ARE THERE TWO TYPES OF BUSINESS CYCLES? A NOTE ON CRISIS DETECTION

Robert Pater*

Abstract

Business cycles are highly irregular fluctuations in economic activity. This article attempts to determine whether there are some properties of business cycles that can make them look more regular. This is done by analysing business cycle dynamics, especially by employing and adjusting to contemporary business cycle analysis the theories of growth cycles and classical cycles. The non-homogeneity of business cycles is surveyed in theory and practice with use of ad hoc filtering, spectral analysis and unobserved components models. With their use business cycles are extracted. Several macroeconomic indicators for 32 economies are analysed to draw up additional characteristics of contemporary business cycles. The author proposes that fluctuations in economic activity lasting 8-19 quarters should be called 'growth cycles' and those lasting 20-40 quarters – 'classical cycles'. The value added of this article is the consideration of the two different type of cycles in light of the same methods of extraction, while to date they have been thought of as the ones that can be analysed with use of different methods of extraction. Another innovation is comparison of the cyclicality of different macroeconomic indicators from the point of view of the two types of cycles, while to date they have been analysed in the light of asingle business cycle. In the article it is shown that dividing business cycles into such defined classical cycles and growth cycles enables us to understand the differences between the cyclicality of various macroeconomic aggregates and countries. It also enables us to distinguish between smaller downturns and severe recessions. Another conclusion is that the duration of contemporary business cycles around the world closes in arange of 2 to 10 years.

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Some problems with business cycle analysis

It is widely accepted that business cycles are fluctuations in economic activity lasting from 1.5 to 8 years (see: Burns & Mitchell, 1946; Baxter & King, 1999). Therefore, business cycles are not periodic, but have a finite frequency interval. Nevertheless, this interval seems to be very wide, e.g., sunspots occur once every approx. 11 years, so their fluctuations are much closer to periodic. The amplitudes of business cycles are also irregular. Irregularities of business cycles make their analysis and forecast very hard. Moreover, there are differences between general behaviour, and cyclicality of different macroeconomic aggregates. As a result the characteristics of cycles of e.g. GDP, unemployment rate, inflation or leading indexes is different because of the properties of particular measurements and also as a result of a specific combination of macroeconomic shocks leading to their creation.

Most analyses focus on a specific definition of the business cycle. Particularly widely analysed are cycles in the form of deviation from trends. With such an approach most economists do not refer to (classical) step cycles or growth rate cycles. The aim of the article is to recall the two types of business cycles – classical and growth cycles –and check whether they exist simultaneously, i.e. whether they are robust to the method of estimation or the other way around – depend only upon the method of extraction. In doing this, the article contributes to the literature on the heterogeneity of the business cycle.

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The main question this article tries to answer is: are there any properties of business cycles that will make them look more regular? To answer this, several sections comprise the article. It starts with presentation of different points of view on the extraction of business cycles and how they affect the result. Next, the theory of growth cycles and business cycles is described, as is empirical analysis of business cycles of 4 macroeconomic indicators for 32 countries from the OECD database. The period analysed in the article is as long as possible for particular countries and is not divided into sub-periods, to draw universal and general characteristics of business cycles across the globe. During these periods changes in the detailed characteristics of business cycles of particular countries have occurred, but have not affected the general characteristics of the business cycle (see e.g. Giannone et al., 2010; Boivin et al., 2009). That is why there is no search for differences across time and countries, which surely exist, but similarities in general behaviour of economic aggregates are noted. The results will lead to a better understanding of business cycles, improve forecasts of their turning points and by this increase the probability of crisis detection.

Literature review

Classical (step) cycles are the ones that have interested economists since the work of Burns and Mitchell (1946). In step cycle analysis a long-run trend is not removed from the time series. Only fluctuations with frequencies higher than cyclical, namely seasonal, irregular and outliers are 'smoothed' out before the analysis. Step cycles are closely related to the definition of recession. Recession is always a step cycle phase and without identifying recession, a particular step cycle cannot be identified. Informally recession is perceived as a negative quarterly real GDP growth by at least two consecutive quarters. The National Bureau of Economic Research (NBER) Business Cycle Dating Committee, knowing the shortcomings of recession being described in terms of GDP, defines it as (Leamer, 2008) "a significant decline in activity spread across the economy, lasting more than a few months, visible in industrial production, employment, real income, and wholesale-retail trade."Bry and Boschan (1971) defined a strict procedure to find a turning point, which is connected to the NBER dating. Banerji (1999) shows that to appropriately date business cycle the '3P' rule finds application. Step cycle analysis defines periods of going into and out of recession. The flaw of this approach is that the cycles are not clearly visible and distinguishable from the (long-run) trend. Step cycles mostly have high variance and are very irregular[1]. They are called 'classical' cycles by Zarnowitz and Ozyildirim (2006). This is a reference to the approach applied classically by NBER.

Strong growth of leading world economies caused economists to start to look at business cycles in the category of deviation from a long-run trend (deviation cycles) rather than recessions (Zarnowitz, 1985). In the 1960s the term 'growth cycle' was created. It encompassed deviation cycles (Mintz, 1967). Step cycle analysis was mostly replaced by the analysis of deviation cycles; however, certain institutions (i.e. NBER) still analyse step cycles, mainly to date recessions. Another way to look at growth cycles is calculation of a simple, usually yearly growth rate. However, it is a different kind of filter than the one used to compute deviation cycle, not being an approximation of an ideal filter (see: Hamilton, 1994). In the basic version it does not filter out irregular fluctuations, which may cause problems in interpretation of some changes. It also causes phase shift.

Growth cycles may also be referred to as a result of the dynamics of economic growth, not levels of economic activity. That is why some economists argue that computation of a growth rate can also be a method to extract them (Giannone & Reichlin, 2005). The development of time series filtering techniques lead to deviation cycles (or growth cycles) to be commonly referred to as business cycles. Therefore an obvious misunderstanding occurs in the meaning of the term 'business cycle'. It sometimes means step cycles, sometimes deviation cycles. Zarnowitz (1992) states:

> Some economists focus on the nature and sources of expansions and contractions, that is, on the business cycles. Others, by abstracting from the long-run trend, actually address growth cycle phenomena while aiming at an analysis of business cycles; that is, they fail to differentiate between the two categories. The latter treatment, frequently implicit in the theoretical literature of recent years, may not be a good practice. General business contractions need to be distinguished from periods of low but positive growth. However,

1 Step cycles in the U.S. economy have so far lasted from 1.5 to 12 years.

mild recessions and severe depressions are also quite different.

Therefore, considering different approaches to business cycle extraction it is worth looking at what kind of fluctuations one can obtain when trying to extract the business cycle. It seems inappropriate to differentiate types of cycles, i.e. growth cycles and classical cycles, only by the method of their extraction and not by the type of process that leads to their occurrence.

A'Hearn and Woitek (2001) confirmed the existence of both longer – 7-10-year cycles and shorter 3-5-year cycles in industrial output. Fukuda (2008) differentiated between classical cycles (calling them business cycles) and growth cycles in the mechanism of their formation, dividing chosen countries into those showing one or the other scheme of cyclical fluctuation. He assumes that either the same process creates cycles and trends or two different processes stand behind these fluctuations. In the case of classical cycles he assumes an endogenous business cycle and interrelation between trend and cycle. If this is true, then there will be a fairly clear answer as to whether endogenous or exogenous factors create business cycles. In opposition to his approach I try to look at classical and growth cycles from the perspective of one universal method of their extraction, to show whether these fluctuations exist simultaneously or are merely another way to look at the same thing.

Real Gross Domestic Product and industrial production are basic indicators used to study business cycles (compare: Baxter & King, 1999). Mansour (2003) identified a common business cycle in the world on the basis of GDP. Its general feature is irregularity of length, phases and timing of turning points. The non-linearity in variance of the U.S. business cycle was found by French and Sichel (1993). Artis et al. (2004) found a higher variance of output around business cycle booms and also similarities in business cycles of European countries. Kim and Murray (2002) and Mills and Wang (2002) showed that during periods of relatively small deviations from long-run trend outputs of U.S. and G-7 economies are driven by permanent shocks, and during dynamic recoveries and recessions transitory shocks dominate. Inklaar et al. (2008) showed that the European business cycle measured by GDP and industrial production is fairly synchronized, which is connected to intra-industry trade intensification. Zimmermann (1997) found that business cycle fluctuations in smaller countries are less persistent but more volatile than in larger ones. On the one hand, Canova et al. (2010) found that business cycles across the world are fairly synchronized and that the 'world business cycle' accounts for 30% of the fluctuations of the basic economic indicators in the G7. On the other hand, there is a visible idiosyncratic component in fluctuations of macroeconomic indicators and countries, especially during expansions. Kose et al. (2008) found that the synchronisation of business cycles of G7 countries increased during the globalisation years, i.e. 1986-2003.

Relatively few articles focus on the cyclical properties of indicators other than the ones showing general economic activity. The cyclicality of the unemployment rate is less often analysed than GDP, although the NBER takes it into account in dating business cycles. Generally the unemployment rate is seen as a variable with a relatively high standard deviation of cyclical fluctuations (see e.g. Danthine & Donaldson, 1993). In Europe unemployment is known to be more persistent and less mean-reverting than in the USA by hysteresis effects and the general rigidity of the labour market (Blanchard & Summers, 1987). Hamilton (2005) pointed that the U.S. unemployment rate rises faster than it falls, which is consistent with inverted (pro-cyclical) GDP behaviour. He also showed that its expansions and recessions may be caused by different factors, for a process with different properties leads both kind of changes. This asymmetry was confirmed by Sichel (1993). Schwartz (2012) found that the duration of cyclical unemployment relates mostly to unemployment outflows.

Inflation, whatever measure is used to describe it – CPI, PPI or GDP deflator – is presented as a growth rate (a yearly growth rate being most commonly used). It means that prices have already been filtered. It is one of the reasons why the inflation rate is quite volatile. Chadha and Prasad (1993), den Haan (2000) and den Haan and Summer (2004) on the example of various countries showed that in the short-run, during which demand shocks prevail, the correlation between output and prices is positive and in the long-run – negative, as a result of supply shock effects on output and prices.

The first of the cyclical properties of composite leading indexes is showing additional, 'false' cycles or omission of cycles. Strangely, the former happens more often. This was observed by Samuelson (1966),

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who wrote "Wall Street indexes predicted nine out of the last five recessions". This has been due to the fact that they are composed of some fragmentary indicators or sentiments (see also: Green & Beckman, 1993). Examples of the former are labour market flows (e.g. inflow or outflow of unemployed), which make up the unemployment rate, but alone are more volatile, because random events have greater impact on them than on the overall labour market situation. Sentiments based on survey results are also more volatile than real factors and, therefore, they make leading indexes also more vulnerable to fluctuations than coincident indexes (see: The Conference Board, 2001). Another property of leading indexes is a lower contribution of the long-run trend, higher – short-run fluctuations (see: i.e. Hymans, 1973). Again this is the result of the features of the leading indexes the index is composed of. Some of them are characterized by a weak trend, e.g. average weekly hours of work, or sentiment indicators. Often these indicators are also normalized or have a finite range of values, which distinguishes them from e.g. GDP. A third feature of leading indexes is the asymmetry of leads, especially in the case of turning points in comparison to coincident indexes (see: e.g. Osborn & Sensier, 2002). Most often leads on peaks are longer than on troughs. Due to the very nature of each cycle, leads can also vary from cycle to cycle. Additionally, each component of the leading index has its own specificity, gaining different meaning in particular cycles and even phases of the cycle, thus affecting the lead length.

Methods

The business cycle analysis presented in this article will be directed into showing the morphology of the cyclicality of chosen variables with respect to two types of cycles. Analysis of the periodic properties of a time series is a frequency domain problem. It has been widely used in business cycle analysis since the work of Harvey (1975). However, the search for different kinds of business cycles has been mostly neglected.

