Basic characteristics of the Euro Area business cycle
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Basic characteristics of the Euro Area business cycle

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BASIC CHARACTERISTICS
OF THE
EURO AREA BUSINESS CYCLE

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Abstract
In this study a set of basic stylised facts characterising euro area macroeconomic fluctuations are computed with reference to two concepts of the business cycle (classical business cycles and deviation or growth cycles) from 1960 to 2002. These stylised facts, computed on the basis of alternative turning point dating methods and alternative reference measures of the cycle, are discussed and compared to the corresponding ones for the US business cycle.

Overall, the study suggests that: i) significant variation of characteristics can be detected across cycles for both fluctuation concepts; ii) classical business cycles are much less frequent than deviation cycles; iii) the phases of classical cycles tend to be asymmetric, both in terms of duration and amplitude, while regimes of deviation cycles appear to be relatively symmetric; iv) very similar regularities characterise euro area and US fluctuations, one main exception being that the US economy experienced more frequent classical cycles, with a somewhat shorter average duration; v) there is no clear evidence that the duration or amplitude of phases has gradually declined over time, apart from US classical cycle recessions.

Subject area: Business cycle analysis.
JEL classification codes: E32.

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1 I thank Mike Artis, Fabio Canova, Neale Kennedy, Gerard Korteweg, Peter McAdam, an anonymous referee and participants to an ECB seminar for useful comments on various versions of the current paper and discussions. All remaining errors are of course the sole responsibility of the author. The opinions expressed in this paper are those of the author and do not necessarily reflect the views of the European Central Bank.
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)

The business cycle: It’s still a puzzle.

Christiano and Fitzgerald (1998, title)

I. Introduction

Despite the importance of the phenomenon known as the business cycle, as synthesised by Schumpeter in the quotation reported above, it still presents several unexplained features such that many analysts in the profession still regard it largely as a puzzle, to use the words of Christiano and Fitzgerald (1998). Several theories of macroeconomic fluctuations have been proposed (and as a result there exist probably more possible explanations of this phenomenon than cycles can be recorded in the last century), but none has so far been capable of providing a satisfactory comprehensive explanation of business cycles. Nevertheless, the profession seems to have reached a broad agreement from a methodological point of view on how to proceed in the analysis of business cycles. The mainstream research strategy starts from the identification of the stylised facts that characterise business cycles, and that therefore need to be explained, and then passes to testing the alternative theories. If a theory is found to outperform the alternatives and reaches a minimum set of criteria, varyingy defined, then it is used as a framework for policy analysis. Following this strategy of research, several studies identifying the main business cycle stylised facts for the US economy have appeared in the past two decades. By contrast, despite the recent publication of a number of studies on business cycles in Europe, a systematic analysis of the main characteristics of the euro area cycle is still missing.

The purpose of this study is to contribute to partially fill this gap by identifying a set of basic stylised facts of the euro area business cycle, including duration and amplitude of cycle phases, which will be compared to the corresponding ones for the US business cycle. The results of this investigation can improve our understanding of the euro area economy along some dimensions, provide a useful reference for the purpose of euro area conjunctural analysis, forecasting and policy analysis and, as already mentioned, can be instrumental in guiding the development of appropriate models of the euro area business cycle and selecting among existing ones².

In the past two years a number of studies with a purpose similar to the current study have appeared. As regards turning points, on the basis of which to compute the basic characteristics, three main approaches have been applied to euro area data. First, an informal approach is sometimes used in dating the cycle, typically with reference to deviation cycles. For example, Döpke (1999) locates the peaks and troughs of three measures of euro area deviation cycles and two growth rates series from 1980 to 1997 by visual inspection. Similarly, Anas and Nguffo-Boyom (2001) determine a quarterly set of turning points from 1970 based on visual inspection of the cyclical series obtained via the Baxter-King filter. Forni et al. (2001) construct a coincident indicator for the euro area from the mid-1980s using a generalised dynamic factor model and derive from it a set of turning points for a measure of the business cycle which resembles the deviation cycle. Altissimo et al. (2001) use an extended approach to that of Forni et al. (2001) and derive a monthly indicator, EUROCOIN, starting from 1987 which they use to detect peaks and troughs for the euro area cycle. Second, some

² For example, it can be used for testing the validity of recent business cycle models as was done by King and Plosser (1994), Simkins (1994) and Balke and Wynne (1995) with reference to the US economy.
papers have used the Bry-Boschan algorithm (BBA) or some simplified version of it. For example, Harding and Pagan (2001) adapt the BBA, originally designed for monthly indicators, to quarterly data and compute a euro area turning points chronology for both the classical cycle and the deviation cycle. Similarly, Ross and Ubide (2001) compute two sets of peaks and troughs for the classical cycle at quarterly frequency, using two versions of a simplified BBA. Also Lommatzsch and Stephan (2001) apply the BBA to euro area classical cycles and deviation cycles, obtained by applying the Hodrick-Prescott filter, computed from real GDP series from 1977 to 1997, and derive various sets of turning point chronologies for several variants of seasonal-adjustment methods. They find that chronologies differ depending on whether the series are adjusted for calendar effects or not, but not depending on whether aggregation of national data takes place before or after seasonal adjustment. A turning points chronology for the euro area deviation cycle, computed by applying the Baxter-King filter, has also been published by the ECB, based on the BBA for monthly industrial production and on an adapted version of the BBA for quarterly GDP. Artis, Marcellino and Proietti (2002) extend Harding and Pagan’s set of rules for quarterly data and compute turning points for the euro area classical cycle and various measures of the deviation cycle. They use these chronologies also to derive some basic stylised facts such as average duration and amplitude of the various cyclical regimes. Third, other papers have adopted Hamilton’s Markov-switching model (MSM) to date euro area fluctuations. For example, Peersman and Smets (2001) apply a multivariate version of the MSM using quarter-on-quarter industrial production data from 1978 to 1998 for seven euro area countries and derive a quarterly set of peaks and troughs on the basis of the smoothed probabilities of the business cycle regimes. A similar approach is followed by Krolzig (2001a), who computes two sets of quarterly chronologies for classical cycles from 1980 to 2000, based on the smoothed probabilities of regimes obtained from a univariate MSM applied to aggregate euro area GDP data and a multivariate MSM using GDP data for eight euro area countries. Anas and Ferrara (2002) is the only study which adopts a comparative perspective across methods using euro area data. They compare the set of turning points derived from a simplified BBA and a three-regimes MSM using monthly industrial production data from 1970 to mid-2002, both for the classical cycle and two variants of the deviation cycle (obtained by applying the Hodrick-Prescott and the Baxter-King filters, respectively). However, the comparison across methods is informal, consisting of a discussion of which turning points captured by the various methods are common. Thus, no study has yet undertaken a comparative analysis of peaks and troughs chronologies and resulting stylised facts across the alternative concepts of the euro area business cycle, that is classical cycles and deviations cycles, as well as relative to the US. This paper aims at filling this gap.

