks in explaining output growth in each quarter of the recessions. Note that the sum of the contributions corresponds broadly (but often not exactly due to the effect of rounding) to the forecast error.

Table 3 – Historical decomposition of real GDP growth during the early 1990s recession

	euro area (1990:1-1993:4)						US (1990:1-1993:4)					
	Actual	Forecast	AD real	AD nom	AS real	AS nom	Actual	Forecast	AD real	AD nom	AS real	AS nom
1990-1	5.5	2.5	3.4	-0.4	0.0	0.0	4.7	2.1	2.5	0.1	0.0	0.0
1990-2	1.8	1.9	-0.9	0.9	0.0	0.0	1.0	0.4	-0.2	0.8	-0.1	0.1
1990-3	3.8	1.6	1.8	0.3	0.0	0.0	0.0	1.4	-3.0	1.5	-0.2	0.1
1990-4	2.3	1.6	1.5	-0.8	-0.1	0.0	-3.0	1.6	-4.4	-0.3	-0.3	0.1
1991-1	2.8	1.5	0.8	0.5	-0.1	0.0	-2.0	1.8	-2.6	-0.9	-0.3	-0.4
1991-2	1.2	1.8	-1.2	0.6	0.2	0.0	2.6	2.2	0.9	-0.5	-0.3	0.0
1991-3	-0.2	1.7	-0.8	-1.1	0.1	0.0	1.9	2.6	-0.4	-0.4	-0.2	0.1
1991-4	3.9	1.8	1.6	0.4	0.1	0.1	1.9	2.8	-0.6	-0.3	-0.2	0.0
1992-1	6.1	1.7	4.5	-0.3	0.0	0.1	4.2	3.0	1.2	0.1	-0.2	-0.1
1992-2	-2.9	1.9	-4.1	-0.8	0.1	0.0	3.9	3.0	0.2	0.6	-0.3	0.1
1992-3	-1.0	2.0	-2.7	-0.3	0.1	0.1	4.0	3.2	0.2	0.5	-0.2	0.1
1992-4	-1.0	1.9	-2.8	-0.2	0.1	0.1	4.5	3.3	0.3	0.8	-0.2	0.1
1993-1	-2.5	2.0	-4.0	-0.4	0.1	-0.1	0.5	3.3	-3.2	0.4	-0.1	0.0
1993-2	0.1	2.0	-2.6	0.5	0.0	0.2	2.0	3.2	-1.2	-0.3	-0.2	0.3
1993-3	1.5	2.0	-0.2	-0.2	0.0	0.0	2.1	3.3	-0.8	-0.5	-0.2	0.0
1993-4	1.1	2.0	-1.5	0.6	0.0	0.0	5.5	3.2	2.3	-0.1	-0.3	0.1

III. 3. 2. Some caveats

Before interpreting the historical decompositions, some caveats should be mentioned. First of all, structural shocks should be thought of as unexpected changes, or the forecast errors experienced by rational agents. Thus, a negative shock could be recorded even in the presence of positive developments, say an increase in government spending during a slowdown, if the extent of the change was less than expected by economic agents. Thus, for example, a negative nominal AD shock could be estimated in a particular quarter even if monetary authorities had cut interest rates during the same quarter. Second, monetary policy can be thought of as resulting from systematic responses to economic developments and unsystematic decisions. Nominal AD shocks capture only the unsystematic part. Thus, even if it is found that nominal AD shocks are not a significant source of fluctuations, it should not be necessarily concluded that monetary policy is not one of the main causes of fluctuations. For example, suppose that monetary policy responds systematically in an aggressive way to some specific shocks such as oil shocks, even if minor. In this case it would emerge that the main source of fluctuations is represented by nominal AS shocks, but the propagation mechanism played a larger role in shaping cyclical dynamics and thus the monetary policy response should be identified as the main driving force of fluctuations. Of course, it is still important to identify the original source of the fluctuation, but the analysis should always go beyond especially when assessing economic policies. Third, real-world events are often not easily mapped to one specific shock: most often they give rise to various structural shocks. For example, German unification can be thought of as implying a nominal AD shock (resulting from the aggressive monetary tightening of the Bundesbank), a real AD shock (resulting from the expansionary German fiscal policy stance) and possibly also as a real AS shock (having increased German labour supply), both for Germany and, given its weight and influence, also for the euro area as a whole. Moreover, some real world events, such as changes in confidence, affect more the propagation mechanisms (i.e. they can be thought of as affecting the vulnerability state of the economy) than give rise to shocks; thus, it is ultimately important to analyse also the propagation mechanisms. Fourth, as already mentioned, shocks are classified on the basis of the primary initial impact. However, since some unexpected changes may affect significantly on impact various variables, they are difficult to classify. For example, wealth changes from stock prices movements affect both private consumption (via the wealth effect) and money demand: it could be that in the euro area (where the wealth effect on consumption is more limited and cash payments are more diffused), the evidence points to a more significant impact on money demand, while in the US (where wealth effect is more important and credit cards are almost universally accepted) on consumption. In the euro area a stock market fall would then be classified as a nominal AD shock, while in the US it should be more appropriately labelled as a real AD shock. Similarly, a depreciation or devaluation could be classified as either a nominal AS shock (as it affects the cost of imported factors of production) or as a real AD shock (affecting exports and imports); in these cases the difference between real and nominal wealth or exchange rate does not help much given the stickyness of prices. Another example is productivity changes: they affect prices and production and thus are both nominal and real AS shocks, as noted by Romer (2002), but temporary changes affect (initially) more prices, while permanent changes affect more potential output. Ultimately, the classification of shocks is an empirical issue, and it can vary over time and across economic areas.

III. 3. 3. Interpretation of early 1990s recessions

Keeping these caveats in mind, let us examine the contributions of the shocks to real GDP growth. As regards the US, which experienced a recession between 1990 and 1991, the main source seems to be represented by negative real AD shocks. Thus, among the factors which have been highlighted as possible main driving forces of the recession already discussed in the introduction, negative consumption shocks can be identified as the main proximate cause of the downturn. A negative contribution from all of the three other shock types can also be observed between the end of 1990 and early 1991 but they all seem to be insignificant compared to the real AD shocks. Looking at Figure 2, it seems that between 1990 and 1991 only one large negative shock can be detected, a negative nominal AS shock in 1990q1, which most likely has to be associated with the invasion of Kuwait by Iraq in February 1990 and the subsequent oil price increase (although the main actual increases in oil prices took place starting from mid-1990, note that shocks should be thought of as unexpected developments; thus, the negative shock in 1990q1 and the positive nominal AS shocks in the second half of 1990 could be rationalised as reflecting first an expected fall which did not materialise and then increases which were less consistent than expected, especially if the experience of the first two oil shocks was taken as reference). Thus, the recession in the US seems to have been caused by a sequence of negative real AD shocks of relatively minor magnitude, which could have had a larger than usual impact due to the high uncertainty and decreasing consumer confidence following the Middle East crisis. This interpretation is supported by the dramatic fall (by an unprecedented 32 percent) in consumer sentiment as measured by the University of Michigan index from its peak in April 1990 to its low in October.[87] This fall in confidence increased the vulnerability of the US economy and presumably amplified the impact of small shocks.

As regards the euro area, a recession can be recorded some time later than that of the US, in particular between 1992 and 1993. According to Table 3, also for the euro area the recession seems to be due mainly to negative real AD shocks. The euro area economy had started to weaken already in late 1990 and in 1991, as a result of the negative spillover

[87] See for example McNees (1992).

effects from the recession experienced in the US and elsewhere in the world (i.e. falling external demand). However, German unification, which as already discussed gave rise to various types of shocks, caused a boom that allowed a recession to be avoided, at least initially. Private consumption and investment boomed in the whole euro area largely as a result of the expansionary German fiscal policy (including the massive transfer payments to the former DDR and the high infrastructure investment in the German Eastern Länder) and new investment opportunities in Germany. Concerned about the effect on inflation, the Bundesbank adopted a tightening monetary policy, which caused an increase in interest rates in the whole euro area given the leading role of Germany in the European Monetary System. The effect of monetary tightening can be seen in the negative output growth recorded in 1991q3 due to the negative contribution from nominal AD shocks. Subsequently, both consumption and investment growth started to decline, in part as a result of the fading out of the boom which followed German unification (for example, large part of the transfers to Eastern Germans from the West were one-off payments which were spent largely immediately) and in part as a result of the increased interest rates. This interpretation is in line with the evidence of Table 3 that the recession was mainly due to negative real AD shocks but to some extent also to negative nominal AD shocks. A visual inspection of Figure 1 suggests that large negative shocks can be observed for all types of disturbances either in 1991 or in 1992. Thus, in the case of the euro area the early 1990s recession seems to have been due more to large shocks than to the cumulative impact of a sequence of small shocks as in the US.