Considering every stationary process has a spectral representation, its autocovariance function $\gamma(\tau)$ or $\tau = 0, \pm1, \pm2, \ldots$ for in a discrete time can be transformed with the use of the Fourier transform to give a power spectrum

$$f(\omega) = \frac{1}{2\pi} \sum_{\tau=-\infty}^{\infty} \gamma(\tau) \exp(-i\omega\tau), \qquad (1)$$

Where
$\omega \in [-\pi, \pi]$

is a frequency measured in radians and is symmetric around 0.

A way to estimate the sample spectrum of a time series $t = 1, 2, \ldots, T$ is obtained based on estimators of autocovariances. The sample spectrum is called a periodogram. Periodograms can be computed as follows (Harvey, 1975)

$$I_y(\omega) = \frac{1}{2\pi} \sum_{\tau=-(T-1)}^{T-1} \hat{\gamma}_\tau \exp(-i\omega\tau) = \frac{1}{2\pi} \left[\hat{\gamma}_0 + 2\sum_{\tau=1}^{T-1} \hat{\gamma}_\tau \cos(\omega\tau) \right] \qquad (2)$$

However, interpretation of a periodogram is limited because of the problems of leakage and inconsistency of such an estimator (Bloomfield, 1976, p. 80-94). To overcome this, a spectral density estimator was proposed. It is of a form

$$S_y(\omega) = \frac{1}{2\pi} \sum_{\tau=-K}^{K} w_\tau \hat{\gamma}_\tau \exp(-i\omega\tau) = \frac{1}{2\pi} \left[w_0 \hat{\gamma}_0 + 2\sum_{\tau=1}^{K} w_\tau \hat{\gamma}_\tau \cos(\omega\tau) \right] \qquad (3)$$

Where w_k for $\tau = 0, \pm1, \pm2, \ldots \pm K$

are weights called a forming lag window, and K is a truncation lag, which describes the length of the lag window. Besides $-w_k = w_k$ and $w_0 = 1$. Various weighting patterns (windows) have been proposed (see Oppenheim & Shafer, 1989). This spectral density estimator is unfortunately biased, but it has a smaller variance, giving in practice 'smoother' estimates, which limits spurious cycle detection.

Apart from type the of window, the results are highly sensitive to the window truncation lag. While a periodogram could show different cycles, wide windows would almost certainly reject such a hypothesis. In this article it is crucial to carefully look at the spectra. To minimize the possibility of detection of 'false' cycles certain rules will be followed:

1) time series will be filtered with use of Baxter-King, BK (1999) and Christiano-Fitzgerald, CF (2003) filters, which are band-pass filters, thus other than cyclical fluctuations, and most white noise will be removed from the analysis,
2) Hodrick-Prescott, HP (1997) high-pass filter will be applied for comparison purposes to estimate and eliminate the trend; periodicities other than approximately the ones of a business cycle will not be taken into account,
3) spectral density estimates will be calculated with the use of a cyclical component extracted with the use of the above filters, to minimize the influence of noise on the estimations,
4) window truncation lag to minimize the possibility of under- as well as over-smoothing; such a low results from the fact that the analyzed time series have already been "smoothed" with the use of filters,
5) length of two possibly identified types of cycles must differ by at least 10 quarters to minimize detection of the same cycles (which still can occur as a result of using methods in the form of approximations),
6) spectral density value at its peak must be at least two times higher than the values at the base of the peak and higher than most spectral density values up to the base of the next cyclical peak; it also should be higher than any spectral density values (which are not peaks) in the vicinity of at least 4 quarters.

A stationarity assumption is necessary to apply spectral analysis. To obtain this the three abovementioned ad hoc filters will be applied to filter the general periodicity of interest and obtain stationary business cycle fluctuations. An augmented Dickey-Fuller (1981) unit root test will then be applied to test nonstationarity vs. stationarity.

The results of spectral density need to be confirmed by another method. An alternative approach to extract interesting components from a time series is model-based signal extraction. Out of different models a special application finds unobserved components models (see e.g.: Mills, 2003 for comprehensive review). These models have been constructed specifically to identify and estimate components of time series.

Let's consider a model in a general form (see: Harvey, 1989)

$$y_t = \mu_t + \psi_t + \varepsilon_t,\ \varepsilon_t \sim N\left(0, \sigma_\varepsilon^2\right), t = 1, \ldots, T \quad (4)$$

where μ_t is a local linear trend

consisting of a stochastic level and slope (drift) of a signal and representing a stochastic long-run trend

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t,\ \eta_t \sim N\left(0, \sigma_\eta^2\right) \quad (5)$$

$$\beta_t = \beta_{t-1} + \xi_t,\ \xi_t \sim N\left(0, \sigma_\xi^2\right) \quad (6)$$

and ψ_t a stochastic cycle

$$\begin{bmatrix} \psi_t \\ \psi_t^* \end{bmatrix} = \rho \begin{bmatrix} \cos\lambda_c & \sin\lambda_c \\ -\sin\lambda_c & \cos\lambda_c \end{bmatrix} \begin{bmatrix} \psi_{t-1} \\ \psi_{t-1}^* \end{bmatrix} + \begin{bmatrix} \kappa_t \\ \kappa_t^* \end{bmatrix} .. \quad (7)$$

In the above model irregular ε_t, level ξ_t and slope disturbances are mutually independent. κ_t and κ_t^* are also mutually independent Gaussian white noise disturbances with zero means, but common variance σ_κ^2. λ_c is a cycle frequency in radians with a period of $2\pi / \lambda_c$ and ρ is a damping factor, whose higher values represent the sharper spectrum peak of the cycle. With $\rho \neq 1$ and $\sigma_\kappa^2 \neq 0$ the cycle is stochastic with changing amplitude and phase. Such a model can be estimated by maximum likelihood methods with the use of Kalman recursions.

This approach enables the estimation of stochastic cycles, inclusion of structural brakes and is not bound by rigorous economic restrictions as alternative methods mostly are. The modelling will be done with the use of the general to specific rule.

The ambiguity of the term 'business cycle' requires some arrangement before starting empirical analysis. In the next part of this article the term 'business cycle' will have a most general meaning for economic fluctuations. At first it will mean fluctuations in economic activity, lasting ca. from 1.5 to 8 years, which is commonly accepted. However, bearing in mind that the longest business cycle recorded in the

U.S. economy lasted 12 years, the exact period will be subject to verification. It will also be used when differentiation between cycles is not needed. Defined in this manner, a business cycle will encompass classical cycles and growth cycles. It will be empirically verified in the next part of this article whether the overall business cycle frequency interval includes two kinds of cycles. The terms 'step cycle', 'deviation cycle' and 'growth rate cycle' will only refer to the method of cycle extraction and will not define its type in any way. This clarification should help to verify what kind of fluctuations the analysed economic time series can be decomposed into, and evaluate the importance of growth cycles and classical cycles.

Results of empirical study

Introduction

Before conducting the quantitative analysis a short comparison of some properties of the business cycles observed so far around the world will be done. Step cycle features for three regions were summed up in Table 1.

Table 1: Step cycle characteristics on the basis of reference dates determined by certain institutions

Region	*Period analysed*	*Number of cycles*	*Average duration of expansion*	*Average duration of contraction*	*Average duration of a cycle (from through to through)*	*Average duration of a cycle (from peak to peak)*	*Minimum duration of a cycle*	*Maximum duration of a cycle*
USA	1945-2010	11	19	4	23	23	6	43
Euro Area	1970-2010	3	41	6	46	45	22	64
Japan	1951-2010	13	12	5	18	17	11	29

Data in quarters. Source:
Data for the USA from NBER: http://nber.org/cycles/cyclesmain.html, 2012-01-20.
Data for Euro Area from CEPR: http://www.cepr.org/data/dating/, 2012-01-20.
Data for Japan from ESRI: http://www.esri.cao.go.jp/en/stat/di/di2e.html, 2012-01-20.

In all three cases – USA, Euro Area (EA) and Japan business cycles are very irregular with several prominent features: expansion is significantly longer that contraction, particular cycles differ with the longest one during the 1990s-2000s, the three regions differ mainly by duration of expansion, and on average, cycles in Japan are the shortest, the U.S. economy cycles – slightly longer, and EA cycles – definitely the longest. Especially the last difference seems peculiar. Of course it is to some extent connected to the different periods analysed, but it still does not explain this tremendous difference.

Deviation cycles based on real GDP are far more regular than step cycles (Table 2). Even considering the different length of the analysed period, the USA, European Union (EU[2]) and Japan deviation cycles have similar length. Also the differences between contractions and expansions are not as huge as in the case of step cycles. Similar results were reported by Zarnowitz (1992).

2 From this point on the EU will be analysed rather than the EA because of the broader range of member countries.

Table 2: Business cycle characteristics on the basis of real GDP cyclical components

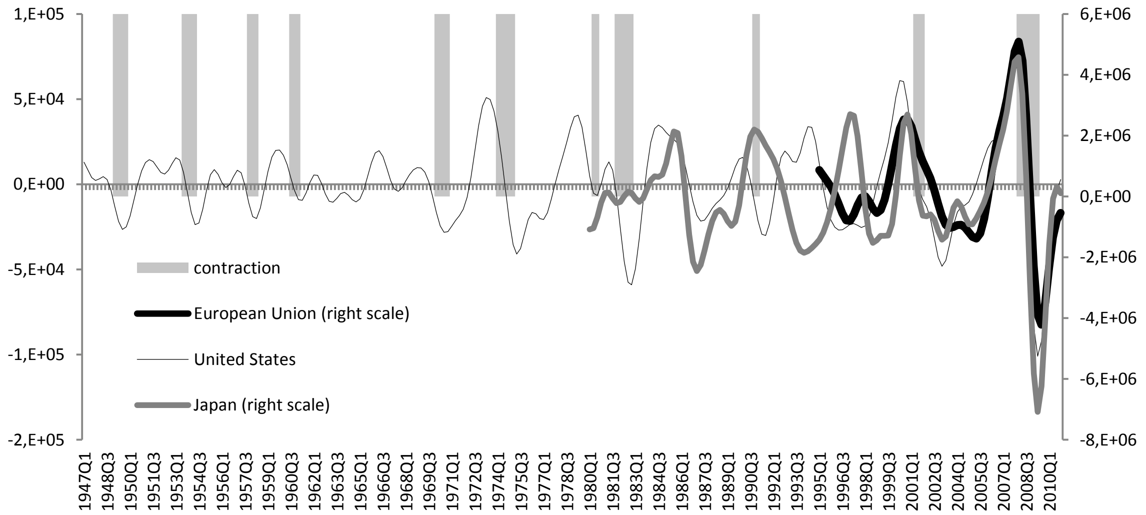
Region	*Period analysed*	*Number of cycles*	*Average duration of expansion*	*Average duration of contraction*	*Average duration of a cycle (from through to through)*	*Average duration of a cycle (from peak to peak)*	*Minimum duration of a cycle*	*Maximum duration of a cycle*
USA	1947-2010	11	11	10	22	23	16	37
European Union	1995-2010	2	15	8	22	22	21	23
Japan	1980-2010	5	12	9	20	21	13	30

Data in quarters.

Classical business cycle recessions (contractions) do not exactly match contractions of deviation cycles (Figure 1)[3]. Canova (1994) reports similar results with the use of the parametric method. He states that Hodrick-Prescott and Baxter-King filters in some cases match the NBER results, however, "false" turning points and omissions of turning points occur. E.g. the drop in GDP during 1981 is considered a contraction, while more significant – the ones in 1988 and 1995 are not. There are also fluctuations, which, in terms of recession and step cycle, are not considered 'cycles'. The examples are the ones during the 1960s, late 1980s or the second half of the 1990s. The difference between step and deviation cycles is that the former may be formed not only by short-run effects of cyclical shocks, but also may be amplified by structural changes that particularly sharp fluctuations may cause (e.g. crises). Therefore, deviation cycle analysis should be supplemented by the analysis of the mutual influence of structural and cyclical changes to find the complete effect of a particular business cycle on the economy.