The paper proceeds as follows. Section II describes the data used in the analysis, and refers to Appendix 1 for more details on the data sources and treatment. Section III summarises the methods used to identify the basic characteristics, including those for detecting turning points. Section IV reports and discusses the results. Finally, Section V summarises the main findings.

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3 See the article on “The information content of composite indicators of the euro area business cycle” in the July 2001 issue of the ECB Monthly Bulletin.

4 Note that such an approach has the drawback that each country receives the same weight, and it would be difficult to advocate for the euro area dating method which assigns the same weight to Luxembourg or Finland as to Germany or France.

5 Other studies have used similar methods to extract a European business cycle, with reference to the whole or most of the European Union member countries, typically including the UK. See for example, Artis, Krolzig and Toro (1999), Krolzig (2001b), Krolzig and Toro (2001). For this reason, these studies are not directly comparable to our analysis.
II. Data

For our analysis there are two options concerning the choice of the time series used to represent the cycle: either a macroeconomic series such as real GDP or employment is used or a composite indicator can be built from a wider set of coincident variables such as real GDP, employment, industrial production, sales and trade. Both approaches have advantages and disadvantages and in both cases some arbitrary decisions have to be taken. In the case of the euro area the choice is mainly dictated by the limited availability of harmonised historical data for several euro area countries. Since our objective is to derive a monthly turning points chronology from the 1960s, our focus will be on monthly GDP indices. The latter are derived by applying the Chow-Lin interpolation method to a quarterly synthetic euro area real GDP index interpolated at monthly frequency using industrial production (excluding construction). A more general approach may be taken in the future as more harmonised historical time series become available. Industrial production is possibly the only monthly coincident indicator which can be constructed for the euro area on the basis of relatively harmonised national data from 1960.

A detailed explanation of how the euro area industrial production and real GDP series were constructed, including sources, aggregation and treatment (i.e. the decomposition into various components via unobserved components models), is reported in Appendix 2. For industrial production the main source of data is Eurostat, but for most countries data for the 1960s and 1970s are taken from the OECD’s Main Economic Indicators (MEI) database. The aggregate monthly industrial production series covers the period 1960m1 to 2002m12 with a coverage of the euro area of 88.4% in 1960 (in terms of 1999 euro area value added) and 96.2% or more from 1961 onwards. The euro area real GDP series is obtained by combining Eurostat data from 1991q1 to 2002q4 with the corresponding data from 1970q1 to 1991q1 from the Area Wide Model (AWM) database and an aggregate based on BIS data for West Germany and Italy and MEI data for France and the Netherlands from 1960q1 to 1970q1. For the US economy, for comparative purposes, we construct a similar monthly real GDP indicator, using chain weighted real GDP and interpolating it with the four monthly indicators which the NBER Dating Committee uses as a reference: total employment, real personal income less transfer payments, industrial production and sales, all available at monthly frequency from 1960m1. Thus, our reference monthly GDP indicators span from 1960m1 to 2002m12.

III. Methods

III.I. Turning points determination

The identification of the basic stylised facts is based on a set of turning points in the various measures of the cycle. In general, we define a peak as the last period of an expansion or upswing and a trough as the last period of a recession or slowdown. However, it is often not sufficient to identify local maxima and minima in the reference series as several complications arise. For example, two local extremum points may be too close to allow the period in between to be classified as a business cycle regime. In order to overcome these problems a number of alternative approaches to identify turning points have been proposed, including the Bry-Boschan algorithm (BBA), Hamilton’s Markov-switching model (MSM) or extensions of it, and various monthly versions of a popular

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6 See Fagan et al. (2001).
7 There is no consensus on the definition of turning points. For example, some analysts define peaks and troughs as the first period of the new phase, see Zellner and Hong (1989).
8 See Bry and Boschan (1971).
turning points determination rule according to which a classical business cycle recession occurs with at least two consecutive quarters of declining output\textsuperscript{10}, which translate into simple rules of thumb.

The BBA is a set of \textit{ad hoc} filters and rules aimed at identifying turning points by imposing constraints on both the duration and amplitude of cyclical fluctuations. Appendix 2 explains in detail the steps of this routine. The general idea is to start from a seasonally adjusted monthly index, adjust it for outliers, then look for local minima and maxima in various smoothed versions of the series, with a decreasing degree of smoothness, refining progressively the turning point chronology and determining the final set of turning points on the basis of the unsmoothed series. The justification for using different smoothed versions of the data is to eliminate irregular or erratic movements in the series but then to identify the final chronology on the basis of the original series in order to ensure that the final local minima and maxima are in effect turning points which refer to the reference series. It is worth noting that it imposes the restriction that, first, each phase should last at least five months and, second, that each cycle should last at least 15 months.

