Robert Pater[‡]

The UK business cycle and the structure of the economy

Abstract

It is widely known that various sectors of an economy may react differently to the business cycle, and, on the other hand, it may be affected by sector-specific shocks. Not much light has been shed so far on the impact of the business cycle on the structure of an economy, and *vice versa*. This study models and empirically tests the relationship, using data on the United Kingdom economy, 1963Q1-2011Q4. The structure of the economy is analyzed taking into account gross value added and employment in NACE Rev1.1 sections (6-branch division). Gross value added is additionally analyzed from the expenditure point of view. The unobserved component model and SVAR/SVEC models are used. The business cycle is found to influence and be influenced by the structure of the economy. Some effects may persist longer than one cycle, affecting the long-run path of the economy.

Keywords: business cycle, economy structure, sectoral cycle, sectoral comovement

JEL Classification: E32

[‡] University of Information, Technology and Management in Rzeszów, Department of Macroeconomics

rpater@wsiz.rzeszow.pl

1. Introduction

Business cycles are commonly viewed as short-run fluctuations around the trend, lasting 1.5-8 years (Baxter and King, 1999). On the other hand, changes to potential GDP or natural unemployment etc. are considered as changes in the long-run trend. Such business cycles are called deviation cycles (Zarnowitz & Ozyildirim, 2006) or growth cycles (Mintz, 1969). They can be extracted with the use of *ad hoc* filters or unobserved component models (see e.g. Mills 2003). However, both short-run and long-run fluctuations may interfere with each other. This is the case of classical cycles (Burns & Mitchell, 1946), which are analyzed without prior detrending, and are longer and more profound than the growth cycles. They are carefully dated mainly by the National Bureau of Economic Research, and follow the definition of recession being 'a significant decline in activity spread across the economy, lasting more than a few months, visible in industrial production, employment, real income, and wholesale-retail trade' (Leamer, 2008). Severe recessions or crises may have long-lasting influence on the real economy in addition to having an impact on its structure. This type of a business cycle more accurately corresponds to the real business cycle (RBC) endogenous short-run fluctuations in which the trend and the cycle are caused by the same factors and may possibly influence each other (see e.g. Fukuda, 2008). Not only recessions may have a severe impact on the economy, as steep expansions may cause faster capital accumulation, technology improvement or labor force changes which raises the long-run trend. These factors may also cause changes in the structure of an economy like changes in the propensity to invest and consume, the labor force participation rate and, eventually, shifts in the sectoral contribution to GDP and employment. Such changes can also be effected by the fact that various sectors of the economy are leading or lagging.

There have been numerous analyses of business cycles but the question remains open as to the effects they have on the structure of an economy. This article raises the following question: Is there any relation between the business cycle and changes in the structure of the economy? To answer this question the United Kingdom economy is analyzed in the period 1963Q1-2011Q4. The structure of the economy is presented in two areas: gross value added and employment distributed according to NACE Rev1.1 sections (6 branches). Gross value added is additionally analyzed from the expenditure point of view. The interdependence of economic fluctuations and structural changes is tested and modeled. The paper is structured as follows. Section I contains literature review. Modeling strategy is explained in Section

II. In Section III data and limitations of the analysis are presented. Section IV follows with discussion of the results, and Section V finally concludes.

2. Literature review

Real business cycle models, while typically assuming homogenous sectors of the economy, pose strong cyclical comovement between them (Hornstein, 2000). Long and Plosser (1983) demonstrate that under standard RBC assumptions comovement between sectors is a result of the propagation mechanism (decision rules and production technology), not a common (serially correlated) shock or shocks. However, Rebelo (2005) claims that 'comovement properties of business cycle models are an important, but under-researched, topic in macroeconomics'. New monetarist models account for the heterogeneity of production and service sector (Alexopoulos, 2007). According to the Austrian economists, the heterogeneity of the economy is an important factor behind the cyclicality of investments (see e.g. Mulligan, 2002). The sectoral heterogeneity due to different sectoral marginal costs and relative prices is one of the challenges faced by New Keynesian economists in achieving a better explanation for the business cycle (Saroliya, 2007). As a matter of fact, the majority of New Keynesian analyses found heterogeneity in price durations across sectors and types of goods (Galí, 2008).