3 Shaded bands represent periods of contraction in the U.S. economy according to NBER. For comparison purposes every figure starts with 1947Q1 and ends with 2010Q4.

Figure 1: Cyclical component of real GDP extracted with the use of the Christiano-Fitzgerald filter (in millions of national currency), assuming a business cycle lasts 1.5-8 years, with contractions (shaded areas) according to NBER



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Yearly growth rate of real GDP is shown in Figure 2. This simple transformation with poor theoretic properties in extracting business cycles shows contractions as step cycles do. It is clear that this method is used in an auxiliary manner in timing recessions. Every major drop in the growth rate of real GDP is considered a contraction. However, there are also shorter deviations over the phases of step cycles. Moreover, some classical cycles, e.g. the one during early 1980s, last as long as fluctuations that are considered merely an oscillation over the phase of the classical cycle, e.g. the ones in the 1960s. Deviation cycles give quite different results during these periods. There are also obvious differences between the results of this method, related to the definition of recession, and deviation cycles, which are extracted on the basis of the definition of the business cycle in terms of frequency of fluctuations. This confirms that the definition of recession does not correspond well with the definition of the deviation cycle. These differences give additional motivation to reconsider the definition of the business cycle.

Figure 2: Yearly growth rate of real GDP and contractions

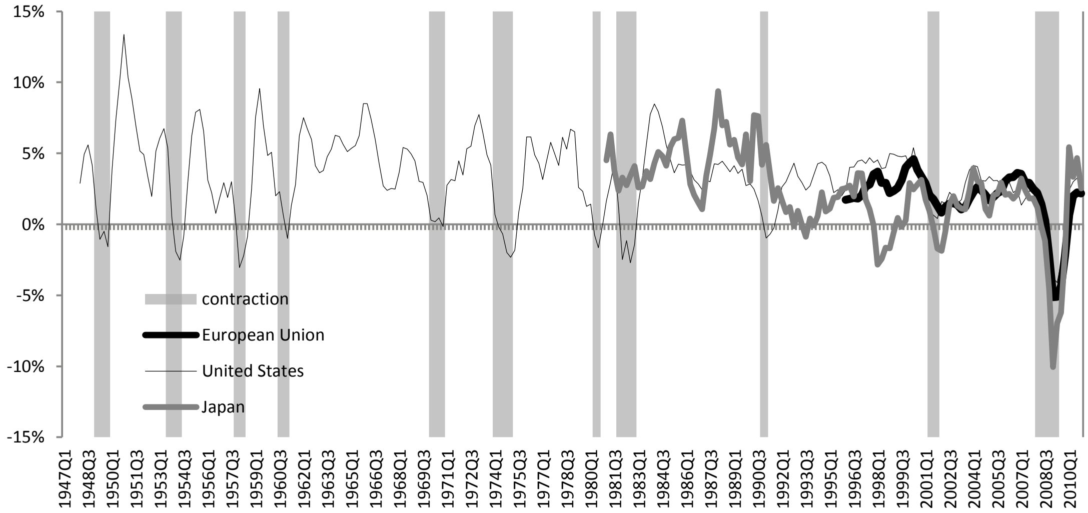
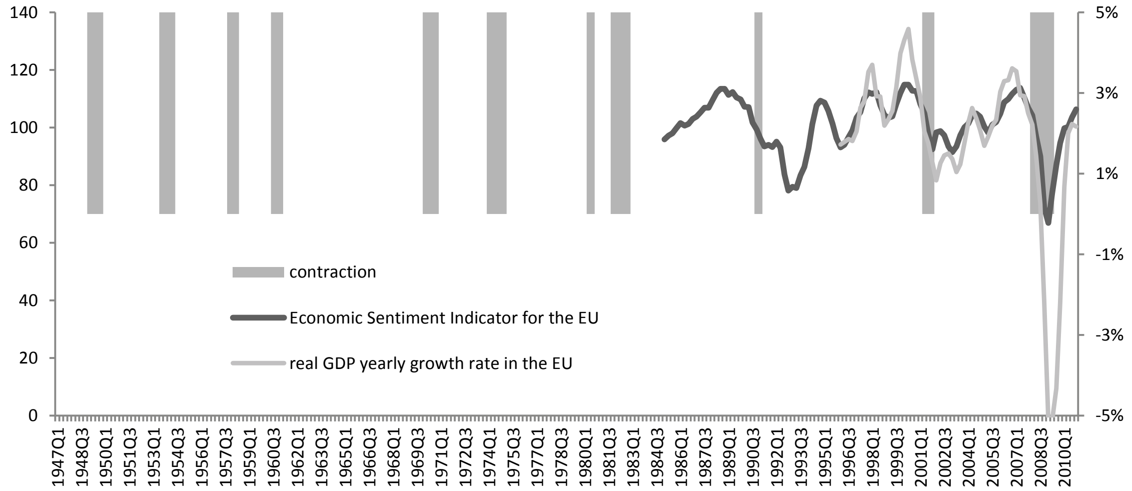


Figure 3 shows that GDP growth and economic sentiments in the EU may show two types of cycles. The first ones, longer, lasting ca. 8 years dominate, but clearly there are also ca. 3-year fluctuations around them. Without analysing the two types of fluctuations the problem of false cycle detection may intensify, because in some periods shorter fluctuations can be perceived as classical cycles – the ones that include recessions

Figure 3: Yearly growth rate of real GDP, seasonally adjusted Economic Sentiment Indicator for the EU and contractions



Econometric analysis

Augmented Dickey-Fuller test results indicated that GDP, and CLI time series for all 32 countries are nonstationary. This and well known Nelson and Plosser (1982) results led to the assumption, made also in this article, that these time series are I(1) processes with drift. In most cases, especially in Europe, inflation rate and unemployment rate turned out to be nonstationary I(1) processes. This may be in contrast with some evidence showing that inflation is stationary (i.e. Culver & Papell, 1997; but see also Charemza et al., 2005). It is important to note, however, that in this article inflation is measured as the yearly growth rate of CPI, not and index of GDP deflator. Nonstationarity of the unemployment rate is even more nonstandard, i.e. Nelson and Plosser (1982) showed that the unemployment rate in the U.S. economy is stationary and Papell et al. (2000) showed the same for European countries. Nevertheless, it may show that in Europe there can be a persistent component of these time series connected to long-run policy effects in the 2000s. In this article for CF filter application it was first assumed that these times series are I(0) and then the analysis was repeated with the assumption that they are I(1). It turned out that in terms of relative importance of fluctuations in the dynamics of business cycles both assumptions gave nearly the same results.

Spectral density estimates of time series, filtered by means of the three methods, showed maximum values for frequencies between ca. 20-32 quarters for all four indicators (GDP, unemployment rate, inflation rate and composite leading index) for most of the analysed countries (Table 3). This frequency interval corresponds to classical cycle fluctuations. However, there were also nearly as many countries for which local maximums of spectral density can be observed for periodicities of about 6-19 quarters (from 1,5 to less than 5 years). It corresponds to the cycles that sensitive methods are especially prone to extract, i.e. growth cycles. In some cases spectral density revealed only one maximum value within the 1.5-8 years range. However, there was no rule as to which periodicity interval – lower or higher – the maximum value was from. Results confirm that economic activity goes through two kinds of cycles within the business cycle periodicity range. Both kinds of fluctuations can be observed (see Figure 3) and are not spurious.

Table 3: Number of countries with spectral density local maximum values for lower and higher business cycle periodicities

Method of extraction	*Interval in quarters*	*GDP*	*Unemploy-ment rate*	*Inflation rate*	*Composite Leading Index*
CF	6-19	18	9	17	18
	20-32	18	28	29	28
BK	6-19	9	11	18	19
	20-32	13	19	29	15
HP	6-19	17	11	24	18
	20-32	21	27	29	28

32 countries in all.

The three basic business cycle extraction methods gave somewhat different results, although the differences do not concern the topic of this article, for every one of them showed types of fluctuations identified as growth cycles and classical cycles. Also visible is the property that the number of identified classical cycles exceeds the number of growth cycles. Among the analysed countries classical cycles were visible mostly in inflation rate (29 out of 32 counties) and unemployment rate (in 25 countries, on the basis of the average results from 3 filters – BK, HP and CF). In CLI these fluctuations were observed in 24 countries, and in GDP – in 17 countries. Growth cycles were also mostly visible in inflation rate – 20 countries showed such fluctuations and CLI – 18 countries. It is understandable considering the great volatility of inflation and the sensitivity of CLI, resulting from the construction of these indicators. GDP in 15 countries showed such fluctuations and unemployment rate – in 10. Real economy – production and labour market – does not change as fast as monetary economy and sentiments.

The highest relative amplitude of business cycles among the analysed indicators measured by coefficient of cyclical component variation[4] is observed in inflation rate (Table 4). The importance of cyclical fluctuations of inflation should be underlined especially in Japan. Growth cycles constitute this fact in a very significant way. Cyclical fluctuations of unemployment rate are also considerable, mostly in the USA. In the EU, where unemployment is more prone to long-run changes they are less important. CLI and GDP have a smaller share of cyclical fluctuations, but growth cycles are almost as significant as classical cycles.

In most of the analysed countries classical cycles to a higher extent than growth cycles contributed to the amplitude of the variables. There were few exceptions. In the case of GDP growth cycles prevail mainly in Poland and Japan. In Poland it is the result of fluctuations of manufacturing and export (Gradzewicz et al., 2010), which shows the relative importance of these sectors in the Polish economy. It may be the same case in Japan, which is well industrialized and export-oriented. The unemployment rate shows strong growth cycles in Australia, which may lead to the conclusion that this labour market is very mobile and adjusts to fluctuations quickly. In the case of inflation and CLI there are more exceptions. Composite leading indexes growth cycles fairly often are so visible that their turning points can be mistaken for classical cycle turning points which may be the reason why 'false' cycles are detected so often. Therefore, it is crucial to recognize these two types of fluctuations. Volatility of growth cycles of inflation is even higher in comparison to classical cycles with the exception of the U.S. economy.

4 Coefficient of cyclical component variation V_S was computed with the use of the formula $V_S = s_C / \overline{x}$, where s_C is the standard deviation of the cyclical component of the variable x_t, and $\overline{x}$ is the mean of absolute values of x_t. A coefficient of the form $z_S = \sum_{t=1}^{T} \left(\left| x_{C,t} \right| / x_t \right)$ where $x_{C,t}$ is the value of cyclical component of x_t was also computed. The results were similar, thus they were not supplemented.

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Table 4: Coefficients of cyclical component variation

Indicator	*Region*	*Business cycles*	*Classical cycles*	*Growth cycles*
GDP	Japan	1,8%	1,4%	1,0%
	USA	1,8%	1,5%	0,9%
	EU	1,6%	1,2%	0,8%
Inflation rate	Japan	60,0%	41,8%	43,0%
	USA	36,9%	27,2%	20,1%
	EU	35,5%	14,4%	28,2%
Unemployment rate	Japan	11,1%	8,1%	6,3%
	USA	16,1%	13,0%	8,5%
	EU	7,7%	5,5%	3,4%
Composite Leading Index	Japan	5,1%	4,1%	2,8%
	USA	3,6%	2,7%	2,3%
	EU	2,8%	2,0%	1,9%

On the basis of CF filter estimations.