Within Hamilton’s basic MSM it is assumed that the growth rate of production follows a stochastic process which depends, among other variables, on an unobserved random state variable. The latter process is assumed to follow an N-states Markov chain. Typically N is set equal to two or three. Since the state variable switches between regimes with a certain probability, the growth rate of production correspondingly fluctuates between regimes with possibly different mean growth rates. If N is two, the model can be interpreted as representing the business cycle if one mean is negative (thus capturing recession or slowdown periods) and the other is positive (representing expansions or upswings). However, it has been found that sometimes a three-regimes characterisation is more appropriate to describe business cycle movements as the expansionary phase can often be decomposed into two sub-phases, one taking place immediately after recessions and characterised by higher positive growth rates (a recovery phase) and a subsequent one with relatively lower positive growth rates\textsuperscript{11}. As a by-product of the estimation it is possible to obtain time series of the probability of being in each regime at any period of time. Using these time series, a simple way to identify turning points suggested by Hamilton (1989) is to assume that there is a turning point when the probability becomes 0.5. If three regimes are assumed, then peaks and troughs can be identified by examining the probability of being in the regime with negative mean. Note that the model requires a stationary variable in order to be estimated. Thus, in the case of classical cycles typically the growth rate of production is modelled. However, this model can be used also to estimate deviation cycles if the level of the cyclical component is modelled.

The most widely quoted and used, especially by the economic press, turning points identification rule of thumb is the rule according to which a period (quarter or month) is recessionary if it belongs to a sequence of at least two quarters of negative growth in real output (either GDP or GNP). Thus, quarter \( t \) is a peak if quarter-on-quarter growth is positive in that period but negative in at least the following two quarters and is a trough if growth is positive in quarter \( t+1 \) and negative in \( t \) and at least in \( t-1 \). Given its widespread use, it is worthwhile to consider also this method to date the cycle. However, the translation to monthly frequency is not obvious, the reason being that two quarters of negative growth can be recorded in theory even if growth is negative in say only two months (if growth in the last month of one quarter and the first month of the following quarter was sufficiently negative to more than compensate for positive growth in the other four months of these two

\textsuperscript{10} According to Pagan (1997) this rule was popularised by Arthur Okun. Niemira and Klein (1994, see p.137) note that this rule is part of a more general set of steps suggested by Shiskin in 1974.

\textsuperscript{11} See for example Sichel (1994), Artis et al. (1999) and Layton and Smith (2000).
quarters) or up to ten months. A number of rules of thumb for monthly data have been proposed but there is no single one as widely referred to as the quarterly version of the rule.

The choice of turning points detection method is not an easy step. However, a set of criteria on the basis of which to select a preferred method can be defined. Among the alternative criteria that have been proposed in the literature we will consider the following ones:

i) **simplicity**: in general, given other characteristics of a method, simplicity can be considered an advantage. There are various aspects of simplicity, including transparency, ease of replication and clarity, which explain its desirability. According to this criterion, probably the rules of thumb rank higher than the other methods considered, followed by the BBA, which is also a set of rules, albeit more complex. By contrast, the MSM is relatively less transparent and is more technically demanding, implying that its replicability is less straightforward;

ii) **robustness**: in all methods there are some arbitrary choices to be made, and different choices can lead to varying classifications. For example, in both the rules of thumb methods and the BBA the minimum duration of a cycle or phase is imposed. Moreover, the MSM has several different possible specifications and it is not always straightforward to test for the most appropriate one (such as for the number of regimes). In addition, results of the MSM may be sample dependent as the methods can produce different turning point chronologies if data for different sample periods is used. On the basis of robustness the rules of thumb and the Bry-Boschan algorithm are probably more stable compared to the method based on the MSM, as the latter is more sensitive to the choice of sample periods and the addition of new data;

iii) **aspects of cycle considered**: as discussed in section II with reference to the definition of the business cycle formulated by Burns and Mitchell, a cycle is characterised by several aspects, ranging from duration to amplitude, diffusion, possible asymmetries and so on. Thus, the more aspects a method takes into account the more complete it is. The MSM is probably the most complete method examined from this point of view as the identification of regimes depends not only on the duration but also on the magnitude of the movements, while the original BBA and the rules of thumb are based essentially only on the duration of phases. However, the BBA is a more complex set of rules compared to simple rules of thumb as for example it allows to avoid (at least some) false signals by identifying outliers and using some smoothing steps in the initial part of the procedure. Thus, this algorithm seems to be preferable to the rules of thumb according to this criterion;

iv) **diffusion among analysts**: a criterion possibly of minor importance but of some relevance is how widely used by analysts the method is, as the more diffused a method is, the easier it is to compare results with those of other studies for the same aggregate or for other countries or variables. Probably the most diffused method among the ones considered here applied in the profession is the BBA, while the MSM is increasingly being used, especially in most recent and extended versions. Very often also rules of thumb are used, but as noted above, while there is a widely accepted one for quarterly data (“at least two consecutive quarters of

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12 See for example Vaccara and Zarnowitz (1978) who propose to identify a turning point of a monthly series when a change in direction of movement in the series takes place for at least three consecutive months.

13 See for example Boldin (1994) and Harding and Pagan (2002b).

14 This was shown for example by Boldin (1996), who found that using the same model specified by Hamilton (1989) but with data for an extended sample period results change significantly.


negative growth” to define recessions and detect peaks and troughs) for monthly data there is a wide range of different rules.