IV. Conclusions

This chapter provides evidence on the sources of fluctuations in the euro area in comparison to the US from 1980 onwards. Overall, the main findings are as follows. First, in line with the traditional view of fluctuations, real AD shocks seem to be the main source of both classical cycles and deviation cycles in both economic areas. Other shocks seem to play a minor role, limited to specific episodes. There is evidence that infrequent large shocks have an important explanatory power for fluctuations, but a significant role can also be found for the cumulative impact of relatively small shocks.

Although the focus of the analysis has been on sources of fluctuations, that is on the impulse mechanisms, it should be stressed that an exhaustive analysis of business cycles should also provide a detailed account of the main propagation mechanisms accounting for cyclical developments. However, such an analysis requires a much broader investigation. For each single type of shock here are multiple channels of transmission such that even considering the general categories of shocks as in our analysis results in a very complicated framework.[88] However, as discussed in section 2 identifying the relative importance of the main sources of fluctuations has important policy implications. Thus, we think that the analysis provides a useful contribution.

[88] For example, Mishkin (1996) provides an overview of the channels of monetary transmission and identifies eleven propagation mechanisms.

Appendix 1 – A taxonomy of macroeconomic shocks

In this appendix we propose a taxonomy of macroeconomic shocks which can be used as a reference framework. Such a classification is consistent with several AS/AD models, including the IS-LM-PC, the IS-MP-IA and several DSGE models.[89]

Figure 1 illustrates the categories of macroeconomic shocks, and provides some example for each category. The most general categories consist of aggregate demand (AD) and aggregate supply (AS) shocks. The definitions of the shocks is typically done with reference to the type of variables that is mainly affected initially after the shock takes place. For example, ***AS shocks*** are typically defined as shocks whose main initial impact is on prices or production. By contrast, ***AD shocks*** can be defined as shocks whose primary initial effect is on spending.[90]

As the figure shows it is possible to disaggregate the general AS and AD categories of shocks at various levels. On the supply side, it is useful to distinguish two categories. The first one, that we label as ***nominal AS shocks***, includes those shocks whose main initial impact is on prices. These are often called also as price shocks, inflation shocks, or (referring implicitly to a sub-category only) cost push shocks and include shocks that affect the costs of production (both labour and non-labour[91]) and shocks to the price setting mechanism of firms.[92] The second sub-group, called here ***real AS shocks***, includes shocks whose main initial impact is on production. These are sometimes called supply shocks[93] or (referring implicitly to a sub-category only) technology shocks and

[89] Note that various alternative classifications are possible. For example, Taylor (1993) classifies the 98 shocks of his model into three groups: financial market shocks, goods market shocks and price shocks. Others stress the distinction between policy and non-policy shocks, or domestic and external shocks. However, it can be observed that these alternative groupings are broadly consistent with that proposed here. For example, Taylor's three above mentioned groups are broadly equivalent to what we define as nominal AD shocks, real AD shocks and nominal AS shocks.

[90] See for example Reifschneider et al. (1999).

[91] Among non-labour nominal AS shocks, disturbances affecting commodity prices such as the oil price and the exchange rate are those most typically stressed (see for example Gordon, 1997).

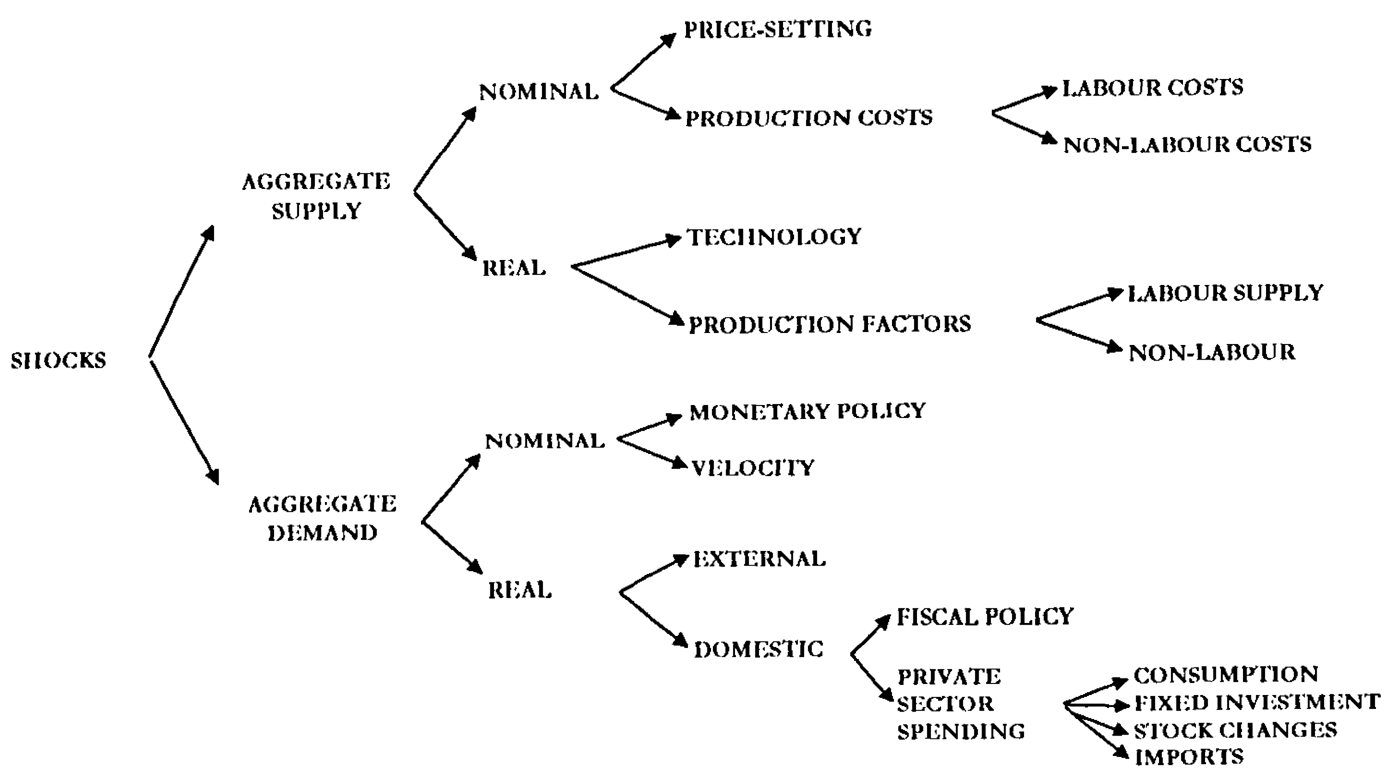
[92] Assuming markup pricing, these shocks can be characterised as a shift in the mark-up function. See Rotemberg and Woodford (1991) and Barro and Tenreyro (2000) on the relevance of the markup for fluctuations.

[93] For instance, by Romer (2002).

include disturbances affecting technological progress or exogenous changes in the factors of production (labour supply and others[94]). With reference to textbook macroeconomic models, it is possible to think of nominal AS shocks as disturbances implying shifts in the short-run supply function and real AS shocks as disturbances implying shifts in the long-run supply function. As regards the demand side, a similar distinction can be made. More precisely, ***nominal AD shocks*** can be defined as shocks to the money market. They are sometimes called money or liquidity shocks (or with reference to the IS-LM model as LM shocks) and include shocks to velocity (for example due to exogenous shifts to money demand) and monetary policy shocks. ***Real AD shocks*** are shocks to the goods and services market. They are sometimes called spending shocks, preferences or taste shocks, or demand shocks (or with reference to the IS-LM model as IS shocks) and can be decomposed further into external shocks (i.e. for example foreign demand shocks) and domestic shocks, including shocks to fiscal policy and to private sector spending. The latter category includes shocks to investment (stressed in traditional Keynesian models, and called often "animal spirits" shocks) and private consumption.

[94] Other inputs include capital, land and energy consumption. On the relevance of labour supply shifts for business cycles see for example Shapiro and Watson (1988) and Chang and Schorfheide (2003).

