Sectoral and Industrial Business Cycles

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Abstract

This article calculates the sectoral and industrial business cycles by means of the band-pass filters by Baxter and King (1999) and Christiano and Fitzgerald (2003), to subsequently analyze the correlations between the sectors and industries and the overall economy. It can be shown that the correlations between the business cycles of the sectors and industries and the overall economy differ strongly. The agriculture sector and the industries mining and quarrying, electricity and education for example exhibit almost no correlation with the overall economy; The wholesale and retail as well as the transport industry on the other hand have a high correlation. By means of an analysis of the leading and lagging correlations it can be shown that the wholesale and retail industry leads the overall economy by two quarters. Thus, the wholesale and retail industry can be used as an indicator for the development of the overall economy.

JEL Classification: E32, E37

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1 Introduction

The formation of the European Monetary Union led to an entire series of articles about the correlation and synchronization of business cycles. Most articles discuss the correlations of business cycles between different countries and regions. But there is no commonly know article which is dealing with the correlation of sectoral and industrial business cycles. Therefore, the following article calculates and analyzes the correlations and betas of sectoral and industrial business cycles.

The analysis of the correlations of sectoral and industrial business cycles is interesting out of four aspects. First, it throws a new light on the relevance of the studies of the convergence and synchronization of business cycles of different countries. If it can be shown that the sectoral and industrial business cycles only correlate weakly, it must be assumed that the business cycles of two countries, which differ strongly in the structure of their sectors and industries, also display a relatively weak correlation.[1] Second, the analysis of the sectoral and industrial correlations of business cycles can give indications of the effectiveness of anti-cyclical investments - which are propagandized by many politicians. If individual sectors or industries only correlate weakly with the overall economy, an anti-cyclical investment would not have the same impact on these sectors or industries as it would have on sectors or industries with a strong correlation. Third, statements about the forecasting ability of individual sectors and industries can be made by means of the leading and lagging sectoral and industrial correlations. Sectors and industries with a high leading correlation with the overall economy are well suited to predict the development of the overall economy. And fourth, the analysis of the correlation of sectoral and industrial business cycles is interesting for the monetary policy. If in an economy a sector, such as the service sector, with a very low cyclical fluctuation grows rapidly, then it must be assumed that the overall cyclical fluctuation is reduced - not due to a better monetary policy, but due to a growing percentage of low fluctuating

[1] Krugman (1993) already pointed out this problem in his article.

gross value added.

Best known in the field of business cycles correlation is probably the article by Backus and Kehoe (1992). However, similar to the approach used in the article at hand are the studies of Christodoulakis, Dimelis, and Kollintzas (1995), Artis and Zhang (1997), Angeloni and Dedola (1999) or Artis and Zhang (1999) which use a Hodrick and Prescott (1997) filter to identify the cyclical components. Yet even more similar to the approach used in this paper are the articles by Bergman, Bordo, and Jonung (1998), Wynne and Koo (2000) and Bergman (2004) which use the band-pass filter proposed by Baxter and King (1999) to extract the business cycles.[2]

The band-pass filters by Baxter and King (1999) and Christiano and Fitzgerald (2003), as well as the filter by Hodrick and Prescott (1997), have the advantage that besides the date of the turning point they also measure the magnitude of the fluctuation of the cycles - a characteristic which is neglected in many articles about the correlation and synchronization of business cycles.

The article at hand deals with sectoral and industrial data of the United Kingdom as is described in section 2. In contrast of the articles of Bergman, Bordo, and Jonung (1998), Wynne and Koo (2000) orBergman (2004) not only the band-pass filter by Baxter and King (1999) is used, but also the one by Christiano and Fitzgerald (2003). The assumptions and specifications which are required for both band-pass filters are discussed in section 3. In section 4 the sectoral business cycles and in section 5 the industrial business cycles of the United Kingdom are calculated and analyzed by means of the filters by Baxter and King and Christiano and Fitzgerald. Thereupon, the correlation and the beta between the sectoral and industrial business cycles on the one hand and the overall economy on the other hand are calculated in section 6. Section 7 then deals with the leading and lagging correlations of the sectoral and industrial cycles. And finally the conclusions drawn from the aforesaid are presented in section 8.

[2]The article of Bergman (2004) also provides a comprehensive literature survey.

2 Data and Definitions

The Office for National Statistics publishes quarterly indices (at constant prices) of the gross value added for 16 industries. In the following these 16 industries are, as shown in table 1, summarized in 4 sectors and 14 industries.[3]

Table 1: Classification, size and returns of sectors and industries

	Weights		Return	Std.
	Q. I 1955	Q. IV 2004		
Agriculture	2.1%	1.6%	1.86%	0.046
Production	45.6%	22.9%	1.66%	0.035
Mining	11.3%	1.7%	-1.34%	0.224
Manufacturing	32.6%	18.7%	1.35%	0.035
Electricity	1.8%	2.5%	3.14%	0.082
Construction	7.3%	5.5%	1.88%	0.053
Services	44.9%	70.1%	2.59%	0.014
Wholesale, Retail†	-	13.3%	2.35%	0.032
Hotels*	-	3.3%	1.79%	0.081
Transport	5.0%	7.2%	3.20%	0.030
Financial**	-	7.8%	3.79%	0.033
Real estate**	-	16.4%	4.97%	0.027
Public admin.	17.2%	5.6%	0.20%	0.012
Education†	-	5.1%	1.48%	0.015
Health†	-	7.5%	3.16%	0.022
Other services**	-	4.7%	3.55%	0.022
GDP	**100.0%**	**100.0%**	**2.47%**	**0.020**
Data series only since:	† : 1973	∗ : 1978	∗∗ : 1986	

The data on the gross domestic product belonging to these statistical series are only available since 1955. Therefore, in the following series available for a longer period of time will only be analyzed since 1955. As most European economies, and certainly also the one of the United Kingdom, were strongly affected by the war and post-war events until the fifties, this circumstance should not be valued too negatively. However, it can be assumed that most economies recovered from these events until the year of 1955, hence an unaltered gross domestic product is at hand since 1955.

Table 1 not only shows the classification of the sectors and industries, but also their size in percentage of the gross domestic product, their average logarithmic return and the respective standard deviation. It can be seen that service sector and its industries transport, financial, real estate, health and other ser-

[3] Whereas the agriculture and construction sector are also considered as industries.

vices as well as the electricity industry were expanding between Quarter I 1955 and Quarter IV 2005. All other sectors and industries were diminishing.

3 Filter Methods

In practice several filter methods are used to extract business cycles from the gross domestic product. The methods from Hodrick and Prescott (1997), Baxter and King (1999) and Christiano and Fitzgerald (2003) are the ones most frequently applied. As the last two methods are very similar - both are approximations of the ideal band-pass filter - only these will be analyzed in the following. The statistical end economical differences between the Baxter and King and the Christiano and Fitzgerald filter are explained in Everts (2006). As the two filters differ amongst others in the accuracy of the approximation of the ideal band-pass filter with respect to the length of the cycles considered and in the amount of calculable data points towards the ends of the data series, both filters will be analyzed and compared in the following sections.

3.1 Baxter and King Filter

For the Baxter and King (1999) filter three specifications are needed: the minimum and maximum duration of the business cycles and the desired length K of the approximated moving-average.[4]

For the minimum and the maximum duration Baxter and King (1999) refer to Burns and Mitchell (1946) and propose the values of 6 and 32 quarters respectively. However in Everts (2005) it was shown that the minimum and maximum duration have changed significantly since Burns and Mitchell. Therefore, in the following the modified Bry and Boschan (1971) procedure developed by Everts is used to determine the minimum and maximum duration as accurately as possible.[5] Table 2 shows the minimum and maximum duration of the business

[4] For a detailed description of the Baxter and King (1999) filter please refer to Everts (2006).

[5] The procedure developed in Everts (2005) is a modified Bry and Boschan (1971) procedure which determines the turning points of quarterly data series.

Table 2: Duration of business cycles since 1955

	Number of cycles	Business cycle duration Min	Max	Mean	Std.
Agriculture	13	6	30	14.80	6.801
Production	11	7	32	16.68	7.060
Mining	13	5	39	13.76	8.843
Manufacturing	12	6	31	15.21	6.554
Electricity	11	6	44	15.59	9.495
Construction	10	7	29	17.35	6.854
Services	2	41	100	61.33	33.501
Wholesale, Retail†	3	6	43	23.00	18.028
Hotels*	7	5	41	18.85	11.029
Transport	5	7	57	27.44	18.208
Financial**	2	6	32	20.25	13.720
Real estate**	2	6	35	20.00	14.166
Public admin.	11	5	23	14.43	5.938
Education†	5	10	51	22.11	13.878
Health†	0	-	-	-	-
Other services**	2	6	49	27.00	24.262
GDP	**6**	**5**	**49**	**23.25**	**17.566**

Data series only since: † : 1973 * : 1978 ** : 1986

cycles for the different sectors and industries calculated with the procedure.