An additional consideration particularly relevant when using monthly indicators is that, despite being derived from rigorous statistical foundations in contrast to the other methods, the MSM has the disadvantage that with typical monthly data such as industrial production it must be estimated with year-on-year growth rates in order to capture business cycle dynamics, with the already mentioned consequence of lagging turning points.

On the basis of these criteria, it is clear that no method outperforms the others in all respects. However, on balance, the previous discussion leads us to choose the BBA. Thus, the turning points chronology obtained with this method will be the main reference for the computation of the basic stylised facts.

III.II. Basic characteristics

The stylised facts that can be computed on the basis of a turning points chronology include the average duration and amplitude of the different phases of the cycle as well as of full cycles (either peak-to-peak or trough-to-trough). Moreover, other measures have been proposed. Figure 1 illustrates some of the various characteristics that are examined with reference to a typical recession: duration (measured by the horizontal segment D), amplitude (measured by the vertical segment A) and severity of recessions or slowdowns (measured by approximation by the grey area delimited by D, A and the index from P to T).

Figure 1 – Duration, amplitude and severity of recessions
IV. Results

IV.I. The business cycle according to the NBER approach: the classical business cycle

By applying the BBA to the monthly real GDP indices in natural log-level the classification of the cycle as shown in Figures 2 and 3 for the euro area and the US respectively is obtained. In the figures the recessionary periods are shown as shaded areas. The specific dates are reported in Appendix 4. It can be observed that the BBA detects three recessions for the euro area: 1974/1975, 1980/1982 and 1992/1993. By contrast to the case of the US, in the euro area no recession is identified in 2001 and in the early 1980s only one recessionary period is recorded instead of two relatively close recessions (sometimes described as a single double-dip recession).

Figure 2 – Euro area recessions identified with the Bry-Boschan algorithm

Figure 3 – US recessions identified with the Bry-Boschan algorithm

Note that the chronology shown is that based on the BBA and monthly GDP, which turns out to be very similar to the official NBER set of turning points. The main differences are that the NBER official dates include also one recession in 1970 and one additional peak is located in early 1960, while with our approach we already find a trough in 2001.
On the basis of the selected turning points chronology it is possible to compute a set of basic stylised facts for the euro area classical business cycle (see Table 1). It is interesting to compare these stylised facts with those for the US business cycle. During the sample period considered only two full (peak-to-peak or trough-to-trough) euro area cycles took place, but if also the incomplete phases are considered then in total four cycles can be detected. On average recessions lasted almost one year, while expansions lasted about eight years. Moreover, expansions tend to be characterised by an amplitude which is much higher than that for recessions. Compared to the euro area, the US economy experienced two more peak-to-peak cycles over the same period. Thus it is not surprising that the euro area cycle lasted on average about one year more than the US cycle. This is mainly due to the longer average duration of expansions in the euro area, by about one year, while recessions tend to have a similar duration. Also regarding amplitude the main difference is found for expansions, during which the percentage increase is on average significantly higher in the euro area.

Table 1 – Basic classical cycle stylised facts

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</thead>
<tbody>
<tr>
<td>number of recessions</td>
<td>3</td>
<td>6</td>
<td>-3</td>
<td>7</td>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>number of expansions</td>
<td>4</td>
<td>6</td>
<td>-2</td>
<td>8</td>
<td>-2</td>
<td></td>
</tr>
<tr>
<td>number of cycles (P to P)</td>
<td>2</td>
<td>4</td>
<td>-2</td>
<td>6</td>
<td>-2</td>
<td></td>
</tr>
<tr>
<td>number of cycles (T to T)</td>
<td>2</td>
<td>5</td>
<td>-3</td>
<td>6</td>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>number of cycles in sample (including incomplete)</td>
<td>4</td>
<td>6</td>
<td>-2</td>
<td>7</td>
<td>-1</td>
<td></td>
</tr>
</tbody>
</table>

| DURATION (number of months) | | | | | |
| average duration of recessions | 10 | 11 | -1 | 11 | 0 |
| minimum duration of recessions | 5 | 7 | -2 | 6 | 1 |
| maximum duration of recessions | 14 | 16 | -2 | 16 | 0 |
| average duration of expansions | 61 | 12 | 49 | 12 | 0 |
| maximum duration of expansions | 133 | 154 | -21 | 120 | 34 |
| average duration of cycles (P to P) | 105 | 81 | 24 | 82 | -1 |
| minimum duration of cycles (P to P) | 66 | 19 | 47 | 18 | 1 |
| maximum duration of cycles (P to P) | 144 | 129 | 15 | 130 | -1 |
| average duration of cycles (T to T) | 72 | 26 | 46 | 28 | -2 |
| minimum duration of cycles (T to T) | 147 | 170 | -23 | 129 | 41 |

| AMPLITUDE | | | | | |
| average amplitude of recessions | -2.3 | -3.0 | 0.8 | -1.9 | 1.6 |
| minimum amplitude of recessions | -1.5 | -1.8 | 0.8 | 0.7 | -2.7 |
| maximum amplitude of recessions | -3.2 | -4.9 | 0.7 | 4.9 | 1.0 |
| average amplitude of expansions | 51.5 | 32.0 | 1.6 | 29.2 | 1.1 |
| minimum amplitude of expansions | 20.2 | 4.6 | 4.4 | 4.3 | 1.1 |
| maximum amplitude of expansions | 101.6 | 78.3 | 1.3 | 50.7 | 1.5 |

| SEVERITY OF RECESSIONS | | | | | |
| average cumulated output loss during recessions | -11.7 | -18.3 | 0.6 | -14.8 | 1.2 |
| minimum cumulated output loss during recessions | -8.7 | -6.4 | 1.4 | -0.7 | 8.6 |
| maximum cumulated output loss during recessions | -17.4 | -35.4 | 0.5 | -35.4 | 1.0 |

Notes: All numbers take into account only phases and cycles that start and end within the sample period considered, unless otherwise specified. The severity of a recession is computed as the output loss from the peak which signals the start of the recession to the next trough and is expressed as a percentage of output at the peak level.

