Do survey indicators let us see the business cycle ? A frequency decomposition

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Abstract

This paper uses a frequency domain approach to gain insight into the correlation between survey indicators and year-on-year GDP growth.

Using the Baxter-King filter, we split up each series into three components: a short-term, a business cycle (oscillations between 18 and 96 months) and a long-term component. We then calculate how much of the variation of the survey series and GDP growth can be ascribed to these different components. Finally, we use this information together with an analysis of the correlation between survey indicators and year-on-year GDP growth at the different frequencies to explain their overall correlation.

We show that survey indicators, similar to year-on-year GDP growth, do not perfectly reflect business cycle movements but contain cycles of other frequencies. Long-term cycles, in particular, are a nontrivial part of the series' variance. Furthermore, there exist some clear relations between the weight of these cycles in the survey indicators and their correlation with GDP growth. In general, the larger the business cycle component, the larger the correlation, while the opposite is true for the short-term component. The evidence for the long-term component is mixed: although a long-term component seems necessary as the correlation at this frequency is the highest, strong or weak long-term components are typically idiosyncratic, dragging down the overall correlation between the indicator and year-on-year GDP growth.

The paper applies this methodology to the euro area countries (EC survey indicators) and to Belgium separately (NBB business survey indicators). The results are highly comparable.

Key Words: Baxter-King, spectral analysis, survey indicators, correlation.
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TABLE OF CONTENTS

1. INTRODUCTION

Survey data are highly valued by researchers and practitioners interested in tracking and assessing the business cycle. Despite the progress made by statistical agencies in speeding up and broadening the dissemination of quantitative activity and demand statistics - such as quarterly national accounts or monthly industrial production and turnover indices - the survey indicators are still considered to convey useful and timely information. Indeed, they cover questions such as appraisal and anticipation of economic agents, which are important in many economic issues but difficult to measure with traditional statistics. Also in terms of actual developments, they provide a timely and good picture of the current evolution of activity.

In particular, survey indicators are in general strongly correlated with year-on-year GDP growth, which is a widely-used benchmark for the business cycle. However, from daily practice we know that year-on-year GDP growth not only exhibits the textbook business cycle movements - with a periodicity between 1.5 and 8 years -, but also contains cycles of other frequencies. The aim of this paper is to look at the importance of these cycles in both GDP growth and survey indicators. For each series, we identify a business cycle component (business cycle frequencies), a short-term irregular component (high frequencies) and a long-term component (low frequencies). Furthermore, we will investigate how these different frequencies interact to help explain the overall correlation between survey indicators and year-on-year GDP growth.

The analysis will first be conducted in a standardised manner for the euro area countries, in order to detect general features for the harmonised EC survey indicators. In a second step, those stylised facts will be checked for the NBB business survey indicators, which are widely used to assess the cyclical position of the Belgian economy. Furthermore, the respective information content and the quality of the NBB survey indicators to track Belgian real GDP growth will be tested within this framework.

Among the various methods proposed in the literature to disentangle different frequency components in a time series, the Baxter-King filter (1999) suits the purpose of our analysis well. Derived in the frequency domain (spectral analysis), it provides a decomposition of the variance of a series into mutual orthogonal components each associated with a particular frequency band. Through the use of well-designed moving average filters, these components can easily be represented in the time domain. It also has the advantage of leaving the frequency components unaffected over the entire frequency domain, due to its symmetry and linearity. While it is an important drawback for a real-time analysis of the business cycle position, the data loss at the start and the end of the sample period inherent to the Baxter-King filter is less problematic in the case of an ex-post descriptive analysis like that conducted in this paper.

Examples of studies employing spectral analysis to survey indicators include Nunes and Rua (2003) and Owens and Sarte (2005). The first study analyses correlations at different frequencies. However, the authors only examine the business cycle frequency band. Their main finding is that correlations with GDP depend on the subsection of the business cycle frequency band considered. The second study calculates the relative size of the business cycle component in survey indicators, as an indication of their usefulness to track GDP growth. However, correlations with GDP growth are not investigated and thus relationships which might exist at the other frequencies are ignored. Our paper differs from these studies since we not only analyse the business cycle frequency band, but also the other (short and long-term) frequencies. Furthermore, besides the relative size of these

frequencies, we will analyse the correlation between survey indicators and year-on-year GDP growth at each frequency to gain insight into their overall correlation.

The paper is organised as follows. Section 2 describes the Baxter-King filter, which is used to decompose the series into a short-term, a business cycle and a long-term component. Furthermore, it presents its analytical properties, motivating its usefulness for the analysis carried out in this paper. Section 3 describes the data set. Section 4 reports in a synthetic way the empirical results for the euro area countries. It is divided into four parts. In Part 1, the survey indicators and year-on-year GDP growth are split into different frequency components (short-term, business cycle and long-term), while in Part 2, we calculate the relative share of these frequency components in the series' overall variance. Part 3 presents the correlations between the survey indicators and year-on-year GDP growth at the different frequencies and calculates the contributions of the latter to the overall correlation. Part 4 explores the link between the frequency weight and the (frequency) correlation to derive some "stylised facts" that allow to explain differences in correlation between survey indicators and year-on-year GDP growth. In Section 5, the same frequency analysis is applied to the monthly gross NBB business survey indicators in order to assess their quality to track Belgian GDP growth. The following issues are considered, firstly the differences in correlation between the various sub-indicators from the NBB business survey and GDP growth are explained by their frequency decomposition (Part 1). Next, the quality of the NBB survey indicators is further assessed by analysing the effect that the specific *"NBB smoothing method"* (NBB, 1990) has on the frequency composition of the survey indicators (Part 2). Finally, Section 6 concludes.

2. METHODOLOGY: SPLITTING UP EACH SURVEY INDICATOR INTO A SHORT-TERM, A BUSINESS CYCLE AND A LONG-TERM COMPONENT

Various approaches have been developed to disentangle movements at different frequency bands from a time series. We use the Baxter-King (BK-) filter, as it presents well-suited characteristics in the context of our ex-post descriptive analysis. The filter is based on concepts of the frequency domain and is applied to the data in the time domain, combining appealing properties of the former and relative ease of use in the latter.

According to the spectral representation theorem, a stationary time series can be represented as the sum of an infinite number of uncorrelated periodic components. Thus, the variance of a series can be decomposed into mutual orthogonal components each associated with a particular frequency band (Granger and Hatanaka, 1964; Hamilton, 1994). For that, an ideal band-pass filter *B** is applied; it multiplies the frequencies of interest by 1 and the frequencies outside this band by 0. The function which represents the factors by which the frequencies are transformed is called the *"gain function"* of the filter:

$$B^*\left(e^{-i\omega}\right), \text{ with } \omega \text{ the frequency and } i \text{ the imaginary number} \quad (1)$$

Represented in the time domain, the ideal band-pass filter *B*(L)*, which completely blocks out the variation from frequencies outside the frequency band of interest, while retaining those inside, follows an infinite two-sided moving average representation:

$$B^*(L) = \sum_{j=-\infty}^{\infty} b_j^* L^j, \text{ with weights } b_j^* \quad (2)$$

The filtered series $\left(y_t^F\right)$, i.e. a frequency component, can thus be represented as:

$$y_t^F = B^*(L)y_t \tag{3}$$

Suppose we are interested in fluctuations with a periodicity between P_U and P_L, where P_U represents the upper and P_L the lower boundary for the wavelength expressed in months or quarters, then the weights of the ideal band pass-filter are given by the formula:

$$b_0^* = \frac{\omega_L - \omega_U}{\pi} \text{ and } b_j^* = \frac{\sin(j\omega_L) - \sin(j\omega_U)}{\pi j}, \text{ for } j \neq 0 \tag{4}$$

$$\text{with } \omega_u = \frac{2\pi}{P_u} \text{ and } \omega_l = \frac{2\pi}{P_L} \quad (0 < \omega_u < \omega_L < \pi)$$

However, ideal band-pass filters only hold for infinite time series. Baxter and King (1999) proposed to approximate the ideal band-pass filter by a two-sided symmetric finite order moving average, constructed by truncating the filter weights at lag *K*:

$$B(L) = \sum_{k=-K}^{K} b_k L^k \text{, with weights } b_k \tag{5}$$

The optimal approximating filter weights b_k are calculated by minimising the quadratic deviation between the gain of the ideal filter and the approximate band-pass filter:

$$\min \int_{-\pi}^{\pi} \left| B^*\left(e^{-i\omega}\right) - B\left(e^{-i\omega}\right) \right|^2 d\omega \tag{6}$$

The approximation of the ideal band-pass filter comes at the cost of leakage (gain function outside the frequency band of interest is not equal to 0) and distortion (gain function inside the frequency band of interest is not equal to 1). Reducing the approximation cost requires to expand the span of the filter, which in turn implies an increasing loss of data due to truncation length. Baxter and King advocate the use of a three-year truncation lag as a good trade-off position between data loss and the quality of the approximation. Therefore, as in other applications of the BK-filter[1], we take *K=36* in the case of monthly data and *K=12* for quarterly data.

The BK-filter allows the researcher to specify the length of the components to be isolated. Following Burns and Mitchell (1946), we define the business cycle component as oscillations between 18 and 96 months. As such, our short-term component will contain all variations of higher frequencies (between 2 and 18 months), while the long-term component will contain the variations of low frequencies (> 96 months). These components can be found by applying BK-filters with the frequency band of interest listed in the table below:

[1] See e.g. Kouparitsas (2003), Massmann and Mitchell (2004).

Baxter-King filter for different frequency bands

Filter	Result	Frequency band of interest			
		Monthly data		Quarterly data	
		Months	Frequency	Quarters	Frequency
		P_L-P_U	$[\omega_L; \omega_U]$	P_L-P_U	$[\omega_L; \omega_U]$
High-pass filter	Short-term component	2-18	$[\pi;\pi/9]$	2-6	$[\pi;\pi/3]$
Business cycle filter	Business cycle component	18-96	$[\pi/9;\pi/48]$	6-32	$[\pi/3;\pi/16]$
Low-pass filter	Long-term component	> 96	$[\pi/48; 0]$	>32	$[\pi/16; 0]$

The gain function of these filters, taking *K=36* for monthly data, is illustrated in Figure 1. As can be seen, differences with respect to the ideal filters are small. In fact, Baxter and King showed that these filters are optimal finite order approximations of *B*(L)* in the sense that their gain is as close as possible to the gain of the ideal filter for a K-order linear filter[2].

(Insert Figure 1 here)

While other approximate finite filters have been proposed, for example by Hodrick and Prescott (1980, 1997) or by Christiano and Fitzgerald (2003), the BK-filter has properties which are useful for the purposes in this paper:

First, as the filter is linear and the gain function approximates that of an ideal band-pass filter, it leaves the amplitude of the extracted components largely unaffected, and one thus can extract an unaffected component for any specified range of periodicity.

Furthermore, since the BK-filter is symmetric, it does not introduce phase shifts, so the timing of the relationship between series at a particular frequency is unaffected.

Finally, due to the orthogonality of the components and the linearity of the filter, the sum of the different frequency components delivers the original series. The latter is particularly useful when calculating basic descriptive statistics such as the weight of the different frequency components in the series' total variance. However, while the extracted components are as close as possible to orthogonal, the sum of the variances in a finite sample will not exactly equal the overall variance of the series. This is due to some limited residual correlation between the components as the sample is not infinite. Taking into account these remaining covariances, the weight of a particular frequency component in the overall variance is calculated as the sum of the component's variance and its covariance with the other components, divided by the series' overall variance:

So for a given series *y*:

$$\text{Weight ST} = \frac{\text{var(ST)} + \text{cov(ST, BC)} + \text{cov(ST, LT)}}{\text{VAR(y)}} \tag{7a}$$

represents the share of the short-term *(ST)* component in the series' total variance;

$$\text{Weight BC} = \frac{\text{var(BC)} + \text{cov(BC, ST)} + \text{cov(BC, LT)}}{\text{VAR(y)}} \tag{7b}$$

[2] The weights of the different BK-filters applied in this paper are reported in the Appendix.

represents the share of the business cycle *(BC)* component in the series' total variance;

$$\text{Weight LT} = \frac{\text{var(LT)} + \text{cov(LT, ST)} + \text{cov(LT, BC)}}{\text{VAR(y)}} \tag{7c}$$

represents the share of the long-term *(LT)* component in the series' total variance.

The main disadvantage of the BK-filter, i.e. the loss of three years of data at both the beginning and the end of the sample period, is relatively benign in the context of an ex-post descriptive analysis of the statistical properties of the series. However, it would limit the usefulness of the filter for a real-time assessment of the business cycle.