For the third variable which is needed for the calculation of the Baxter and King (1999) filter, namely the desired length K of the moving average, Baxter and King propose a value of 12 quarters. As it is preferable to remain as comparable as possible to other authors, a K-value of 12 quarters is chosen in the following.[6]

3.2 Christiano and Fitzgerald Filter

The filter by Christiano and Fitzgerald (2003) only requires two specifications, namely the minimum and the maximum duration of the business cycles.[7]

Christiano and Fitzgerald (2003) calculate their filter, just like Baxter and King (1999), with 6 and 32 quarters respectively. However, as already mentioned in the previous section and as shown in Everts (2005) these values are out of date. Thus, in the following, the minimum and maximum durations from table 2 are also applied for the Christiano and Fitzgerald filter.

[6] Furthermore a detailed analysis of the optimal value of K showed that $K = 12$ leads to a very good approximation for all sectors and industries.

[7] For a detailed description of the Christiano and Fitzgerald (2003) filter please refer to Everts (2006).

4 Sectoral Business Cycles

In this section the two filters by Baxter and King (1999) and Christiano and Fitzgerald (2003) are applied to the 4 sectors of the United Kingdom as defined in table 1.

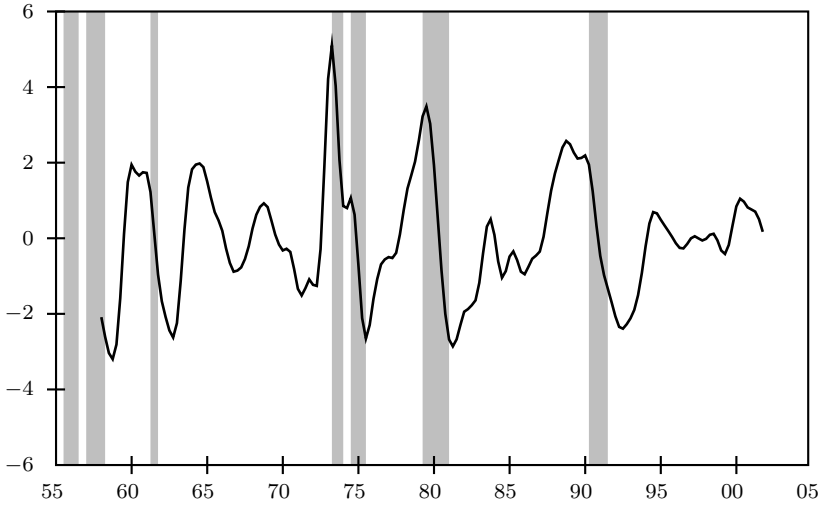
Table 2 shows that the minimum and maximum durations are not the same lengths for all sectors. Hence, the question arises whether the filters by Baxter and King (1999) and Christiano and Fitzgerald (2003) can be applied to individual sectors with different minimum and maximum durations. This question can be answered positively, as the proper minimum and maximum duration for each individual sector has to be employed in order to get an accurate analysis of the business cycles. In Everts (2005) it could be shown that the variability of the growth rate of the long-term trend is overestimated (underestimated) and the amplitudes of the medium-term business cycles underestimated (overestimated) if the maximum duration is chosen too short (long). Moreover, it was shown that if the minimum duration is chosen too long (short), the amplitudes of the medium-term business cycles are overestimated (underestimated).

4.1 Baxter and King Filter

In the following, the Baxter and King (1999) filter is calculated on the basis of the minimum and maximum durations from table 2 for the overall economy as well as for each of the 4 sectors.

Figure 1 shows the filtered business cycles of the overall economy of the United Kingdom and (hatched gray) the recessions according to the procedure developed in Everts (2005). When taking a closer look at the filtered data, it becomes apparent that the first and last twelve quarters are missing. Those are the $K = 12$ quarters which are needed for the approximation by Baxter and King (1999). Moreover it is apparent that the large recessions, thus the time-frames in which the filtered business cycles point strongly downwards, coincide

Figure 1: Overall business cycles according to Baxter and King



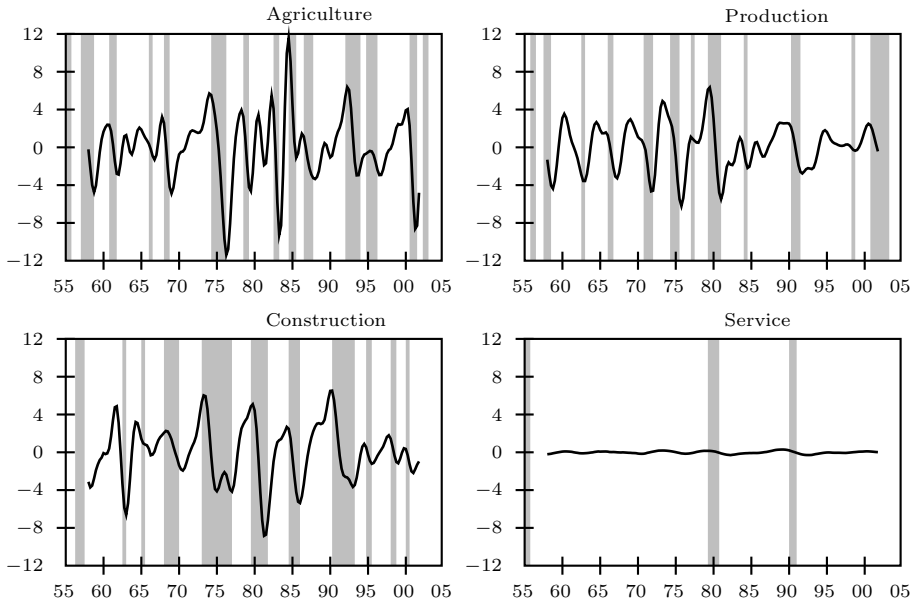
relatively well with the recessions of the procedure.[8]

Figure 2 shows the filtered data for the individual sectors of the United Kingdom as well as (hatched gray) the recessions according to the procedure developed in Everts (2005). All four diagrams of figure 2 are equally scaled. As the data - as mentioned in section 2 - are indexed, the cycles are comparable to each other. It becomes apparent that the agriculture sector exhibits the largest and the service sector the smallest business fluctuations. If the scaling is compared to the scaling of the gross domestic product, it becomes clear that the sectors agriculture, production and construction feature higher amplitudes than the overall economy, thus these sectors are exposed to higher fluctuations than the overall economy. The service sector on the other hand clearly exhibits smaller amplitudes and consequently is less affected by fluctuations than the overall economy.

To measure these differences between the maximum business fluctuations, the average of the maximum and minimum amplitudes of the different sectors were calculated and compared with the average of the maximum and minimum amplitude of the overall economy. The maximum business fluctuation of the

[8]The discrepancy of Quarter II 1991 to Quarter IV 1992 is a stagnation phase.

Figure 2: Sectoral business cycles according to Baxter and King



overall economy amounts to 0.042.[9] The maximum business fluctuation of the agriculture sector exceeds the maximum business fluctuation of the overall economy by 177%, that of the production sector by 51% and that of the construction sector by 65%. The maximum business fluctuation of the service sector on the other hand is 93% smaller than the one of the overall economy. Thus, the graphical interpretation, according to which the agriculture sector disposes exceptionally high and the service sector remarkably low business fluctuations, can be affirmed.

Moreover, figure 2 shows that the boom and recession phases of the individual sectors occur at different points in time. This insight is discussed in section 6, where the correlations between the individual sectors and the overall economy are analyzed.

[9] All filters were calculated based on logarithmic values. For the graphs these values were multiplied by 100 in order to emphasize the scaling differences.

4.2 Christiano and Fitzgerald Filter

In the following, the business cycles for the overall economy and the 4 sectors are calculated by means of the Christiano and Fitzgerald (2003) filter.