An additional measure which captures an important aspect of classical cycles is the output loss which is determined by recessions. A possible way to compute an approximation of this measure is simply to calculate, for each recession, the grey area as shown in the example of Figure 1. In particular, it can be computed as the sum of the (negative) growth rates recorded in each month of the recession, expressed as a percentage of the level of the series reached in correspondence to the peak. This measure, which combines information on both duration and amplitude of recessions, can be interpreted as the loss in production due to the recessions. From Table 1, we can observe that on average the cumulated output loss caused by recessions was about 12 percent of the output recorded in the period of the peak in the case of the euro area. The average severity of recessions is somewhat larger in the US (about 18 percent), which also exhibits a wider range of values.
These basic stylised facts confirm that classical business cycles are characterised by asymmetry. In particular, recessions tend to last shorter periods of time than expansions. In addition, the amplitude of expansions tends to be much greater than that of recessions (in absolute terms)\textsuperscript{18}.

Given the wide ranges of variation shown for duration and amplitude of phases and severity of recessions, the question emerges as to which extent all cycles are alike. Figures 4 and 5 report these characteristics for recessions and expansions\textsuperscript{19} respectively.

\textbf{Figure 4 – Duration, amplitude and severity of recessions}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{duration_amplitude_severity.png}
\end{figure}

\textsuperscript{18} Note that part of the asymmetry in amplitude as we measure it is artificially determined by the fact that we express it as a percentage of turning points. Therefore, the amplitude of recessions will be lower even if the change compared to expansions is the same because production in the base period (in the peak) is always at a higher level compared to production in the base period of expansions (in the trough). For example, if at the peak production is at level 100, during the recession it falls by 20 to a level of 80 at the trough and subsequently in the expansion it grows again by 20, then the negative amplitude of the recession will be 20\% but the positive amplitude of the expansion will be 25\%. However, the disparity between amplitudes found in the data is such that this effect explains a small fraction of the asymmetry.

\textsuperscript{19} In the case of the euro area also characteristics of the incomplete expansions at the start and end of the sample are reported, but their incompleteness should be borne in mind.
The very low number of observations (especially as regards euro area recessions) does not allow for a formal statistical testing of no significant variation, but some general remarks on degrees of variation and general tendencies can be made. A first general observation is that there appears to be a wide degree of variation of all regimes characteristics across business cycles, both in the euro area and the US. The main tendency that can be detected regards US recessions, which seem to be decreasing over time in terms of duration, amplitude and, as a result, severity.\footnote{This finding is consistent with evidence that the US cycle has become less volatile since the mid-1980s (see for example Stock and Watson, 2002).}

The substantial degree of variation across cycles of recession characteristics suggests that there might be scope to classify recessions according to their severity, as recently suggested by Nordhaus (2002), see Table 2. Taking as a reference his classification, on the basis of the severity measure euro area recessions could be divided into two groups, one consisting of “mild downturns” (in 1974/5 and in 1980/1982) and the other (in 1991/93) consisting of what he labels a “typical recession” (in the sense of being in between a mild downturn and a deep and prolonged recession, rather than in terms of representativity, as the sample is very limited). For the US the classification based on the severity measure would differ somewhat from the one proposed by Nordhaus: the 1973/75 recession is probably more appropriately described as a “deep and prolonged recession” rather than a typical recession, and considering separately the two early 1980s recessions, rather than as a unique event, allows to classify the short 1980 recession as a “typical recession” and the 1981/82 recession as a “deep and prolonged recession”. Finally, the two most recent US recessions (in 1990/91 and 2000/01) could be labelled as “mild downturns”.
Table 2 – Classification of historical recessions

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Category I (pause in economic activity)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category II (mild downturn)</td>
<td>1974/75, 1980/81</td>
<td>1990/91, 2000/01</td>
</tr>
<tr>
<td>Category III (typical recession)</td>
<td>1992/93</td>
<td>1980</td>
</tr>
<tr>
<td>Category IV (deep and prolonged recession)</td>
<td>1973/75, 1981/82</td>
<td></td>
</tr>
<tr>
<td>Category V (depression)</td>
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</tbody>
</table>

IV.II. The deviation cycle

The deviation cycle is extracted by estimating a basic unobserved components model to the monthly GDP indices. Appendix 1 describes in detail the specification procedure of the model and shows the estimates of the parameters and components of the model. Figures 6 and 7 show the cyclical components of monthly GDP (expressed as percentage deviation from trend) for the euro area and the US, respectively. Slowdowns identified by applying the BBA to the cyclical indicators are again highlighted as shaded areas in the charts.

Figure 6 – Euro area deviation cycle slowdowns

![Figure 6 - Euro area deviation cycle slowdowns](image1)

Figure 7 - US deviation cycle slowdowns

![Figure 7 - US deviation cycle slowdowns](image2)
Although it appears from the turning points chronologies that the euro area and US deviation cycles are not perfectly synchronised, they share several common basic stylised facts over the sample period considered. For example, both economic areas have experienced about the same frequency of cycles. Moreover, the average duration of slowdowns and upswings (between one and a half years and two years) is very similar and also the range of duration of phases is broadly similar. The amplitude of regimes is measured in a similar way as for the acceleration cycle, but taking percentage deviations from trend instead of growth rates. Average amplitudes of slowdowns and upswings appear very similar, and differences between the euro area and US are minor. Thus, deviation cycles, similar to acceleration cycles, appear to be relatively symmetric as regards duration and amplitude of regimes in both economic areas. Overall, the symmetry of deviation cycles is particularly marked in the case of the euro area, while in the case of acceleration cycles it appears that symmetry is relatively more evident for the US.