3. DATA SET

The analysis consists mainly in comparing the statistical properties of real GDP growth and of business survey indicators, across the euro area countries (Section 4) and in greater detail for Belgium separately (Section 5).

Quarterly GDP data at constant prices and adjusted for seasonal and calendar effects for the euro area member states were taken from Eurostat, with the exception of Ireland and Portugal which were drawn from the OECD Economic Outlook database due to the availability of longer time-series. Series for the euro area aggregate were obtained from the ECB. All GDP series start in 1980Q1, with the exception of Austria (1988Q1) and Germany (1991Q1), and end in 2007Q1. Due to the methodology applied, three years of observations are lost at the beginning and end of each series (both survey and GDP data). Results are therefore reported until 2004Q1, with varying starting points depending on the series availability.

Business and confidence indicators cover the complete set of seasonally adjusted monthly individual sub-indicators - i.e. the various questions of the monthly surveys - and aggregate confidence indicators published by the European Commission (DG ECFIN) for the euro area and its member states, with the exception of Luxembourg and Slovenia. The data set includes survey data for industry, construction, retail trade, services and consumers. In general, indicators are available from January 1985 with a few exceptions for some countries. Survey data on the services sector in general start in 1995. This gives us 40 series of monthly survey indicators for each country and the euro area aggregate. As such, the data set contains in total 480 survey data series. For reasons of presentation, in Section 4, results in the tables are shown as averages across countries for each question.

In Section 5, the in-depth analysis for Belgium is mainly based on the monthly business survey indicators published by the NBB. There, the database usually starts in January 1980, except for the business service sector (July 1994).

Results reported for survey data were calculated using monthly observations (e.g. variance decomposition). Comparisons between survey data and GDP (e.g. correlation analysis) are based on a quarterly basis, by taking averages over the quarter for the survey data. For the latter, time-spans of GDP and survey data were balanced[3].

[3] Taking account of the data loss caused by the BK-decomposition, the survey series in most cases contain 258 monthly observations (86 quarterly observations). For the services indicators, the sample counts 84 monthly observations (28 quarterly observations).

4. STYLISED FACTS ABOUT THE INFORMATION CONTENT OF BUSINESS CYCLE SERIES IN THE EURO AREA COUNTRIES

4.1. Choice of a reference series and cyclical properties

Business cycle movements are commonly understood as *"a type of fluctuation found in many economic activities"*[4]. As such, they are not directly captured by the observation of a specific variable, but should be derived as common factors affecting a broad set of economic series. However, it is common practice to use year-on-year GDP growth in volume terms as reference variable. This choice can be motivated by the following reasons:

- GDP is an aggregate measure that summarises the development of value added, of final demand and of income across sectors, thus covering a large number of economic variables. In addition, its movements are strongly correlated with other cyclical variables, such as employment;

- while GDP in level series contains a stochastic trend, taking the growth rate, or other difference-transformation, of GDP leads to a stationary series. This is more in line with the concept of a business cycle, i.e. some periodic fluctuation within bounded ranges;

- next to trend evolution, irregular movements should also be excluded from a pure business cycle reference variable. Therefore, year-on-year growth is preferred above quarter-on-quarter growth, as the short-term component dominates the variance of the latter.

In fact, there seems to be a consensus that survey indicators are most useful to track year-on-year GDP growth rather than quarter-on-quarter GDP growth. This is shown in Gayer (2005) and ECB (2006), for instance. As an example of the relatively strong co-movements between the EC survey indicators and year-on-year GDP growth, maximum absolute cross-correlations with their appropriate sign are reported in Table 1. For all 40 indicators, the absolute value of the correlation with year-on-year GDP growth is higher than with quarter-on-quarter GDP growth.

(Insert Table 1 here)

Application of the Baxter-King filter to the year-on-year GDP growth and the EC business and consumer surveys delivers three separate components for each series: a short-term (< 1.5 years), a business cycle (1.5 - 8 years) and a long-term component (> 8 years). The three components, together with the original series, are illustrated in Figure 2 for GDP in the euro area and Belgium.

(Insert Figure 2 here)

Note that, due to the properties of the filter, the three first years and three last years of observations are lost, and that the sum of the three components equals the original series.

From the visual inspection of the three frequency components, it appears that the development of the year-on-year GDP growth rates is driven not only by a business cycle component, but also by a non-trivial long-term cycle. This long-term cycle should not be confused with a long-term *"trend"*, as the year-on-year GDP growth is a stationary process; it simply reflects a fluctuation of the growth

[4] Burns and Mitchell (1946).

rate with a periodicity longer than 8 years. In the euro area, two (nearly complete) long-term cycles are observed over the period 1984-2004, with peaks in 1989 and 1999. The high-frequency short-term component has relatively small amplitude and only plays a minor role in the dynamics of the series. The decomposition for Belgium provides a similar picture, even if the amplitude of the short-term and, above all, the business cycle component is larger than that for the euro area.

4.2. Variance decomposition in different frequency components

Summarising the results of the decomposition for the individual euro area countries, Table 2 shows the share of the total variance of the GDP growth rates attributable to the three components.

(Insert Table 2 here)

First, the short-term component largely dominates in the case of the quarter-on-quarter growth (right panel), counting for more than 50 p.c. of the variance in a large number of countries. This result reflects the large degree of noise, due to irregular movements, in this series, confirming its limited usefulness for business cycle analysis.

Turning to the year-on-year GDP growth, about 60 p.c. of the variation is driven by the business cycle component, while the long-term component accounts for 30 p.c. of total variance. The remaining 10 p.c. is explained by the short-term component. The results differ somewhat across countries. While GDP growth has a strong business cycle component in Austria and Belgium, as well as in Germany, France and Italy, the long-term cycle dominates in Ireland and is important in Finland and Portugal. In general, the business cycle component is stronger for the core countries of the euro area than for those at the periphery, which show evidence of long-term cycles. In some cases, the latter might be related to catching-up forces.

(Insert Table 3 here)

Table 3 presents the same results for the EC survey indicators, obtained by applying the BK-filter to the monthly observations. Although confidence indicators are developed to reflect business cycle conditions, we see that, on average, typical business cycle movements only represent 47 p.c. of the indicators' variance. Actually, as in the case of year-on-year GDP growth, their movement seems to depend in a non-trivial way on long-term cycles, which account for 35 p.c., while short-term variations explain 18 p.c. of total variance.

In general, the business cycle component dominates the aggregate confidence indicators for all sectors, except for construction, where the indicator is mainly driven by a long-term cycle. The largest business cycle components are found for the industrial confidence indicator and the Economic Sentiment Indicator (ESI), for which this frequency band accounts for over 60 p.c. of their total variation. The services and retail confidence indicators are most prone to short-term variations, which account for slightly more than 20 p.c. of their total variation. Table 4 shows for each country individually the main confidence indicators ranked according to the importance of the different frequency components. From this table and the standard deviations listed in Table 3, it is clear that the results found are relatively stable and can be generalised across countries.

(Insert Table 4 here)

Traditionally, an indicator with a strong business cycle component is regarded as having favourable properties, i.e. it tends to reflect changing business cycle conditions. Whether or not such an indicator also leads to a higher correlation with year-on-year GDP growth is uncertain, as both GDP growth and, to a larger extent, business and consumer surveys are not exclusively determined by typical business movements but contain cycles of other frequencies. As illustrated by Table 2 and 3, these other frequencies can be quite substantial. Consequently, the overall correlation between the indicators and year-on-year GDP growth will not only depend on the correlation at the business cycle frequency but also on the correlation at the short-term and long-term frequency.

4.3. Correlation between survey indicators and GDP frequency by frequency

In this section we analyse the contemporaneous correlation between the survey indicators and GDP growth frequency by frequency. Note that, alternatively, we could have analysed the maximum absolute correlation. However, the number of leads/lags that needs to be introduced to obtain the maximum cross-correlation with GDP growth is not necessarily the same for all frequency components. Moreover, it is difficult to give any interpretation on leads/lags of short-term components. In order to maintain the consistency of the decomposition, the analysis is therefore done on the contemporaneous correlation. Although the frequency components of the confidence indicators are available on a monthly basis, the correlation analysis is calculated on a quarterly basis - by taking quarterly averages of the frequency components -, as the GDP figures are only available quarterly.

(Insert Table 5 here)

In addition to the overall correlation, Table 5 shows the correlation frequency by frequency. On average the overall absolute correlation between the confidence indicators and year-on-year GDP growth amounts to 46 p.c. Looking at the different frequencies, we see that somewhat surprisingly, given the documented co-movement of macro-economic indicators at the business cycle frequency (Stock and Watson, 1999), correlations at this frequency (41 p.c.) are not higher than the overall correlation (46 p.c.). In fact, we find the highest correlation at the long-term frequency (49 p.c.). On the other hand, short-term components are hardly correlated (7 p.c.). Although the business cycle frequency is judged to be the most important, some of the correlation between confidence indicators and year-on-year GDP growth is thus caused by co-movement of their long-term cycles.

(Insert Figure 3 here)

The importance of the frequencies for the overall correlation can be formalised by calculating the contribution of the frequencies to the overall correlation. More specifically, the following relation holds:

$$\mathrm{Corr}(\mathrm{Ind}, \mathrm{GDP}) = \sum_{i} \sqrt{\mathrm{Weight\ i}_{\mathrm{Ind}} \mathrm{Weight\ i}_{\mathrm{GDP}}}\, \mathrm{Corr}(\mathrm{i}_{\mathrm{Ind}}, \mathrm{i}_{\mathrm{GDP}}) \qquad (8)$$

Where i represents the frequency components (short-term, business cycle, long-term) in the indicator (Ind) or GDP. As such, the overall correlation between the indicator and GDP is a

weighted average of the correlations per frequency, with the weight equal to the geometric average of the weights of the frequency component in the indicator and GDP growth[5].

Consequently, the contribution of frequency j to the total correlation is given by:

$$\frac{\text{Weight } j_{\text{Ind}} \text{Weight } j_{\text{GDP}} \text{Corr}(j_{\text{Ind}}, j_{\text{GDP}})}{\sum_i \sqrt{\text{Weight } i_{\text{Ind}} \text{Weight } i_{\text{GDP}}} \text{Corr}(i_{\text{Ind}}, i_{\text{GDP}})} \quad (9)$$

Applying this formula to the various EC indicators considered, it appears that the short-term component contributes on average 7 p.c. to the overall correlation, while the business cycle and long-term frequency explain respectively 51 p.c. and 42 p.c. In general, the contribution of the long-term frequency to the overall correlation is higher than its weight in the business cycle indicator and GDP, given the strong correlation at this frequency, while the opposite holds for the short-term component. As such, the long-term frequency explains a substantial part of the indicator's correlation with year-on-year GDP growth.

This is most clearly illustrated by the retail confidence indicator (Figure 3), for which the long-term cycle goes hand in hand with that of GDP growth while the correlation at business cycle frequency is only half as strong. Adding the three frequencies together gives an overall correlation of 42 p.c. between the retail confidence indicator and year-on-year GDP growth. As can be seen, the business cycles between 1993 and 2000 are far less present in the retail confidence indicator, resulting in a weak correlation at the business cycle frequency. Nonetheless, the confidence indicator more or less tracks GDP growth in this time period due to the upward long-term cycle it shares with GDP growth.

4.4. Relationship between frequency weight, frequency correlation and overall correlation

Both the weight of the frequencies in the indicators' variance and the correlation at the different frequencies intervene to determine the overall correlation between the indicator and GDP. The relationship between the frequency weight and the frequency correlation presents interesting features, which give further insight in the overall correlation between survey indicators and GDP based on a frequency decomposition. In figure 4, the upper panel plots the relationship between the share of the frequencies in the indicators' total variance and the correlation at each frequency. The bottom panel plots the relation between the share of the frequency components and the overall correlation.

(Insert Figure 4a and 4b here)

The following stylised facts can be drawn :

First, the irregular movements contained in the indicators are predominantly idiosyncratic, i.e. weakly correlated with the short-term component of GDP growth. Therefore, a large weight of the short-term component in the variance decomposition is harmful for the overall correlation.

[5] Note that this identity holds for orthogonal components. Due to the finite sample, the weighted average of the frequency correlations does not fully match the overall correlation. As the difference is small, it is equally spread among the frequency components.

Second, regarding the business cycle component, the frequency correlation is relatively high and furthermore tends to increase with the weight of the business cycle component in the indicator. As a consequence, there exists a highly significant positive relationship between this weight and the overall correlation of the indicator with GDP growth.