Figure 3: Overall business cycles according to Christiano and Fitzgerald

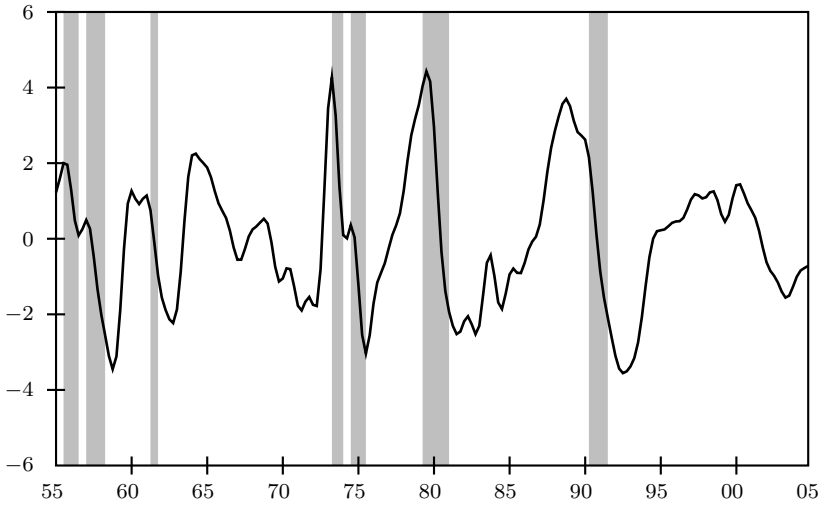
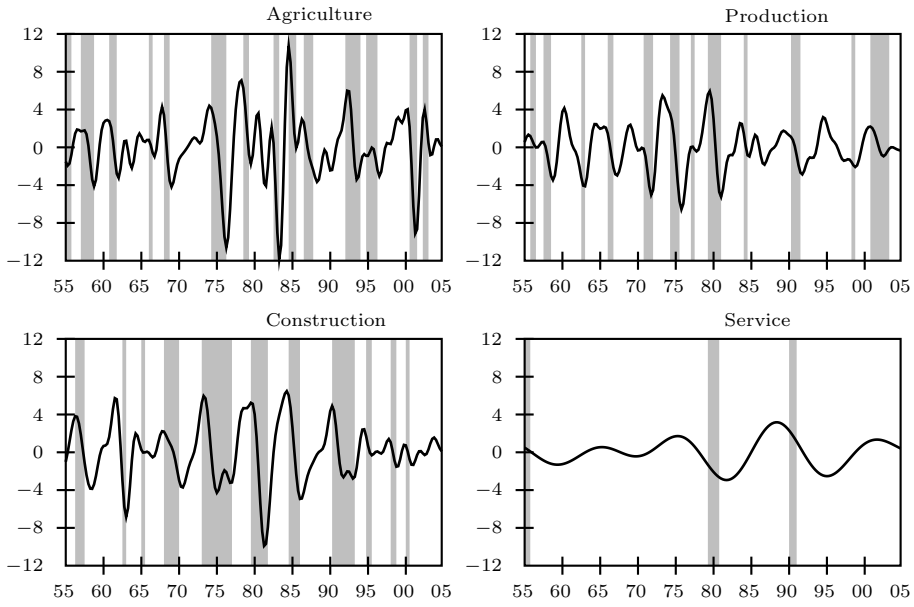


Figure 3 again shows the overall business cycles calculated from the gross domestic product as well as (hatched gray) the recessions according to the procedure developed in Everts (2005). A visual comparison of the figures 1 and 3 shows that the results according to the Baxter and King (1999) filter and the Christiano and Fitzgerald (2003) filter are very similar. The main difference arguably lies therein that the Christiano and Fitzgerald filter is not missing the first and last 12 quarters. If one measures the correlation between the two filters, it amounts to 0.92. In other words: The two filters do not just look very similar but they are in fact very similar.

Figure 4 displays the business cycles of the individual sectors and their recessions. When comparing figure 2 with figure 4 it becomes clear that the business cycles for the sectors agriculture, production and construction calculated by means of the Baxter and King (1999) filter are very similar to the ones calculated with the Christiano and Fitzgerald (2003) filter. The correlation coefficients amount to 0.93 for the agriculture sector, to 0.94 for the production

Figure 4: Sectoral business cycles according to Christiano and Fitzgerald



sector and to 0.90 for the construction sector. However, the business cycles of the service sectors differ quite strongly; the correlation between the results of the Baxter and King (1999) and the Christiano and Fitzgerald (2003) filter merely adds up to 0.56. One reason for this might be the extremely long minimum and maximum durations of this sector. Table 2 makes apparent that the minimum duration of the service sector is with 41 quarters more than eight times as high as the minimum duration of the overall economy; the maximum duration is with 100 quarters approximately twice as high as the maximum duration of the overall economy. In Everts (2006) it was shown that the filters by Baxter and King and Christiano and Fitzgerald mainly differ at low frequencies, thus high cycle durations. Hence, it is not surprising that the two filters deliver very different data for the service sector.

In accordance with figure 2 it becomes apparent in figure 4 that the agriculture sector possesses uncommonly high business fluctuations. The average of the maximum and minimum amplitudes of the overall economy for the Christiano and Fitzgerald (2003) filter amounts to 0.040 - hence lies slightly lower than

the average value for the Baxter and King (1999) filter. The maximum business fluctuation of the agriculture sector is by 182%, the one of the production sector by 57% and the one of the construction sector by 105% higher than the maximum business fluctuation of the overall economy. These values are 5% to 20% larger than the equivalent values for the Baxter and King filter. However, the largest difference can again be observed in the service sector. The maximum business fluctuation in this sector is for the Christiano and Fitzgerald filter only 23% smaller than that of the overall economy, while it was 93% smaller for the Baxter and King filter.

From the sectoral business cycles according to Christiano and Fitzgerald (2003) it becomes apparent that the boom and recession phases of the individual sectors diverge strongly. Common cycles can hardly be identified. That the boom and recession phases do not proceed synchronously can already be conjectured from the data of table 2, which makes apparent that the individual sectors exhibit different amounts of cycles. The service sector for example features only 2 cycles, while the agriculture sector shows 13.

5 Industrial Business Cycles

In the following, the two filters by Baxter and King (1999) and Christiano and Fitzgerald (2003) are once again calculated, however this time not as in section 4 for the 4 sectors, but for the 14 industries of the United Kingdom (see table 1).

For reasons of space the business cycles and recessions of the 14 different industries are not reproduced in individual figures for the Baxter and King (1999) and the Christiano and Fitzgerald (2003) filter, but each together in the figures 5 and 6. Moreover, an attempt is made to describe the filtered business cycles as precisely as possible in the tables 3 and 4.

5.1 Baxter and King Filter

Figures 5 and 6 show the filter by Baxter and King (1999) as dotted line; the recession according to the procedure developed in Everts (2005) are displayed gray hatched. It shall be emphasized that the y-axis are not equally scaled. It is remarkable in the figures 5 and 6 that the industries wholesale and retail, hotels, financial, real estate, education and health possess a shorter data set. These data series are - as already mentioned in table 2 - only available since 1973, 1978 and 1986 respectively. As the health industry furthermore does not exhibit a business cycle, but only a recession, and therefore does not have any specifications about the minimum and maximum duration of the business cycles, no filter can be calculated for this industry.

Table 3 shows the characteristics of the business cycles. A first characteristic attribute is the amount of business cycles. However, this amount is not calculated on the basis of the gray hatched areas (as it is the case in table 2) but by means of a modified procedure from Everts (2005). The procedure was modified in a way that it is applicable to filtered data and only measures peaks above zero and troughs below zero. By means of these turning points the amount of business cycles is computed. The second characteristic attribute is (as already in section 4) the average of the maximum and minimum amplitude, which to simplify matters is referred to as maximum amplitude. A third attribute then shows the difference between the maximum amplitude of an industry and the maximum amplitude of the overall economy. This difference indicates whether an industry is exposed to stronger or weaker business fluctuations than the overall economy. The fourth and last characteristic attribute of the filtered business cycles denotes the standard deviation. Together with the maximum amplitude and the amount of business cycles this figure shall allow a statement about the variability of the cycles.

From table 3 and from the figures 5 and 6 it becomes apparent that the industries agriculture, mining and quarrying and electricity exhibit an extraordinarily high amount of business cycles as well as very large business fluctuations.

Table 3: Characteristics of industrial business cycles according to Baxter and King

	Number of cycles	Maximum amplitude	Difference to GDP	Standard deviation
Agriculture	13	0.115	176.5%	0.033
Production	10	0.063	51.3%	0.022
Mining	12	0.278	568.7%	0.061
Manufacturing	9	0.062	49.1%	0.026
Electricity	11	0.179	331.1%	0.037
Construction	10	0.077	85.1%	0.028
Services	5	0.003	-92.9%	0.001
Wholesale, Retail†	6	0.058	39.4%	0.024
Hotels*	5	0.051	21.8%	0.023
Transport	6	0.045	8.7%	0.020
Financial**	2	0.038	-9.5%	0.016
Real estate**	4	0.045	8.5%	0.021
Public admin.	12	0.016	-61.8%	0.006
Education†	6	0.012	-70.0%	0.006
Health†	0	-	-	-
Other services**	1	0.040	-4.4%	0.016
GDP	**10**	**0.042**	**0.0%**	**0.015**

Data series only since: † : 1973 ∗ : 1978 ∗∗ : 1986

The public administration industry also possesses many business cycles, but the business fluctuations in this industry are marginal. Not necessarily astonishing is the fact that the education industry possesses minor business fluctuations as well.

Interesting is amongst others the remarkable recession in the electricity industry during 1984/85 as shown in figure 5. Thereby it must be mentioned that the electricity industry, as apparent from table 1, spans electricity as well as gas and water supply. Glacing at the mining and quarrying industry, one sees that also this industry was in a recession during 1984/85. The recessions in both industries are due to a strike of the miners which affected the mining and quarrying industry as well as the electricity industry. During this strike the energy crises in the United Kingdom reached its peak; shortly afterwards - 1986 for the gas and 1990 for the electricity - began the privatization phase.