Table 4 – Basic deviation cycle monthly stylised facts

<table>
<thead>
<tr>
<th>FREQUENCY</th>
<th>Euro area (BBA on mly cycle of IP)</th>
<th>US (BBA on mly cycle of IP)</th>
<th>EA v US</th>
</tr>
</thead>
<tbody>
<tr>
<td>number of slowdowns</td>
<td>11</td>
<td>11</td>
<td>=</td>
</tr>
<tr>
<td>number of upswings</td>
<td>12</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>number of cycles (P to P)</td>
<td>11</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>number of cycles (T to T)</td>
<td>11</td>
<td>11</td>
<td>=</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DURATION* (number of months)</th>
<th>Euro area (BBA on mly cycle of IP)</th>
<th>US (BBA on mly cycle of IP)</th>
<th>EA v US</th>
</tr>
</thead>
<tbody>
<tr>
<td>average duration of slowdowns</td>
<td>19</td>
<td>18</td>
<td>1</td>
</tr>
<tr>
<td>minimum duration of slowdowns</td>
<td>6</td>
<td>6</td>
<td>=</td>
</tr>
<tr>
<td>maximum duration of slowdowns</td>
<td>44</td>
<td>35</td>
<td>9</td>
</tr>
<tr>
<td>average duration of upswings</td>
<td>21</td>
<td>27</td>
<td>-6</td>
</tr>
<tr>
<td>minimum duration of upswings</td>
<td>5</td>
<td>5</td>
<td>=</td>
</tr>
<tr>
<td>maximum duration of upswings</td>
<td>38</td>
<td>59</td>
<td>-21</td>
</tr>
<tr>
<td>average duration of cycles (P to P)</td>
<td>41</td>
<td>46</td>
<td>-5</td>
</tr>
<tr>
<td>minimum duration of cycles (P to P)</td>
<td>20</td>
<td>22</td>
<td>-2</td>
</tr>
<tr>
<td>maximum duration of cycles (P to P)</td>
<td>62</td>
<td>67</td>
<td>-5</td>
</tr>
<tr>
<td>average duration of cycles (T to T)</td>
<td>39</td>
<td>44</td>
<td>-5</td>
</tr>
<tr>
<td>minimum duration of cycles (T to T)</td>
<td>21</td>
<td>19</td>
<td>2</td>
</tr>
<tr>
<td>maximum duration of cycles (T to T)</td>
<td>82</td>
<td>74</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AMPLITUDE (percentage)</th>
<th>Euro area (BBA on mly cycle of IP)</th>
<th>US (BBA on mly cycle of IP)</th>
<th>EA v US</th>
</tr>
</thead>
<tbody>
<tr>
<td>average amplitude of slowdowns</td>
<td>-2.8</td>
<td>-4.5</td>
<td>0.6</td>
</tr>
<tr>
<td>minimum amplitude of slowdowns</td>
<td>-0.6</td>
<td>-1.2</td>
<td>0.5</td>
</tr>
<tr>
<td>maximum amplitude of slowdowns</td>
<td>-6.3</td>
<td>-9.1</td>
<td>0.7</td>
</tr>
<tr>
<td>average amplitude of upswings</td>
<td>3.1</td>
<td>4.6</td>
<td>0.7</td>
</tr>
<tr>
<td>minimum amplitude of upswings</td>
<td>1.0</td>
<td>1.2</td>
<td>0.8</td>
</tr>
<tr>
<td>maximum amplitude of upswings</td>
<td>5.8</td>
<td>9.1</td>
<td>0.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GAIN WHEN ABOVE TREND</th>
<th>Euro area (BBA on mly cycle of IP)</th>
<th>US (BBA on mly cycle of IP)</th>
<th>EA v US</th>
</tr>
</thead>
<tbody>
<tr>
<td>average cumulated output gain when above trend</td>
<td>46.1</td>
<td>58.4</td>
<td>0.8</td>
</tr>
<tr>
<td>minimum cumulated output gain when above trend</td>
<td>0.4</td>
<td>1.1</td>
<td>0.4</td>
</tr>
<tr>
<td>maximum cumulated output gain when above trend</td>
<td>147.1</td>
<td>116.7</td>
<td>1.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LOSS WHEN BELOW TREND</th>
<th>Euro area (BBA on mly cycle of IP)</th>
<th>US (BBA on mly cycle of IP)</th>
<th>EA v US</th>
</tr>
</thead>
<tbody>
<tr>
<td>average cumulated output loss when below trend</td>
<td>-37.5</td>
<td>-58.8</td>
<td>0.6</td>
</tr>
<tr>
<td>minimum cumulated output loss when below trend</td>
<td>-0.4</td>
<td>-5.8</td>
<td>0.1</td>
</tr>
<tr>
<td>maximum cumulated output loss when below trend</td>
<td>-139.9</td>
<td>-109.7</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Notes: see text for an explanation of the measures.
Table 4 also shows two additional measures: gains when above trend and losses when below trend, expressed as cumulated changes as percentage deviations from trend. It should be stressed that the slowdown and upswing phases discussed so far (identified by the maxima and minima of the deviation cycle) do not coincide with the below-trend and above-trend regimes (delimited by the turning points located where the deviation cycle is zero) considered in this last set of stylised facts. From Table 4 we can observe that the average cumulated gain during above-trend period is very similar to the average cumulated loss during below-trend periods, and also the ranges – which appear to be very wide - are almost identical, both for the euro area and the US. Thus, also along this dimension deviation cycles appear to be symmetric. Of course, it cannot be concluded from these measures that stabilising growth around trend would imply no net economic benefit.