There are various empirical analyses of the cyclicality of economies from the expenditure point of view. Lucas (1977) shows that production of (producer and consumer) durable goods is more volatile than that of nondurable goods, agriculture exhibits less volatile cycles, and business profits are more procyclical than other profits. Hornstein and Praschnik (1997) and Tang (2007) confirm the result of higher volatility of cyclical fluctuations for the durable goods sector than the nondurable goods sector, and found it also for employment. Kydland and Prescott (1990) report that in the US economy during the period 1954-1989, consumption and investments were coincident with GNP, with higher correlation between investments and GNP. They also found that exports were lagging and moderately correlated, and that imports were coincident and highly correlated with GNP. Both consumer durable and nondurable products as well as services were procyclical, with the exception of acyclical government purchases. They did not find, however, any appealing differences in the cyclicality of these types of goods. Inventories were less correlated with GNP than fixed capital investment. Burda and Wyplosz (2000) find importing procyclical, and government consumption acyclical. Backus *et al*. (1992) and Backus and Kehoe (1992) find that consumption of nondurable goods is approximately 0.5 less volatile than output. They also observe slightly countercyclical

behavior of net exports. According to them, it is mainly expenditure of durables that increases the volatility of consumption – without them, the cyclicality is of even lower amplitude. Blackburn and Ravn (1992) confirm the results for the types of goods for the UK economy. Canova (1998) uses different methods to check the volatility of consumption and investment, and finds that the cyclical component of the former accounts for 34%-98% of output variability, and for the latter the figure is 216%-672%. He also demonstrates that if a cyclical shock to US GNP occurs, it affects investments and consumption at approximately the same time and, again, investments are much more volatile. Perez (2001) concludes that in major European economies exports are procyclical and coincident, and its cyclical component is more volatile than output (by 1.7 to 3 times higher). He also finds industrial production to be strongly procyclical, coincident and more volatile than GDP. Its cyclical component accounts for 1.7-2.8 times higher amplitude than that of output. He notes that the service sector is more stable than the industrial sector. Montgomery (2006) analyzes the lagged response of investment spending to changes in its determinants and explains it by the heterogeneity of capital goods.

Going deeper into the sectoral breakdown of an economy, we know that the majority of business sectors are synchronized by gross value added and employment over the business cycle, but their productivity exhibits weak correlation. This phenomenon is called a comovement puzzle (Veldkamp and Wolfers 2007). Shea (2002) and Basu *et al*. (2006) find that in the US economy the majority of aggregate output fluctuations is a result of industry comovement, while the rest is due to changes in total factor productivity. The importance of sector-specific shocks is underlined by Stockman (1988) and Durlauf (1989). The latter argues that technological shocks may not be the same in all sectors. Engle and Issler (1995) show that sectoral cycles in the US economy are almost identical in timing and seem to share a common component. However, business cycles generating transitory shocks are the most important for manufacturing and trade. Caporale (1997) studies UK sectoral shocks, and finds limited evidence for an impact of asymmetric shocks, although sufficient evidence is found for the impact of aggregate shocks on the sectors of the economy. Hughes (1997) shows various industries exhibit different behavior in the business cycle. Harvey and Mills (2002) analyze UK sectoral output, and find significant transitory shocks in manufacturing and construction and prevalent permanent shocks in agriculture and services. They also note that manufacturing and the sectors of electricity, gas and water supply are cyclically coincident, services are characterized by cycles with a significantly smaller amplitude, and

construction and agriculture cycles differ significantly from the others. The cycles of mining and quarrying and, to a lesser degree, agriculture, behave countercyclically and exhibit large amplitude. Studies for Korea confirm the general findings for other countries that manufacturing is leading in the business cycle, especially in heavy and chemical industries (Yang & Kim 2005). Skrzypczyńska (2012) points that the patterns of the sectoral cycles in Poland differ from each other. Pater (2011) shows that employment lags in comparison to GDP.

Cheung and Westermann (2003) reach inconclusive results on the interactions between various sectors of the German economy in the short and long run. Using seasonally adjusted time series, they find the limited long-run relationship between the output of manufacturing, mining and agriculture and GDP, and considerable evidence of short-run interactions. In the case of seasonally unadjusted time series, they present quite opposite findings. Eickmeier (2007) indicates sectoral transitions between cyclical fluctuations across countries, with the examples of the USA and Germany. Cheng (2011) finds evidence that the new-firm formation rate over the business cycle is different across states and sectors in the USA, and that in the US economy the national share of new firms is the highest (in comparison to the regional one), implying that the business cycle may be the key factor behind firm formation. However, the latter conclusion was not the case of the UK economy (see Ashcroft *et al*., 1991). Buch and Lipponer (2005) find different, for the most part negative, effects of the world business cycle on German sectors. Mulligan (2002) analyzes the relationship between employment in production sectors and government security interest rates in the US economy. He observes different reactions of employment in different stages of production: a positive relationship between interest rates and sectors representing the late stage of production (countercyclical sectors), and a negative relation for the early stage of production sectors (procyclical sectors). Cubadda *et al*. (2002) find long-run relationships between some of sectors of the Italian economy, hence challenging the RBC assumption of independent sectoral productivity shocks. They find however weak evidence of any short-run relationships. Liu and Spector (2005) argue that non-production employment changes lag over the business cycle, and its amplitude is smaller than in the case of production workers. Finally, Jaimovich and Siu (2012) indicate the direct impact of business cycle phases, i.e. recession and jobless recoveries, on the structure of the labor market, i.e. job polarization. This is a visible example for the importance of the relationship between the business cycle and the structure of an economy. Recent studies by Burren and Neusser (2013) conclude that approximately