In the following, not the single recessions or booms shall be analyzed but the interrelationships of the business cycles of the individual industries as such. It becomes apparent from table 3 that the sectors agriculture, production and construction as well as their industries feature exceedingly high business fluctu-

ations. The service sector on the other hand exhibits smaller maximum amplitudes than the overall economy.

A similar result is reflected in the standard deviations of the individual sectors and industries in table 3. The standard deviation of the business cycles of the sectors agriculture, production and construction and their industries is higher than the standard deviation of the business cycles of the overall economy, the standard deviation of the service sector on the other hand is lower.

Figure 5: Sectoral and industrial business cycles (I)
⟶ Christiano and Fitzgerald, ⇢ Baxter and King

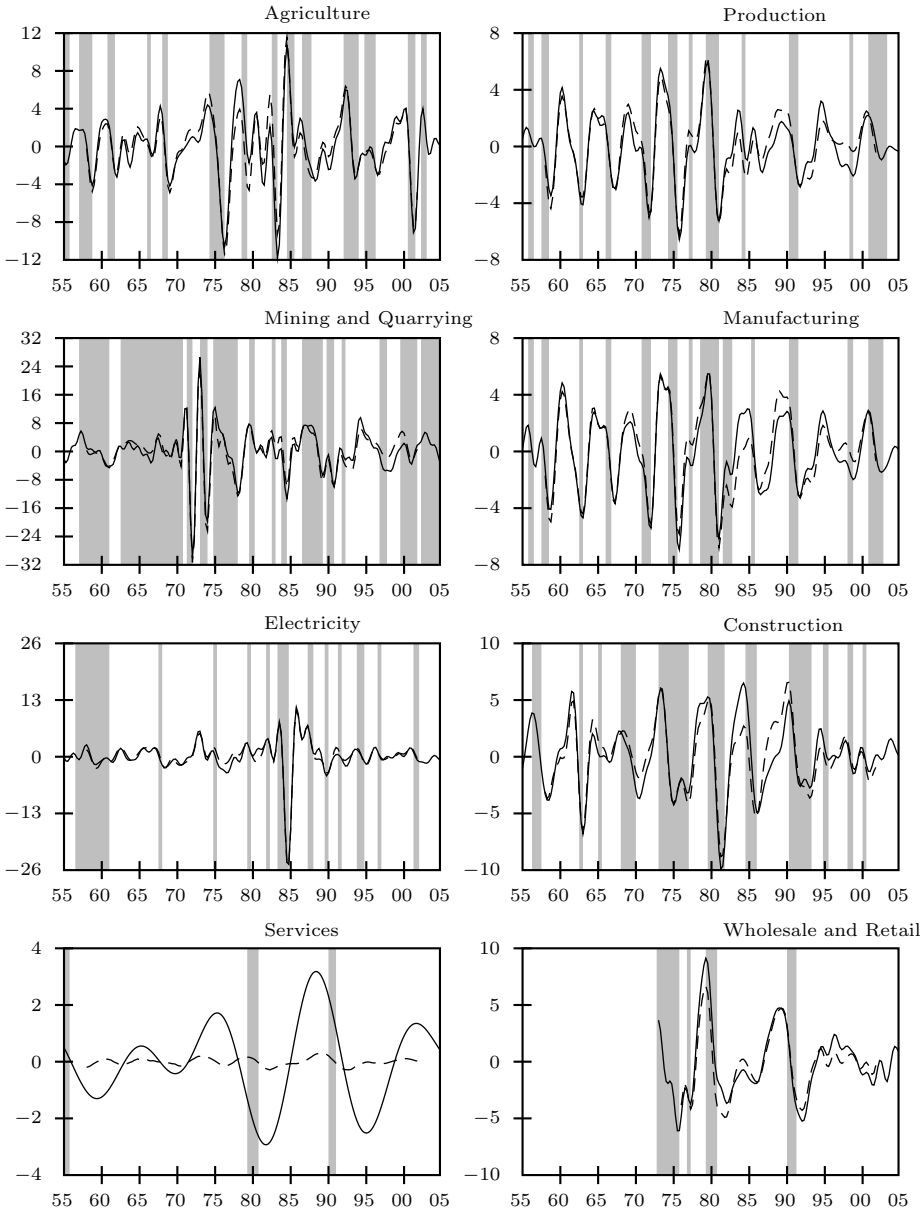
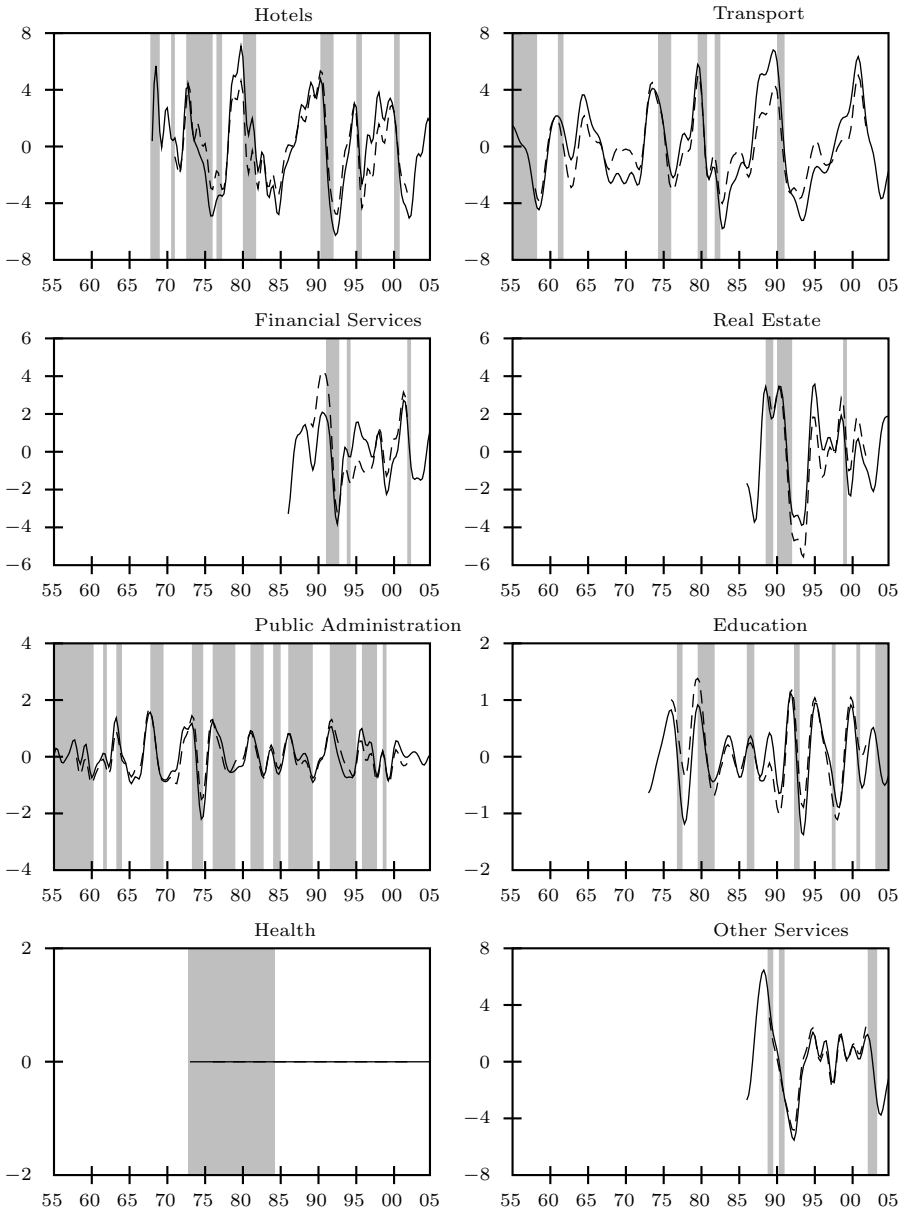


Figure 6: Sectoral and industrial business cycles (II)
⟶ Christiano and Fitzgerald, ⇢ Baxter and King



5.2 Christiano and Fitzgerald Filter

Figures 5 and 6 show the filter by Christiano and Fitzgerald (2003) (solid line) and the recessions according to the procedure developed in Everts (2005) (hatched gray).

Table 4 again shows the amount of business cycles calculated by means of the filtered data with a modified procedure following Everts (2005). As the amount of business cycles in table 4 is based upon a Christiano and Fitzgerald (2003) filter, but the same figure in table 3 is based upon a Baxter and King (1999) filter, some differences between the amounts of business cycles of the two tables can arise. Furthermore, table 4 states the average of the maximum and minimum amplitude (referred to as maximum amplitude), the difference of the maximum amplitude of the industry to the maximum amplitude of the overall economy, as well as the standard deviation of the filtered business cycles.