Figure 1 – A taxonomy of macroeconomic shock



examples	
economic events	main variable(s) affected initially
changes in market structure	mark-up
increase in minimum wage	wages
oil supply disruption	commodity prices
technological advances	productivity
demographic changes	labour supply
natural disaster	capital
change in inflation target	money supply (interest rates)
changes in liquidity preferences	money demand
foreign country recession	foreign demand
reform of automatic stabilisers	government spending, taxes
changes in preferences	consumption
wave of investors' pessimism	fixed investment
new inventory method	stock changes
new import tariff	imports

Appendix 2 – A macro AS/AD model

In this appendix we show how the impact of the four shocks considered (nominal AD shocks, real AD shocks, nominal AS shocks and real AS shocks) on inflation, the real interest rate, output growth and the output gap differs. These dynamics allow for an identification of these categories of shocks by the imposition of sign restrictions in the SVAR. The illustration is carried out within a version of a macroeconomic AS/AD model which has become very popular in recent years. The illustration is useful in particular to show the different impact of output growth and the output gap to the two categories of AS shocks, a fact that is rarely stressed (as typically the focus is either on output growth or more often on the output gap).

The model is a version of what is often labelled as IS-MP-IA.[95] In particular, we adopt the version of Romer (2002) slightly generalized so as to allow for a non-zero response of all variables to all four shocks already in the first period. Note, however, that the predictions are broadly consistent with other versions of the macro AS/AD model, including alternative versions of the IS-MP-IA model, the IS-LM-PC model and models of the New Neoclassical Synthesis class.[96]

Consider a large open economy, with flexible exchange rates.[97] In order to keep the analysis as simple as possible, and without loss of generality, we follow the literature and normalize average growth of real output and potential output to zero. The model consists of three basic equations:

$$y_t = \alpha - \beta r_t + u_t \tag{1}$$

$$r_t = r^* + a(\Pi_t - \Pi^*) + b(y_t - y_t^N) \tag{2}$$

[95] See Hall and Taylor (1997, chapter 16), Romer (2000, 2002) and Taylor (2000) for simple illustrations at intermediate level, and Taylor (1999) for applications to optimal monetary policy analysis in the euro area and references to the literature on this model.

[96] See King (2000), Walsh (2003) and Woodford (2003) for a review and discussion of this literature. See in particular Ireland (2004) who considers both output growth and the output gap with a New Keynesian model and shows responses to the four categories of shocks broadly consistent with the ones illustrated in our macro model.

[97] Alternatively a closed economy can be assumed, with results qualitatively unchanged.

$$\Pi_t = \Pi_{t-1} + k_1(y_t - y_t^N) + k_2(y_{t-1} - y_{t-1}^N) + z_t \qquad (3)$$

where the endogenous variables are *yt* (real output), *rt* (the real interest rate) and Πt (the inflation rate) and the exogenous variables are y_t^N (the natural level of real output, also called potential output), *ut* (variable level of expenditure independent of the real interest rate) and *zt* (shocks to inflation). The difference between real output and potential output is defined as the output gap, or the deviation cycle. All parameters are assumed to be positive.

Equation 1 summarises the equilibrium in the goods and services market, and can be thought of as a traditional IS curve. More specifically, it represents a negative relationship between output and the real interest rate, arising from the negative impact of an increase in real interest rates on investment (and possibly on consumption, especially of durable goods, and, via the impact on the exchange rate, net exports). The parameter α captures the fixed spending component (deriving from the subsistence level of consumption and so on), while the term *ut* includes the components of expenditure which are influenced by all variables determining consumption (such as income taxes, real wealth, expected future income), investment (such as capital taxes, expected future marginal product of capital), government spending and net exports (such as foreign demand and the real exchange rate) other than the real interest rate. Changes in *ut* capture real AD shocks.

Equation 2 represents a monetary policy rule as an interest rate feedback rule, that is, the reaction function of the central bank, in the form of a Taylor rule expressed in terms of real interest rates.[98] Given r^*, the monetary authorities' implicit estimate of the real interest rate (defined as the real interest rates which would be observed when real output equals potential output in the absence of real AD shocks) , an increase of the inflation rate over the inflation target (Π^*) and increase in the output gap will trigger an increase in the real interest rate. Despite the simplicity of this rule, it has proved to capture

[98] See Taylor (1993). Our formulation is slightly more general than that of Romer (2002) who assumed for simplicity that real interest rates react to inflation and real output but not to potential output. Thus, in Romer's model real output, and therefore output growth is unchanged in the first period after a real AS shock.

reasonably well the behaviour of several central banks of advanced economies over at least the past two decades.[99] Moreover, it can be shown that it can be derived as an optimal monetary policy in the class of AS/AD models which includes the model considered here.[100] An example of a nominal AD shock is represented by a change in the inflation target.[101]

The central bank is assumed to be able to broadly control the real interest rate by changing the nominal money supply (high powered money). This can be shown to be the case if prices do not adjust fully and instantaneously after shocks take place (and in the absence of the extreme case of a liquidity trap).[102] In the background of the model is a money market equilibrium condition (an LM relationship):

$$\frac{M_t}{P_t} = L(i_t, y_t) = L(r_t + \Pi_t^e, y_t)$$

where *L(.)* represents the demand for money function, *Mt* is the money stock (high powered money), *Pt* is the price level, *it* is the nominal interest rate, Π_t^e is the expected inflation rate and the last equality makes use of the Fischer identity. However, under the assumption that the central bank follows an interest rate rule, the LM relationship is irrelevant for the determination of output, inflation and the interest rate, its role consisting in determining the money supply needed to support the desired interest rate.[103]

Combining (1) and (2) yields an aggregate demand equation:

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[99] See for example Clarida et al. (1998) for evidence on the G-3 and Peersman and Smets (1999) for an assessment with reference to the euro area.

[100] See Romer (2001, pp.503-508).

[101] Note that an alternative formulation of equation 2 is obtained by adding an error term to the equation, capturing nominal AD shocks other than the change in the inflation target. Other examples of nominal AD shocks include velocity or money demand shocks and monetary policy shocks other than the change in inflation target (such as deliberate attempts to deviate temporarily from the policy rule or involuntary deviations due to imperfect information or forecasting errors, problems particularly relevant in real time). Moreover, especially in empirical specifications, also some lagged interest rate term is included in order to capture the tendency of central banks to smooth interest rates (see Clarida et al, 1998). However, the simpler formulation is enough for our purposes.

[102] See Romer (2002).

[103] Thus, in the basic IS-MP-IA model money demand, or velocity, shocks are not relevant for explaining business cycles. However, in more general versions of the interest rate rule which include an error term and under the assumption of imperfect information money demand shocks can have an impact on output.

$$y_t = \alpha\gamma - \beta r^* - a\beta\gamma(\Pi_t - \Pi^*) + b\beta\gamma y_t^N + \gamma u_t \qquad (4)$$

where $\gamma \equiv 1/(1+b\beta)$.

Equation 3, summarizing inflation determination, represents the short- to medium-run aggregate supply function. This aggregate supply function can be derived from various aggregate supply theories as well as from a price-setting and wage-setting system combined with Okun's law.[104] The error term z_t captures nominal AS shocks and is influenced by exogenous changes in relative prices such as the relative price of oil and other commodities, changes in the nominal exchange rate, changes in the price-setting[105] or wage-setting[106] processes.

Note that this is a slightly more general representation than the aggregate supply function used for example by Hall and Taylor (1997), Romer (2002) or Taylor (2000), where only the lagged deviation cycle matters (a relationship often labelled as inflation adjustment - IA- line because in the inflation/output space it is represented by an horizontal line shifting up and down in response to supply shocks and the past period deviation cycle). Similarly, it is a slightly more general function compared to the textbook expectations augmented Phillips curve (PC), where typically only the current deviation cycle affects inflation.[107] Compared to the IA line, we also add the current deviation cycle to allow for excess demand or supply have some effect on inflation already within the first period (in contrast for example to Romer 2002 where inflation changes only in the second period following all shocks except the nominal AS shock). We also use a slightly more general form compared to the textbook expectations augmented PC, because including both the current and the lagged deviation cycle yields a model consistent with the evidence that it is

[104] See for example Hall and Taylor (1997) or Mankiw (2003) for the former and Layard et al. (1991) or Blanchard (2000) for the latter.

[105] This would imply a change in the mark-up, assuming mark-up pricing by firms, arising for example from changes in the degree of market power by firms.

[106] Arising, for example, from changes in the degree of power by unions.

[107] The textbook version of the expectations augmented PC assumes that expected inflation can be approximated by the simplest form of adaptive expectations, that is lagged inflation. Note that in empirical analyses of the expectations augmented PC typically also lagged values of the deviation cycle are added to obtain a better specification (see for example Gordon, 1997).

not only the gap that matters for inflation but also is the rate of change of output.[108] Despite the more general form than the IA relationship used by Hall and Taylor (1997) and Romer (2002), we will call it the IA line because it also shifts up and down in response to changes in the (previous period's) deviation cycle.