Third, the long-term components, i.e. cycles with a periodicity longer than 8 years, show on average the strongest correlation and thus are necessary for a well-correlated indicator, as these movements are also significantly present in the reference series. However, although necessary, containing a long-term cycle is not a sufficient condition as, in contrast to the business cycle frequency, there exists no positive relation between the weight of the long-term cycle in the indicators' variance and the correlation with GDP growth. The hump-shaped relation indicates that the long-term cycle should neither be too dominant or too weak, as in the latter cases, it tends to be idiosyncratic, lowering the overall correlation.

An example of the latter includes industry selling price expectations for the months ahead, although there is some co-movement on the business cycle frequency, overall correlation is lowered due to idiosyncratic long-term cycles.

5. A FREQUENCY DECOMPOSITION OF NBB SURVEY INDICATORS AS AN INDICATION OF THEIR QUALITY

The NBB business survey indicators are widely followed by practitioners as they provide timely information on economic activity in Belgium, but also on that in the euro area. Linking survey results to GDP growth is not always an easy task, as sometimes survey indicators tend to be disturbed by variations not contained in GDP growth. This section describes the results from a frequency analysis applied to the gross monthly NBB business survey indicators for Belgium, to give an insight into this subject. Both Belgian year-on-year GDP growth and the NBB gross monthly business survey series are split into a short-term, business cycle and long-term component.

The analysis in the previous section showed that survey indicators tend to be better correlated with GDP if they have a large business cycle component and to a certain extent also a long-term cycle, as GDP does. As we shall see, the NBB business survey indicators are on average well correlated with GDP growth as they have the desired frequency composition. However, some indicators provide disturbed signals, containing variations, mostly short-term noise or idiosyncratic long-term cycles, which are not represented in GDP. In these cases, caution should be warranted when interpreting the signals from these indicators, as they are likely not to be instructive about GDP growth.

Apart from providing insight into the different indicators' correlation with GDP growth, an application of the BK-filter to the NBB smoothed monthly business survey series, shows that the simple statistical smoothing technique that the NBB applies to the gross indicators, successfully blocks out the undesired short-term variation and keeps the data loss limited compared to more sophisticated filters, as the BK-filter in this paper .

5.1. Frequency analysis of NBB survey indicators: correlations explained

Similar to Section 4.3, Table 6 reports the overall correlation and the correlation frequency by frequency for the NBB survey indicators and GDP growth. On average the overall absolute correlation between the NBB survey indicators and year-on-year GDP growth amounts to 52 p.c. The highest correlation is found for industry (78 p.c.), the overall confidence indicator (76 p.c.) and the services sector (69 p.c.), while the correlation for the building (47 p.c.) and trade (42 p.c.) sector is substantially lower. These results are strongly comparable with the average results found for the euro area, with the exception of the services sector, for which the correlation is considerably higher in the NBB survey's case[6].

(Insert Table 6 here)

To gain insight into these correlations, a frequency decomposition is performed. A correlation analysis at the different frequencies shows similar results as the euro area: on average, the highest correlation is measured at the long-term frequency (59 p.c.), followed by the business cycle frequency (54 p.c.) and the short-term frequency (16 p.c.). Furthermore, the same relation between the weight of the different frequency components and the overall correlation with GDP is found as can be seen from Figure 4b[7]. In general, correlation will be lower as the short-term component has a higher weight, while the opposite is true for the business cycle component. As regards the long-term component, the evidence is mixed: both strong or weak long-term cycles seem to cause less correlation between the surveys and GDP growth, while a medium weight increases the correlation.

Given these relationships, the differences in correlations can be well explained by the weight of the different frequency components in the indicator:

(Insert Table 7 here)

The strong correlation of the industry and services confidence indicators with GDP growth can be explained by the large weight of the business cycle component in both indicators, as shown in the left panel of Table 7, of respectively 69 p.c. and 54 p.c. Furthermore, both indicators tend to show short-term variation only to a minor extent, which is beneficial. The same holds for the overall synthetic curve, whose correlation (76 p.c.) is marginally lower than that for the industrial indicator; most likely due to its stronger long-term cycle.

The weak correlation of the trade and construction confidence indicators has different reasons. Although the weight of the business cycle component of the trade sector is not substantially lower than the services sector, for instance, it is prone to a much higher short-term variation (21 p.c.), which drags down the overall correlation. On the other hand, rather than by a strong short-term component, the low correlation of the construction sector seems to be mainly caused by its strong

[6] This result does not seem to be influenced by the shorter sample of the services sector, as the correlation coefficient is highly significant. Furthermore, for the euro area, results were calculated over a comparable sample size.

[7] Compared to the euro area, the relationships are somewhat less strong. Furthermore, the difference between the average long-term frequency correlation and the average business cycle frequency correlation is smaller. Combined with a lower weight of the long-term frequency in Belgian GDP, this results in a relative lower contribution of the long-term frequency to the overall correlation (30 p.c.), while the contribution of the business cycle frequency is larger (54 p.c.) compared to the euro area.

long-term component. This long-term component turns out to be even somewhat more pronounced in Belgium (68 p.c.) than on average in the euro area (49 p.c.).

Another notable difference compared to the euro area is the size of the short-term component of the services confidence indicator, which is clearly lower for the NBB indicator (8 p.c.) than the average result for this indicator in the euro area (23 p.c.). These differences seem to provide some explanation for the relatively good correlation of the service indicator with GDP growth in Belgium and the relatively low correlation of the construction indicator compared to the average results of the euro area.

Although the size of the short-term component remains generally contained for the composite confidence indicators, some sub-indicators tend to show a more sizeable short-term variation, which might be harmful for their correlation with GDP growth. The largest short-term component is found for the reported trend in sales of the trade sector. More than 50 p.c. of its variation concerns oscillations between 2 and 18 months, which in principle, are not informative about the stance of the business cycle. Generally speaking, these short-term movements are also strongly present in the comparable questions about the trend of activity in the other sectors. On the other hand, the questions related to the respondents' assessment turn out to be amongst those with the lowest short-term variation. The latter also holds for employment expectations, and to a lesser extent also for demand forecasts. The differences in frequency composition are illustrated in Figure 5 in case of sales trends in the trade sector and appraisal of the total order book in industry.

(Insert Figure 5 here)

Regarding the long-term cycle (Figure 6), the construction sector stands out with the largest share of its variation explained by oscillations with a length of over 96 months. As was already clear from its weight (68 p.c.), this cycle seems to display some idiosyncratic behaviour, indicated by the correlation at this frequency with GDP growth which remains limited to 55 p.c. The other sectors, which have a more benign long-term cycle, show a generally higher long-term frequency correlation with GDP. The long-term cycle contained in the services survey, in particular, seems to match the one contained in GDP growth, suggesting that the long-term cycle might be closely related to the services sector[8]. Furthermore, regardless of their weight, it is clear that the indicators related to prices follow an idiosyncratic long-term cycle, although the price survey indicators in the services sector seem to display some evidence of countercyclical behaviour at the low frequency. Amongst other things, this idiosyncratic behaviour motivates why price variables are not included in the NBB's overall synthetic curve.

(Insert Figure 6 here)

[8] Note that this result might however be biased by the small sample size in case of the services survey indicator as no complete long-term cycle is captured. Nevertheless, the correlation coefficient is significant.

5.2. NBB smoothing procedure as an efficient smoothing method

Apart from the gross survey results on which the previous results are based, the NBB also publishes so called *"smoothed"* business survey series, which aim to turn down the amount of short-term variation in the gross series. In contrast to an approximate ideal band-pass filter, which theoretically allows this variation to be blocked out completely, the NBB smoothing procedure is based on a simple statistical smoothing method.

This method which can be described as a centred weighted moving average of medians, consists of two steps. First, a centred moving median over five observations is calculated from the gross series. Next, from the obtained series, a centred weighted moving average is taken over again five observations with weights of 1/8, 1/4, 1/4, 1/4, 1/8. Due to the two-month data loss in each step, the value for a given month is only available after four months. Although such a filter does not allow any precise frequency band to be extracted, it has the advantage of limiting the data loss to just four months, compared to 36 months of data loss in case of the BK-filter.

Applying the Baxter-King filter to the smoothed NBB series on an ex-post basis enables us to examine whether this procedure efficiently reduces the short-term variations. The right panel of Table 7 presents the results. From this table, it is obvious that the NBB smoothing procedure successfully blocks out short-term variations. The average share of oscillations between 2 and 18 months in the smoothed indicators is almost zero. Even for indicators which are disturbed to a large extent by short-term variations in the first place, the NBB smoothing procedure reduces this amount to a minimum (< 10 p.c.). The only exception to this is the forecasts for activity in the services sector, which seem to follow rather persistent short-term movements. As such, the NBB smoothing procedure is an efficient alternative for a band-pass filter to block out short-term variations, with the advantage of less data loss and simplicity.

(Insert Figure 7 here)

Furthermore, as illustrated in the case of the NBB trade confidence indicator in Figure 7, it can be shown that the smoothed indicator is almost identical to the sum of the frequency components obtained by applying respectively a business cycle and low band-pass filter, i.e. by keeping the business cycle and the long-term components.

Although the short-term component is reduced in the smoothed indicator with respect to the gross indicator, no significant improvement is obtained in terms of correlation with GDP. This can be mainly explained by the fact that correlations are calculated on a quarterly basis while the indicators are available on a monthly basis. Averaging the indicators over three months introduces on a quarterly basis a smoothing similar to the NBB's method. Nevertheless, the elimination of short-term components in the monthly series is warranted in view of detecting in a timely manner the business cycle and long-term movements of the economy.

6. CONCLUSION

Survey indicators are on average well correlated with year-on-year GDP growth. However, results differ across indicators. This paper uses a frequency approach to gain insight into the correlation of these indicators with GDP growth and applies it to the euro area countries (EC survey indicators) and to Belgium separately (NBB business survey indicators). Using the Baxter-King filter, we split up the survey indicators and year-on-year GDP growth into three components: a short-term, business cycle (oscillations between 18 and 96 months) and long-term component.

Although survey indicators are designed to track the business cycle situation, we show that they do not perfectly reflect business cycle movements but also contain cycles of other frequencies. This is a feature they broadly share with year-on-year GDP growth.

Given the presence of movements at the short-term, business cycle and long-term frequency in both year-on-year GDP growth and survey indicators, the overall correlation between them depends on the correlation at these different frequencies. The following stylised facts emerge:

Irregular movements contained in the indicators are predominantly idiosyncratic, i.e. weakly correlated with the short-term component of GDP growth. Therefore, a large weight of the short-term component in the variance of a survey indicator is harmful for its overall correlation with GDP growth.

At the business cycle frequency, correlation is strong, and furthermore, it tends to increase with the weight of the business cycle component in the indicator. As such, the larger this weight, the stronger the overall correlation of the indicator with GDP growth.

The correlation is on average strongest at the long-term frequency. However, in contrast to the business cycle frequency, there exists no positive relationship between the weight of the long-term cycle in the indicators' variance and the correlation with GDP growth. Thus, it appears that a long-term component is a necessary, but not a sufficient condition as weak or strong long-term cycles typically tend to be idiosyncratic with respect to those of GDP growth, as is the case, for example, of price expectations for the months ahead in the industry.

These relationships provide some evidence why certain confidence indicators are better correlated with GDP growth than others. Well-correlated indicators, such as overall confidence indicators (EC economic sentiment indicator, NBB overall synthetic curve) and industry indicators generally contain a high business cycle component with a slight long-term cycle. Less correlated indicators, on the other hand, are often highly influenced by a short-term component (e.g. trade confidence indicator) or an idiosyncratic long-term component (e.g. construction confidence indicator).

In general, the results for the NBB survey indicators in Belgium's case and the average results for the euro area countries based on the EC survey indicators show similar results, although there are some small differences. While the services indicator in Belgium has a relatively high correlation with GDP growth due to its strong business cycle component, this is less the case for the euro area as the corresponding services indicator is more prone to short-term variations reducing its correlation with GDP. On the other hand, the construction indicator is somewhat less correlated with GDP growth in Belgium due to a stronger long-term cycle.

Finally, an application of the frequency decomposition to the NBB smoothed monthly business survey series showed that the simple statistical smoothing technique that the NBB applies to the gross indicators, successfully blocks out the undesired short-term variation, producing more useful business cycle indicators.