A visual inspection of Figures 8 and 9 suggests that differences in the characteristics of the various phases of the deviation cycle the degree of variation of deviation cycle phases characteristics is significant for both the euro area and the US. No clear pattern can be identified either for slowdowns or for upswings, even after controlling for some outliers.

Figure 8 – Duration and amplitude of deviation cycle slowdowns
V. Conclusions

Basic characteristics 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 business cycle from 1960 to 2002, and discussed it in comparative perspective with respect to the US business cycle.

It was documented that classical business cycles are much less frequent than deviation cycles. For the euro area three times as many deviation cycles can be detected as classical cycles over the sample period, while for the US there are about twice as many deviation cycles as classical cycles. In general, classical cycles tend to last between seven and nine years, while deviation cycles last on average between three and four years.

Another common characteristic is that the phases of classical cycles tend to be asymmetric, both in terms of duration and amplitude. More precisely, expansions last on average seven to eight years, compared to a one year average duration of recessions, and display an average amplitude ten to twenty times larger than recessions. By contrast, deviation cycle regimes appear to be relatively symmetric both in terms of duration and amplitude.

The analysis suggests that euro area business cycle characteristics are very similar to the corresponding ones for the US. However, some differences emerge. In particular, the US economy experienced more frequent classical cycles (two more) compared to the euro area, while the number of deviation cycles is the same. As a consequence, classical cycles tended to last a shorter period of time in the US.
The question as to whether fluctuations have changed over time has also been addressed, mainly by inspecting the characteristics of cycles rather than by statistical testing due to the relatively short sample of observations available. Evidence for a significant degree of variation of characteristics across business cycles is apparent for both economic areas and for all concepts of the cycle. As regards the classical cycle, the main patterns which can be highlighted are represented by the decreasing duration, amplitude and severity of US recessions over time (while for the euro area an opposite pattern can be observed, but given that only three recessions have been detected for the euro area, it is difficult to refer to general tendencies in the latter case).

References


Appendix 1 – Sources, aggregation and treatment of the data

Sources

Euro area real GDP: Eurostat ESA 95 data from 1991q1 to 2002q4, projected backwards using the quarter-on-quarter growth rates of the corresponding index from the AWM database up to 1970q1, and projected further back to 1960q1 using national data from the BIS database (for West Germany and Italy) and OECD Main Economic Indicators (for France and the Netherlands), using Eurostat 2001 fixed GDP weights (at PPP exchange rates). Thus, the resulting index covers at least 75% of the euro area over the whole sample period.

Euro area industrial production (excluding construction): Eurostat data from 1985m1 to 2002m12, projected backwards using an aggregate derived from non-seasonally adjusted OECD Main Economic Indicators national data available from 1960m1 for all euro area countries except Spain (available from 1961m1), Greece (available from 1962m1), and Ireland (available from 1975m7). Aggregation was done using 1995 fixed value added at factor costs weights. The aggregate index was seasonally adjusted by modelling a basic unobserved components model with stochastic seasonal component (see below for details). Thus, the resulting index covers at least 90% of the euro area over the whole sample period (about 98% from 1961m1).


US monthly indicators: total civilian employment (BLS), real personal income less transfer payments (BEA), industrial production index (Federal Reserve Board), manufacturing and trade sales (Conference Board). All these data are available from 1960m1 to 2002m12 through the DRI-WEFA database.

Derivation of monthly GDP indices:
The monthly GDP indices for the euro area and the US were computed by interpolating the quarterly real GDP indices using the above-mentioned monthly indicators and the Chow and Lin method.\footnote{See Rünstler and Sédillot (2002): “Short-term estimates of euro area real GDP by means of monthly data”, December 2002, forthcoming ECB Working Paper, for an explanation of this method. I thank Franck Sédillot for allowing me to use his Eviews codes for the Chow and Lin method.}

Estimation of deviation cycles via unobserved components models
In order to estimate the various components of the series, a univariate unobserved components model is adopted and was applied to the series in natural logarithms levels.

The statistical formulation is as follows. The monthly real GDP index, $y_t$, is assumed to be composed of a trend, $\mu_t$, a cycle, $\psi_t$, a seasonal component, $\gamma_t$, and an irregular term, $\varepsilon_t$:

$$y_t = \mu_t + \psi_t + \gamma_t + \varepsilon_t, \quad \varepsilon_t \sim NID(0, \sigma^2_\varepsilon) \quad (1)$$

All four components are stochastic and the disturbances driving them are mutually uncorrelated. The stochastic trend is modeled as a linear local trend:

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t, \quad \eta_t \sim NID(0, \sigma^2_\eta) \quad (2)$$
\[ \beta_t = \beta_{t-1} + \zeta_t \quad \zeta_t \sim NID(0, \sigma^2_{\zeta}) \] (3)

where \( \beta_t \) is the slope, and the error terms \( \eta_t \) and \( \zeta_t \) are mutually uncorrelated. The stochastic cycle is specified as

\[
\begin{bmatrix}
\psi_j \\
\psi_j^*
\end{bmatrix} = \rho \begin{bmatrix}
\cos \lambda_j & \sin \lambda_j \\
-\sin \lambda_j & \cos \lambda_j
\end{bmatrix} \begin{bmatrix}
\psi_{j,t-1} \\
\psi_{j,t-1}^*
\end{bmatrix} + \begin{bmatrix}
\kappa_j \\
\kappa_j^*
\end{bmatrix} \sim NID \left( \begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma^2_{\kappa} & 0 \\ 0 & \sigma^2_{\kappa^*} \end{bmatrix} \right) \] (4)