Finally, the exogenous potential output level can be thought of as given by a long-run production function which can be represented as a vertical line in inflation/output space:

$$y_t^N = A_t^N F(L_t^N, K_t^N)$$

where A_t^N is trend productivity, L_t^N is trend labour supply and K_t^N is trend capital. This relationship represents the long-run aggregate supply (LRAS) function. Changes in the productivity factor or the inputs can be thought of as real AS shocks.

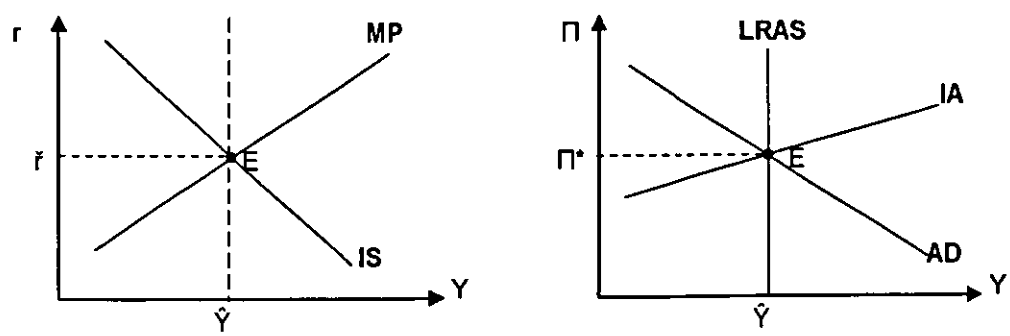
Figure A1 represents the long run equilibrium of the model, corresponding to points E in both the right hand side and the left hand side graphs. In the long run equilibrium real output equals potential output and the output gap is zero. In the equilibrium depicted in Figure 1 the real interest rate equals the natural rate of interest and inflation equals the inflation target but these two conditions are not necessarily satisfied in all equilibria, as will become clear in the analysis of the responses to the various shocks.

We will now consider the effects of the four types of shocks under consideration. A negative (positive) real AD shock is represented by a negative (positive) value of *ut*. A negative (positive) nominal AD shock can be represented by a decrease (increase) in Π^*. A negative (positive) real AS shock is represented by an exogenous fall (increase) in y_t^N. Finally, a negative (positive) nominal AS shock is represented by a positive (negative) value of *ξt*.

[108] Note that including current and lagged deviation cycle is equivalent to including both the (current or lagged) deviation cycle in levels and the change in the deviation cycle from the previous to the current period. Thus, given the approximate equality of the change in the deviation cycle and the difference between output growth and potential output growth, our specification allows for the effects of both of the deviation cycle and the output growth to be taken into account. See also Gordon (1997, p.16) for a discussion of this point and Romer (1996) for the evidence on the significance of the rate-of-change effect.

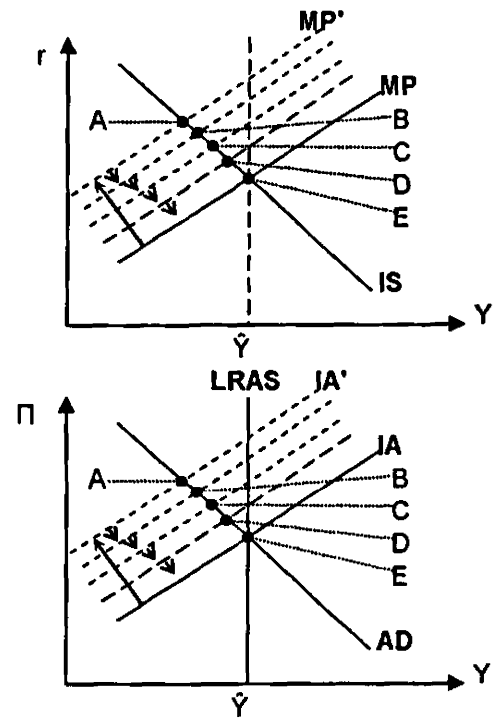
First let's consider the impact of permanent shocks. Then the impact of transitory shocks will be discussed.

Figure A1 – The long-run equilibrium



A permanent negative nominal AS shock.

Figure A2 – The impact of a permanent negative nominal AS shock



Starting from a long-run equilibrium condition in period 0 (point E in Figure A1), consider for example a permanent increase in relative oil prices from period 1 onwards. This can be represented by a positive value in εt in period 1 (while before and after it is zero). This will cause in period 1 an increase in inflation (see equation 3). In graphical terms, the IS line will shift up to IA' (see lower panel). As a result the output gap becomes negative. This happens because the increase in inflation will trigger an increase in interest rates (see equation 2), represented by an upward shift in the MP line to MP' (see the upper panel), which leads to a fall in real output (see equation 1). Thus, in period 1 the economy moves to point A.

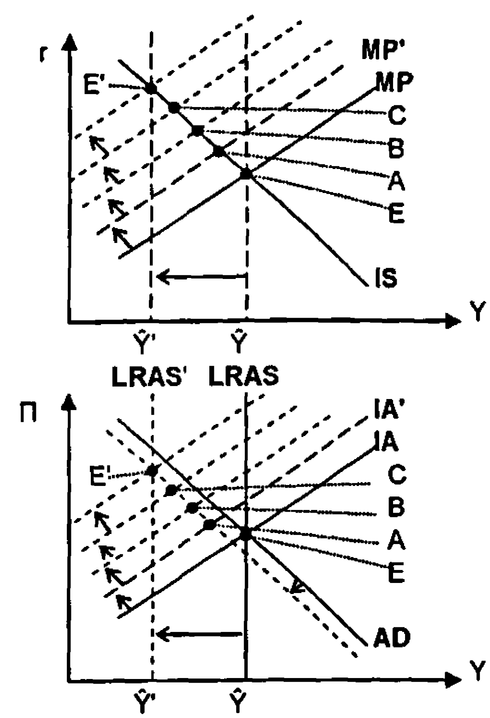
In period 2, the negative gap starts to exert negative inflationary pressures, thus IA' starts to move down slowly. The decreasing inflation and the reduction of the gap also lead the central bank to start to decrease interest rates, thus MP' starts to move down. The economy moves to point B.

In period 3 the process continues, with falling inflation and interest rates, increasing output and a further reduction of the gap, with the economy moving to point C.

This continues until the economy reaches its new long run equilibrium, which is represented by the starting point E, where inflation is again at the target level, the gap has closed and interest rates are at the natural level. The only long-run impact is on the level of prices which will be higher. Note that since potential output has not changed during the whole process, the pattern of real output tracks that of the gap.

A permanent negative real AS shock.

Figure A3 – The impact of a permanent negative real AS shock



Starting from a long-run equilibrium condition in period 0 (point E in the figure), consider a permanent increase in the natural unemployment rate, determining a permanent fall in the natural output level from period 1 onwards. In graphical terms, the shock implies a leftward shift in the LRAS vertical line to LRAS'. Moreover, in their respective spaces the IA and MP lines will shift up and the AD line will move slightly down. Thus the economy moves from point E to point A, where inflation and interest rates are slightly higher and, despite output being slightly lower, the output gap has increased substantially and become significantly positive. Intuitively, the fall in potential output on impact creates excess demand (a positive gap) which in turn gives rise to inflationary pressures leading the central bank to tighten interest rates, fact which depresses output. The latter change creates some slight deflationary pressures but not enough to offset the large initial inflationary impact.

In period 2, both the IA line and the MP line move further upwards, and the economy moves up along the AD and IS lines to point B. Intuitively, the positive output gap exerts positive inflationary pressure, inflation increases, thus the monetary authority raises further interest rates, which reduces slightly excess demand. Note that results would not change significantly if, following the increase in the natural interest rate due to the fall in potential output, the central bank adjusted its implicit estimate of the natural interest rate

– for example, if $r_t^* = r_{t-1}^N$. This would shift slightly the AD line further down but inflation can be shown to be still increasing.

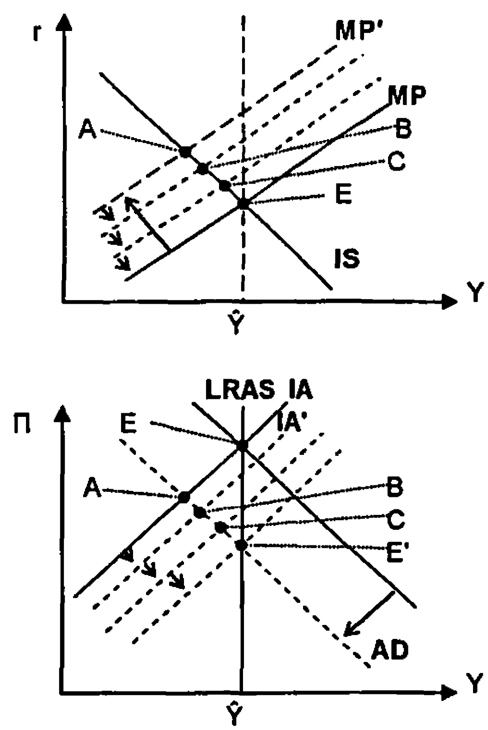
In period 3, the adjustment continues as in period 2 with the economy moving to point C, where inflation and interest rates are higher, output lower and the gap is reduced (but still positive).