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Table 1: Maximum cross-correlation of EC survey indicators with year-on-year and quarter-on-quarter GDP growth[1]
(Average across countries)

		Year-on-year		Quarter-on-quarter	
		Corr.	Lead/ lag	Corr.	Lead/ lag
INDUSTRY	**Industrial Confidence Indicator**	**0.72**	**0**	**0.47**	**-1**
	Production trend observed in recent months	0.67	0	0.47	-1
	Assessment of order-book levels*	0.72	0	0.49	-2
	Assessment of export order-book levels	0.62	0	0.44	-2
	Assessment of stocks of finished products*	-0.52	0	-0.36	-1
	Production expectations for the months ahead*	0.67	0	0.47	0
	Selling price expectations for the months ahead	0.39	0	0.31	-1
	Employment expectations for the months ahead	0.63	-1	0.44	-3
RETAIL	**Retail trade Confidence Indicator**	**0.45**	**-1**	**0.27**	**-2**
	Business activity over recent months*	0.41	-4	0.27	-4
	Assessment of stocks*	-0.10	4	-0.09	3
	Orders placed with suppliers	0.36	0	0.26	-2
	Expected business activity*	0.49	0	0.32	-1
	Employment expectations	0.35	-1	0.27	-2
CONSTRUCTION	**Construction Confidence Indicator**	**0.54**	**-1**	**0.37**	**-2**
	Trend of activity over recent months	0.50	0	0.34	-2
	Factors limiting building activity (sum of 7 factors = 100 p.c.)	0.27	-1	0.19	-2
	Assessment of order books*	0.54	-2	0.37	-4
	Employment expectations for the months ahead*	0.50	0	0.35	-1
	Price expectations for the months ahead	0.47	-1	0.33	-2
SERVICES	**Services Confidence Indicator**	**0.62**	**-1**	**0.40**	**-2**
	Business situation over recent months*	0.56	-2	0.37	-4
	Evolution of demand in recent months*	0.54	-1	0.37	-2
	Evolution of demand expected in the months ahead*	0.51	-1	0.37	-1
	Evolution of employment in recent months	0.58	-1	0.44	-3
	Evolution of employment expected in the months ahead	0.62	-1	0.49	-3
CONSUMER	**Consumer Confidence Indicator**	**0.62**	**-1**	**0.41**	**-2**
	Financial situation over last 12 months	0.65	-3	0.44	-4
	Financial situation over next 12 months*	0.55	-1	0.37	-3
	General economic situation over last 12 months	0.69	-2	0.48	-3
	General economic situation over next 12 months*	0.56	0	0.40	-2
	Price trends over last 12 months	-0.41	3	-0.27	2
	Price trends over next 12 months	-0.31	4	-0.21	4
	Unemployment expectations over next 12 months*	-0.61	-1	-0.42	-3
	Major purchases at present	0.51	-1	0.36	-3
	Major purchases over next 12 months	0.41	-3	0.26	-4
	Savings at present	-0.18	3	-0.16	1
	Savings over next 12 months*	0.26	-3	0.15	-4
	Statement on financial situation of household	-0.10	4	-0.09	2
ESI	**Economic Sentiment Indicator**	**0.75**	**0**	**0.52**	**-2**
Summary statistics[2]					
	Min.	0.10	-4	0.09	-4
	Max.	0.75	4	0.52	4
	Average	0.50	0	0.35	-2

Sources: EC, ECB, OECD, NBB.
[1] This table shows the cross-correlations with the largest absolute value, considering a maximum lead/lag of 4 quarters. The corresponding lead ("+")/lag("-") of the confidence indicator with respect to GDP is indicated in the column, next to it.
[2] Calculated on absolute values in case of correlation coefficients.
(*) Component of an aggregate confidence indicator.

Table 2: Percentage of GDP growth rates' variance attributable to different frequency components[1]

	Year-on-year growth rate		
	2-6	6-32	>32
Belgium	0.07	0.77	0.16
Germany	0.10	0.67	0.23
Netherlands	0.15	0.56	0.29
France	0.01	0.63	0.37
Italy	0.04	0.64	0.32
Spain	0.14	0.51	0.35
Portugal	-0.01	0.51	0.49
Greece	0.33	0.46	0.22
Austria	-0.01	0.71	0.31
Ireland	0.09	0.40	0.51
Finland	0.02	0.51	0.48
Euro area	0.03	0.61	0.35
Min.	-0.01	0.40	0.16
Max.	0.33	0.77	0.51
Average	0.08	0.58	0.34

	Quarter-on-quarter growth rate		
	2-6	6-32	>32
Belgium	0.52	0.42	0.06
Germany	0.68	0.26	0.06
Netherlands	0.73	0.22	0.06
France	0.33	0.46	0.21
Italy	0.43	0.43	0.14
Spain	0.72	0.19	0.09
Portugal	0.21	0.43	0.35
Greece	0.92	0.06	0.02
Austria	0.10	0.67	0.23
Ireland	0.64	0.19	0.16
Finland	0.41	0.32	0.27
Euro area	0.55	0.32	0.14
Min.	0.10	0.06	0.02
Max.	0.92	0.67	0.35
Average	0.52	0.33	0.15

Sources: EC, ECB, OECD, NBB.

[1] Variances are calculated for three non-overlapping frequency components: a short-term (2-6 quarters), a business cycle (6-32 quarters) and long-term component (> 32 quarters). The percentage of variance attributable to a particular component is calculated as the sum of the component's variance and its covariance with the two other components, divided by the series' overall variance.

Table 3: Percentage of EC survey indicators' variance attributable to the different frequency components[1]
(Average across countries)

		MEAN			STDEV		
		2-18	18-96	>96	2-18	18-96	>96
INDUSTRY	**Industrial Confidence Indicator**	**0.05**	**0.67**	**0.27**	**0.06**	**0.11**	**0.13**
	Production trend observed in recent months	0.20	0.60	0.20	0.17	0.10	0.10
	Assessment of order-book levels*	0.03	0.64	0.32	0.05	0.10	0.11
	Assessment of export order-book levels	0.06	0.69	0.25	0.07	0.10	0.12
	Assessment of stocks of finished products*	0.14	0.63	0.23	0.12	0.10	0.15
	Production expectations for the months ahead*	0.18	0.60	0.22	0.10	0.10	0.05
	Selling price expectations for the months ahead	0.12	0.65	0.23	0.07	0.16	0.15
	Employment expectations for the months ahead	0.08	0.54	0.38	0.08	0.13	0.14
RETAIL	**Retail Trade Confidence Indicator**	**0.22**	**0.48**	**0.30**	**0.19**	**0.13**	**0.19**
	Business activity over recent months*	0.26	0.43	0.31	0.20	0.09	0.22
	Assessment of stocks*	0.50	0.37	0.13	0.18	0.14	0.11
	Orders placed with suppliers	0.30	0.42	0.28	0.25	0.08	0.20
	Expected business activity*	0.24	0.51	0.25	0.16	0.13	0.16
	Employment expectations	0.28	0.35	0.37	0.20	0.11	0.24
CONSTRUCTION	**Construction Confidence Indicator**	**0.08**	**0.43**	**0.49**	**0.11**	**0.11**	**0.18**
	Trend of activity over recent months	0.39	0.36	0.25	0.23	0.11	0.16
	Factors limiting building activity (sum of 7 factors = 100 p.c.)	0.27	0.32	0.40	0.18	0.13	0.21
	Assessment of order books*	0.06	0.42	0.52	0.07	0.13	0.17
	Employment expectations for the months ahead*	0.16	0.42	0.42	0.17	0.11	0.18
	Price expectations for the months ahead	0.12	0.49	0.39	0.11	0.09	0.16
SERVICES	**Services Confidence Indicator**	**0.23**	**0.50**	**0.27**	**0.15**	**0.11**	**0.12**
	Business situation over recent months*	0.19	0.53	0.28	0.11	0.13	0.12
	Evolution of demand in recent months*	0.31	0.45	0.24	0.21	0.14	0.13
	Evolution of demand expected in the months ahead*	0.48	0.35	0.17	0.23	0.14	0.11
	Evolution of employment in recent months	0.30	0.38	0.32	0.21	0.13	0.18
	Evolution of employment expected in the months ahead	0.34	0.42	0.24	0.19	0.16	0.15
CONSUMER	**Consumer Confidence Indicator**	**0.11**	**0.50**	**0.39**	**0.14**	**0.13**	**0.17**
	Financial situation over last 12 months	0.03	0.44	0.53	0.03	0.12	0.14
	Financial situation over next 12 months*	0.10	0.47	0.43	0.09	0.15	0.23
	General economic situation over last 12 months	0.02	0.50	0.48	0.03	0.12	0.13
	General economic situation over next 12 months*	0.14	0.54	0.32	0.15	0.11	0.15
	Price trends over last 12 months	0.04	0.41	0.55	0.06	0.07	0.10
	Price trends over next 12 months	0.13	0.50	0.37	0.07	0.18	0.21
	Unemployment expectations over next 12 months*	0.05	0.52	0.43	0.04	0.10	0.13
	Major purchases at present	0.05	0.42	0.53	0.05	0.12	0.15
	Major purchases over next 12 months	0.30	0.27	0.43	0.26	0.09	0.20
	Savings at present	0.13	0.37	0.50	0.09	0.12	0.16
	Savings over next 12 months*	0.16	0.28	0.56	0.19	0.14	0.24
	Statement on financial situation of household	0.17	0.23	0.60	0.17	0.18	0.31
ESI	**Economic Sentiment Indicator**	**0.06**	**0.62**	**0.31**	**0.05**	**0.09**	**0.10**
Summary statistics							
	Min.	0.02	0.23	0.13	0.03	0.07	0.05
	Max.	0.50	0.69	0.60	0.26	0.18	0.31
	Average	0.18	0.47	0.35	0.13	0.12	0.16

Sources: EC, NBB.

[1] Variances are calculated for three non-overlapping frequency components: a short-term (2-18 months), a business cycle (18-96 months) and long-term component (> 96 months). The percentage of variance attributable to a particular component is calculated as the sum of the component's variance and its covariance with the two other components, divided by the series' overall variance. The standard deviations are a measure of the dispersion of the share of a particular frequency component in a particular indicator across countries.

(*) Component of an aggregate confidence indicator.

Table 4: Ranking of EC aggregate confidence indicators according to the importance of the different frequency components[1]

4a: According to the importance of the short-term component

	1	2	3	4	5	6
Average	**SERVICES**	**RETAIL**	**CONSUMER**	**INDUSTRY**	**ESI**	**CONSTRUCTION**
Belgium	RETAIL	SERVICES	CONSUMER	INDUSTRY	ESI	CONSTRUCTION
Germany	RETAIL	CONSUMER	SERVICES	INDUSTRY	CONSTRUCTION	ESI
Netherlands	SERVICES	INDUSTRY	RETAIL	CONSUMER	ESI	CONSTRUCTION
France	SERVICES	RETAIL	CONSUMER	ESI	INDUSTRY	CONSTRUCTION
Italy	SERVICES	RETAIL	CONSTRUCTION	CONSUMER	ESI	INDUSTRY
Spain	SERVICES	CONSTRUCTION	RETAIL	CONSUMER	INDUSTRY	ESI
Portugal	SERVICES	RETAIL	INDUSTRY	ESI	CONSUMER	CONSTRUCTION
Greece	RETAIL	INDUSTRY	ESI	SERVICES	CONSTRUCTION	CONSUMER
Austria	CONSTRUCTION	CONSUMER	RETAIL	ESI	SERVICES	INDUSTRY
Ireland	SERVICES	INDUSTRY	RETAIL	CONSTRUCTION	ESI	CONSUMER
Finland	RETAIL	SERVICES	CONSUMER	INDUSTRY	ESI	CONSTRUCTION
Euro area	RETAIL	SERVICES	CONSUMER	INDUSTRY	ESI	CONSTRUCTION

4b: According to the importance of the business cycle component

	1	2	3	4	5	6
Average	**INDUSTRY**	**ESI**	**CONSUMER**	**SERVICES**	**RETAIL**	**CONSTRUCTION**
Belgium	INDUSTRY	ESI	CONSTRUCTION	CONSUMER	SERVICES	RETAIL
Germany	INDUSTRY	CONSUMER	ESI	SERVICES	RETAIL	CONSTRUCTION
Netherlands	INDUSTRY	ESI	CONSTRUCTION	SERVICES	CONSUMER	RETAIL
France	ESI	INDUSTRY	SERVICES	RETAIL	CONSUMER	CONSTRUCTION
Italy	INDUSTRY	ESI	CONSUMER	CONSTRUCTION	SERVICES	RETAIL
Spain	INDUSTRY	ESI	CONSTRUCTION	CONSUMER	RETAIL	SERVICES
Portugal	INDUSTRY	ESI	RETAIL	SERVICES	CONSTRUCTION	CONSUMER
Greece	CONSUMER	SERVICES	ESI	INDUSTRY	RETAIL	CONSTRUCTION
Austria	ESI	INDUSTRY	RETAIL	SERVICES	CONSTRUCTION	CONSUMER
Ireland	INDUSTRY	ESI	RETAIL	CONSTRUCTION	SERVICES	CONSUMER
Finland	INDUSTRY	ESI	CONSUMER	SERVICES	RETAIL	CONSTRUCTION
Euro area	INDUSTRY	ESI	CONSUMER	SERVICES	RETAIL	CONSTRUCTION

