Cycles in the Euro-zone
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Luxembourg: Office for Official Publications of the European Communities, 2003

ISBN 92-894-5387-7
ISSN 1725-4825

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Cycles in the Euro-zone

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Abstract: This paper investigates the relationships between the estimates of cycle attained by applying Dynamic Factor Analysis, Hodrick and Prescott and Baxter-King filters to three important sources for economic analysis: Industrial Production index, Business Surveys and GDP. The analysis is conducted for the Euro-zone using direct and indirect approaches to compute Euro-zone aggregate.

Keywords: Business cycle extraction, Baxter-King filter, Hodrick Prescott filter, Dynamic Factor Analysis.

1. Introduction

The identification of the Euro-zone Business Cycle is a major issue for the short-term economic analyst. On the one hand, the economist can easily comment, from this cycle estimate, on the current evolution of the economy and on the other hand, he can use it to define some leading indicator.

Nevertheless, to estimate the Business Cycle, the analyst has to face two main problems. The first one is the multiplicity of economic indicators depicting the many faces of the economic activity: Industrial Production Index, Business Climate, GDP etc. The second one is the multiplicity of statistical methods to extract the so-called “cycle” from an economic indicator. The most common statistical tools to extract the cycle are the Baxter-King filter (1995, [1]) and the Hodrick-Prescott filter (1981, [2]).

Business surveys are also often used by economists to assess the situation of the various economies. Recently, some studies have been conducted to construct coincident or leading indicators from them, for Member States but also for the Euro-zone (Doz and Lenglart [4] [5], Forni and al [7] [8], INSEE [10], and Saint-Aubin [13]). DG ECFIN publishes, on a regular basis, a leading indicator, the so-called “business climate” computed from these surveys. The construction of this indicator is based on Dynamic Factor Analysis and it is defined as the common factor of a set of business survey indicators. Similar indicators have been compiled at the national level (INSEE [10]) making use of the same methodology. These tools are briefly introduced in Section 2.

Moreover, as most of the European indicators are computed from Member States data, the cycle estimate can be derived from the aggregation of national cycles (the so-called “Indirect approach”) or from the European aggregate (the “Direct approach”).

This paper investigates the relationships between the various estimations of the cycle one
can get by applying the various methods to the various economic indicators (see also Canova [3], for a similar analysis on US economic series).

The analysis focuses on three important macro-economic indicators:

- **Industrial Production Index (IPI)**, that measures the physical volume of output of the nation's manufacturing sector, broadly used as a proxy measure for the aggregate economy.
- **Gross Domestic Product (GDP)**, considered the most important economic indicator. It represents a broad measure of economic activity and signals the direction of overall aggregate economic activity.
- **The Business Climate**, derived from the Industrial Business Surveys (BS), typically used to predict the turning points of total industrial production or gross domestic product in industry, but also used as a proxy measure for GDP.

Three different strategies are used:

- The first one (Cycle 1) is obtained by applying the HP or BK filter to the Euro-zone aggregate. This is the direct approach where each country, in the construction of the aggregate, has got a weight proportional to the size of its industrial sector or its GDP.
- The second one (Cycle 2) is computed in two steps. First, a cycle is computed for each country by applying a HP or BK filter to the national indicator. The twelve national cycles are then reduced to a unique Euro-zone cycle by using a Dynamic Factor Analysis. In this approach, the countries are not weighted (HP/BK then DFA).
- The third one (Cycle 3) is also obtained by a two step procedure. First, the twelve national indicators are summarised by using a Dynamic Factor Analysis. The Euro-zone cycle is then derived by applying a HP or BK filter to the common factor. In this approach, the countries are not weighted (DFA then HP/BK).

The various estimations of the cycle for the three macroeconomic indicators are presented in Section 3 and compared in Section 4.

The results obtained in this paper show that both filters give generally the same indications about the state of the economy. On one hand, the Baxter-King filter gives smoother cycles easier to interpret, but on the over hand, does not give reliable estimations for the end of the series.

The main differences do not come from the filter used but from the indicator on which cycle estimates are based. In particular, the cycles based on the Business Climate look smoother, due to the dynamic factor analysis used in the construction of the basic indicator. They also appear, as one would have expected, to lead in some occasions the cycles based on IPI and GDP.

The impact of the German unification is more visible on the GDP than on the BC or on the IPI. For the GDP an indirect approach seems to be more appropriate: as the countries are not weighted, the German figures do not get the same importance than in the direct approach. In this particular case, the indirect approaches give more robust estimates of the cycle. But if we consider only the period after 1991, direct and indirect approaches give very similar results.
2. Methodology

2.1 The data

Industrial production indexes, computed on a monthly basis by the Euro-zone Member States, measure the changes in industrial production activity (excluding Construction). They are considered as key indicators and are often used as a proxy of the Gross Domestic Product (GDP) evolution, given that Industrial sector represents more than 50% of the variations of the Eurozone GDP.