This continues until the economy reaches its new long run equilibrium, which is represented by point E', where the gap has closed. However, inflation and the interest rate are now steady at a higher level and output is at a lower level. In the long run the fact that inflation is steady above the target implies that the real interest rate will be steady above the estimated natural rate of interest (even if adjusted by the central bank).

A permanent negative nominal AD shock

Starting from a long-run equilibrium condition in period 0 (point E in the figure), let's assume the central bank decreases (permanently) its inflation target from period 1 onwards. In graphical terms, this implies first of all an upward shift in the MP line (note that already in period 1 inflation increases slightly, fact which implies a slight downward movement of the MP curve, thus the immediate upward shift is slightly counterbalanced). At the same time, the AD line will move downwards. Thus the economy moves along the IS and IA lines from point E to point A, where inflation and interest rates are slightly higher, output is lower and the output gap has become negative.

Figure A4 – The impact of a permanent negative nominal AD shock



Intuitively, the new inflation target induces the central bank to raise interest rates, which depresses output and creates deflationary pressures. Thus, inflation starts to fall.

In period 2, the IA line starts to move down due to the fall in real output in period 1. At the same time the MP line starts to move down because of the fall in inflation. Thus, the economy moves along the IS and AD lines from point A to point B, where inflation and interest rates are lower, output is higher and the output gap is still negative but starts to decrease in absolute terms. Intuitively, the negative output gap exerts deflationary pressures, inflation falls, thus the monetary authority starts to decrease interest rates, which induces output growth.

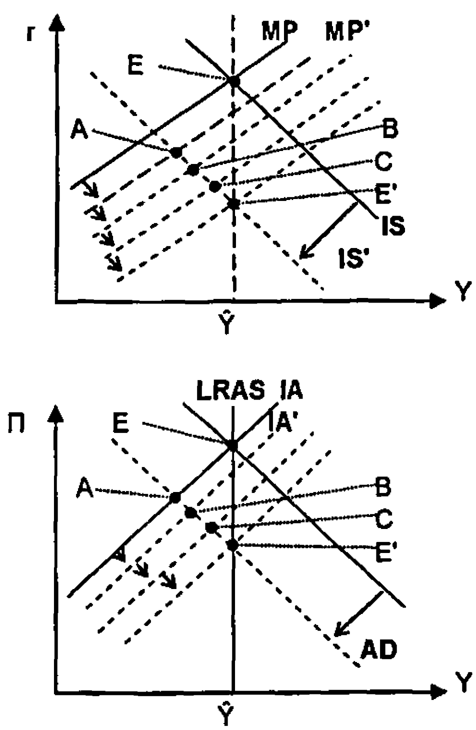
In <u>period 3</u>, the adjustment continues as in period 2 with the economy moving to point C, where inflation and interest rates are lower, output higher and the gap is reduced (but still negative).

This continues until the gap has closed and the economy reaches its <u>new long run equilibrium</u>, which is represented by point E' in the lower chart and the initial point E in the upper chart. Thus, all endogenous variables return to the initial level except the inflation rate which is now lower.

A permanent negative real AD shock

Starting from a long-run equilibrium condition in period 0 (point E in the figure), consider a permanent fall in government expenditure (represented by a lower value in u_t) from period 1 onwards. In graphical terms, this implies first of all a downward shift in the IS and AD lines. The fall in inflation also induces a fall in the MP line. Thus the economy moves from point E to point A, where inflation, interest rates and output are lower and the gap has become negative. Intuitively, the fall in output caused by the lower government expenditure creates a negative output gap, which determines deflationary pressures and induces the central bank to cut interest rates.

Figure A5 – The impact of a permanent negative real AD shock



In period 2, the IA line starts to move down due to the fall in real output in period 1 and the MP line shifts down further because of the fall in inflation. Thus, the economy moves along the IS and AD lines from point A to point B, where inflation and interest rates are lower, output is higher and the output gap is still negative but starts to decrease in absolute terms. Intuitively, the decreasing inflation, due to the fall in output in the previous period and the negative output gap causes the monetary authority to decrease interest rates, which induces output growth.

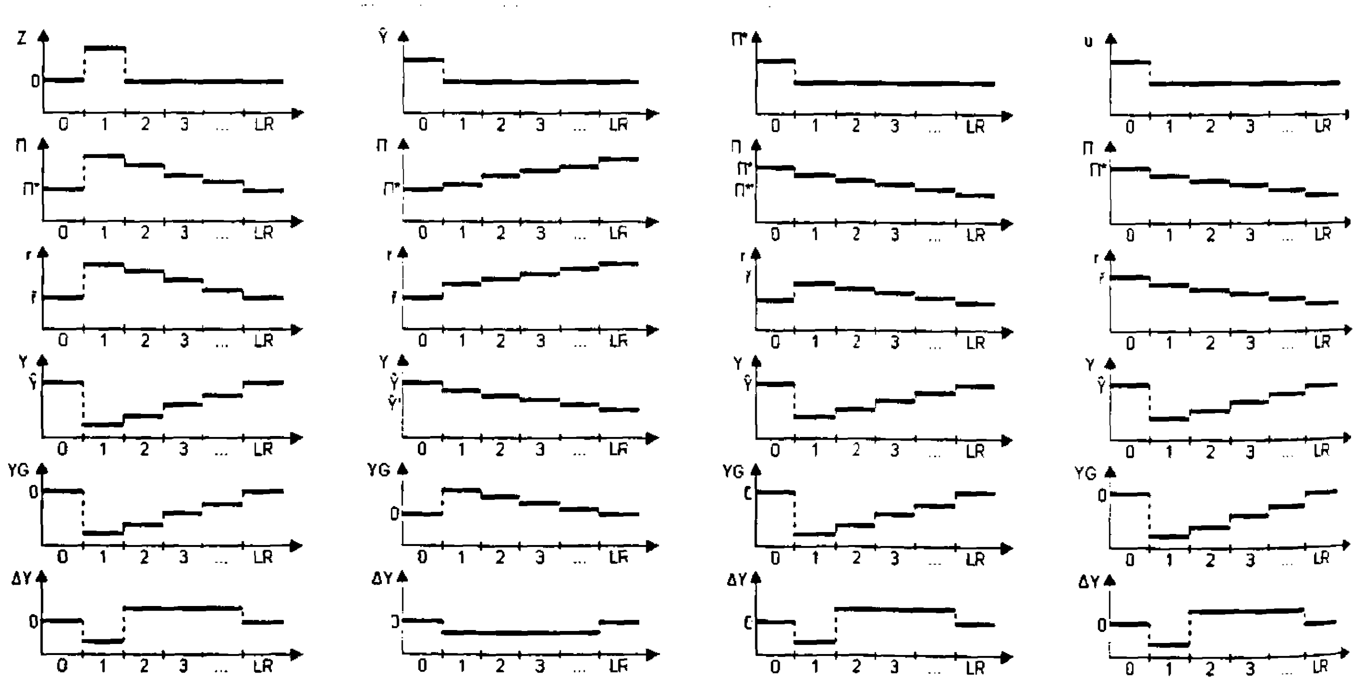
In period 3, the adjustment continues as in period 2 with the economy moving to point C, where inflation and interest rates are lower, output higher and the gap is reduced (but still negative).

This continues until the gap has closed and the economy reaches its new long run equilibrium, which is represented by point E', where output has returned to the initial level, while inflation and interest rates stabilize at lower levels. In general, the lower government expenditure has been compensated by higher investment and possibly also higher expenditure on other interest sensitive components such as private consumption of durable goods.

Figure A6 summarises the pattern of the endogenous and exogenous variables in response to the four shocks examined.

Figure A6 – Responses of the variables to the four permanent negative shocks

a) nominal AS **b) real AS** **c) nominal AD** **d) real AD**



Overall, in the short run (period 1) a negative permanent AS shock causes an increase in inflation and interest rates and a fall in output (negative output growth). A nominal AS shock also causes a fall in the output gap (which becomes negative starting from a zero level) while a real AS shock causes the output gap to increase (or become positive if starting from a zero level). By contrast, a negative permanent AD shock causes a fall in inflation, output (negative output growth) and the output gap (which becomes negative starting from a zero level). A nominal AD shock also causes an increase in the interest rates, while a real AD shock causes a fall in interest rates.