4c: According to the importance of the long-term component

	1	2	3	4	5	6
Average	**CONSTRUCTION**	**CONSUMER**	**RETAIL**	**ESI**	**SERVICES**	**INDUSTRY**
Belgium	CONSTRUCTION	CONSUMER	SERVICES	RETAIL	ESI	INDUSTRY
Germany	CONSTRUCTION	RETAIL	SERVICES	ESI	CONSUMER	INDUSTRY
Netherlands	RETAIL	CONSUMER	CONSTRUCTION	ESI	SERVICES	INDUSTRY
France	CONSTRUCTION	CONSUMER	INDUSTRY	ESI	RETAIL	SERVICES
Italy	CONSTRUCTION	RETAIL	CONSUMER	ESI	INDUSTRY	SERVICES
Spain	CONSUMER	RETAIL	ESI	SERVICES	INDUSTRY	CONSTRUCTION
Portugal	CONSUMER	CONSTRUCTION	ESI	RETAIL	INDUSTRY	SERVICES
Greece	CONSTRUCTION	INDUSTRY	ESI	RETAIL	SERVICES	CONSUMER
Austria	INDUSTRY	SERVICES	CONSUMER	ESI	RETAIL	CONSTRUCTION
Ireland	CONSUMER	SERVICES	CONSTRUCTION	ESI	RETAIL	INDUSTRY
Finland	CONSTRUCTION	ESI	CONSUMER	SERVICES	RETAIL	INDUSTRY
Euro area	CONSTRUCTION	SERVICES	RETAIL	CONSUMER	ESI	INDUSTRY

Sources: EC, NBB.

[1] The short-term, business cycle and long-term component contain respectively variations between 2 and 18 months, 18-96 months and over 96 months.

Table 5: Contemporaneous correlation of EC survey indicators with year-on-year GDP growth[1]
(Average across countries)

		Overall	Short-term	Business cycle	Long-term
INDUSTRY	**Industrial Confidence Indicator**	**0.72**	**0.18**	**0.65**	**0.66**
	Production trend observed in recent months	0.67	0.13	0.61	0.70
	Assessment of order-book levels*	0.72	0.15	0.62	0.69
	Assessment of export order-book levels	0.62	0.14	0.59	0.50
	Assessment of stocks of finished products*	-0.52	-0.13	-0.53	-0.32
	Production expectations for the months ahead*	0.67	0.11	0.64	0.62
	Selling price expectations for the months ahead	0.39	0.07	0.53	0.02
	Employment expectations for the months ahead	0.59	0.04	0.59	0.54
RETAIL	**Retail trade Confidence Indicator**	**0.42**	**0.01**	**0.31**	**0.57**
	Business activity over recent months*	0.33	0.00	0.24	0.51
	Assessment of stocks*	-0.05	0.03	-0.09	-0.14
	Orders placed with suppliers	0.36	-0.03	0.33	0.37
	Expected business activity*	0.49	0.02	0.37	0.66
	Employment expectations	0.33	0.08	0.34	0.33
CONSTRUCTION	**Construction Confidence Indicator**	**0.52**	**0.04**	**0.45**	**0.48**
	Trend of activity over recent months	0.50	0.11	0.44	0.56
	Factors limiting building activity (sum of 7 factors = 100 p.c.)	0.26	0.09	0.11	0.42
	Assessment of order books*	0.49	0.06	0.39	0.53
	Employment expectations for the months ahead*	0.50	0.00	0.49	0.47
	Price expectations for the months ahead	0.47	0.13	0.48	0.35
SERVICES	**Services Confidence Indicator**	**0.57**	**0.01**	**0.47**	**0.73**
	Business situation over recent months*	0.47	0.02	0.39	0.60
	Evolution of demand in recent months*	0.52	-0.07	0.53	0.69
	Evolution of demand expected in the months ahead*	0.50	0.03	0.50	0.65
	Evolution of employment in recent months	0.54	0.09	0.35	0.73
	Evolution of employment expected in the months ahead	0.60	0.13	0.47	0.68
CONSUMER	**Consumer Confidence Indicator**	**0.60**	**0.04**	**0.57**	**0.54**
	Financial situation over last 12 months	0.54	0.09	0.38	0.67
	Financial situation over next 12 months*	0.53	0.08	0.46	0.51
	General economic situation over last 12 months	0.63	0.05	0.50	0.75
	General economic situation over next 12 months*	0.56	0.06	0.52	0.50
	Price trends over last 12 months	-0.31	-0.05	-0.15	-0.48
	Price trends over next 12 months	-0.06	0.00	-0.01	-0.14
	Unemployment expectations over next 12 months*	-0.57	-0.06	-0.53	-0.46
	Major purchases at present	0.48	0.06	0.35	0.56
	Major purchases over next 12 months	0.32	0.02	0.21	0.47
	Savings at present	-0.09	0.04	-0.09	-0.10
	Savings over next 12 months*	0.21	-0.03	0.19	0.24
	Statement on financial situation of household	-0.02	0.03	0.06	-0.02
ESI	**Economic Sentiment Indicator**	**0.75**	**0.12**	**0.67**	**0.79**
Summary statistics[2]					
	Min.	0.02	0.00	0.01	0.02
	Max.	0.75	0.18	0.67	0.79
	Average	0.46	0.07	0.41	0.49
	p.m. Average contribution (p.c.)[3]		0.07	0.51	0.42

Sources: EC, ECB, OECD, NBB.

[1] The short-term, business cycle and long-term frequencies contain respectively movements between 2-6 quarters, 6-32 quarters and over 32 quarters. This table shows for each frequency the contemporaneous correlation of the survey series and year-on-year GDP growth.

[2] Calculated on absolute values in case of correlation coefficients.

[3] Contribution of the frequencies to the overall correlation, calculated as in formula 9.

(*) Component of an aggregate confidence indicator.

Table 6: Contemporaneous correlation of NBB business survey indicators with year-on-year GDP growth[1]

		GROSS SERIES				SMOOTHED SERIES
		Overall	Short-term	Business cycle	Long-term	Overall
OVERALL	**Synthetic curve**	**0.76**	**0.26**	**0.77**	**0.73**	**0.76**
INDUSTRY	**Synthetic curve**	**0.78**	**0.22**	**0.80**	**0.71**	**0.79**
Trend	Production rate*	0.74	0.17	0.79	0.84	0.78
	Domestic orders*	0.72	0.07	0.77	0.59	0.72
	Export orders*	0.60	0.11	0.71	0.41	0.62
	Selling prices	0.51	0.06	0.77	0.05	0.54
Appraisal	Total order book*	0.75	0.15	0.76	0.73	0.75
	Export order book*	0.71	0.15	0.75	0.59	0.71
	Stock of finished products*	-0.54	-0.11	-0.64	-0.36	-0.55
Forecasts	Employment*	0.71	0.21	0.77	0.68	0.71
	Demand*	0.75	0.28	0.80	0.57	0.76
	Selling prices	0.42	0.01	0.75	-0.05	0.42
TRADE	**Synthetic curve**	**0.42**	**0.07**	**0.29**	**0.61**	**0.43**
Trend	Sales*	0.32	0.07	0.25	0.46	0.34
	Selling prices	0.03	0.06	0.39	-0.15	0.03
Appraisal	Sales*	0.31	0.00	0.23	0.37	0.34
	Stocks*	-0.15	0.00	-0.14	-0.08	-0.15
Forecasts	Demand*	0.46	0.11	0.28	0.85	0.48
	Orders to Belgian suppliers*	0.37	0.00	0.32	0.47	0.35
	Orders to foreign suppliers*	0.48	0.07	0.31	0.86	0.51
	Selling prices	0.30	-0.04	0.45	0.32	0.31
CONSTRUCTION	**Synthetic curve**	**0.47**	**0.27**	**0.52**	**0.55**	**0.47**
Trend	Activity*	0.46	0.22	0.40	0.60	0.45
	Order book*	0.54	0.12	0.55	0.69	0.56
	Equipment*	0.44	0.14	0.43	0.62	0.46
	Employment*	0.39	0.09	0.29	0.59	0.41
	Selling prices	0.47	0.21	0.57	0.37	0.46
Assessment	Order book*	0.30	0.31	0.33	0.32	0.29
Forecasts	Employment*	0.41	0.02	0.49	0.43	0.41
	Demand*	0.53	0.25	0.56	0.54	0.53
	Selling prices	0.48	0.26	0.63	0.40	0.48
SERVICES	**Synthetic curve**	**0.69**	**0.34**	**0.60**	**0.98**	**0.69**
Trend	Activity*	0.70	0.17	0.70	0.98	0.73
	Employment*	0.60	-0.03	0.45	0.99	0.64
	Selling prices*	0.30	0.31	0.47	-0.60	0.33
Assessment	Activity*	0.68	0.22	0.59	0.99	0.68
Forecasts	Activity*	0.65	0.35	0.59	0.96	0.68
	Employment*	0.60	0.25	0.48	0.94	0.63
	Demand*	0.71	0.44	0.64	0.97	0.72
	Selling prices	0.42	0.32	0.60	-0.65	0.43
Summary statistics[2]						
	Min.	0.03	0.00	0.14	0.05	0.03
	Max.	0.78	0.44	0.80	0.99	0.79
	Average	0.52	0.16	0.54	0.59	0.53
	p.m. Average contribution (p.c.)[3]		0.06	0.64	0.30	

Source: NBB.

[1] The short-term, business cycle and long-term frequencies contain respectively movements between 2-6 quarters, 6-32 quarters and over 32 quarters. This table shows for each frequency the contemporaneous correlation of the survey series and year-on-year GDP growth.

[2] Calculated on absolute values in case of correlation coefficients.

[3] Contribution of the frequencies to the overall correlation, calculated as in formula 9.

(*) Component of a synthetic indicator.

Table 7: Percentage of NBB business survey indicators' variance attributable to the different frequency components[1]

		GROSS SERIES			SMOOTHED SERIES		
		2-18	18-96	>96	2-18	18-96	>96
OVERALL	**Synthetic curve**	**0.05**	**0.61**	**0.34**	**0.00**	**0.62**	**0.38**
INDUSTRY	**Synthetic curve**	**0.08**	**0.69**	**0.23**	**0.01**	**0.72**	**0.27**
Trend	Production rate*	0.34	0.54	0.11	0.07	0.76	0.18
	Domestic orders*	0.32	0.50	0.18	0.04	0.69	0.27
	Export orders*	0.35	0.55	0.10	0.06	0.82	0.13
	Selling prices	0.17	0.57	0.26	0.03	0.65	0.32
Appraisal	Total order book*	0.03	0.63	0.33	-0.01	0.64	0.37
	Export order book*	0.06	0.64	0.30	0.00	0.65	0.35
	Stock of finished products*	0.21	0.61	0.18	0.05	0.72	0.23
Forecasts	Employment*	0.08	0.60	0.32	0.00	0.64	0.36
	Demand*	0.10	0.60	0.29	0.02	0.64	0.34
	Selling prices	0.07	0.55	0.37	0.02	0.56	0.42
TRADE	**Synthetic curve**	**0.21**	**0.47**	**0.32**	**0.00**	**0.58**	**0.42**
Trend	Sales*	0.56	0.28	0.16	0.03	0.61	0.35
	Selling prices	0.11	0.20	0.68	0.01	0.21	0.79
Appraisal	Sales*	0.28	0.38	0.34	0.01	0.49	0.49
	Stocks*	0.43	0.34	0.22	0.09	0.55	0.35
Forecasts	Demand*	0.32	0.40	0.28	0.04	0.54	0.42
	Orders to Belgian suppliers*	0.28	0.41	0.31	0.04	0.54	0.43
	Orders to foreign suppliers*	0.26	0.43	0.31	0.04	0.55	0.41
	Selling prices	0.18	0.25	0.58	0.02	0.27	0.71
CONSTRUCTION	**Synthetic curve**	**0.04**	**0.28**	**0.68**	**-0.01**	**0.29**	**0.72**
Trend	Activity*	0.54	0.21	0.26	0.07	0.37	0.56
	Order book*	0.12	0.32	0.56	0.01	0.35	0.64
	Equipment*	0.10	0.25	0.65	0.00	0.27	0.73
	Employment*	0.21	0.26	0.53	0.01	0.32	0.66
	Selling prices	0.05	0.42	0.54	-0.01	0.44	0.57
Assessment	Order book*	0.00	0.27	0.73	-0.02	0.27	0.75
Forecasts	Employment*	0.04	0.30	0.66	-0.01	0.30	0.71
	Demand*	0.11	0.28	0.61	0.01	0.30	0.69
	Selling prices	0.03	0.37	0.60	-0.01	0.38	0.63
SERVICES	**Synthetic curve**	**0.08**	**0.54**	**0.38**	**0.01**	**0.57**	**0.41**
Trend	Activity*	0.36	0.40	0.24	0.05	0.59	0.37
	Employment*	0.10	0.44	0.46	-0.02	0.52	0.50
	Selling prices*	0.18	0.60	0.22	0.03	0.71	0.25
Assessment	Activity*	0.04	0.50	0.46	-0.01	0.53	0.48
Forecasts	Activity*	0.37	0.47	0.16	0.19	0.60	0.21
	Employment*	0.09	0.56	0.35	0.01	0.61	0.38
	Demand*	0.15	0.55	0.30	0.05	0.62	0.33
	Selling prices	0.23	0.59	0.18	0.03	0.73	0.24
Summary statistics							
	Min.	0.00	0.20	0.10	-0.02	0.21	0.13
	Max.	0.56	0.69	0.73	0.19	0.82	0.79
	Average	0.18	0.45	0.37	0.02	0.53	0.45

Source: NBB.