Business surveys are conducted every month by the European Commission (Economic and Financial Affairs Directorate General) in the main sectors of European economies. They are essentially qualitative surveys that collect opinions directly from managers. As they are fast and generally considered to be reliable, they are often used by economists to assess the situation of the various economies. DG ECFIN publishes, on a regular basis, a leading indicator, the so-called “business climate” computed from these surveys by applying a Dynamic Factor Analysis.

Quarterly National Accounts (QNA) give a complete and coherent picture of the economic situation. As not all Member States compile QNA, Euro-zone aggregates are currently compiled through an estimation procedure based on the sum of seasonally adjusted data for the available Member States.

All these indicators have been seasonally adjusted before the cycle extraction.

2.2 Factor Analysis

Factorial analysis is a statistical technique used to summarise the information of a set of variables by a single “common factor”. Therefore, the purpose of factorial analysis is on one hand to reduce the number of variables and on the other hand to detect a structure in the relationships between variables.

Factorial analysis assumes it is possible to describe the relationship among original variables by means of a set of unobserved quantities called factors. These factors may be associated with all variables (the common factors) or specific to a variable (unique factors).

Let:
- \( I \) be the number of variables and \( J \) the number of common factors \((J \ll I)\);
- \( T \) be the number of observations for each variable;
- \( y_{it} \) represents the value of a variable \(y_i\) in time \(t\);
- \( F_{jt} \) represents the value of the common factor \(F_j\) in time \(t\);
- \( u_{it} \) represents the value of the specific factor \(u_j\) in time \(t\).

The factor model that describes the original variables as a function of the unobserved variables \( F_1, F_2, \ldots, F_J \) (common factors) and the additional sources of variation \( u_1, u_2, \ldots, u_T \) (specific factors) can be written as follows:

\[
y_{it} = \lambda_{i1} F_{1t} + \lambda_{i2} F_{2t} + \cdots + \lambda_{ij} F_{jt} + u_{it} \quad \text{for } i=1,2,\ldots,I \text{ and } t=1,2,\ldots,T
\]

The weights (loadings) \( \lambda_{ij} \) relate the specific association between factors and original variables. They are the contributions of the factor \( F_j \) for the evolution of the variable \( y_i \).
The original variables are supposed to be centred. The specific factors and the common factors are supposed to be uncorrelated.

This static analysis can be extended to time series analysis (Doz and Lenglart [4] [5], Forni and al [7] [8]), taking into account the dynamic relationships existing between the indicators.

2.3 Cycle extraction

"Why is it that, in capitalist economies, aggregate variables undergo repeated fluctuations about trend, all of essentially the same character? Prior to Keynes’ General Theory, the resolution of this question was regarded as one of the main outstanding challenges to economic research, and attempts to meet this challenge were called business cycle theory." (Lucas, 1977).

The challenge is still present and during the last years there has been a large debate regarding the capabilities of different statistical methods to decompose time series into trend and cycle. Among them, the Baxter and King and Hodrick Prescott filter are often used techniques.

2.3.1 The Hodrick Prescott filter

The Hodrick Prescott filter (HP) assumes that an observed time series $y_t$ is the sum of a cyclical component and a growth component. The deviations with respect to the growth component are, on average, zero for long periods of time. A measure of smoothness for the trend component is the sum of the squares of its second differences. The HP filter chooses the growth component to minimise the following loss function:

$$\min_{\tau} \sum_{t=1}^{T} \left( y_t - \tau_t \right)^2 + \lambda \sum_{t=2}^{T-1} \left( \tau_{t+1} - \tau_t \right) \left( \tau_t - \tau_{t-1} \right)^2$$

where $\lambda$ is the smoothness parameter. When $\lambda=0$, the growth component is simply the series and when $\lambda$ approaches infinity, the growth component approaches a linear trend. The default values are usually $\lambda=1600$ for a quarterly series and $\lambda=14400$ for a monthly series. These values suppress very low frequency fluctuations and emphasises those in a 8 year period.

2.3.2 The Baxter-King filter

The Baxter-King (BK) filter is a symmetric linear filter, a moving average, that permits to extract the cycle component from a series $X_t = T_t + C_t + I_t$, where $T_t$, $C_t$ and $I_t$ designate, respectively, the trend, the cycle and the irregular components. The trend is supposed to correspond to low frequencies and the irregular to high frequencies. The coefficients of the Baxter-King band pass filter (all the details can be found in Baxter and King [1]) are calculated so that the filter removes all the frequencies that are not associated with the business cycle. To define the filter, you have to precise its length, e.g. the number of coefficients, and the frequencies associated with the cycle.