Considering the general periodicity of the business cycle, aside from the very few exceptions (probably being the result of the particular method of extraction) local maximum values of spectral density for fluctuations shorter than 8 quarters were not identified. Significantly more exceptions were found considering the lower boundary of business cycle frequency. Especially the cycles extracted with the use of the HP filter for many countries lasted longer than the most commonly accepted maximum length of 8 years. This was the case in 3 countries' GDP, 17 countries' unemployment rate and 8 countries' inflation rate and CLI. In almost all of the above cases classical cycles lasted up to 40 quarters. Therefore it is advisable to think of the business cycle as fluctuations lasting from 2 to 10 years rather than from 1.5 to 8 years. This was also noticed, for example by Gradzewicz et al. (2010).

According to the above results business cycle fluctuations of the analysed indicators were decomposed into classical and growth cycles using a CF filter (other filters showed similar results and were not included). This time it was assumed that business cycles last 2-10 years, growth cycles – 8-19 quarters, classical cycles – 20-40 quarters (Appendix A). It turned out that in almost all cases, the definition of recession corresponded to contraction in classical cycles. Exceptions are recessions in 1960 and 1980 which, based on the data for the USA and according to the stated assumptions, were results of contractions in growth cycles. These contractions should not have been called recessions in terms of classical cycles as they were defined in this article. With the use of the presented approach, the business cycles of the USA, EU and Japan seem much more alike in contrast with the ones observed using standard methods (Table 6, Appendix A). Classical and growth cycle periodicity is similar across countries and indicators. Although measured in different periods, on average, classical cycles lasted 29 quarters with 25 the shortest and 35 the longest, which gives the coefficient of variation for these cycles of 12%. The average growth cycle lasted 15 quarters with the minimum of 12 and maximum of 17 quarters. This gives the coefficient of variation of 11%. Zarnowitz (1992) for different periods, countries and indicators reported coefficients of variations for deviation cycles and step cycles equaling from 30% to even 79%. The approach presented in this article significantly lessens this broad range of differences between business cycles across countries, indicators and even periods.

To confirm the existence of two types of business cycles in another step, unobserved components models for 32 countries were built. At first one cycle in each of the models was implemented and in the second step a model with two cycles was estimated. The main features of the models according to the properties of the cycles were presented in Table 5.

Table 5: Business cycles descriptive statistics according to the UC models

	1 cycle				*2 cycles*							
	Mean	*S.d.*	*Min*	*Max*	*Mean 1*	*S.d. 1*	*Min 1*	*Max 1*	*Mean 2*	*S.d. 2*	*Min 2*	*Max 2*
GDP	16	5	8	25	12	3	7	22	27	7	19	45
Unemploymentrate	15	8	7	45	12	5	7	24	27	9	16	47
Inflation	12	5	6	22	10	3	6	20	27	7	17	43
CLI	11	3	6	19	11	2	7	15	26	6	16	42

32 countries in all.

According to the models with one stochastic cycle, the cycles were fairly short, lasting from 11 to 16 quarters. Most irregular across countries were unemployment rate cycles which can be the effect of institutional properties of particular economies (detailed results were presented in Appendix B). The most similar according to periodicity and also the shortest were the cycles of composite leading indexes. Implementation of two business cycles in almost all cases improved the models according to the coefficient of determination measure, wherein prediction error variance is compared with the variance of first differences and a positive value indicates a better model than a random walk with drift. In the case of most of the variables and countries two cycles within the business cycle frequency interval were indeed found. In some cases shorter or longer cycles (from out of the business cycle interval) were found. There were also cases in which two types of identified cycles had similar frequency (noted 'similar period of cycles', see appendix B). In such cases only one cycle was modelled. However, in most cases business cycles with significantly different periodicity were confirmed. In almost all countries two types of business cycles were found in inflation, slightly less in the unemployment rate and GDP and least in CLI. CLI for 15 out of 32 countries did not prove to exhibit classical (longer) cycle fluctuations, but only short ones, i.e. the ones lasting 11 quarters on average. It may be one of the reasons why leading indexes often fail to predict crises – major contraction in the economy caused by classical cycles. They are quite accurate in predicting growth (short) cycle contractions. Besides these exceptions all shorter and longer cycles are surprisingly similar across countries and indicators according to periodicity. Shorter cycles lasted 10-12 quarters on average and dispersed between 6 and 24 quarters, again with the unemployment rate the most differing between countries. Also unemployment and GDP cycles were slightly longer than the ones found in inflation and CLI. Longer cycles lasted 26-27 quarters on average, which, depending on the country and indicator, ranged between 16 and 47 quarters.

As an example, an unobserved components model for the GDP of the United Kingdom will be described in more detail. The period analysed in this case is 1963Q1-2010Q4. Of all possible restrictions the best results gave the imposition of and estimating smooth trend with stochastic cycle models. Two alternative models were constructed. The results show that model 1 contains one stochastic cycle, which can be called the 'business cycle'. Model 2 contains two stochastic cycles, shorter 'growth cycle' and longer 'classical cycle'. In model 1 the cycle lasted 4,26 years (0,369 in frequency units) and it was moderately close to deterministic, with damping factor of 0,913. This cycle turned out to be similar to the HP and CF filters estimates. In the case of model 2 the first cyclical component lasted 3,30 years (0,476 in frequency units), thus, it can be perceived as a growth cycle. The second cycle lasted 5,44 years (0,289 in frequency units), which means that it could be the 'classical cycle'. They were also more deterministic, especially the classical cycle, with damping factors of 0,921 for growth cycle and 0,983 for classical cycle. The longer cycle had higher amplitude than the shorter one. The estimated shorter, growth cycles were found to be very similar to the ones extracted with the use of CF filter. The longer ones, classical cycles were not that similar – CF estimates showed longer and more irregular cycles than the ones taken from model 2. However, they were not completely different, showing similar periods of expansions and contractions.

Conclusion

This article shows that business cycles, i.e. the ones that are usually thought of as fluctuations lasting 1.5-8 years are not homogenous. Considering that the above interval is very wide this finding may help in dividing it into lesser intervals with different statistical properties and probably economic explanation, which in turn may help in business cycle analysis and forecasting. Two methods were used to confirm the existence of two types of cycles within business cycle frequency interval – ad hoc filters with spectral analysis and unobserved components models. After analysis of 32 countries from the OECD database, including the USA, Japan and the EU, two main conclusions may be articulated:

1) business cycles are fluctuations in economic activity lasting 2-10 years. There are very few exceptions of 1.5-year cycles, and many more examples of 8-10-year cycles.
2) within business cycle periodicity two sub-cycles exist. The first one lasting 20-40 quarters is proposed to be called 'classical cycle', because it corresponds to the classically observed cycles, dated by NBER (step cycles). This is most important because its contraction phase means recession or crisis. The second one lasting 8-19 quarters is proposed to be called 'growth cycle'. They correspond to the dynamics of classical cycles. These cycles are shorter than classicals and observable in detrended data.

The division into two types of cycles has significant economic meaning – contraction of growth cycles are not recessions, they are merely slowdowns. Therefore, their turning points should not be mistaken for the classical cycle turning point, which is clear advice for leading index analysts, for leading indexes are especially prone to show growth cycles, not classical. Considering a division of business cycles into classical and growth cycles, the definitions of recession, step cycle and deviation cycle correspond to themselves. The division proposed in this article is not connected to the method of cycle extraction, but to the very properties of these cycles, statistical and economic. So far growth and classical cycles have been connected to the method of extraction, and it has not been clearly distinguished which one is the 'business cycle'. As a result, a growth cycle could have been perceived as a 'pure' or uninterrupted cycle, while a classical cycle could have been the one mixed with a long-run trend and other structural changes in the economy. However, this article shows that two types of cycles exist independently. Also thanks to this division the definition of recession becomes more specified. It is connected to cyclical fluctuations lasting 20-40 quarters, or, to be specific, to their contraction. Growth cycles defined as in this article are especially visible in inflation rate and composite leading indexes. They may be connected to monetary changes and the changes in economic sentiments. They also influence the real economy, which, however, was found to show classical cycles more strongly than inflation and sentiments. Therefore, dividing business cycles into classical and growth cycles enables us to understand the differences between the cyclicality of various macroeconomic aggregates. Certain short-run movements of quite different macroeconomic aggregates can be connected to themselves.

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References

A'Hearn, B., Woitek, U. (2001). More International Evidence on the Historical Properties of Business Cycles. *Journal of Monetary Economics 47*, 321-346.

Artis, M., Krolzig, H. M., Toro, J. (2004). The European Business Cycle. *Oxford Economic Papers 56*, 1-44.

Banerji, A. (1999). The Three Ps: Simple Tools for Monitoring Economic Cycles. *Business Economics 34*, 72-76.

Baxter, M., King, R. (1999). Measuring Business Cycles: Approximate Band-Pass Filters for Economic Time Series. *Review of Economics and Statistics 81*, 575-593.

Blanchard, O., Summers, L. (1987). Hysteresis in Unemployment. *European Economic Review 31*, 288-295.

Bloomfield, P. (1976). *Fourier Analysis of Time Series: An Introduction*. New York: Wiley & Sons.

Boivin, J., Giannoni, M., Mojon, B. (2009). *How Has the Euro Changed the Monetary Transmission Mechanism?* In: D. Acemoglu, K. Rogoff, M. Woodford (Eds.), NBER Macroeconomics Annual. Chicago: University of Chicago Press.

Bry, G., Boschan, C. (1971). *Cyclical Analysis of Time Series: Selected Procedures and Computer Programs*. New York: National Bureau of Economic Research.

Burns, A. F., Mitchell, W. C. (1946). *Measuring Business Cycles*. New York: National Bureau of Economic Research.

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

Canova, F., Ciccarelli, M., Ortega, E. (2005). Similarities and Convergence in G-7 Cycles. *Journal of Monetary Economics 54*, 850-878.

Chadha, B., Prasad, E. (1993). Interpreting the Cyclical Behavior of Prices. *IMF Staff Papers 40*, 266-298.

Charemza, W. W., Hristova, D., Burridge, P. (2005). Is Inflation Stationary? *Applied Economics 37*, 901-903.

Christiano, L., Fitzgerald, T. J. (2003). The Band Pass Filter. *International Economic Review 44*, 435-465.

Comin, D., Gertler, M. (2006). Medium Term Business Cycles. *American Economic Review 96*, 523-551.

Culver, S. E., Papell, D. H. (1997). Is There a Unit Root in the Inflation Rate? Evidence from Sequential Break and Panel Data Models. *Journal of Applied Economics 12*, 436-444.

Danthine, J. P., Donaldson, J. B. (1993). Methodological and Empirical Issues in Real Business Cycle Theory. *European Economic Review 37*, 1-35.

den Haan, W. J. (2000). The Comovement of Output and Prices. *Journal of Monetary Economics 46*, 3-30.

den Haan, W. J., Sumner, S. W. (2004). The Comovement Between Real Activity and Prices in the G7. *European Economics Review 48*, 1333-1347.

Dickey, D. A., Fuller, W. A. (1981). Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. *Econometrica 49*, 1057-1072.

French, M. W., Sichel, D. E. (1993). Cyclical Patterns in the Variance of Economic Activity. *Journal of Business and Economic Statistics 11*, 113-119.

Fukuda, K. (2008). Differentiating Between Business Cycles and Growth Cycles: Evidence from 15 Developed Countries. *Applied Economics 40*, 875-883.

Giannone, D., Lenza, M., Reichlin, L. (2010). *Business Cycles in the Euro Area*. In: L. Alesina, F. Giavazzi (Eds.) Europe and the Euro, Chicago: University of Chicago Press.

Giannone, D., Reichlin, L. (2005). *Euro Area and US Recessions, 1970-2003*. In: L. Reichlin (Ed.) The Euro Area Business Cycle: Stylized Facts and Measurement Issues (p. 83-93). London: Centre for Economic Policy Research.