[1] Variances are calculated for three non-overlapping frequency components: a short-term (2-18 months), a business cycle (18-96 months) and long-term component (> 96 months). The percentage of variance attributable to a particular component is calculated as the sum of the component's variance and its covariance with the two other components, divided by the series' overall variance.

(*) Component of a synthetic indicator.

Figure 1: Gain functions of the applied BK-filters and the ideal band-pass filters

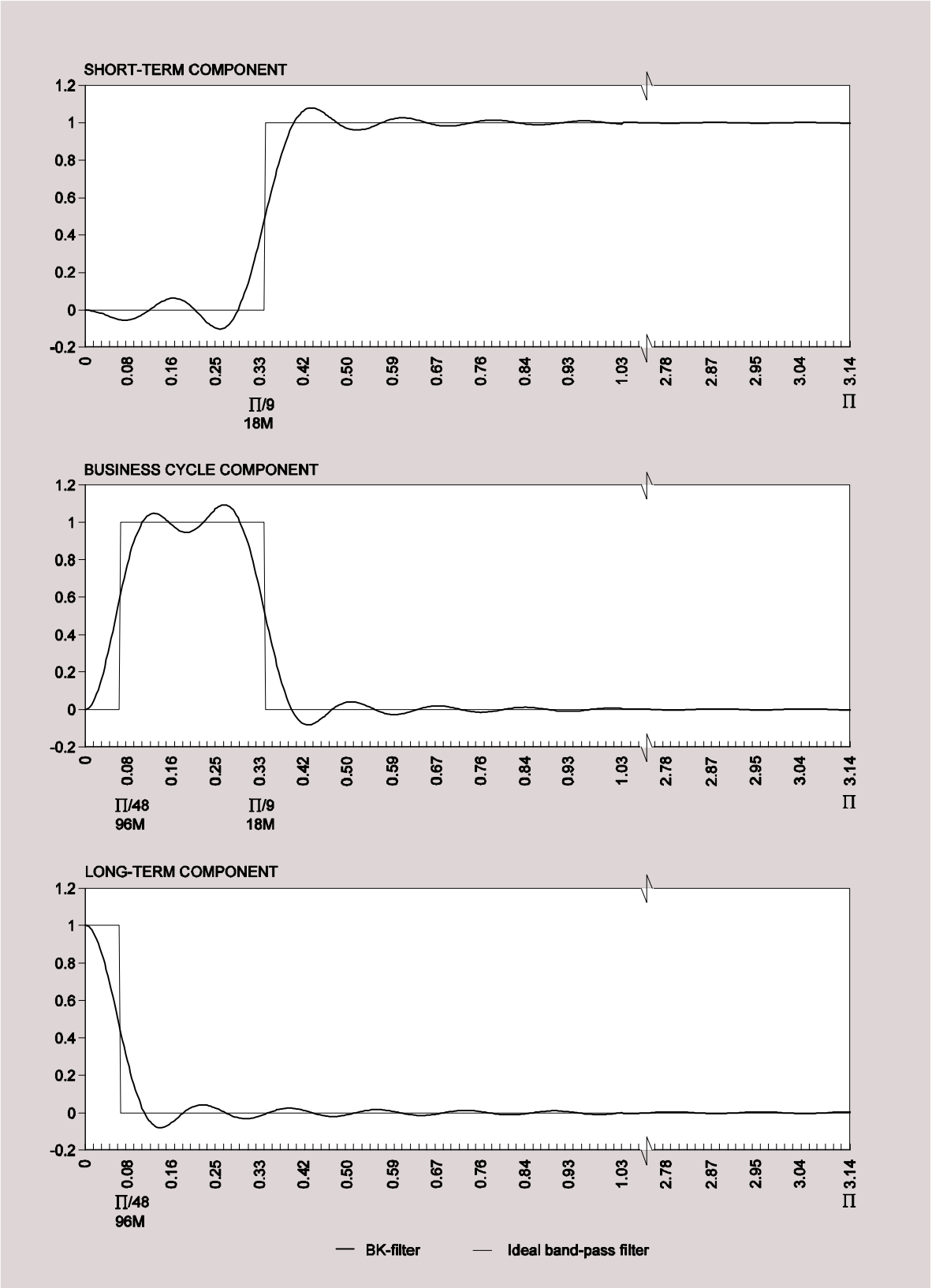
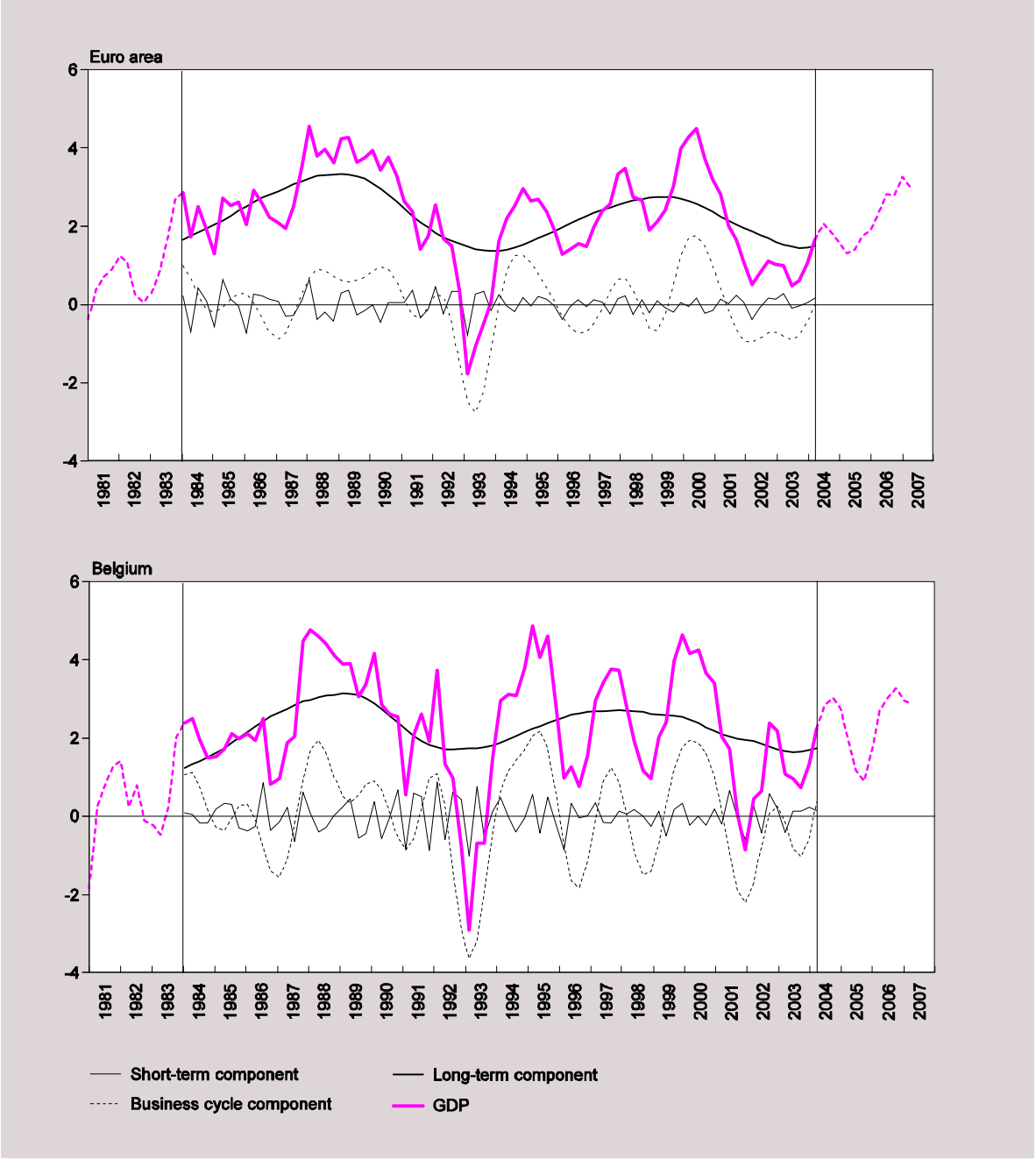


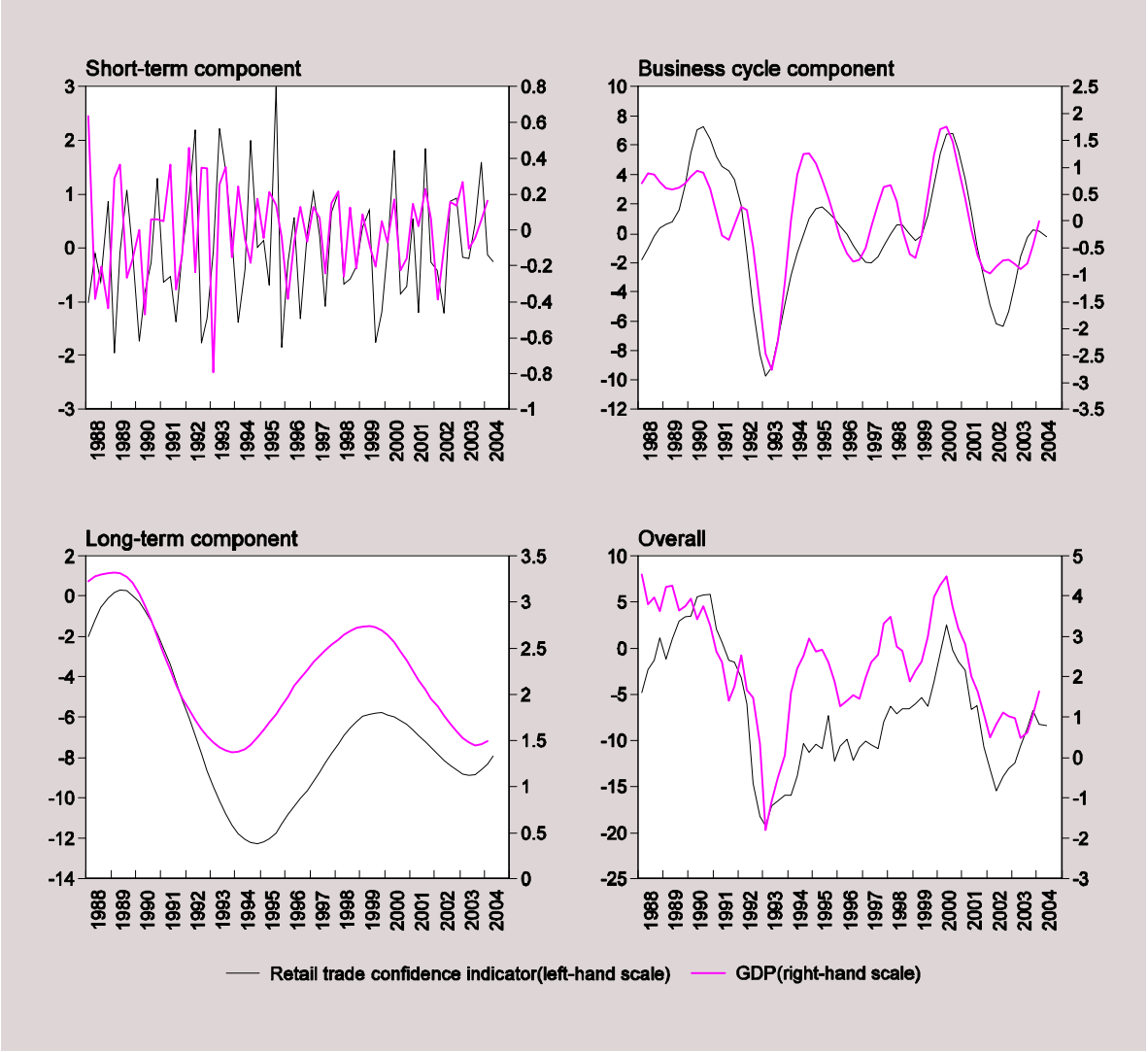
Figure 2: Frequency decomposition of year-on-year GDP growth[1]



Sources: EC, ECB, NBB.