Table 4: Characteristics of industrial business cycles according to Christiano and Fitzgerald

	Number of cycles	Maximum amplitude	Difference to GDP	Standard deviation
Agriculture	12	0.113	182.2%	0.034
Production	10	0.063	56.7%	0.023
Mining	14	0.283	608.6%	0.062
Manufacturing	10	0.062	55.2%	0.025
Electricity	13	0.180	350.9%	0.038
Construction	13	0.082	105.1%	0.030
Services	3	0.076	90.5%	0.030
Wholesale, Retail†	3	0.076	91%	0.030
Hotels*	5	0.067	67.2%	0.031
Transport	6	0.063	58.0%	0.029
Financial**	6	0.033	-18.1%	0.014
Real estate**	3	0.037	-6.5%	0.022
Public admin.	16	0.019	-52.8%	0.006
Education†	8	0.013	-68.6%	0.006
Health†	0	-	-	-
Other services**	3	0.060	50.2%	0.026
GDP	**7**	**0.040**	**0.0%**	**0.018**
Data series only since:	† : 1973	∗ : 1978	∗∗ : 1986	

It can be seen in table 4 and figures 5 and 6 that both the sectors agriculture, production and construction and their industries exhibit surpassing maximum business fluctuations. For the service sector and its industries financial, real estate, public administration and education on the other hand the business

fluctuations appear to be lower than those of the overall economy.

The standard deviations of the sectors agriculture, production and construction and their industries are on average again larger than the standard deviation of the overall economy. This leads to the conclusion that the business cycles of some sectors or industries have to be negatively correlated with the business cycles of the overall economy. This aspect, namely the correlation of the individual sectors and industry towards the overall economy, will be discussed in section 6.

6 Correlations of Sectoral and Industrial Cycles

In the following section two different figures are calculated: on the one hand the correlation between the sectors and the overall economy and on the other hand the weighted beta of the sectors. The beta is mainly used as a financial ratio and is being calculated as $\beta_i = \frac{\sigma_{i,M}}{\sigma_M^2}$ whereas $\sigma_{i,M}$ is the covariance of the sector i and the overall economy M and σ_M^2 the variance of the overall economy. Taking into account that the covariance can be represented as $\sigma_{i,M} = \rho_{i,M}\sigma_i\sigma_M$, the beta can be written as $\beta_i = \rho_{i,M}\frac{\sigma_i}{\sigma_M}$. Thereby, $\rho_{i,M}$ measures the correlation of the sector i with the overall economy M and σ_i and σ_M state the standard deviation of the sector i and the overall economy M respectively. Thus, the beta of a sector numeralizes the correlation of the sector towards the overall economy standardized with the ratio of the standard deviation of the sector and the standard deviation of the overall economy. If the standard deviation of the sector is smaller (larger) than the standard deviation of the overall economy, then the beta is smaller (larger) than the correlation. However, in the following the weighted beta is utilized as ratio because it not only allows to make a statement about the strength of the correlation but also about the magnitude of the fluctuations with respect to the size of the sector. The weighted beta is

defined as

$$\tilde{\beta}_i = \omega_i \rho_{i,M} \frac{\sigma_i}{\sigma_M}$$

whereas ω_i is the weight of the sector i in respect to the overall economy, $\rho_{i,M}$ the correlation of the sector i with the overall economy M and σ_i and σ_M the standard deviation of the sector i and the overall economy M respectively.

As the correlations and thus also the weighted betas vary relatively strongly over time, 10-year rolling windows are calculated in the following. The time varying 10-year correlations are then displayed in figures 7 and 8. Moreover, the average of the 10-year rolling windows over the whole horizon is indicated in tables 5 and 6. For all sectors and most industries the longest data set is 50 years. However, for the hotels industry it is 37 years, for the industries wholesale and retail, education and health only 32 and for the industries financial intermediation, real estate and other services merely 19 years.

As mentioned in section 5 the filter methods by Baxter and King (1999) and Christiano and Fitzgerald (2003) differ in various aspects.[10] Hence, in the following the correlations and the weighted betas are analyzed separately for both filters.

6.1 Baxter and King Filter

Besides the average of the 10-year rolling windows for the sectors and industries, table 5 also shows the standard deviation of the 10-year rolling windows and the correlations and weighted betas of the last ten years. As a Baxter and King (1999) filter is analyzed here, for which - as already mentioned before - the last $K = 12$ quarters are missing, the last ten years correspond to the time period between 1992 and 2001.

Furthermore, figures 7 and 8 show the correlation of the 10-year rolling

[10] Everts (2006) showed that the main differences between the two filters lie in two assumptions; namely the assumption about the spectral density and the assumption about the symmetry of the filter weights.

windows over time. However, it shall be pointed out that a 10-year rolling window for quarterly data only contains forty data points and hence reacts relatively strongly to small changes.

Table 5: Correlation and weighted beta according to Baxter and King

	Correlation			Weighted Beta		
	Mean	Std.	92-01	Mean	Std.	92-01
Agriculture	-0.068	0.362	-0.428	-0.004	0.015	-0.023
Production	0.901	0.052	0.949	0.442	0.097	0.336
Mining	0.076	0.211	0.630	0.014	0.026	0.046
Manufacturing	0.887	0.047	0.921	0.417	0.075	0.282
Electricity	0.070	0.365	0.138	0.003	0.011	0.004
Construction	0.767	0.105	0.645	0.093	0.021	0.049
Services	0.796	0.149	0.903	0.045	0.023	0.075
Wholesale, Retail†	0.899	0.074	0.693	0.196	0.024	0.124
Hotels*	0.777	0.066	0.532	0.045	0.009	0.039
Transport	0.855	0.057	0.822	0.064	0.023	0.136
Financial**	0.486	0.085	0.618	0.060	0.010	0.072
Real estate**	0.850	0.008	0.858	0.288	0.023	0.312
Public admin.	-0.261	0.323	-0.477	-0.006	0.011	-0.014
Education†	-0.157	0.552	0.134	-0.004	0.015	0.006
Health†	-	-	-	-	-	-
Other services**	0.706	0.071	0.786	0.063	0.011	0.074
GDP	**1.000**	**0.000**	**1.000**	**1.000**	**0.000**	**1.000**

Data series only since: † : 1973 ∗ : 1978 ∗∗ : 1986

At first sight, the correlations of the individual sectors and industries in table 5 are astoundingly diverse: over the whole time horizon they vary between -0.261 and 0.901, over the last then years even between -0.477 and 0.949. The average correlation over all sectors and industries amounts to 0.512, both for the whole time horizon and for the last ten years. Hence, the mean of the correlations did not change, but the variance of the individual values did.

Looking at the individual values, it can be noticed that the sectors and industries can be divided into two classes: into a class with a relatively high correlation of over 0.75 and into a class with a relatively low correlation of below 0.1. As often - amongst others also for anti-cyclical investments - mainly sectors and industries with a high correlation are of interest. From table 5 it appears that the sectors production, construction and services as well as the industries manufacturing, wholesale and retail, hotels, transport and real estate exhibit 10-year correlations which are above 0.75.

Examining the cross-correlations between the individual sectors and indus-

tries in appendix A table 9, it can be seen that also here some sectors and industries feature a high correlation to each other. For example the manufacturing industry possesses a correlation of 0.83 with the wholesale and retail industry and 0.82 with the transport industry. Furthermore, the industries wholesale and retail and transport are with 0.79 relatively strongly correlated with each other.

From table 5 as well as table 9 in appendix A it becomes apparent that the average correlations of the individual sectors and industries vary strongly. Figures 7 and 8 show yet another interesting aspect: sectors and industries with a low correlation, as for example the agriculture sector or the industries mining and quarrying, electricity, public administration and education are exposed to relatively high fluctuations of the correlation over time. Sectors and industries with a high correlation on the other hand, such as the sectors production and construction as well as the industries manufacturing, wholesale and retail and transport, are relatively stable in respect to the variation of the correlation over time.

To actually serve a government which desires to invest anti-cyclically as a decision base, a high and stable correlation alone is not enough. Rather, a sector or industry should also exhibit a high weighted beta and thus, have a strong impact on the overall economy.