Gradzewicz, M., Growiec, J., Hagemejer, J., Popowski, P. (2010). The Business Cycle in Poland – Conclusions from Spectral Analysis. *Bank & Credit 41*, 41-76.

Green, G. R., Beckman, M. A. (1993). Business Cycle Indicators: Upcoming Revisions of Composite Leading Indicators. *Survey of Current Business 73*, 44-51.

Hamilton, J. D. (1994). *Time Series Analysis*. Princeton: Princeton University Press.

Hamilton, J. D. (2005). What's Real About the Business Cycle? *Federal Reserve Bank of St. Louis Review 87*, 435-452.

Harvey, A. C. (1975). Spectral Analysis in Economics. *The Statistician 24*, 1-36.

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

Henderson, R. (1916). Note on Graduation by Adjusted Average. *Transactions of the American Society of Actuaries 17*, 43-48.

Hymans, S. H. (1973). On the Use of Leading Indicators to Predict Cyclical Turning Points. *Brookings Papers on Economic Activity 2*, 339-384.

Hodrick, R. J., Prescott, E. C. (1997). Postwar U.S. Business Cycles: An Empirical Investigation. *Journal of Money, Credit and Banking 29*, 1-16.

Inklaar, R., Jong-A-Pin, R., de Haan, J. (2008). Trade and Business Cycle Synchronization in OECD Countries. A re-examination. *European Economic Review 52*, 646-666.

Kim, C. J., Murray, C. J. (2002). Permanent and Transitory Components of Recessions. *Empirical Economics 27*, 163–183.

Kitchin, J. (1923). Cycles and Trends in Economic Factors, *Review of Economics and Statistics 5*, 10-16.

Leamer, E. E. (2008). What's A Recession, Anyway? (National Bureau of Economic Research Working Paper 14221). Retrieved from: *http://www.nber.org/papers/w14221.pdf.*

Mansour, J. M. (2003). Do National Business Cycles Have an International Origin? *Empirical Economics 28*, 223–247.

Mills, T. C. (2003). Modelling Trends and Cycles in Economic Time Series. New York: Palgrave Macmillan.

Mills, T. C., Wang, P. (2002). Plucking Models of Business Cycle Fluctuations: Evidence from the G-7 countries. *Empirical Economics 27*, 255–276.

Mintz, I. (1969). Dating Postwar Business Cycles: Methods and Their Application to Western Germany, 1950-1967 (Occasional Paper No 107). New York: National Bureau of Economic Research.

Nelson, C. R., Plosser, C. I. (1982). Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications. *Journal of Monetary Economics 10*, 139-162.

Oppenheim, A. V., Schafer, R. W. (1989). *Discrete-Time Signal Processing*. London: Prentice-Hall.

Osborn, D., Sensier, M. (2002). The Prediction of Business Cycle Phases: Financial Variables and International Linkages. *National Institute Economic Review 182*, 96-105.

Papell, D. H., Murray, C. J., Ghiblawi, H. (2000). The Structure of Unemployment. *Review of Economics and Statistics 2*, 309-315.

Samuelson, P. (1966 September 19). Science and Stocks. *Newsweek*, 92.

Sichel, D. E. (1993). Business Cycle Asymmetry. *Economic Inquiry 31*, 224–236.

Schwartz, J. (2012). Labor Market Dynamics over the Business Cycle: Evidence from Markov Switching Models. *Empirical Economics 43*, 271–289.

Stock, J. H., Watson, M. W. (2005). Understanding Changes In International Business Cycle Dynamics. *Journal of the European Economic Association 5*, 968-1006.

The Conference Board (2001) Business Cycle Indicators Handbook. Retrieved from: *http://www.conference-board.org/pdf_free/economics/bci/BCI-Handbook.pdf.*

Zarnowitz, V. (1992). *Business Cycles. Theory, History, Indicators, and Forecasting*. Chicago and London: National Bureau of Economic Research.

Zarnowitz, V. (1985). Recent Work on Business Cycles in Historical Perspective: A Review of Theories and Evidence. *Journal of Economic Literature 23*, 523-580.

Zarnowitz, V., Ozyildirim, A. (2006). Time Series Decomposition and Measurement of Business Cycles, Trends and Growth Cycles. *Journal of Monetary Economics 7*, 1717-1739.

Zimmermann, C. (1997). International Real Business Cycles Among Heterogeneous Countries, *European Economic Review 41*, 319-356.

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Appendix A Table 6: Length of classical cycles and growth cycles on the basis of CF filter estimations

Indicator	*Region*	*Period analysed*	*Number of cycles*	*Average duration of expansion*
				Classica
GDP	Japan	1980-2011	3	13
	USA	1947-2011	9	14
	EU	1995-2011	1	14
Inflation rate	Japan	1956-2011	6	13
	USA	1956-2011	7	13
	EU	1997-2011	0	29
Unemployment rate	Japan	1955-2011	6	16
	USA	1955-2011	7	14
	EU	1998-2011	1	13
Composite leading index	Japan	1959-2011	6	13
	USA	1955-2011	8	13
	EU	1969-2011	4	22
				Growth
GDP	Japan	1980-2011	7	6
	USA	1947-2011	15	8
	EU	1995-2011	2	8
Inflation rate	Japan	1956-2011	12	8
	USA	1956-2011	12	8
	EU	1997-2011	3	8
Unemployment rate	Japan	1955-2011	13	8
	USA	1955-2011	12	8
	EU	1998-2011	2	8
Composite leading index	Japan	1959-2011	14	7
	USA	1955-2011	14	8
	EU	1969-2011	14	6

Average duration of contraction	*Average duration of a cycle (from through to through)*	*Average duration of a cycle (from peak to peak)*	*Minimum duration of a cycle*	*Maximum duration of a cycle*
l cycles				
17	30	33	24	40
12	25	26	19	36
10	24	23	23	24
18	31	27	22	48
15	28	29	22	41
-	-	-	-	-
17	33	33	23	44
15	28	29	20	43
13	26	-	26	26
16	30	30	20	41
12	25	25	16	37
14	35	35	25	44
n cycles				
8	14	15	10	22
8	16	16	10	26
8	16	15	13	18
9	17	17	8	30
9	17	17	9	28
6	14	14	9	19
8	16	16	11	24
9	17	17	11	25
7	16	16	14	17
6	13	13	10	20
8	15	16	8	26
6	12	12	8	17

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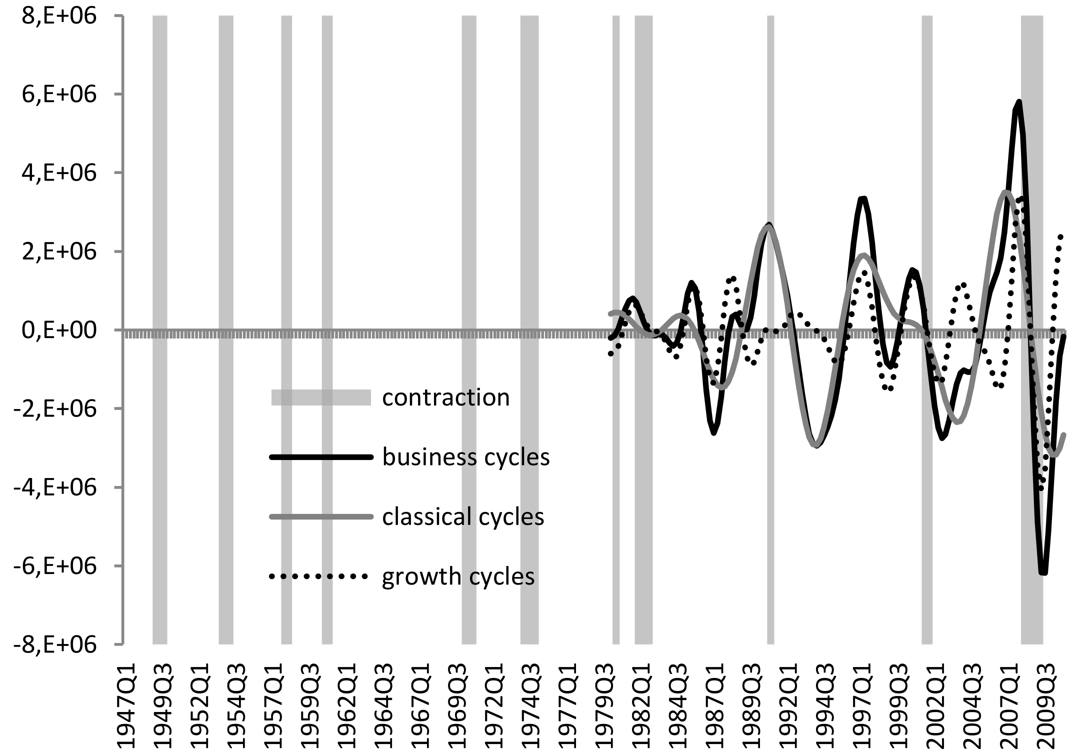
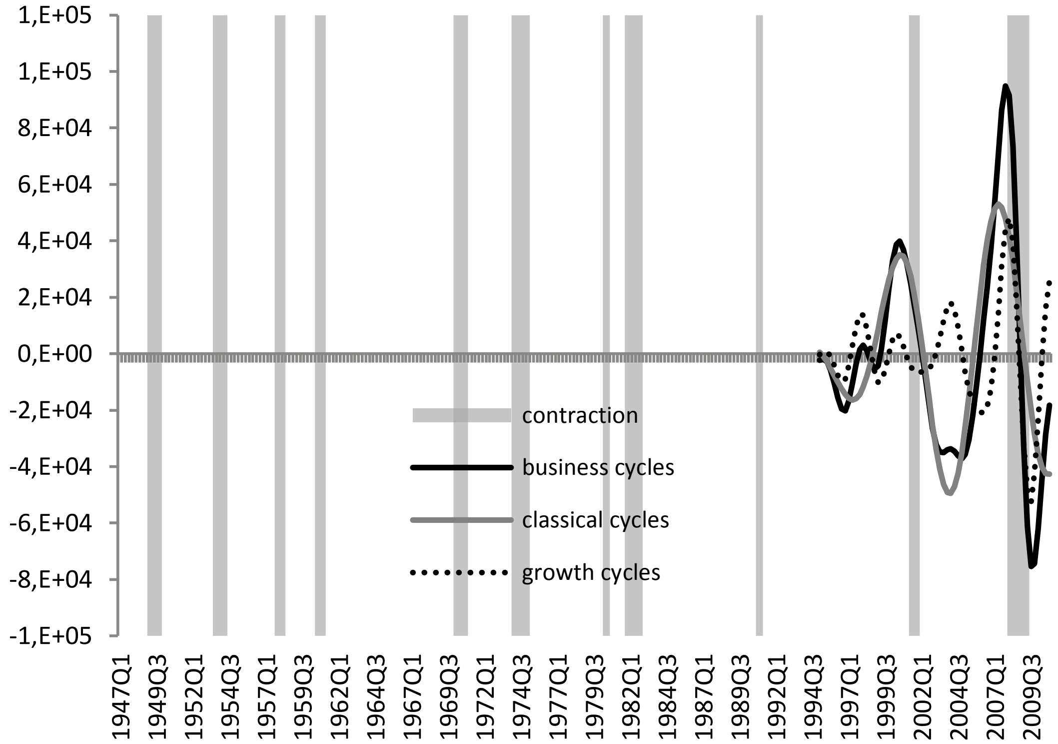
Appendix B

Figure 4: Classical cycles and growth cycles on the background of business cycles according to CF filter