where \( \lambda_j \) is the angular frequency measured in radiants \((0 < \lambda_j < \pi)\) and \( \rho \) is a damping factor \((0 < \rho < 1)\). The stochastic cycle becomes a first-order autoregressive process if the frequency is 0 or \( \pi \). Finally, the seasonal component can be modeled as a stochastic trigonometric seasonal:

\[
\gamma_t = \sum_{j=1}^{(s/2)} \gamma_{j,t} = \begin{bmatrix}
\cos \lambda_j & \sin \lambda_j \\
-\sin \lambda_j & \cos \lambda_j
\end{bmatrix} \begin{bmatrix}
\gamma_{j,t-1} \\
\gamma_{j,t-1}^*
\end{bmatrix} + \begin{bmatrix}
\omega_j \\
\omega_j^*
\end{bmatrix} \sim NID \left( \begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma^2_{\omega} & 0 \\ 0 & \sigma^2_{\omega^*} \end{bmatrix} \right) \] (5)

where \( s \) is the number of seasons in the year and the seasonal frequencies \( \lambda_j = 2\pi j / s \), with \( j = 1, \ldots, (s/2) \). Note that both \( \psi_j \) and \( \gamma_j \) 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 to obtain the likelihood function and thus to estimate the parameters \((\lambda_t \) and \( \rho \)), the variances and the various components.\[22\]

Among the possible specifications it was found that for both the euro area and the US indices the most adequate one in terms of diagnostics and goodness of fit was that with a "smooth trend" (i.e. fixed level and stochastic slope), an AR(1) cycle, a stochastic trigonometric seasonal component (needed to capture the residual seasonality) and an irregular component. Outliers, detected via auxiliary residuals, were found and corrected for by inserting dummies, in 1968m5, 1970m5 and 1984m6 for the euro area, and in 1978m1, 1979m3, 1987m1, 1992m12 and 1993m12 for the US. The resulting components are plotted below in figure 1.

**Figure 1 – UC trends and cycles**

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\[22\] See for example Proietti (2002) and references therein for the details of the statistical treatment. All computations have been carried out with STAMP 6.01 (see Koopman et al., 2000) and Ox 3.00 (see Doornik, 2001).
Appendix 2 – The Bry-Boschan Algorithm

The table below describes in detail the steps of the Bry-Boschan algorithm for the location of turning points. This table is taken from Bry and Boschan (1971, p. 21).

Table 1 - Procedure for programmed determination of turning points

| I. | Determination of extremes and substitution of values |
| II. | Determination of cycles in 12-month moving average (extremes replaced) |
|     | A. Identification of points higher (or lower) than 5 months on either side |
|     | B. Enforcement of alternation of turns by selecting highest of multiple peaks (or lowest of multiple troughs) |
| III. | Determination of corresponding turns in Spencer curve (extremes replaced) |
|     | A. Identification of highest (or lowest) value within ±5 months of selected turn in 12-month moving average |
|     | B. Enforcement of minimum cycle duration of 15 months by eliminating lower peaks and higher troughs of shorter cycles |
| IV. | Determination of corresponding turns in short-term moving average of 3 to 6 months, depending on MCD (months of cyclical dominance) |
|     | A. Identification of highest (or lowest) values within ±5 months of selected turn in Spencer curve |
| V. | Determination of turning points in unsmoothed series |
|     | A. Identification of highest (or lowest) value within ±4 months, or MCD term, whichever is larger, of selected turn in short-term moving average |
|     | B. Elimination of turns within 6 months of beginning and end of series |
|     | C. Elimination of peaks (or troughs) at both ends of series which are lower (or higher) than values closer to end |
|     | D. Elimination of cycles whose duration is less than 15 months |
|     | E. Elimination of phases whose duration is less than 5 months |
| VI. | Statement of final turning points |

The general idea is to start from a seasonally adjusted monthly index, adjust it for outliers, then look for local minima and maxima in various smoothed versions of the series, with a decreasing degree of smoothness, refining progressively the turning point chronology and determining the final set of turning points on the basis of the unsmoothed series.

The first step consists in the identification and substitution of extreme values, or outliers. This is done by computing a Spencer curve, computing the ratios of the original curve to the Spencer curve, identifying the ratios which are outside a range defined by plus and minus 3.5 the standard deviation of the ratios, and substituting the corresponding values in the original curve by the values of the Spencer curve in the same period.

The Spencer curve is a 15-months centered moving average whose weights from t-7 to t+7 are \{-0.0094, -0.0188, -0.0156, 0.0094, 0.0656, 0.1438, 0.2094, 0.2313, 0.2094, 0.1438, 0.0656, 0.0094, -0.0156, -0.0188, -0.0094\}. 

Then the turning points in various smoothed curves are identified, starting from a 12-months moving average, then identifying the corresponding turns in a Spencer curve, then identifying the corresponding turns in a short-term moving average, and finally identifying the corresponding turns in the unsmoothed series. In each some rules are enforced regarding the minimum duration of phases and the alternation of peaks and troughs. The justification for using different smoothed versions of the data first is to eliminate irregular or erratic movements in the series. However, the final chronology is identified on the basis of the original series in order to ensure that the final local minima and maxima are in effect turning points which refer to the reference series. Thus, the use of smoothed versions of the reference series should not lead to the wrong conclusion that in effect the BBA identifies turning points of a deviation cycle series.

The MCD of a series is the “number of months required for the systematic trend-cycle forces to assert themselves against the irregular component. Technically, it is that span over which the average change in the irregular component becomes smaller than the average change in the trend-cycle component” (p.25).

The restrictions imposed are that, first, each phase should last at least five months and, second, that each cycle should last at least 15 months\(^{23}\).

\(^{23}\) For estimation of the BBA I used the GAUSS code written by Mark Watson (for the paper Watson, 1994), whom I thank for allowing me to use it.