Thus, <u>over the short run in the presence of a negative output growth response to any negative permanent shock, the response of inflation allows us to identify AS and AD shocks, the response of the output gap allows us to distinguish between nominal and real AS shocks, and the response of real interest rates allows us to differentiate between nominal and real AD shocks</u>.

The same applies to temporary shocks. Compared to the case of the permanent shocks, transitory shocks will have the same impact in period 1 in all cases for all variables and only the adjustment thereafter differs. In general, in period 2 there will be a quick tendency to return to the initial equilibrium but for some variables the adjustment will require various periods (mainly due to the lags in the IA relationship). Thus, <u>the short run responses will be the same in the case of temporary shocks and the same identification restrictions can be imposed</u>.

Appendix 3 – The econometric method

It is assumed that the data generating process can be approximated by a vector autoregression (VAR):

$$Y_t = \mu + A(L) \cdot Y_{t-1} + u_t \qquad u_t \sim (0, \Sigma)$$

where Y_t is the vector of the variables considered, $A(L)$ is a matrix polynomial in the lag operator, and u_t is the vector of reduced form innovations. The reduced form VAR, which can be estimated consistently via OLS, represents the starting point of the analysis. The corresponding Wold MA representation is

$$Y_t = \Phi + B(L) \cdot u_t \quad \text{with} \quad \Phi = [1 - A(L)L]^{-1} \cdot \mu \quad \text{and} \quad B(L) = [1 - A(L)L]^{-1}$$

In order to derive the structural shocks from the reduced form residuals u_t two steps are followed. The first step, of statistical nature, consists of the construction of innovations e_t from the reduced form residuals u_t with the property of being serially and contemporaneously uncorrelated.[109] The second step, of economic nature, consists of using implications from economic theory to select among the components of the orthogonal innovations vector e_t those which have a meaningful economic interpretation.

Step1

More precisely, for any non-singular orthogonal matrix V satisfying $\Sigma = V \cdot V'$, an orthogonal decomposition of the Wold MA representation with contemporaneously uncorrelated innovations with unit variance-covariance matrix can be derived

$$Y_t = \Phi + C(L) \cdot e_t \quad \text{with} \quad C(L) = B(L) \cdot V, \; e_t = V^{-1} \cdot u_t \text{ and } e_t \sim (0, I)$$

[109] This step is typically required in structural VAR analysis (since at least Bernanke, 1986), justified by the nature of the structural shocks, which for this property are also called sometimes the primitive shocks.

However, there is a multiplicity of these decompositions: for any orthonormal matrix Q (i.e. such that $Q \cdot Q' = I$), $\Sigma = \hat{V} \cdot \hat{V}' = V \cdot Q \cdot Q' \cdot V'$ is an admissible decomposition of Σ. The idea of Canova and de Nicolo' (2002) (henceforth CdN) is to explore the space of orthogonal decompositions via a class of orthogonal matrices like Q, called rotation matrices. These can be expressed in terms of sine and cosine functions and ones and are of the form

$$Q_{m,n} = \begin{bmatrix} 1 & 0 & 0 & \dots & 0 & 0 \\ 0 & 1 & 0 & \dots & 0 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ 0 & 0 & \cos(\theta) & \dots & -\sin(\theta) & 0 \\ \vdots & \vdots & \vdots & 1 & \vdots & \vdots \\ 0 & 0 & \sin(\theta) & \dots & \cos(\theta) & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ 0 & 0 & 0 & \dots & 0 & 1 \end{bmatrix}$$

where subscripts m and n indicate that only rows m and n are rotated by the angle θ. The algorithm proposed by CdN to search within the set of possible identifications uses some results from Press et al. (1997):

Result 1: if P is the matrix of eigenvectors and D is the matrix with the eigenvalues such that $\Sigma = P \cdot D \cdot V'$, it can be shown that $P = \prod_{m,n} Q_{m,n}(\theta)$ where $\theta \in (0, 2\Pi)$.

Result 2: given P and D of a matrix Σ so that $\Sigma = V \cdot V'$, where $V = P \cdot D^{0.5}$, then $\hat{V} = P \cdot D^{0.5} \cdot Q_{m,n}$ satisfies $\Sigma = \hat{V} \cdot \hat{V}'$ with $Q_{m,n} = Q_{m,n}(\theta)$.

Note that in a system of N variables there are N(N-1)/2 matrices of bivariate rotations and N(N-1)/4 combinations of bivariate rotations matrices. In our case N=4. Hence, there are in total nine rotations matrices. An example of a bivariate rotation matrix is

$$Q_{1,3} = \begin{bmatrix} \cos(\theta) & 0 & -\sin(\theta) & 0 \\ 0 & 1 & 0 & 0 \\ \sin(\theta) & 0 & \cos(\theta) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

while an example of a combination of bivariate matrices would be

$$Q_{(1,3),(2,4)} = \begin{bmatrix} \cos(\theta) & 0 & -\sin(\theta) & 0 \\ 0 & \cos(\theta) & 0 & -\sin(\theta) \\ \sin(\theta) & 0 & \cos(\theta) & 0 \\ 0 & \cos(\theta) & 0 & \sin(\theta) \end{bmatrix}$$

The interval [0,2Π] can be grid into M points, such that the uncountable set of identification is transformed into a large but finite set.

The precise algorithm consists of the following steps:

1) derive one decomposition by constructing matrices P and D of the residuals' matrix Σ;
2) construct matrices $P_{m,n} = P \cdot Q_{m,n}(\theta)$ from which to derive [N(N-1)/2 +N(N-1)/4]·M further decompositions(i.e. starting from an eigenvalue-eigenvector decomposition as in point 1, decuple it in one direction at a time, for each angle 0);
3) for each decomposition compute disturbances and check if the required sign restrictions (as imposed in the second step) on the endogenous variables of the VAR are satisfied.

Step 2

The second, economic, step consists in deriving from each decomposition the orthogonal shocks e_t and the impulse response of each variable to the shocks given by the coefficient of the lag polynomial C(L)·α, where α satisfies α·α '=1 and characterises the shock. On the basis of economic theory restrictions need to be derived either on the sign of the pairwise dynamic cross-correlations of impulse response functions (as done by CdN) or on the sign of the impulse response functions for a number J of periods (as done by Peersman, 2005). Thus, the idea is to get all decompositions which recover some interpretable disturbance and select them on the basis of a set of criteria. For example, CdN first choose those that maximise the number of shocks that are consistent with economic theory on the basis of the implied contemporaneous correlations between two variables; then, if not enough to pin down one decomposition, they also consider correlations shifted by one lead and lag, and so on; finally, if still not enough they consider correlations between multiple pairs of variables. Thus, they impose an increasing number of restrictions until one decomposition is selected. This decomposition can then be used to derived the structural shocks, compute their impact on the variables of interest and implement the usual shock accounting exercises, from variance decompositions to historical decompositions.

Despite the basic idea is that of CdN, we deviate from CdN in various respects. For example, while CdN impose the restrictions on the sign of the (conditional) correlations of the impulse responses, we apply them to the sign of the cumulative impulse responses. This also differentiates our approach from Peersman (2005) which imposes the restrictions on the sign of the impulses response functions in all periods from 1 to N (with N equal to 4). As discussed in the main text, several models imply impulse response functions whose shape may imply changes in sign even in short horizons, possibly due to adjustment costs or some source of inertia, while the sign of the overall (or cumulative) responses over various periods tend to be less ambiguous in terms of sign. Furthermore, we impose all restrictions derived from economic theory and make them more binding, if necessary, by increasing the time horizon over which they must hold. For example, if more than one decomposition satisfies all restrictions over the first N quarters after the shock, we impose it over the first N+1 etc until only one decomposition is selected. CdN by contrast impose the restriction first on the contemporaneous correlations, then on correlations shifted and lagged by one period and so on. While CdN are not clear on the time horizon over which they impose the restrictions, and Peersman (2005) arbitrarily imposes the restrictions on four quarters, we choose an economic criterion: the starting horizon is represented by the minimum among the average durations of business cycle phases. The reason is that any shock which is a potential source of a cyclical regime should exert its impact typically over a period corresponding to the average phase duration. Since the average duration of phases of fluctuations tend to differ across both regime and concept of the cycle, we choose the minimum of such average durations as starting point.

Appendix 4 – Data sources and definitions

All data are quarterly indices and span the period from 1980q1 to 2003q4. Real GDP data are expressed as quarter-on-quarter growth rates, inflation data are expressed as quarterly inflation rates (annualized quarter-on-quarter growth rates), output gap series are expressed as percentage deviations from potential output and real interest rates are in percentages. Ex post real interest rates were expressed as the difference between nominal interest rates and the quarterly inflation rate for the corresponding period. The data is plotted in Figures 1 and 2.