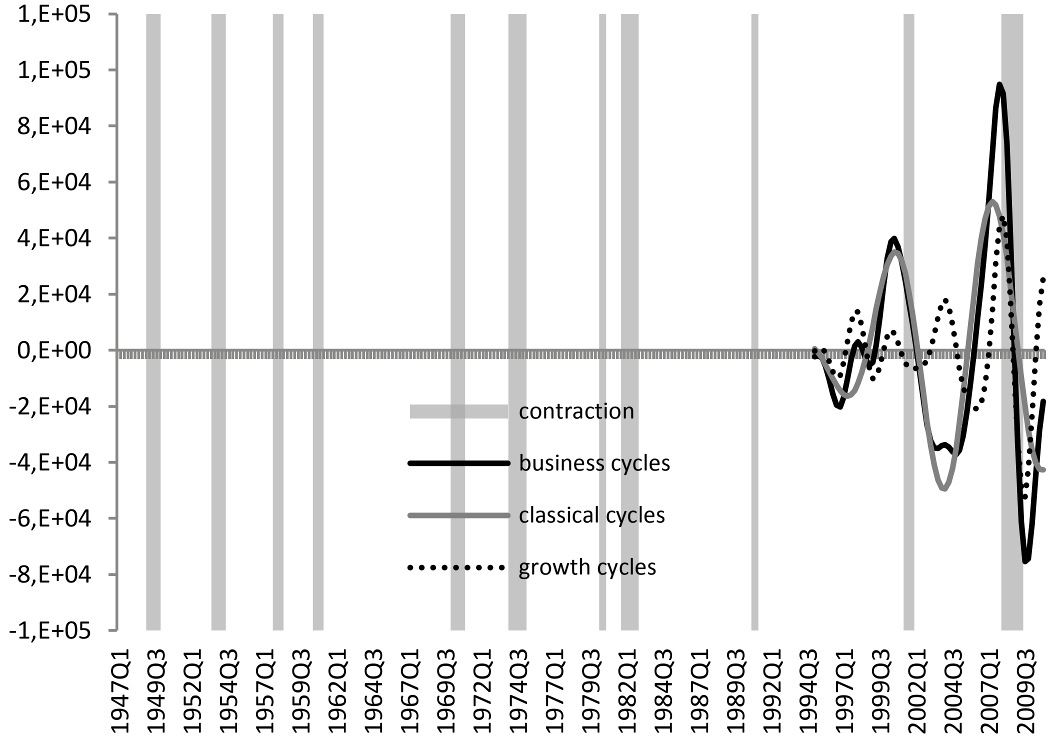
a) GDP in Japan



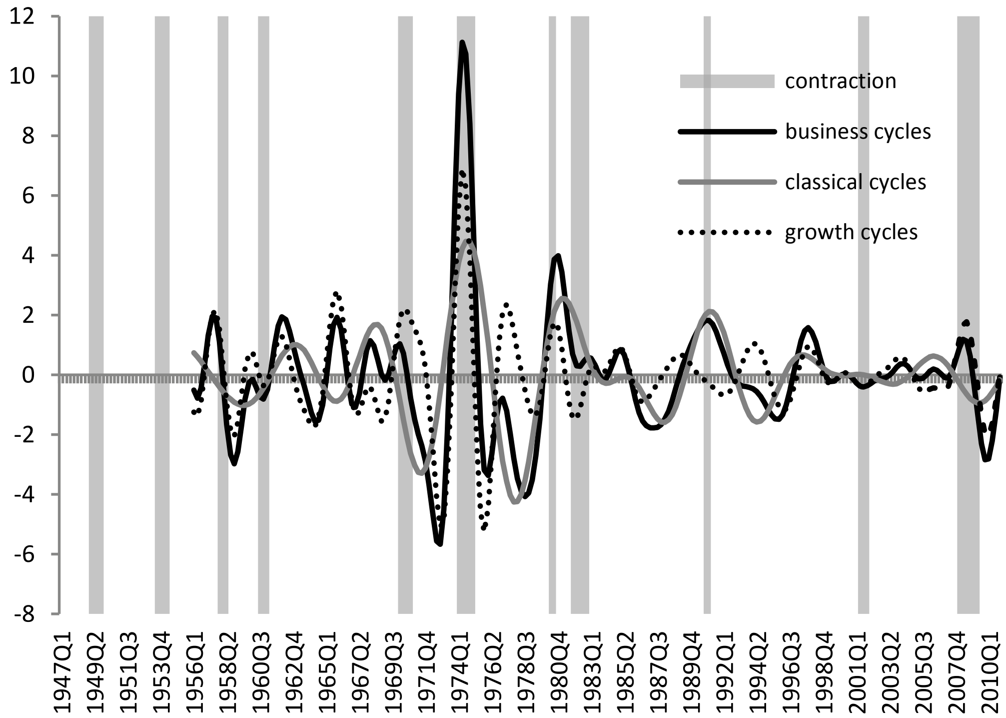
b) GDP in the USA



c) GDP in the EU



d) Inflation in Japan



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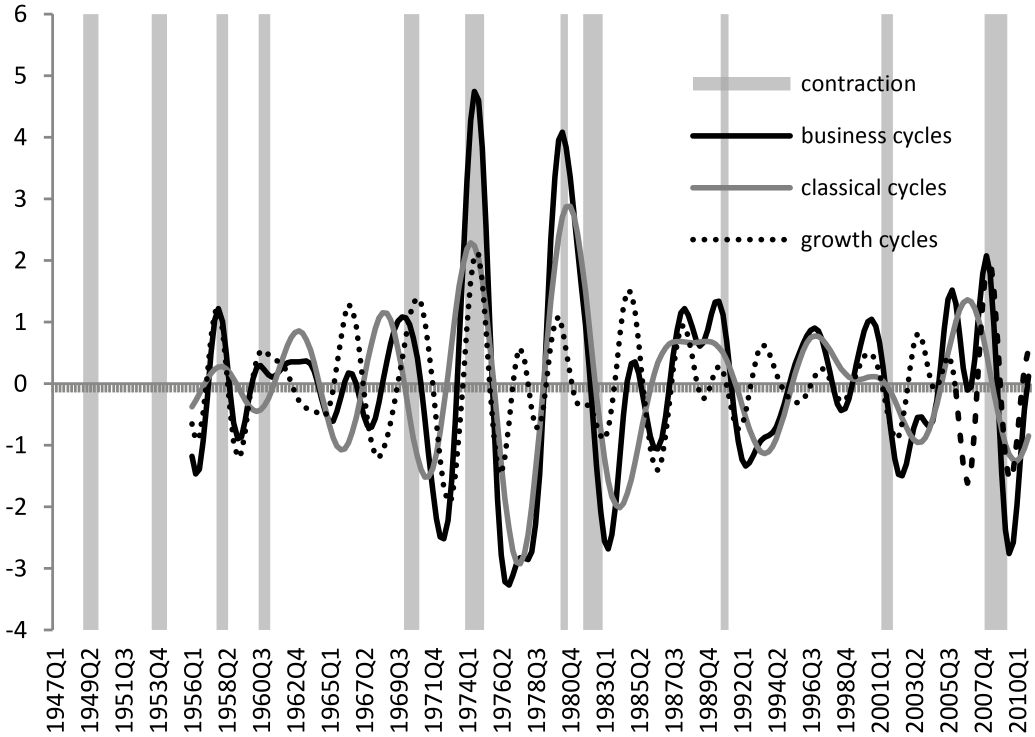
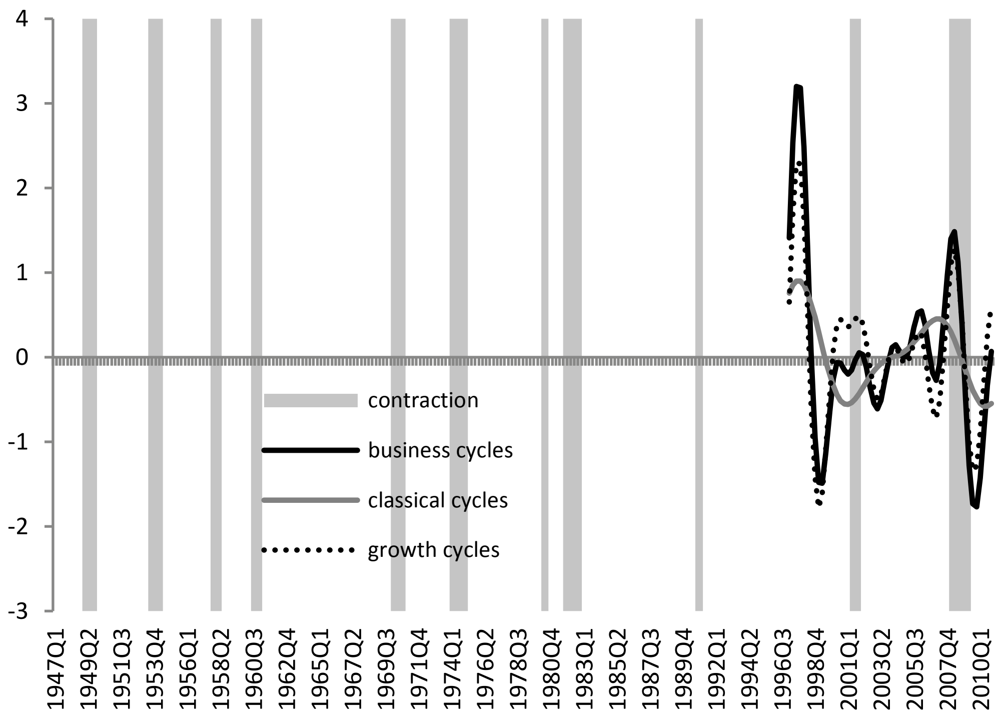
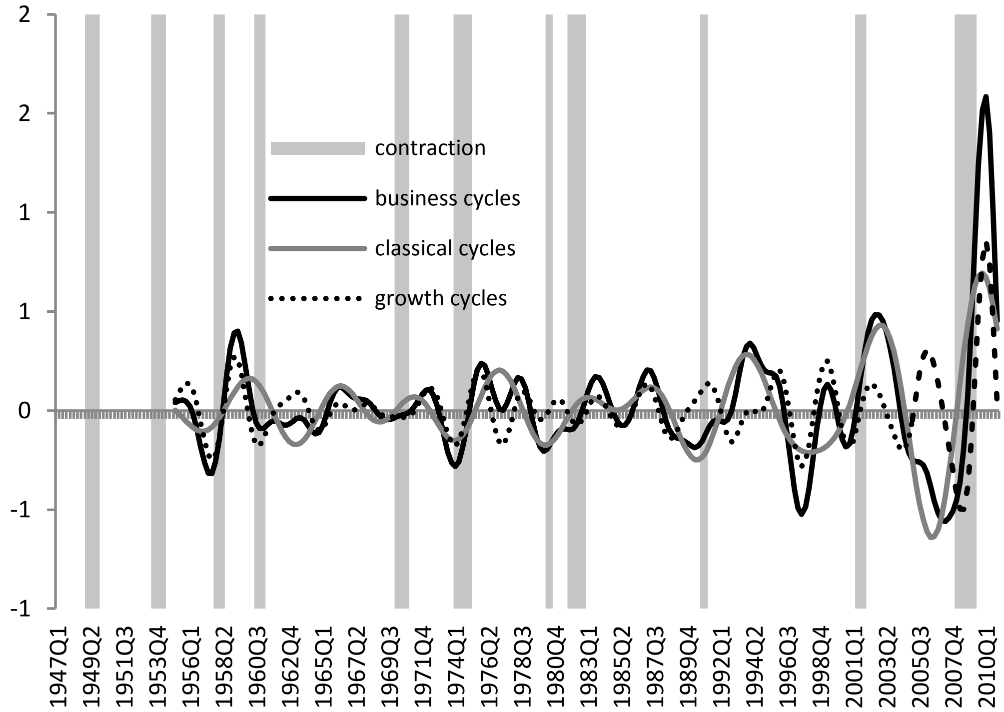
e) Inflation in the USA