For example:

- if you have a monthly series
- if you assume the period of the cycle to be between 3 and 6 years, e.g. associated with frequencies between $2\pi/36$ and $2\pi/36$,
• if you fix the span of the filter to 71, you will obtain the coefficients presented in Figure 1. These parameters (the span of the filter, the low and high frequencies) play the same role than the $\lambda$ parameter for the Hodrick-Prescott filter.

**Figure 1:** Baxter-King filter coefficients. Low frequency: 3 years, High frequency: 6 years.

In our example, to calculate the value of the cycle at date $t$, you need to have 35 points in the past, the current point and 35 points in the future. Therefore, to estimate the cycle for the end points, you must define 35 other filters. In the paper, the filters used at the ends of the series are symmetric filters of decreasing spans (69, 67, 65 …., 5, 3 in our example).

### 2.4 The various cycle estimates

In the applications, we will use three different estimates of the cycle for each of the HP and BK filters:

- The first one (Cycle 1) is obtained by applying the HP or BK filter to the Euro-zone aggregate. This is the direct approach where each country gets a weight proportional to the size of its industrial sector or its GDP.
- The second one (Cycle 2) is computed in two steps. First, a cycle is computed for each country by applying a HP or BK filter to the national indicator. The twelve national cycles are then summarised in a unique Euro-zone cycle by using a Dynamic Factor Analysis. In this approach, the countries are not weighted.
- The third one (Cycle 3) is also obtained by a two step procedure. First, the twelve national indicators are summarised by using a Dynamic Factor Analysis. The Euro-zone cycle is then derived by applying a HP or BK filter to the common factor. In this approach, the countries are not weighted.

*Seasonally adjusted data are used in the computations and all the cycle estimates are standardised to facilitate the comparisons.*
3. **Application to alternative cycle extractions for the Euro-zone**

3.1 **Industrial Production Index (IPI)**

Figure 2 presents the three estimates derived from the BK filter; Figure 3 those deriving from the HP filter and

In each case, one can note that the cycle estimates provide us with the same economic message, especially after 1991. Hodrick-Prescott estimates are not as smooth as the Baxter-King estimates and therefore not so easy to interpret. Nevertheless, the end points of the BK estimate do not seem very reliable, due to the estimation procedure that is based on a decreasing span symmetric filter.

**Figure 2**: IPI - Cycles for the Euro-zone – Baxter King Filter

**Figure 3**: IPI – Cycles for the Euro-zone – Hodrick Prescott Filter
Cycle in the Euro-zone

Figure 4: IPI – Direct Cycles for the Euro-zone – Baxter King and Hodrick Prescott Filters

A more cautious analysis of the graphs shows that turning points are sometimes different. Table 1 presents the chronology of the turning points for each cycle estimate. Nevertheless it is difficult to detect any systematic delay, especially during the last period.

Table 1: Turning point chronology for the Euro-zone IPI,

<table>
<thead>
<tr>
<th></th>
<th>Baxter-King</th>
<th></th>
<th>Hodrick-Prescott</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cycle 1</td>
<td>Cycle 2</td>
<td>Cycle 3</td>
</tr>
<tr>
<td>Max</td>
<td>SEP90</td>
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<td>APR90</td>
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<tr>
<td>Max</td>
<td>NOV99</td>
<td>NOV99</td>
<td>NOV99</td>
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</tbody>
</table>
3.2 Gross Domestic Product (GDP)

The same exercise is done for the Euro-zone GDP and the results are displayed in Figures 5, 6 and 7.

**Figure 5:** GDP - Cycles for the Euro-zone – Baxter King Filter

![GDP - Cycles for the Euro-zone – Baxter King Filter](image1)

**Figure 6:** GDP - Cycles for the Euro-zone – Hodrick Prescott Filter

![GDP - Cycles for the Euro-zone – Hodrick Prescott Filter](image2)
The graphs reveal a strong difference between the direct and the two indirect approaches at the beginning of the period, before 1991. This is of course an effect due to the German unification. The indirect approaches, in which the countries are not weighted, is less affected by this effect.

After 1991, the economic message given by each cycle estimate is quite the same. As in the IPI case, one can note some differences in the turning point timing (see Table 2) but it is impossible to come to any systematic conclusion.

Table 2: Turning point chronology for the Euro-zone GDP.