Real GDP: For the euro area data from Eurostat, available from 1991q1, were projected backwards using the quarter-on-quarter growth rates of the corresponding index from the Area Wide Model (AWM) database up to 1980q1. For the US the data are from the Bureau of Economic Analysis (BEA), and correspond to billions of chained 2000 dollars.

Inflation: For the euro area unadjusted HICP data from Eurostat, available from 1990q1, were projected backwards using the quarter-on-quarter growth rates of the corresponding index from the Area Wide Model (AWM) database up to 1980q1. The aggregate index was seasonally adjusted using a basic unobserved components model (with stochastic trend and seasonal components, using STAMP). For the US CPI data from the Bureau of Labor Statistics (BLS) was used (monthly data were transformed to quarterly frequency by averaging).

Output gap: For the euro area the two series considered were, first, OECD Economic Outlook data and, second, the estimate from the multivariate unobserved components model of Proietti, Musso and Westermann (2002).[110] For the US

[110] The common cycles variant was estimated. The common cycles specification is estimated under the assumption that all cyclical variables in the system (total factor productivity, unemployment, labour force participation) follow the relatively short cycle in capacity utilisation. See T. Proietti, A. Musso and T. Westermann (2002): "Estimating potential output and the output gap for the euro area: a model-based production function approach", *European University Institute, Florence, Working paper ECO* 2002/09.

estimates from the Congressional Budget Office (CBO) and from the OECD Economic Outlook database were used.

Nominal interest rates: For the euro area three months money market interest rates data from the AMW database were used. For the US three month Treasury Bill (Secondary Rate) interest rates were used, obtained from the Federal Reserve Board of Governors.

Figure 1 – Euro area data

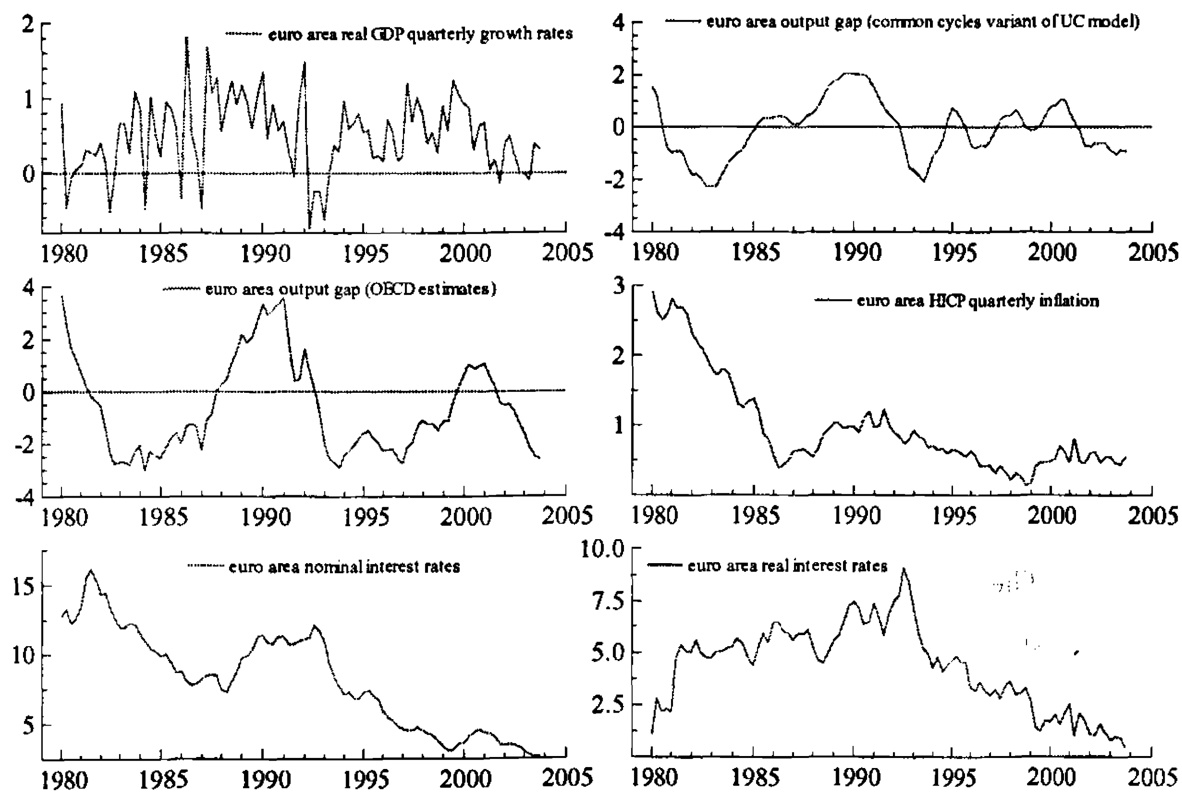
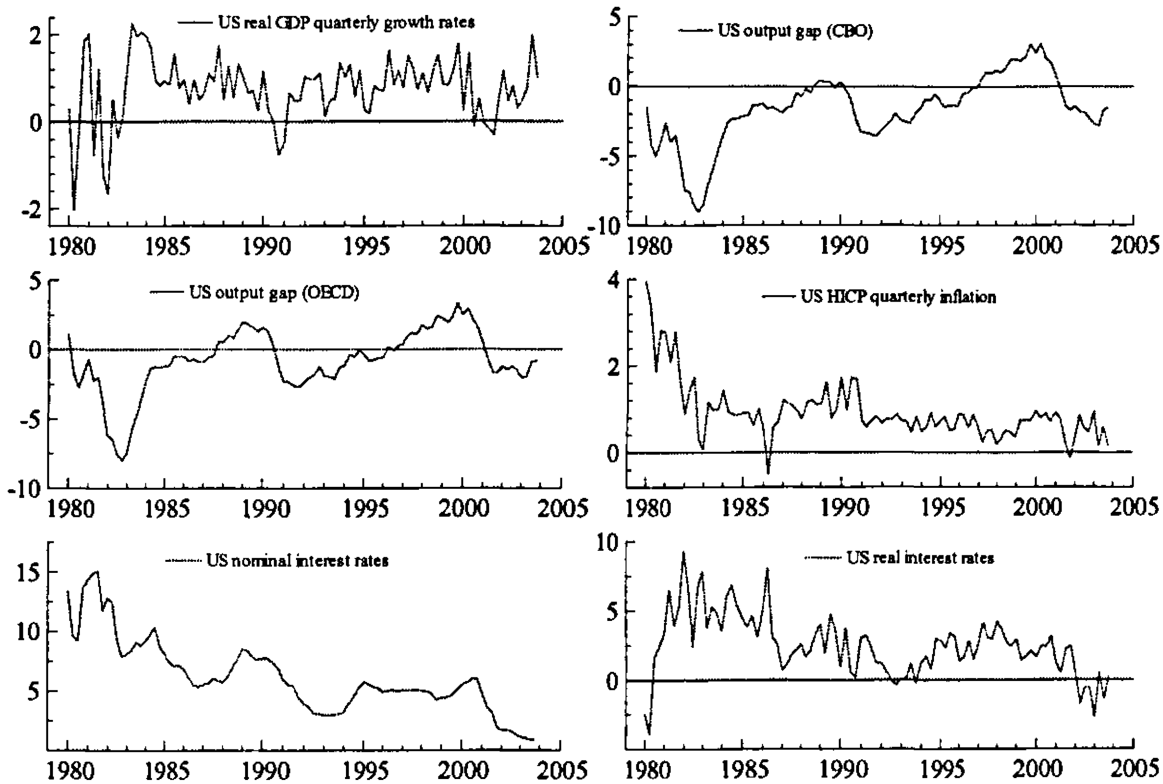


Figure 2 – US data



Appendix 5 – Impulse response functions and structural shocks series

Figures 1 and 2 show the impulse responses of one-standard deviation shocks over a time horizon of ten years together with confidence bands computed with a bootstrap algorithm (with 10000 draws).