Figure 7: Correlations between the sectors and industries and the overall economy (I)
⟶ Christiano and Fitzgerald, ⇢ Baxter and King

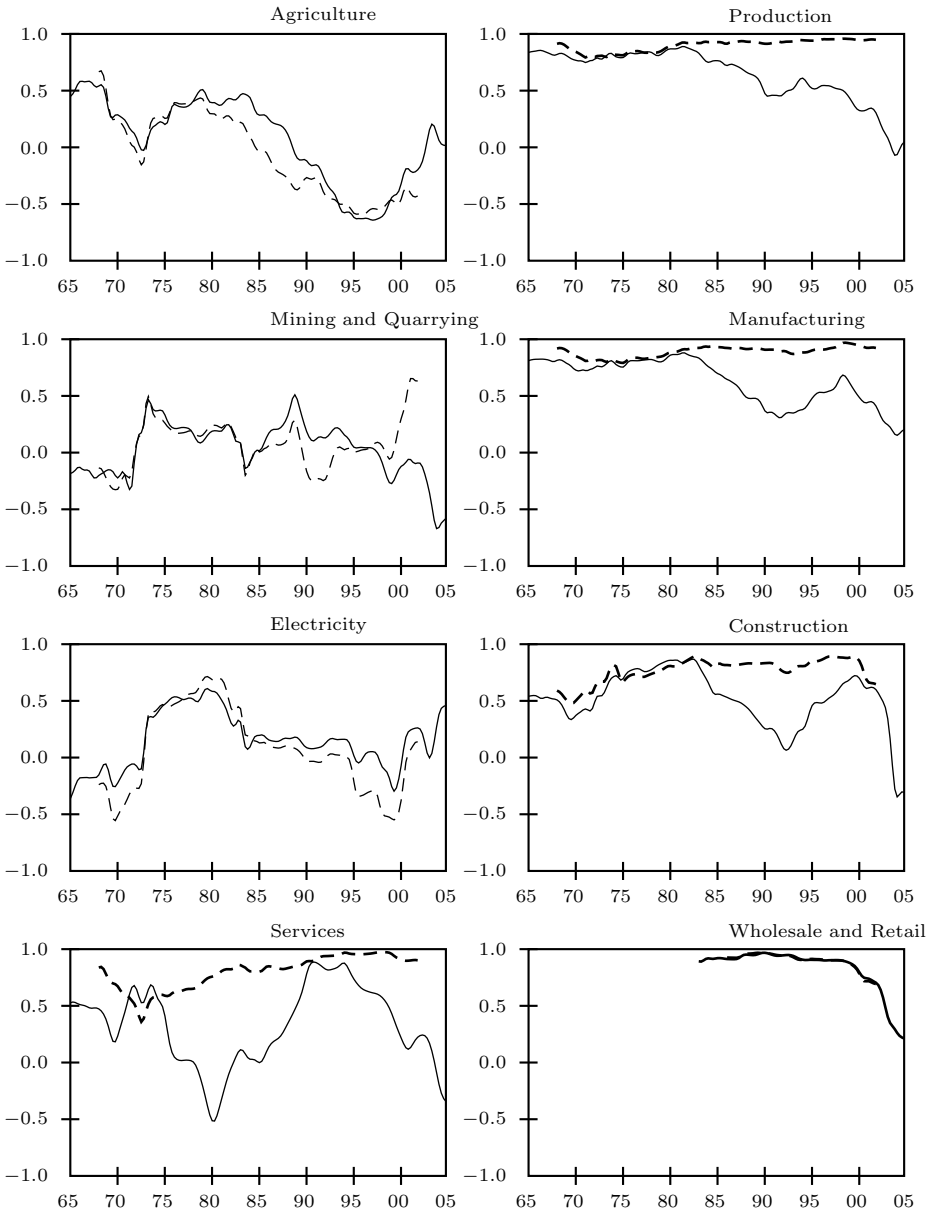
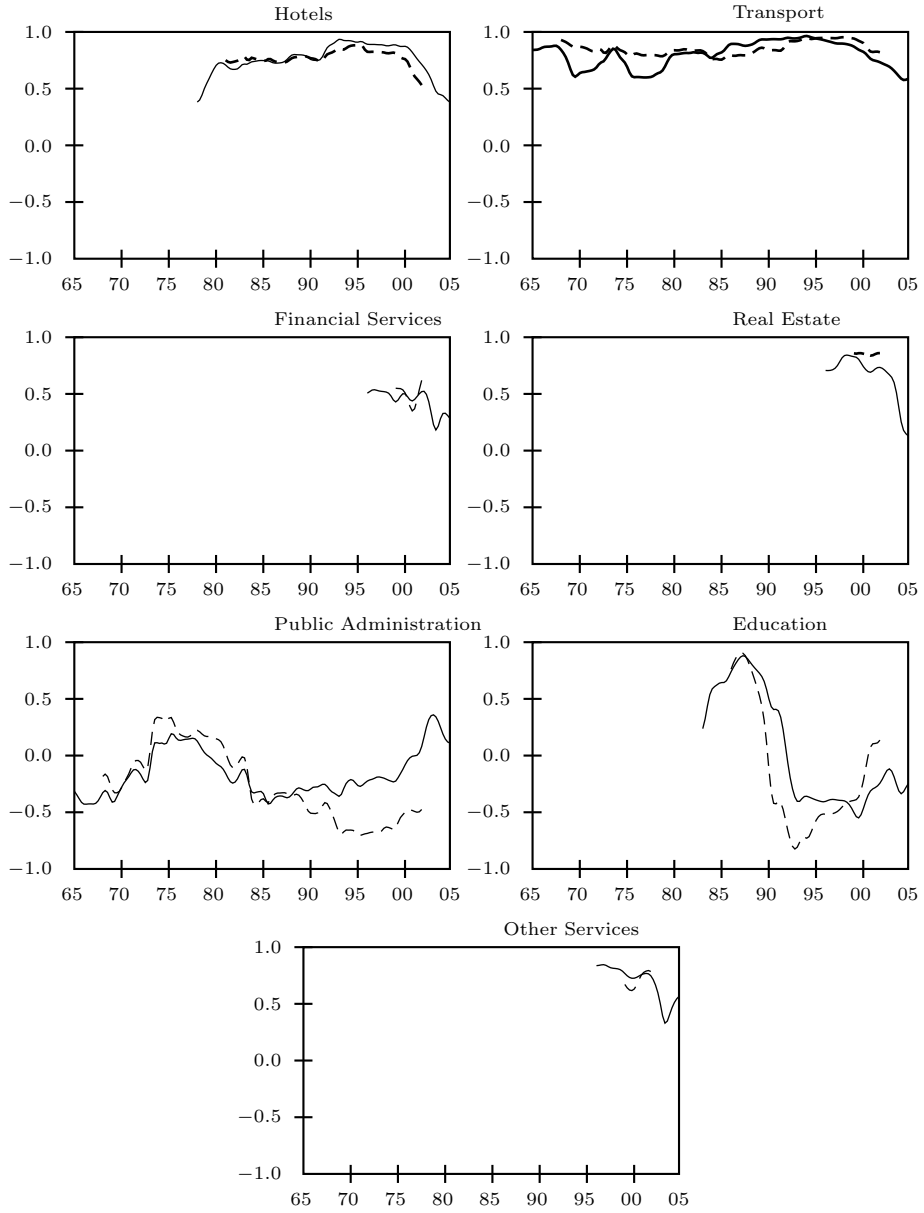


Figure 8: Correlations between the sectors and industries and the overall economy (II)
⟶ Christiano and Fitzgerald, ⇢ Baxter and King



6.2 Christiano and Fitzgerald Filter

Table 6 and figures 7 and 8 show the 10-year rolling windows for the correlations and weighted betas according to the Christiano and Fitzgerald (2003) filter. The values stated in table 6 are the averages of all 10-year rolling windows. Moreover, the correlations and weighted betas over the last ten years (thus the last forty quarters) were calculated again. Unlike the Baxter and King (1999) filter, the Christiano and Fitzgerald (2003) filter does not loose any data at the beginning and at the end of a data series. Thus, if the correlation and the weighted beta are calculated over the last ten years, the figures obtained are corresponding to the time period between 1995 and 2004.[11]

Table 6: Correlation and weighted beta according to Christiano and Fitzgerald

	Correlation			Weighted Beta		
	Mean	Std.	95-04	Mean	Std.	95-04
Agriculture	0.072	0.375	0.016	0.004	0.013	0.001
Production	0.641	0.232	0.049	0.310	0.202	0.016
Mining	0.031	0.237	-0.582	0.009	0.027	-0.036
Manufacturing	0.623	0.203	0.203	0.276	0.170	0.058
Electricity	0.147	0.244	0.458	0.007	0.008	0.013
Construction	0.515	0.252	-0.309	0.055	0.029	-0.015
Services	0.327	0.349	-0.343	0.146	0.198	-0.365
Wholesale, Retail†	0.832	0.194	0.212	0.149	0.043	0.039
Hotels*	0.752	0.143	0.381	0.041	0.005	0.035
Transport	0.803	0.114	0.589	0.072	0.025	0.128
Financial**	0.436	0.102	0.281	0.027	0.006	0.030
Real estate**	0.661	0.197	0.128	0.116	0.028	0.034
Public admin.	-0.160	0.203	0.108	-0.005	0.008	0.003
Education†	0.044	0.495	-0.250	0.000	0.014	-0.016
Health†	-	-	-	-	-	-
Other services**	0.693	0.155	0.568	0.043	0.011	0.048
GDP	**1.000**	**0.000**	**1.000**	**1.000**	**0.000**	**1.000**
Data series only since:	$\dagger$: 1973	$*$: 1978	$**$: 1986			

Once more the correlations of the individual sectors and industries are strikingly different and vary over the whole time horizon between -0.160 and 0.832. The correlations from 1995 to 2004 differ between -0.582 and 0.589. It is obvious that the minimum and maximum correlations decrease towards the end of the time horizon. Also the average correlation declines strongly over the years: over the whole time horizon the average correlation amounts to 0.44 and over the

[11] The cross-correlations of the individual sectors and industries are to be found in appendix A, table 10.

time horizon from 1995 to 2004 only to 0.114. This fact allows for an interesting hypothesis: the correlations seem to break down towards the end of the nineties, and the sectors and industries behave towards the turn of the millennium as if they would be uncoupled from the overall economy.