<table>
<thead>
<tr>
<th></th>
<th>Baxter-King</th>
<th>Hodrick-Prescott</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cycle 1</td>
<td>Cycle 2</td>
</tr>
<tr>
<td>Min</td>
<td>87Q3</td>
<td>87Q2</td>
</tr>
<tr>
<td>Max</td>
<td>89Q2</td>
<td>90Q1</td>
</tr>
<tr>
<td>Min</td>
<td>90Q1</td>
<td>91Q1</td>
</tr>
<tr>
<td>Max</td>
<td>91Q3</td>
<td>92Q1</td>
</tr>
<tr>
<td>Min</td>
<td>93Q3</td>
<td>93Q3</td>
</tr>
<tr>
<td>Max</td>
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<td>95Q1</td>
</tr>
<tr>
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<td>96Q3</td>
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<tr>
<td>Max</td>
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<tr>
<td>Min</td>
<td>99Q1</td>
<td>99Q1</td>
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</tbody>
</table>
3.3 Business Climate (BC)

In this case, the basic European and national indicators are computed as the first factor of a Dynamic factor Analysis performed on the main variables of the business survey in Industry. The results of the cycle extractions are displayed in Figures 8, 9 and 10.

Figure 8: BC - Cycles for the Euro-zone – Baxter King Filter

![Figure 8: BC - Cycles for the Euro-zone – Baxter King Filter](image1)

Figure 9: BC - Cycles for the Euro-zone – Hodrick Prescott Filter

![Figure 9: BC - Cycles for the Euro-zone – Hodrick Prescott Filter](image2)
As the basic indicator result from a first smoothing through Dynamic Factor Analysis, the cycle estimates are also smoother, especially the ones obtained by applying a Hodrick-Prescott filter. All the estimates are very close to each other and depict the same economic history. We still have the same problems we encountered in the IPI and GDP cases, in the estimation of the end points with the Baxter-King filter.

### Table 3: Turning point chronology for the Euro-zone Business Climate.

<table>
<thead>
<tr>
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<th>Baxter-King</th>
<th>Hodrick-Prescott</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cycle 1</td>
<td>Cycle 2</td>
</tr>
<tr>
<td>Max</td>
<td>APR89</td>
<td>JUN89</td>
</tr>
<tr>
<td>Min</td>
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<td>MAY91</td>
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<tr>
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<td>APR00</td>
<td>MAR00</td>
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The chronology of the turning points, presented in Table 3, is a bit different. No clear rule can be derived but it seems that the Hodrick-Prescott cycle 2 estimate, e.g. the first common factor of national cycle estimates, leads a bit the other estimates.
4. Global Comparison of BC, IPI and GDP Cycles in the Euro-zone

Figures 11 and 12 compare the cycle estimates obtained from the different indicators (BC, IPI and GDP). The “cycle 2” indirect approach has been used as in this case the estimates are not really affected by the German unification effect. If the story remains the same, we can detect now a quite strong difference in the timing of the turning points. Table 4 summarises the results. It appears that the cycle estimates computed from the BC indicator seem to lead estimates based on the IPI.

Table 4: Turning point chronology for the Euro-zone (Cycle 2 approach).

<table>
<thead>
<tr>
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<th>Baxter-King</th>
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<th>Hodrick-Prescott</th>
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<tbody>
<tr>
<td></td>
<td>BC</td>
<td>IPI</td>
<td>GDP</td>
<td>BC</td>
</tr>
<tr>
<td>Max</td>
<td>JUN89</td>
<td>AUG89</td>
<td>90Q1</td>
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<td>Max</td>
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Table 5 shows the correlations between the “cycle 2” estimates and confirms the good link that exists between the cycle estimations for each indicator, especially for the BK filter.

Table 5: Correlations between “Cycle 2” estimates.
5. Conclusions

In this paper we compared three alternative approaches for extracting cycle from Euro-zone macroeconomic indicators with two different filters: Hodrick-Prescott Direct and Baxter King.

There is no definitive theoretical criterion in favour of one of the statistical approaches to extract cycle and decisions can only be taken on the basis of empirical evidences. If the Baxter-King filter gives smoother cycles than the Hodrick-Prescott, the estimation of the end points seem less reliable.

The results obtained in this paper show that both filters give generally the same indications about the state of the economy.

The main differences do not come from the filter used but from the indicator on which cycle estimates are based. In particular, the cycles based on the Business Climate look smoother, due to the dynamic factor analysis used in the construction of the basic indicator. They also appear, as one would have expected, to lead in some occasions the cycles based on IPI and GDP.

The impact of the German unification is more visible on the GDP than on the BC or on the IPI. For the GDP an indirect approach seems to be more appropriate: as the countries are not weighted, the German figures do not get the same importance than in the direct approach. In this particular case, the indirect approaches give more robust estimates of the cycle. But if we consider only the period after 1991, direct and indirect approaches give very similar results.
References