Figure 1 – Impulse response functions for the euro area

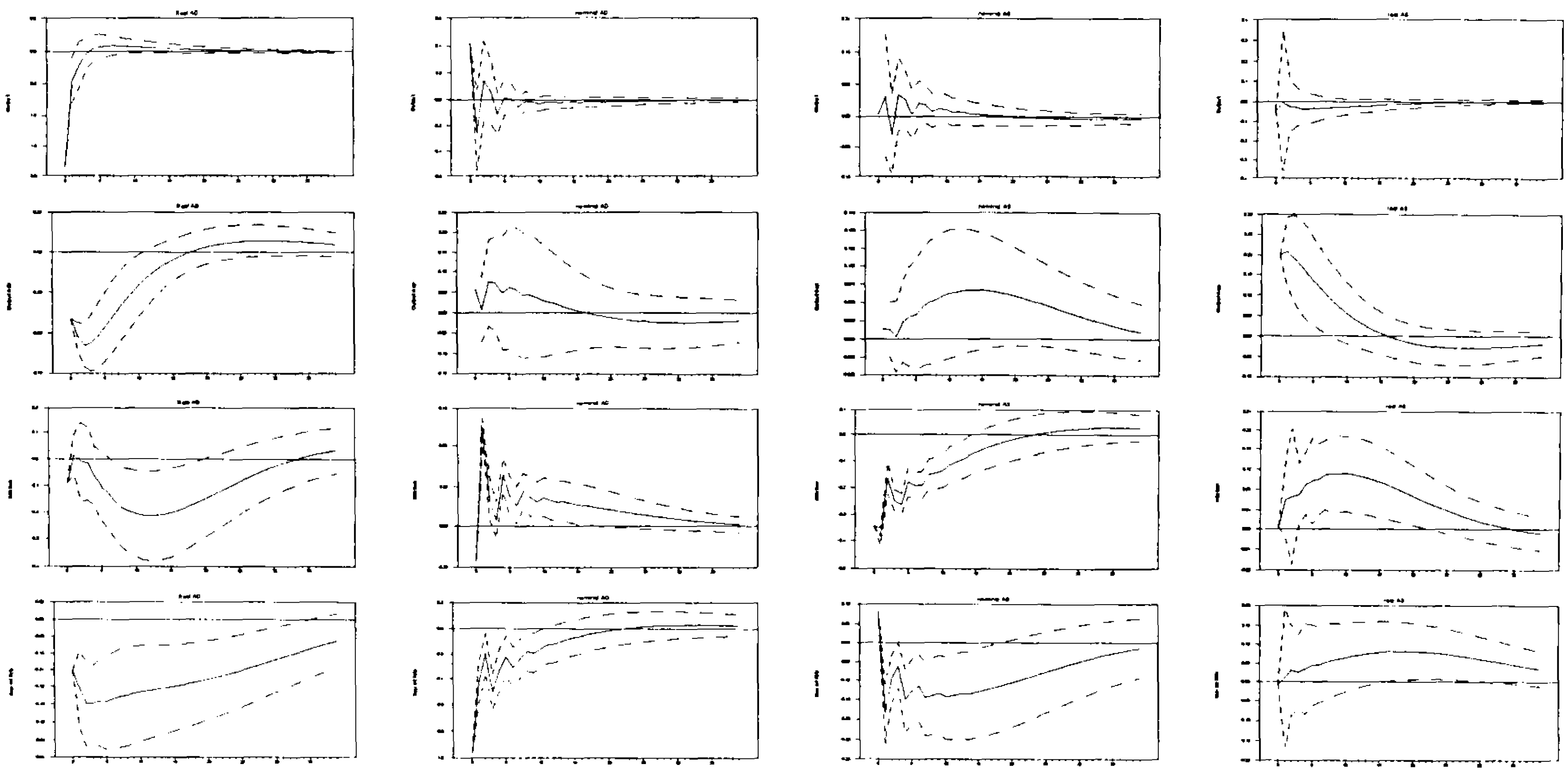
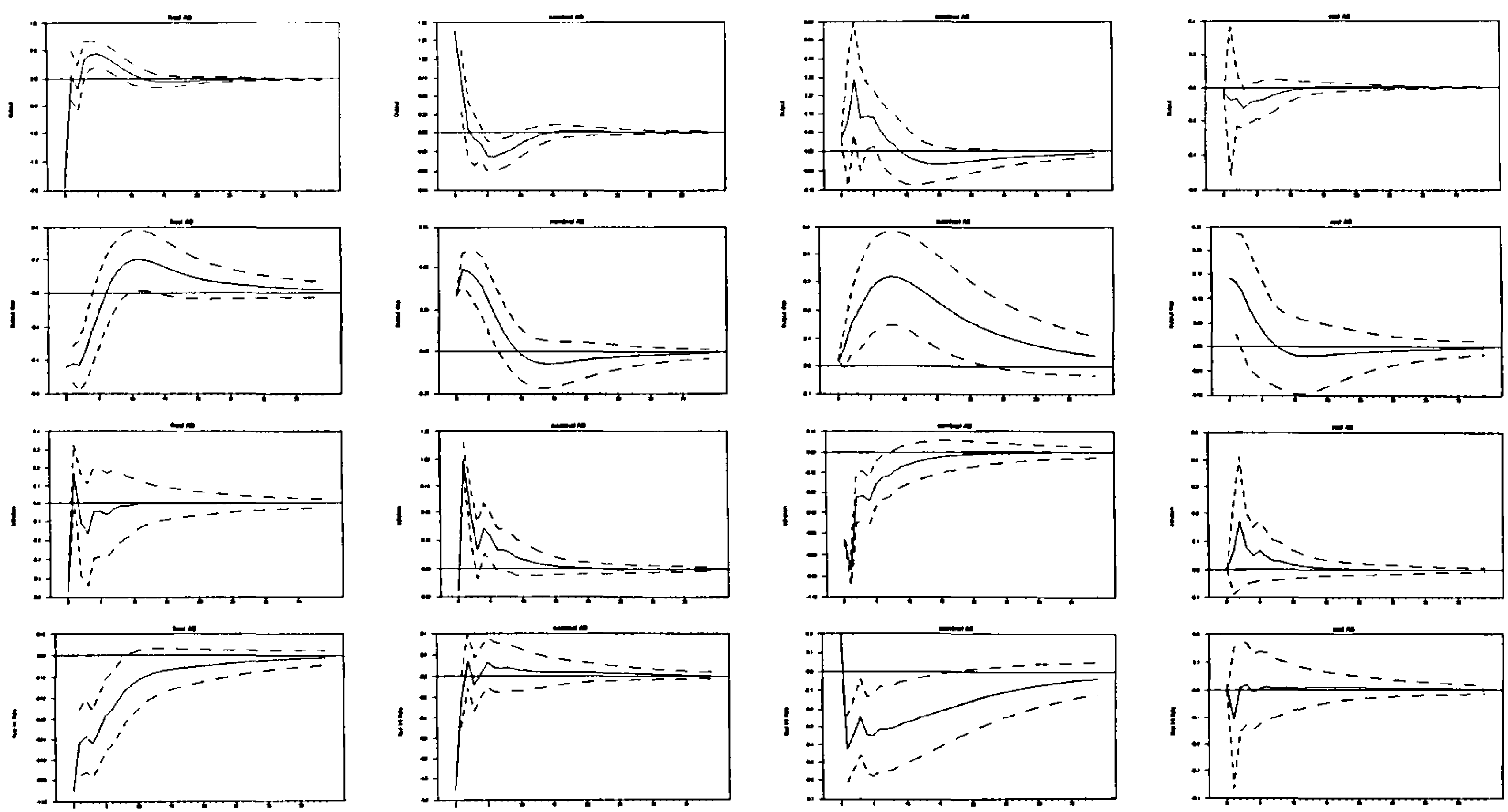


Figure 2 – Impulse response functions for the US



Conclusions

This dissertation provides an analysis of the euro area business cycle. Focusing on the concept of the deviation cycle, the analysis has concentrated on the period from 1960 to 2003 and has adopted a comparative perspective with the US. We have pursued such an objective in three main steps. First, the question of whether it can be concluded that the euro area business cycle exists was assessed in chapter 1. As shown in that chapter, sufficient evidence can be found supporting the view that a region specific business cycle in the euro area exists. In chapter 2 we have identified a set of stylised facts of the euro area business cycle. These stylised facts can serve as a useful guide in the analysis and modelling of macroeconomic fluctuations in the euro area. Finally, in chapter 3 we have addressed the question of the sources of the business cycle, using an approach which combines insights from economic theory and a robust empirical method based on structural VAR analysis.

Overall, the findings of this dissertation enhance our understanding of the euro area business cycle along various dimensions. However, several questions remain open. These include the relevance of specific asymmetries which may characterise fluctuations, the importance of open economy aspects and how to model in detail cyclical developments. Our analysis can only represent a starting point for a thorough understanding of macroeconomic fluctuations in the euro area. At the same time it has to be recognised that such an objective can only represent a long term research programme. Such research programme is worthwhile and we hope, starting from what has been learned from this dissertation, to be able to undertake it.

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