[1] Frequency components are obtained by applying a BK-filter with varying bandwidth to year-on-year GDP growth. The short-term component contains variations between 2 and 6 quarters, the business cycle component has oscillations between 6 and 32 quarters, while the long-term component contains the remaining slow-moving variations (>32 quarters).

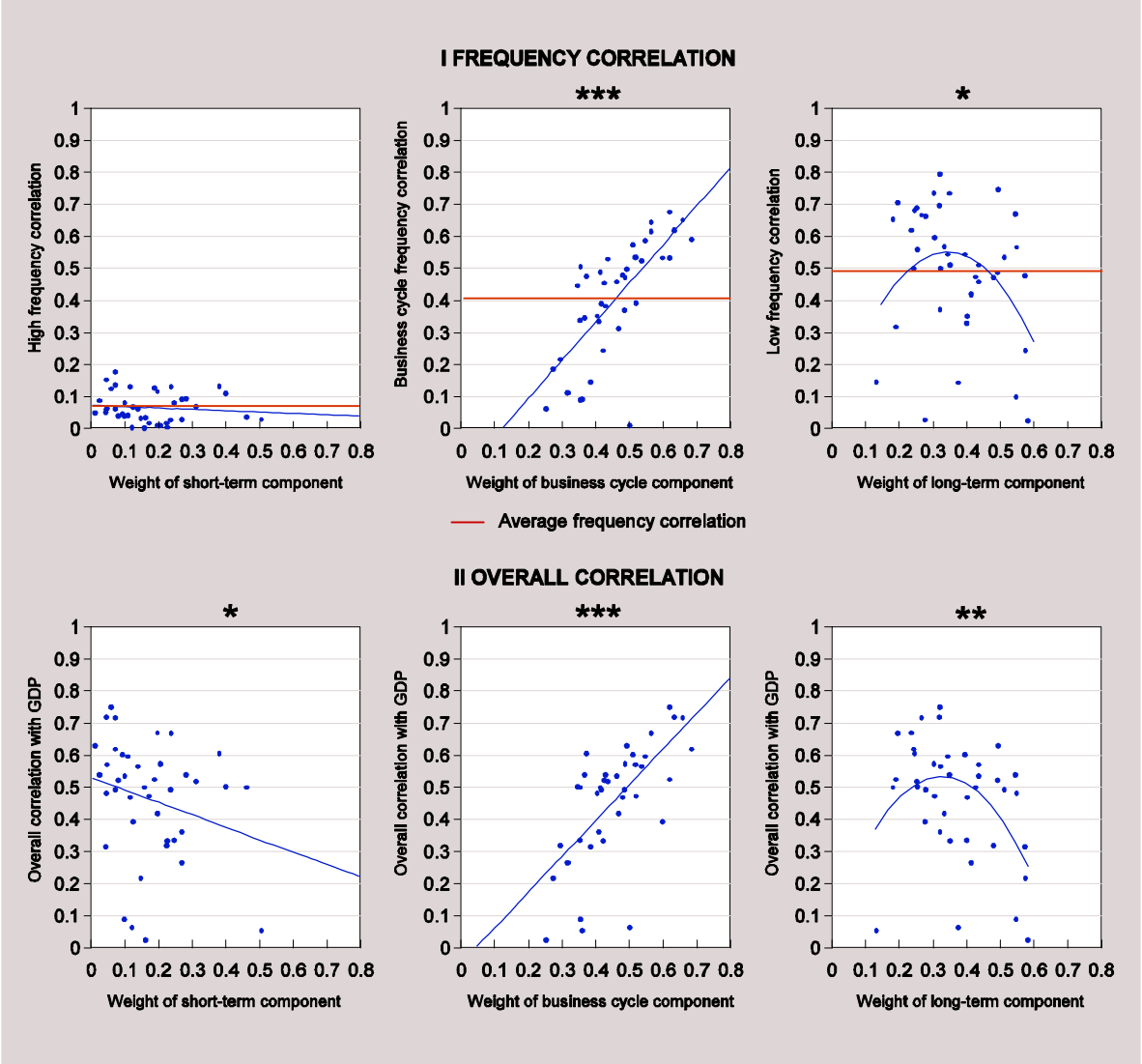
Figure 3: Comovement of the euro area retail confidence indicator and GDP at different frequencies[1]



Sources: EC, ECB, NBB.

[1] Frequency components are obtained by applying a BK-filter with varying bandwidth to the monthly observations of the retail confidence indicator and year-on-year GDP growth. The short-term component contains variations between 2 and 6 quarters, the business cycle component has oscillations between 6 and 32 quarters, while the long-term component contains the remaining slow-moving variations (>32 quarters). For the confidence indicator, quarterly averages of the extracted components are shown.

Figure 4a: Relationship between frequency weight, frequency correlation and overall correlation: EC survey indicators[1]
(Average across countries)

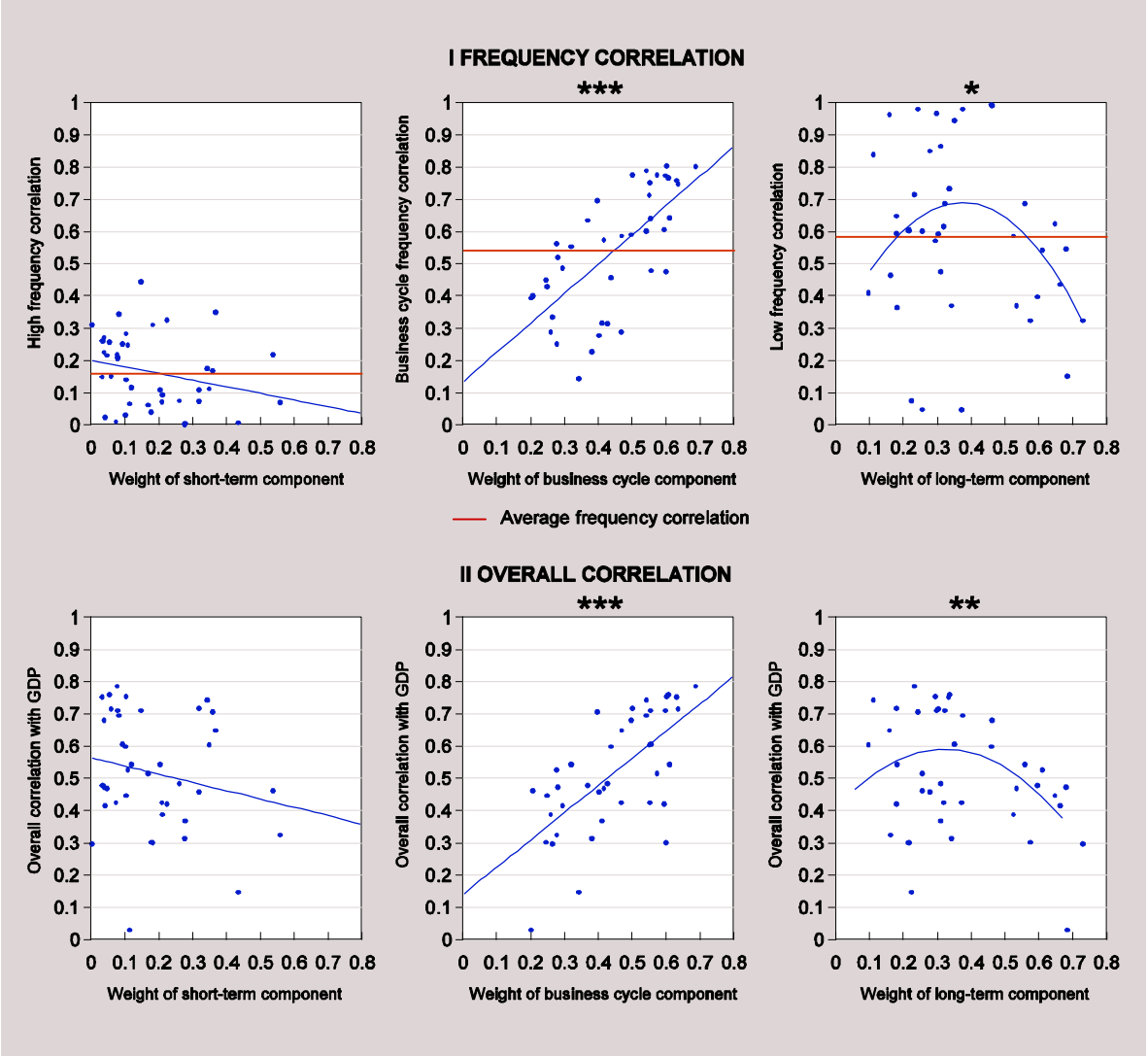


Sources: EC, ECB, OECD, NBB.

[1] Frequency components are obtained by applying a BK-filter with varying bandwidth to the monthly and quarterly observations. The frequency correlation is the absolute contemporaneous correlation between a particular frequency component of the survey indicator with the corresponding frequency component of year-on-year GDP growth. The weights indicate the relative size of a particular frequency component in a certain survey indicator, calculated as in formula (7). The overall correlation is the absolute contemporaneous correlation between a particular survey indicator and year-on-year GDP growth. Weights and correlations are averaged across countries.

***,**,* indicate a significant relation at respectively the 1 p.c., 5 p.c., 10 p.c. significance level.

Figure 4b: Relationship between frequency weight, frequency correlation and overall correlation: NBB business survey indicators[1]