Unfortunately, at this point no known statistical test can be applied to investigate the assumption under consideration of a structural break in the correlations. The test by Chow (1960), Quandt (1960) and the test described by Stock (2004) cannot be applied if the structural break occurs towards the end of the data series. Thus, the question whether the correlations collapsed towards the end of the nineties must be left unanswered at the current point in time and remains subject of future investigations. However, observing the correlations in figures 7 and 8 it can be clearly recognized that the correlations broke down towards the turn of the millennium (between Quarter II 1998 and Quarter III 2001) amongst others in the service sector as well as in the industries wholesale and retail, hotels and real estate.

In contrast to the Baxter and King (1999) filter, the correlations cannot be divided into two classes (a class with a high correlation and a class with a low correlation) for the Christiano and Fitzgerald (2003) filter. Comparing the tables 5 and 6 it becomes apparent that the sectors production and construction as well as the manufacturing industry feature according to the Christiano and Fitzgerald filter an average correlation which is approximately 0.26 smaller than the average correlation according to the Baxter and King filter. For the Christiano and Fitzgerald filter these sectors and industries, together with the industries hotels and real estate, constitute a third class which exhibits a correlation between 0.5 and 0.75.

It is remarkable that when applying the Christiano and Fitzgerald (2003) filter less industries exhibit high correlations. One reasons for this difference might be the fact that the Christiano and Fitzgerald filter possesses 24 quarters more data than the Baxter and King filter; then again the afore mentioned breakdown of the correlations towards the turn of the millennium also plays a

role.

Examining the figures 7 and 8 it becomes apparent that - same as for the Baxter and King (1999) filter - the sectors and industries with a relatively low correlation (as for example the industries wholesale and retail, transport or hotels) exhibit a comparatively stable correlation with the overall economy. On the other hand, sectors and industries with a relatively low correlation, as for example the agriculture sector or the industries mining and quarrying, electricity, public administration or education, show a comparatively high variability of the correlation over time.

In figures 7 and 8 it is also remarkable that between 1980 and 2000 the correlations calculated according to the Christiano and Fitzgerald (2003) filter for the production sector and the industries manufacturing and construction differ strongly from the significantly high correlations calculated according to the Baxter and King (1999) filter.[12] Thereby, it is interesting that the sectors production and construction as well as the manufacturing industry are evidently connected as they all belong to the secondary sector. Already in the figures 5 and 6 it can be recognized that the filters by Baxter and King and Christiano and Fitzgerald lead to relatively different results for the business cycles of these sectors and industries between 1980 and 2000.

7 Leading and Lagging Correlations of Sectoral and Industrial Business Cycles

It is often assumed that some sectors and industries are leading or lagging the overall economy. Therefore, the leading and lagging correlations of the sectors and industries shall be analyzed in the following. For this purpose, as already in section 6, the average of the 10-year rolling windows is calculated. The 10-year correlations of the rolling windows are again based upon the data of the two

[12] Also the correlations for the service sector strongly depend on whether they are calculated by means of the Baxter and King (1999) or the Christiano and Fitzgerald (2003) filter.

filters by Baxter and King (1999) and Christiano and Fitzgerald (2003).

7.1 Baxter and King Filter

Table 7 shows the leading and lagging correlations according to the Baxter and King (1999) filter for the 2 and 4 quarters leads and lags.

Table 7: Leading and lagging correlations according to Baxter and King

	Leading		Lagging	
	2-Q.	4-Q.	2-Q.	4-Q.
Agriculture	-0.132	-0.096	0.091	0.147
Production	0.661	0.200	0.724	0.290
Mining	0.115	0.017	-0.178	-0.236
Manufacturing	0.596	0.119	0.765	0.388
Electricity	0.131	0.145	-0.061	-0.092
Construction	0.586	0.237	0.653	0.300
Services	0.683	0.405	0.711	0.458
Wholesale, Retail†	0.909	0.688	0.666	0.310
Hotels*	0.646	0.347	0.692	0.443
Transport	0.567	0.126	0.810	0.517
Financial**	0.134	-0.280	0.708	0.760
Real estate**	0.531	0.172	0.894	0.646
Public admin.	-0.208	-0.127	-0.269	-0.181
Education†	-0.243	-0.265	-0.079	-0.055
Health†	-	-	-	-
Other services**	0.845	0.785	0.370	-0.040
GDP	0.749	0.306	0.749	0.307
Data series only since:	† : 1973	∗ : 1978	∗∗ : 1986	

Table 7 shows that the 2 quarters auto-correlation of the overall economy amounts to 0.749, the 4 quarters auto-correlation to approximately 0.306.

Examining the correlations of the sectors and industries with the overall economy it is striking that the industries wholesale and retail and other services exhibit very high 2 quarters leading correlations.[13] In other words: the wholesale and retail industry is well suited for half-year forecasts of the overall economy. Admittedly this is not surprising as the consumer confidence is considered to be a relatively good indicator for the future development of the overall economy.

The 4 quarters leading correlation with the overall economy on the other hand is only significantly higher than 0.75 for the other services industry. For the wholesale and retail industry the 4 quarters leading correlation is with 0.688

[13]Whereas for the other services industry it must be noted that the data set available is very short - namely from 1986 to 2004.

still relatively high; but in contrast to the half-year forecast it is not suited for a year forecast of the overall economy.

Considering the lagging correlations it is remarkable that the industries manufacturing, transport and real estate exhibit a significantly high 2 quarters lagging correlation with the overall economy. These industries cannot be used to forecast the overall economy, however the overall economy can forecast the development of these industry on a half-year basis.

Not apparent in table 7, but nevertheless interesting, is the fact that the wholesale and retail industry exhibits with 0.820 and 0.834 a significantly high 2 quarters and 4 quarters leading cross-correlation with the real estate industry. The wholesale and retail industry can thus be employed for half-year as well as year forecasts for the real estate industry. Furthermore the wholesale and retail industry also features a high 2 quarters leading cross-correlation with the industries hotels and transport. And last but not least the construction sector and the manufacturing industry show a high 2 quarters leading cross-correlation with the real estate industry.

7.2 Christiano and Fitzgerald Filter

Table 8 shows the leading and lagging correlations according to the Christiano and Fitzgerald (2003) filter; again only the 2 and 4 quarters leads and lags are indicated.

It is interesting that according to the Christiano and Fitzgerald (2003) filter the wholesale and retail industry exhibits a high 2 quarters leading correlation as well. Hence, it can be concluded that the wholesale and retail industry truly is well suited for half-year forecasts of the overall economy. The second high value is the 2 quarters lagging correlation with the transport industry, which seems to behave rather sluggishly compared to the overall economy.

Analyzing the cross-correlations between the individual sectors and industries it can be concluded that only two industries possess a significantly high cross-correlation: the wholesale and retail industry has a high 2 quarters leading

Table 8: Leading and lagging correlations according to Christiano and Fitzgerald

	Leading		Lagging	
	2-Q.	4-Q.	2-Q.	4-Q.
Agriculture	0.025	0.013	0.142	0.125
Production	0.447	0.073	0.484	0.116
Mining	0.079	0.024	-0.187	-0.230
Manufacturing	0.383	-0.013	0.514	0.188
Electricity	0.168	0.154	0.082	0.090
Construction	0.378	0.110	0.404	0.116
Services	0.315	0.275	0.318	0.282
Wholesale, Retail†	0.837	0.680	0.655	0.378
Hotels*	0.655	0.417	0.694	0.516
Transport	0.604	0.280	0.773	0.564
Financial**	0.325	0.123	0.417	0.276
Real estate**	0.524	0.341	0.594	0.303
Public admin.	-0.042	0.060	-0.241	-0.213
Education†	0.030	0.019	0.028	-0.020
Health†	-	-	-	-
Other services**	0.720	0.635	0.488	0.229
GDP	0.791	0.428	0.791	0.428
Data series only since:	† : 1973	∗ : 1978	∗∗ : 1986	

correlation with the hotels industry and the construction sector shows a high 2 quarters leading correlation with the real estate industry.