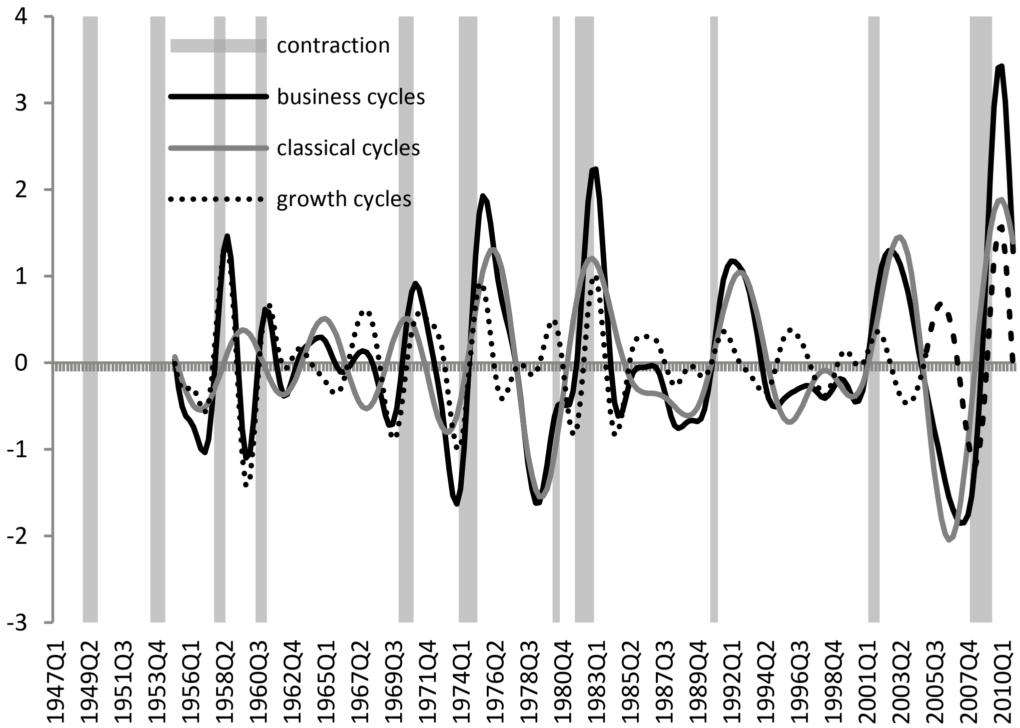
f) Inflation in the EU



g) Unemployment rate in Japan



h) Unemployment rate in the USA



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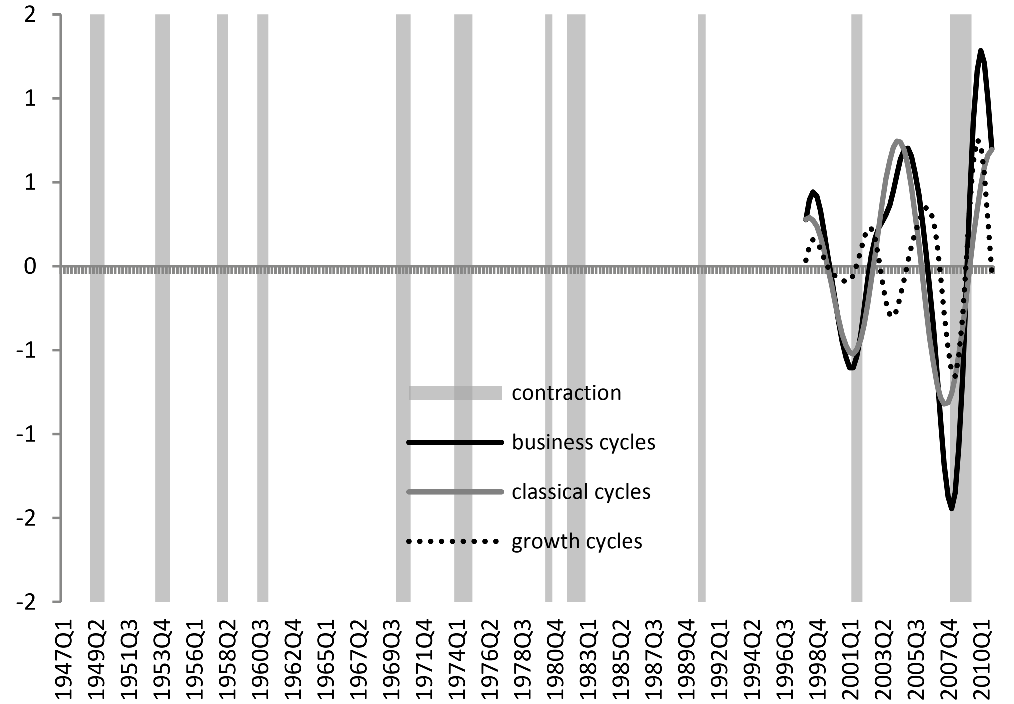
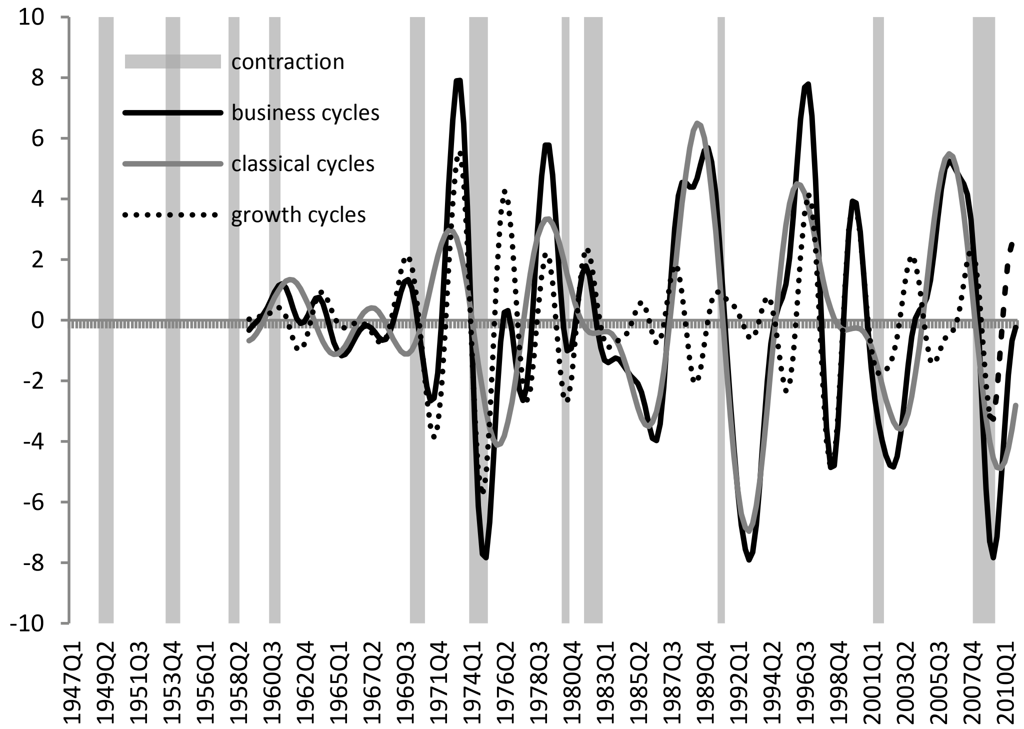
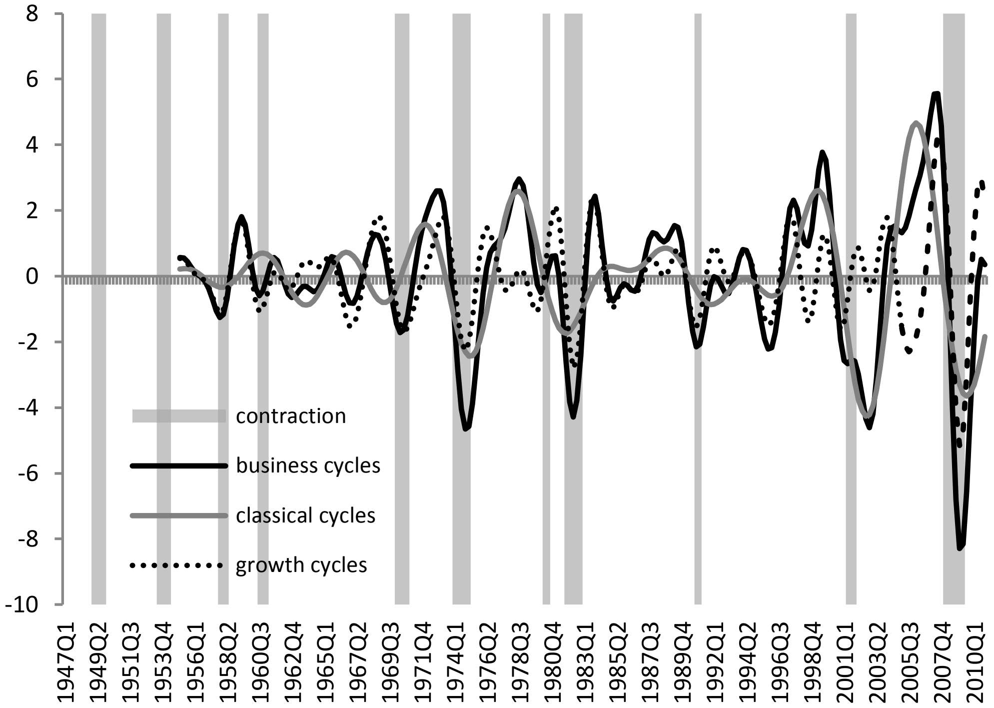
i) Unemployment rate in the EU



j) CLI in Japan



k) CLI in the USA



l) CLI in the EU

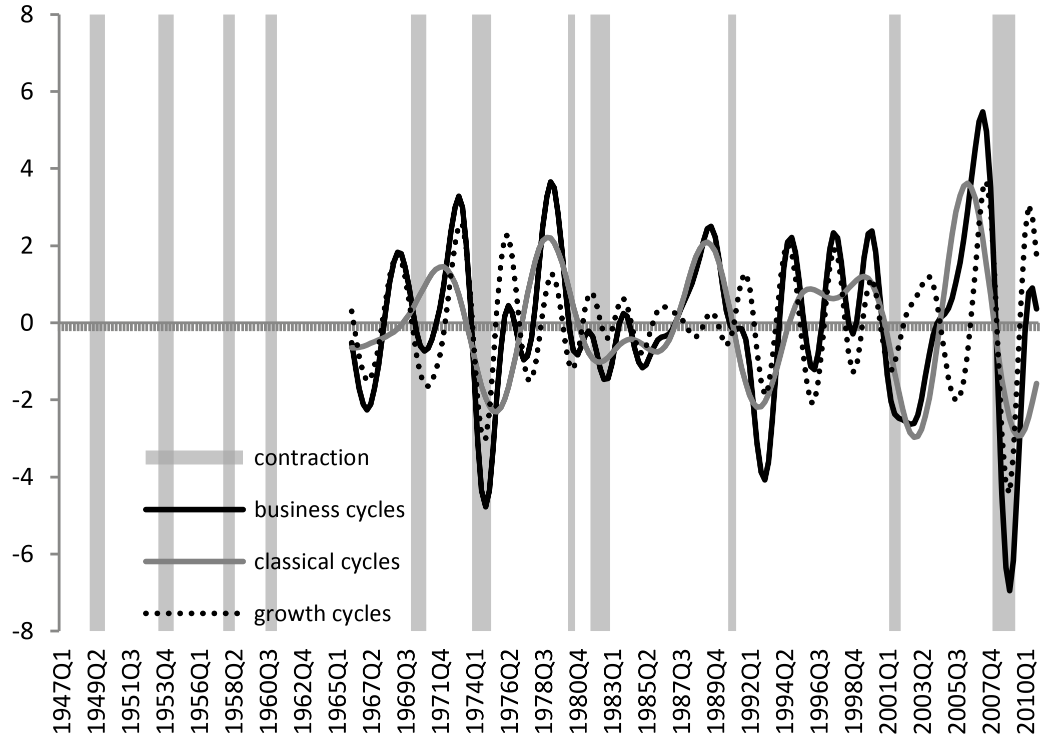


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Table 7: Cyclicality of GDP according to unobserved components models