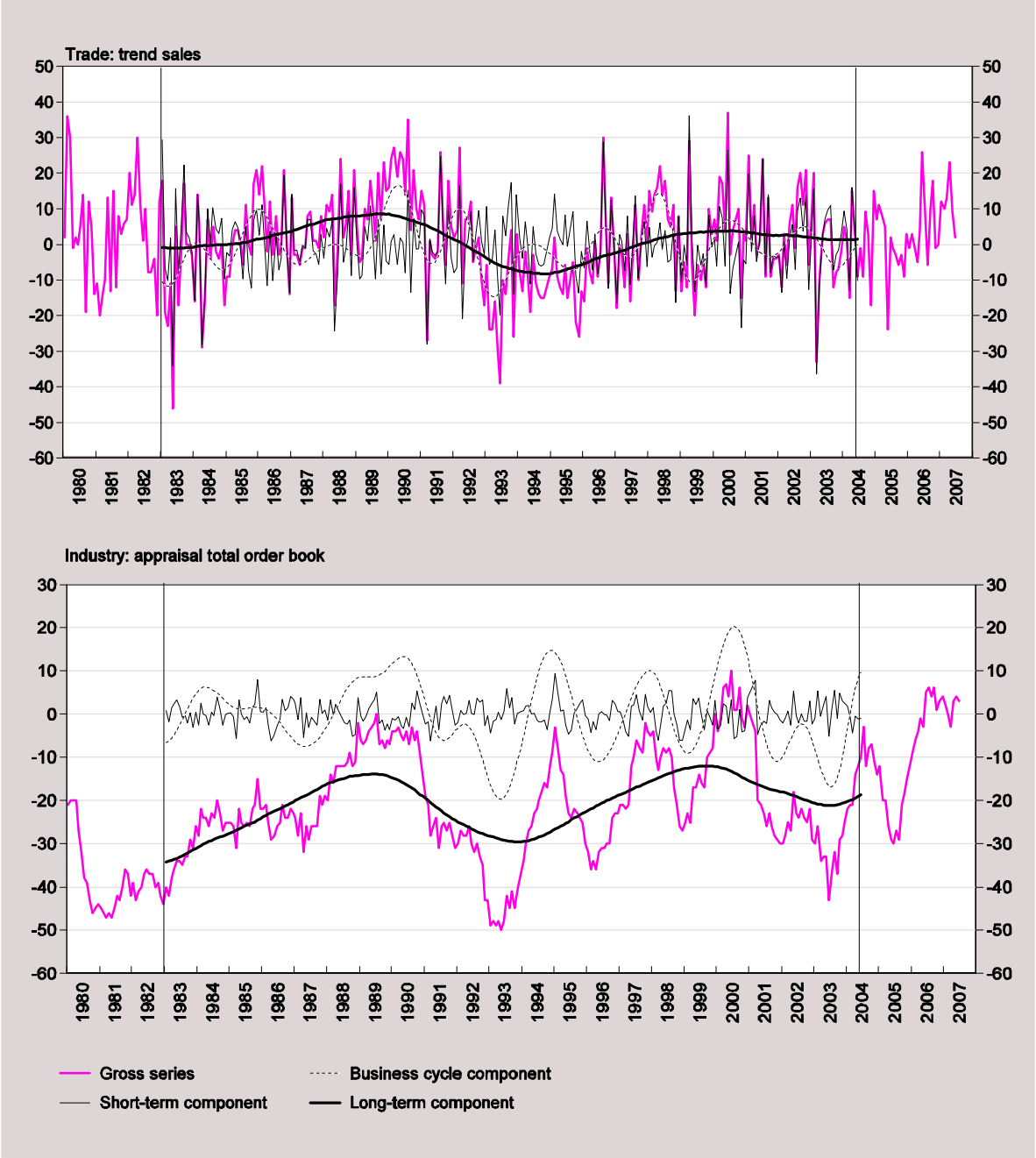


Sources: EC, NBB.

[1] Frequency components are obtained by applying a BK-filter with varying bandwidth to the monthly and quarterly observations. The frequency correlation is the absolute contemporaneous correlation between a particular frequency component of the survey indicator with the corresponding frequency component of year-on-year GDP growth. The weights indicate the relative size of a particular frequency component in a certain survey indicator, calculated as in formula (7). The overall correlation is the absolute contemporaneous correlation between a particular survey indicator and year-on-year GDP growth.

***,**,* indicate a significant relation at respectively the 1 p.c., 5 p.c., 10 p.c. significance level.

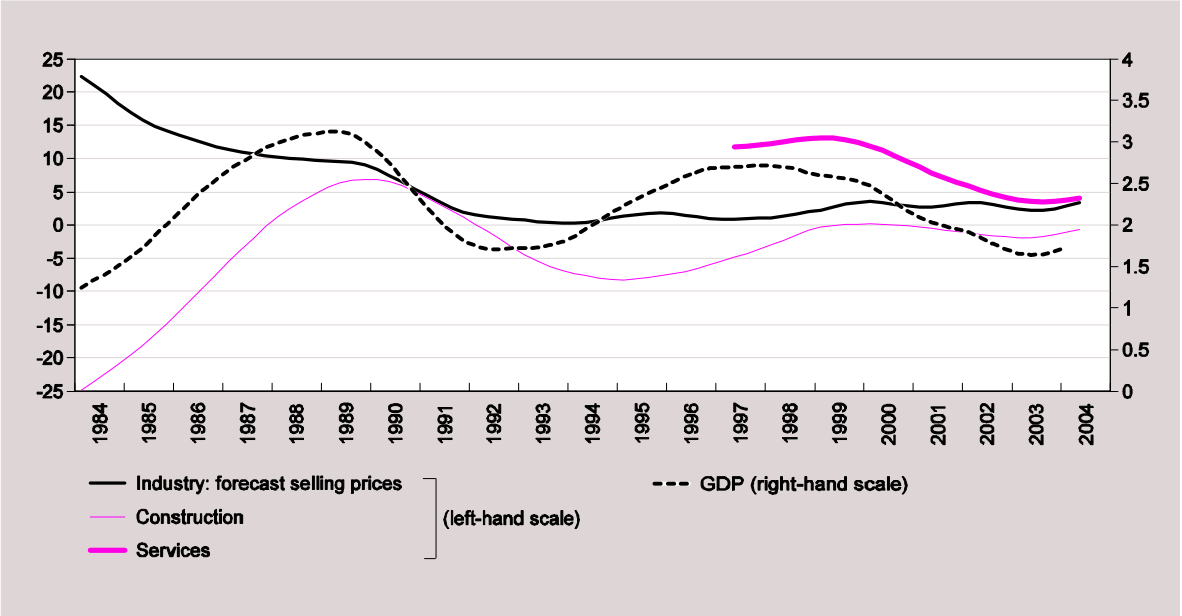
Figure 5: Frequency decomposition of some indicators from the monthly NBB business survey[1]



Source: NBB.

[1] Frequency components are obtained by applying a BK-filter with varying bandwidth to the monthly observations of the gross survey series. The short-term component contains variations between 2 and 18 months, the business cycle component has oscillations between 18 and 96 months, while the long-term component contains the remaining slow-moving variations (>96 months).

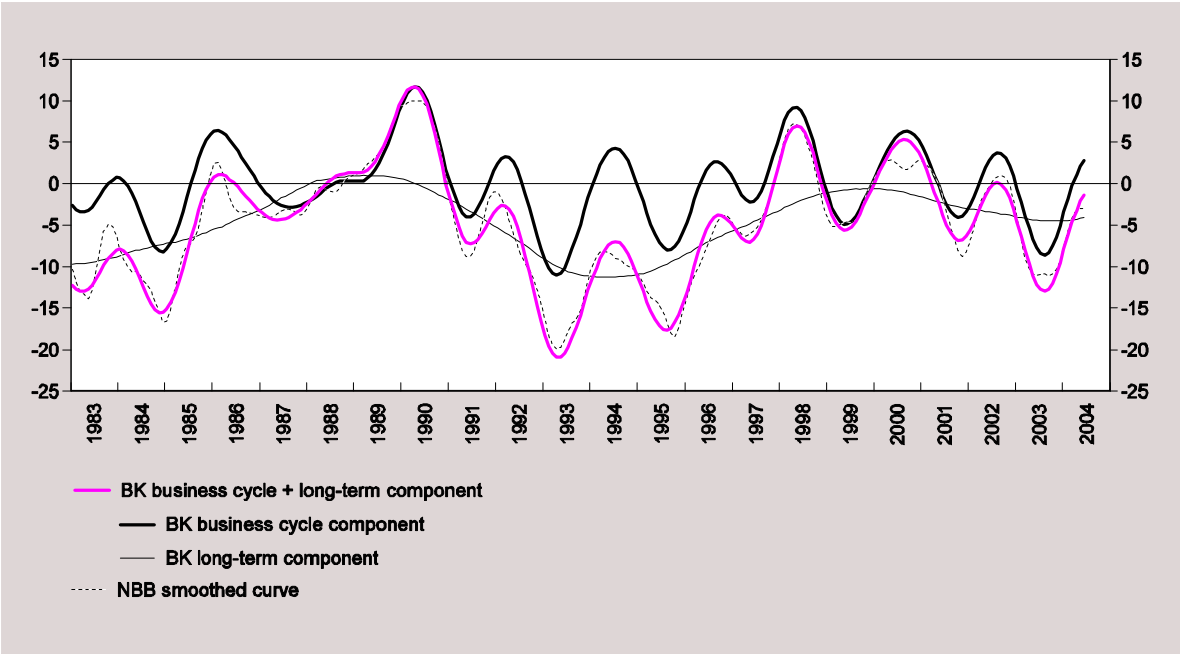
Figure 6: Development of long-term cycles[1] in Belgian GDP growth and selected NBB business survey indicators



Sources: EC, NBB.

[1] The long-term component is obtained by applying a BK-filter with a bandwidth that retains oscillations above 32 quarters. It has been applied to the monthly observations of the gross NBB survey indicators as well to quarterly observations of Belgian year-on-year GDP growth. For the survey indicators, quarterly averages of the extracted long-term components are shown.

Figure 7: Trade confidence indicator: NBB smoothed curve vs. Baxter-King decomposition[1]



Source: NBB.

[1] Frequency components are obtained by applying a BK-filter with varying bandwidth to the monthly observations of the the gross NBB trade confidence indicator. The business cycle component contains oscillations between 18 and 96 months, while the long-term component contains the remaining slow-moving variations (>96 months). The total of the business cycle and long-term components thus excludes short-term variations (2-18 months).

Appendix: Weights of the different BK-filters applied in this paper

Minimising equation (6) delivers the weights of the Baxter-King filter used in this paper. The weights are symmetrical. It can be shown that the weights (b_k) equal:

$$b_k = \begin{cases} \dfrac{\sin\left(\dfrac{2\pi k}{P_L}\right) - \sin\left(\dfrac{2\pi k}{P_u}\right)}{\pi k} - \dfrac{C}{1+2K} & \text{for } 1 \le k \le K \\ \dfrac{2}{P_L} - \dfrac{2}{P_u} - \dfrac{C}{1+2K} & \text{for } k = 0, \end{cases}$$

$$\text{with} \quad C = \frac{2}{P_L} - \frac{2}{P_u} + 2\sum_{k=1}^{K}\left(\left(\sin\left(\frac{2\pi k}{P_L}\right) - \sin\left(\frac{2\pi k}{P_u}\right)\right) \Big/ \pi k\right)$$

and P_L and P_u the lower and upper boundary for the wavelength in months or quarters.

This table shows the weights to obtain the short-term, business cycle and long-term component in case of *K=36* for monthly data and *K=12* for quarterly data:

Moving average weights of the BK-filter for different frequency intervals[1]

	Monthly data			Quarterly data		
Lag (k)	Short-term	Business cycle	Long-term	Short-term	Business cycle	Long-term
0	0.8882	0.0925	0.0056	0.6649	0.2777	0.0175
1	-0.1095	0.0903	0.0056	-0.2775	0.2204	0.0171
2	-0.1030	0.0838	0.0055	-0.1396	0.0838	0.0159
3	-0.0926	0.0734	0.0054	-0.0018	-0.0521	0.0139
4	-0.0790	0.0600	0.0053	0.0671	-0.1184	0.0113
5	-0.0634	0.0445	0.0052	0.0533	-0.1012	0.0079
6	-0.0466	0.0279	0.0050	-0.0018	-0.0422	0.0040
7	-0.0299	0.0114	0.0049	-0.0412	0.0016	-0.0004
8	-0.0143	-0.0040	0.0046	-0.0363	0.0015	-0.0052
9	-0.0007	-0.0174	0.0044	-0.0018	-0.0279	-0.0103
10	0.0102	-0.0280	0.0041	0.0258	-0.0501	-0.0156
11	0.0179	-0.0354	0.0038	0.0232	-0.0423	-0.0210
12	0.0223	-0.0395	0.0035	-0.0018	-0.0119	-0.0263
13	0.0234	-0.0403	0.0032			
14	0.0217	-0.0382	0.0028			
15	0.0177	-0.0338	0.0024			
16	0.0121	-0.0278	0.0020			
17	0.0057	-0.0210	0.0015			
18	-0.0007	-0.0141	0.0011			
19	-0.0064	-0.0079	0.0006			
20	-0.0109	-0.0029	0.0001			
21	-0.0138	0.0005	-0.0004			
22	-0.0149	0.0021	-0.0009			
23	-0.0143	0.0021	-0.0014			
24	-0.0122	0.0005	-0.0020			
25	-0.0089	-0.0023	-0.0026			
26	-0.0049	-0.0057	-0.0031			
27	-0.0007	-0.0093	-0.0037			
28	0.0032	-0.0126	-0.0043			
29	0.0064	-0.0152	-0.0049			
30	0.0085	-0.0168	-0.0055			
31	0.0094	-0.0171	-0.0060			
32	0.0091	-0.0162	-0.0066			
33	0.0077	-0.0141	-0.0072			
34	0.0053	-0.0112	-0.0078			
35	0.0024	-0.0077	-0.0084			
36	-0.0007	-0.0040	-0.0090			

[1] In case of monthly (quarterly) data, the short-term component contains fluctuations between 2-18 months (2-6 quarters), the business cycle component contains fluctuations between 18-96 months (6-32 quarters) and the long-term component contains movements longer than 96 months (32 quarters).

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