8 Conclusions

The article at hand first calculates the sectoral and industrial business cycles on the basis of the band-pass filters by Baxter and King (1999) and Christiano and Fitzgerald (2003), to subsequently analyze the correlations between the cycles of the sectors as well as industries and those of the overall economy.

When calculating the sectoral and industrial business cycles it stands out that the business cycles of the sectors and industries diverge strongly in the amount of cycles, in the point in time of the turning points as well as in the amplitudes of the cycles. The sectors agriculture, production and construction as well as the industries mining and quarrying, manufacturing and electricity for example clearly exhibit more business cycles and higher fluctuations than the overall economy.

The calculated correlations between the sectoral and industrial business cycles and the cycles of the overall economy show that the correlations for the

individual sectors and industries are very different. The agriculture sector as well as the industries mining and quarrying, electricity and education possess nearly no correlation with the overall economy. The wholesale and retail as well as the transport industry on the other hand exhibit a high correlation.

This result, namely the fact that a high correlation between the business cycles of sectors and industries and the business cycles of the overall economy is not self-evident, has an impact on three different aspects: Firstly, it reveals that attention must be payed with anti-cyclical investments that the sector or industry under consideration possesses a high correlation with the overall economy. If the correlation of the sector or industry with the overall economy is low, and hence if it is unclear whether a sector or industry is at the same time in a recession as the overall economy, the employment effect attained with the anti-cyclical investment will turn out to be only marginal. Secondly, the varying correlations between the sectors or industries and the overall economy also have implications on the interpretation of correlation comparisons of business cycles between different countries. The studies about the convergence and synchronization of business cycles of different countries, which are mainly made in connection to exchange rate regimes and currency unions, should attend to the fact that the compared countries feature a similar weighting of the sectors and industries. From the results presented in this article it becomes clear that - only to name an example - the business cycles of a country with a large agriculture sector will correlate only weakly with the business cycles of a country with a large production sector. The conclusion that the weighting of the sectors and industries must be similar in order to find a high correlation between the business cycles of different countries, may also explain the consistently found fact that groups of countries and regions feature very similar business cycles - neighboring countries and regions which nota bene in many cases have a similar structure of sectors and industries. Thirdly, the low correlations between certain sectors and industries and especially the low cyclical fluctuation of the service sector may tells a new story about the monetary policy of industrialized countries.

The business cycles of an industrialized country with a growing service sector could exogenously become less fluctuating. In other words: The reduction of the business cycle fluctuation of some industrialized countries could be due to an growing sector or industry with a low cyclical fluctuation and not due to a better monetary policy.

However, the article at hand not only calculates the correlations and cross-correlations but also the leading and lagging correlations of the sectors and industries with the overall economy. Thereby it can be shown that the wholesale and retail industry features a high 2 quarters leading correlation with the overall economy. In other words, it is shown that the development of the wholesale and retail industry is well suited for half-year forecasts of the overall economy.

A Cross-Correlations

Table 9: Cross-correlations according to Baxter and King

	Agri	Prod	Mini	Manu	Elec	Cons	Serv	Whol	Hote	Tran	Fina	Real	Publ	Educ	Othe	GDP
Agri	-	-0.16	-0.28	-0.03	-0.09	0.02	0.12	-0.44	-0.23	0.09	-0.13	-0.20	0.08	0.22	-0.59	-0.07
Prod	-0.16	-	0.09	0.94	0.06	0.63	0.63	0.85	0.73	0.79	0.28	0.74	-0.43	-0.11	0.75	0.90
Mini	-0.28	0.09	-	-0.06	0.33	-0.11	-0.08	0.08	0.07	0.00	-0.31	0.21	0.08	0.30	0.61	0.08
Manu	-0.03	0.94	-0.06	-	-0.11	0.65	0.64	0.83	0.68	0.82	0.37	0.76	-0.46	-0.17	0.65	0.89
Elec	-0.09	0.06	0.33	-0.11	-	-0.06	0.22	-0.15	0.12	0.08	0.11	-0.28	0.18	0.08	0.03	0.07
Cons	0.02	0.63	-0.11	0.65	-0.06	-	0.68	0.73	0.65	0.64	0.54	0.71	-0.19	-0.27	0.33	0.77
Serv	0.12	0.63	-0.08	0.64	0.22	0.68	-	0.85	0.78	0.83	0.51	0.84	-0.19	-0.19	0.64	0.80
Whol	-0.44	0.85	0.08	0.83	-0.15	0.73	0.85	-	0.71	0.79	0.05	0.56	-0.67	-0.25	0.87	0.90
Hote	-0.23	0.73	0.07	0.68	0.12	0.65	0.78	0.71	-	0.74	0.44	0.61	-0.43	-0.26	0.58	0.78
Tran	0.09	0.79	0.00	0.82	0.08	0.64	0.83	0.79	0.74	-	0.48	0.79	-0.32	-0.19	0.56	0.85
Fina	-0.13	0.28	-0.31	0.37	0.11	0.54	0.51	0.05	0.44	0.48	-	0.55	0.04	-0.24	0.02	0.49
Real	-0.20	0.74	0.21	0.76	-0.28	0.71	0.84	0.56	0.61	0.79	0.55	-	-0.35	-0.14	0.53	0.85
Publ	0.08	-0.43	0.08	-0.46	0.18	-0.19	-0.19	-0.67	-0.43	-0.32	0.04	-0.35	-	0.41	-0.68	-0.26
Educ	0.22	-0.11	0.30	-0.17	0.08	-0.27	-0.19	-0.25	-0.26	-0.19	-0.24	-0.14	0.41	-	-0.07	-0.16
Othe	-0.59	0.75	0.61	0.65	0.03	0.33	0.64	0.87	0.58	0.56	0.02	0.53	-0.68	-0.07	-	0.71
GDP	-0.07	0.90	0.08	0.89	0.07	0.77	0.80	0.90	0.78	0.85	0.49	0.85	-0.26	-0.16	0.71	-

Table 10: Cross-correlations according to Christiano and Fitzgerald

	Agri	Prod	Mini	Manu	Elec	Cons	Serv	Whol	Hote	Tran	Fina	Real	Publ	Educ	Othe	GDP
Agri	-	-0.03	-0.23	0.07	-0.10	0.10	0.06	-0.21	-0.06	0.13	-0.71	-0.30	-0.03	0.29	-0.48	0.07
Prod	-0.03	-	0.10	0.93	0.09	0.58	0.01	0.51	0.41	0.48	0.43	0.48	-0.42	0.13	0.50	0.64
Mini	-0.23	0.10	-	-0.07	0.29	-0.16	0.00	0.10	0.11	-0.04	0.02	-0.05	0.11	0.32	0.26	0.03
Manu	0.07	0.93	-0.07	-	-0.11	0.63	0.00	0.47	0.35	0.48	0.48	0.60	-0.46	0.03	0.46	0.62
Elec	-0.10	0.09	0.29	-0.11	-	-0.12	0.09	0.07	0.25	0.17	0.18	-0.22	0.11	-0.02	0.22	0.15
Cons	0.10	0.58	-0.16	0.63	-0.12	-	-0.01	0.47	0.39	0.32	0.40	0.56	-0.24	-0.11	0.32	0.51
Serv	0.06	0.01	0.00	0.00	0.09	-0.01	-	0.10	0.01	0.57	-0.01	-0.04	0.01	0.31	0.02	0.33
Whol	-0.21	0.51	0.10	0.47	0.07	0.47	0.10	-	0.77	0.57	0.29	0.60	-0.37	-0.11	0.71	0.83
Hote	-0.06	0.41	0.11	0.35	0.25	0.39	0.01	0.77	-	0.61	0.28	0.61	-0.29	-0.16	0.56	0.75
Tran	0.13	0.48	-0.04	0.48	0.17	0.32	0.57	0.57	0.61	-	0.27	0.38	-0.19	0.16	0.48	0.80
Fina	-0.71	0.43	0.02	0.48	0.18	0.40	-0.01	0.29	0.28	0.27	-	0.57	0.15	-0.19	0.46	0.44
Real	-0.30	0.48	-0.05	0.60	-0.22	0.56	-0.04	0.60	0.61	0.38	0.57	-	0.05	-0.25	0.51	0.66
Publ	-0.03	-0.42	0.11	-0.46	0.11	-0.24	0.01	-0.37	-0.29	-0.19	0.15	0.05	-	0.22	-0.22	-0.16
Educ	0.29	0.13	0.32	0.03	-0.02	-0.11	0.31	-0.11	-0.16	0.16	-0.19	-0.25	0.22	-	-0.18	0.04
Othe	-0.48	0.50	0.26	0.46	0.22	0.32	0.02	0.71	0.56	0.48	0.46	0.51	-0.22	-0.18	-	0.69
GDP	0.07	0.64	0.03	0.62	0.15	0.51	0.33	0.83	0.75	0.80	0.44	0.66	-0.16	0.04	0.69	-

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