Country	1 cycle		2 cycles			Remarks
	Period in quarters	R_d^2	Period in quarters	Period 2 in quarters	R_d^2	
Australia	18	0,11	-	-	-	longcycles
Austria	-	-	-	-	-	shortcycles
Belgium	-	-	-	-	-	shortcycles
Canada	12	0,19	10	23	0,23	
Czech Republic	23	0,28	8	22	0,32	
Denmark	13	0,01	10	26	0,09	
Estonia	13	0,54	13	19	0,58	
Finland	14	0,27	14	35	0,28	
France	12	0,08	12	34	0,12	
Germany	21	0,17	8	22	0,24	
Greece	-	-	-	-	-	longcycles
Hungary	8	0,58	-	-	-	similar period of cycles
Ireland	14	0,19	14	25	0,24	
Israel	21	0,15	14	24	0,26	
Italy	18	0,25	12	22	0,30	
Japan	14	0,05	-	-	-	longcycles
Korea	16	0,15	12	22	0,18	
Luxembourg	23	0,15	16	25	0,24	
Netherlands	13	0,18	13	31	0,26	
New Zealand	11	0,04	11	37	0,12	
Norway	22	0,12	22	40	0,15	
Poland	15	0,26	-	-	-	similar period of cycles
Portugal	12	0,11	12	29	0,20	
Slovak Republic	19	0,01	18	45	0,30	
Slovenia	25	0,31	7	24	0,35	
Spain	14	0,76	-	-	-	similar period of cycles
Sweden	23	0,30	16	25	0,30	
Switzerland	8	0,35	8	21	0,41	
Turkey	11	0,01	11	31	0,27	
United Kingdom	17	0,15	13	22	0,16	
United States	24	0,21	10	27	0,25	
Euro area	13	0,38	-	-	-	similar period of cycles

Table 8: Cyclicality of the rate of unemployment according to unobserved components models

Country	1 cycle		2 cycles			Remarks
	Period in quarters	R_d^2	Period in quarters	Period 2 in quarters	R_d^2	
Australia	18	0,25	11	20	0,31	
Austria	8	0,16	8	30	0,34	
Belgium	15	0,12	22	44	0,18	
Canada	10	0,27	10	36	0,31	
Czech Republic	8	0,05	8	23	0,14	
Denmark	10	0,35	11	21	0,39	
Estonia	18	0,30	13	19	0,34	
Finland	10	0,55	10	21	0,55	
France	12	0,47	12	23	0,49	
Germany	9	0,87	9	16	0,87	
Greece	10	0,39	-	-	-	similar period of cycles
Hungary	9	0,29	9	16	0,38	
Ireland	12	0,50	12	22	0,52	
Israel	10	0,27	-	-	-	similar period of cycles
Italy	22	0,28	-	-	-	shortcycles
Japan	14	0,10	-	-	-	similar period of cycles
Korea	11	0,20	11	24	0,27	
Luxembourg	8	0,46	8	20	0,50	
Netherlands	13	0,17	13	36	0,27	
New Zealand	10	0,20	11	25	0,24	
Norway	45	0,06	23	47	0,07	
Poland	20	0,46	20	43	0,52	
Portugal	13	0,32	13	40	0,39	
Slovak Republic	10	0,45	9	21	0,53	
Slovenia	25	0,16	24	30	0,17	
Spain	12	0,64	12	33	0,64	
Sweden	19	0,39	-	-	-	similar period of cycles
Switzerland	23	0,23	12	25	0,27	
Turkey	7	0,53	7	17	0,63	
United Kingdom	20	0,64	12	21	0,67	
United States	27	0,20	11	31	0,28	
Euro area	13	0,74	-	-	-	similar period of cycles

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Table 9: Cyclicality of inflation rate according to unobserved components models

Country	1 cycle		2 cycles			Remarks
	Period in quarters	R_d^2	Period in quarters	Period 2 in quarters	R_d^2	
Australia	18	0,08	12	26	0,11	
Austria	7	0,08	11	39	0,08	
Belgium	10	0,06	10	34	0,18	
Canada	12	0,20	12	29	0,27	
Czech Republic	9	0,31	-	-	-	similar period of cycles
Denmark	12	0,13	12	28	0,16	
Estonia	14	0,41	13	21	0,46	
Finland	13	0,09	8	28	0,20	
France	9	0,38	8	20	0,45	
Germany	8	0,06	8	37	0,10	
Greece	20	0,13	10	26	0,21	
Hungary	20	0,08	10	24	0,11	
Ireland	21	0,07	20	43	0,09	
Israel	18	0,31	10	19	0,34	
Italy	10	0,23	10	31	0,27	
Japan	14	0,11	12	25	0,14	
Korea	10	0,15	14	32	0,12	
Luxembourg	9	0,04	9	33	0,16	
Netherlands	6	0,09	6	36	0,12	
New Zealand	11	0,17	10	21	0,23	
Norway	11	0,11	11	24	0,18	
Poland	6	0,66	-	-	-	similar period of cycles
Portugal	10	0,13	10	27	0,14	
Slovak Republic	8	0,28	8	24	0,39	
Slovenia	10	0,24	9	19	0,28	
Spain	12	0,07	12	26	0,10	
Sweden	14	0,09	10	18	0,12	
Switzerland	8	0,07	8	34	0,20	
Turkey	8	0,10	8	17	0,15	
United Kingdom	19	0,12	9	21	0,22	
United States	22	0,14	10	22	0,16	
Euro area	11	0,25	9	17	0,30	

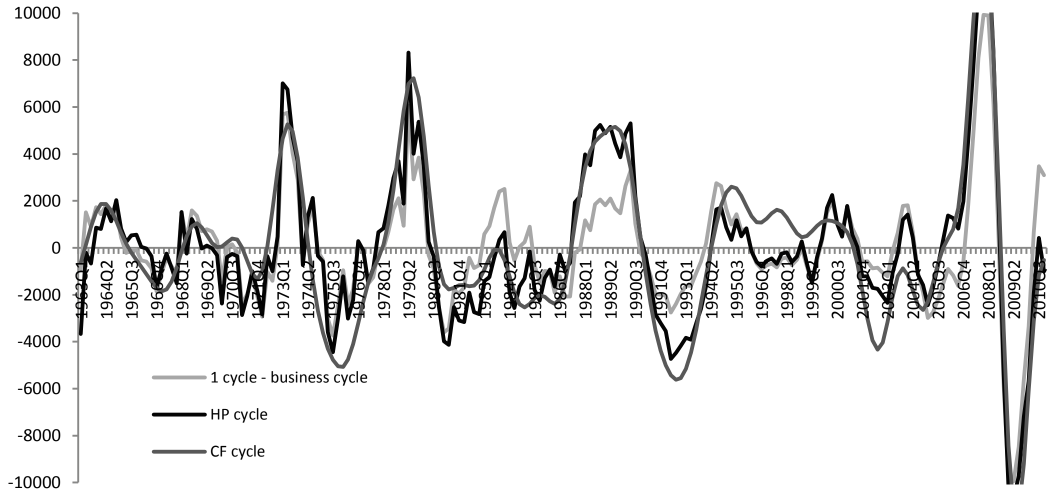
Table 10: Cyclicality of CLI according to unobserved components models

Country	*1 cycle*		*2 cycles*			*Remarks*
	Period in quarters	R_d^2	*Period in quarters*	*Period 2 in quarters*	R_d^2	
Australia	11	0,52	-	-	-	similar period of cycles
Austria	8	0,54	-	-	-	similar period of cycles
Belgium	11	0,29	11	22	0,36	
Canada	9	0,39	-	-	-	similar period of cycles
Czech Republic	8	0,56	-	-	-	similar period of cycles
Denmark	11	0,29	10	32	0,34	
Estonia	-	-	-	-	-	shortcycles
Finland	12	0,17	12	24	0,27	
France	11	0,33	11	22	0,39	
Germany	14	0,26	7	16	0,34	
Greece	11	0,48	-	-	-	longcycles
Hungary	7	0,44	-	-	-	similar period of cycles
Ireland	14	0,23	12	24	0,28	
Israel	12	0,21	8	20	0,29	
Italy	11	0,37	-	-	-	similar period of cycles
Japan	13	0,14	12	31	0,22	
Korea	10	0,46	-	-	-	similar period of cycles
Luxembourg	12	0,26	12	22	0,34	
Netherlands	8	0,46	-	-	-	similar period of cycles
New Zealand	11	0,22	10	34	0,25	
Norway	14	0,17	-	-	-	similar period of cycles
Poland	15	0,55	15	31	0,55	
Portugal	6	0,37	-	-	-	similar period of cycles
Slovak Republic	6	0,42	-	-	-	similar period of cycles
Slovenia	-	-	-	-	-	shortcycles
Spain	12	0,37	12	22	0,40	
Sweden	19	0,13	13	30	0,18	
Switzerland	12	0,30	11	25	0,35	
Turkey	11	0,11	10	42	0,19	
United Kingdom	8	0,18	7	20	0,28	
United States	9	0,24	-	-	-	similar period of cycles
Euro area	13	0,32	12	28	0,34	

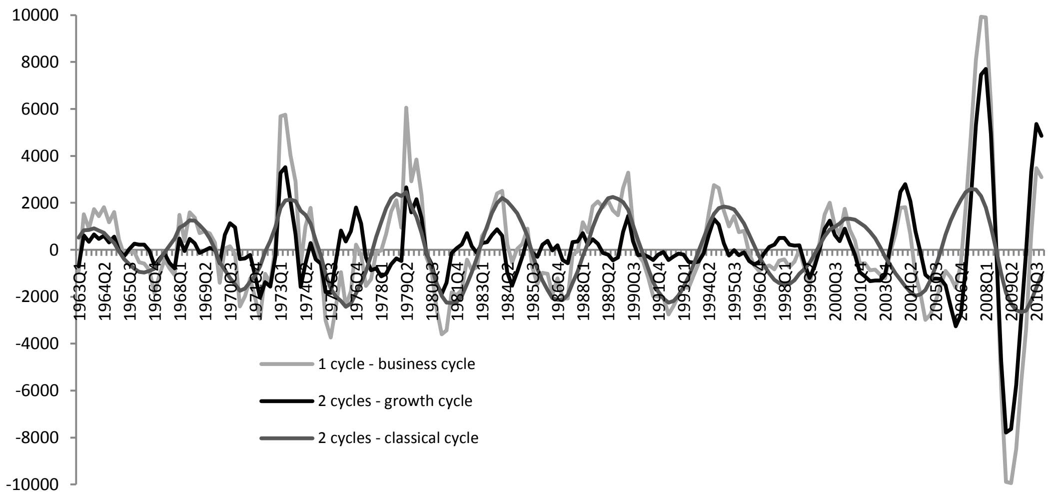
Appendix C

FIGURE 5: COMPARISON OF THE UNOBSERVED COMPONENTS MODELS ESTIMATED FOR THE UK

a) One cycle model and ad hoc filters



b) One cycle model and two cycles model



c) Two cycles model and ad hoc filters