30% of the decline in US GDP volatility observed over the period 1949-2005 was due to the shift of production to services. This indicates a relation between business cycle properties and long-run sectoral shifts.

It may therefore seem that much has been said about the cyclicality of sectors of an economy. It is not however clear how the business cycle affects its structure. This article is aimed to analyze changes of the structure of an economy over the business cycle, their causes and effects. In this article testing and modelling procedures are applied which have some advantages over more popular *ad hoc* filtering techniques.

3. Modelling strategy

To analyze the dynamic relationship between the business cycle and the structure of the UK economy, a vector autoregressive (VAR) model is used which takes the following reduced form:

$$\begin{bmatrix} Y_t \\ \psi_t \end{bmatrix} = \delta + \sum_{i=1}^{j} A_i \begin{bmatrix} Y_{t-i} \\ \psi_{t-i} \end{bmatrix} + Dt + \begin{bmatrix} \upsilon_{Y,t} \\ \upsilon_{\psi,t} \end{bmatrix} \tag{1}$$

where Y_t is a vector of $n-1$ shares of components of GDP or employment (the main components of GDP are determined by an expenditure category or NACE branches, and employment components are determined by the NACE branches), δ is a deterministic terms vector, t is a vector of deterministic trend components, while A_i and D are matrices of parameters of endogenous and time trend variables, respectively, and v_t is an n-dimensional zero-mean process with positive and definite covariance matrix Σ_v. The purpose of the deterministic trend component is to test whether long-run changes occurred in the structure of the UK economy. Because only stationary time series should remain in the model (1), it is impossible to include a stochastic trend[1]. ψ_t is an unobserved business cycle estimated with the use of an unobserved components model in the form (Harvey, 1989):

$$y_t = \mu_t + \psi_t + \varepsilon_t, \qquad \varepsilon_t \sim N(0, \sigma_\varepsilon^2), t = 1, \dots, T, \tag{2.1}$$

where y_t is UK GDP, μ_t is a local linear trend consisting of a stochastic level and a slope (drift) of a signal, and representing the stochastic long-run trend:

[1] Constructing a VAR model with non-stationary time series causes serious problems because of the unit roots they contain. The most appropriate situation seems to be when there are as many cointegrating vectors as endogenous variables in the system (see Seddighi *et al*., 2000).

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t, \qquad \eta_t \sim N\left(0, \sigma_\eta^2\right) \tag{2.2}$$

$$\beta_t = \beta_{t-1} + \xi_t, \qquad \xi_t \sim N\left(0, \sigma_\xi^2\right), \tag{2.3}$$

and ψ_t is a stochastic cycle:

$$\begin{bmatrix} \psi_t \\ \psi_t^* \end{bmatrix} = \rho \begin{bmatrix} \cos\lambda_c & \sin\lambda_c \\ -\sin\lambda_c & \cos\lambda_c \end{bmatrix} \begin{bmatrix} \psi_{t-1} \\ \psi_{t-1}^* \end{bmatrix} + \begin{bmatrix} \kappa_t \\ \kappa_t^* \end{bmatrix}. \tag{2.4}$$

In the above model, the irregular ε_t, level η_t and slope ξ_t disturbances are mutually independent. κ_t and κ_t^* are also mutually independent Gaussian white-noise disturbances with zero means and common variance σ_κ^2. λ_c is a cycle frequency in radians with a period of $2\pi/\lambda_c$, and ρ is a damping factor, for which higher values represent the sharper spectrum peak of the cycle. With $\rho \neq 1$ and $\sigma_\kappa^2 \neq 0$, the cycle is stochastic with a changing amplitude and phase. The goodness of fit of the unobserved components models was evaluated on the basis of prediction error variance and the R_D^2 coefficient. The former is the variance of one-step-ahead prediction errors measured in the steady state. The latter is a variant of the coefficient of determination and informs how much information is gained by the model in comparison to a random walk (in the case of a random walk model $R_D^2 = 0$).

According to the frequency response function, the estimator (2.4) is much more accurate in business cycle extraction than the differences of logarithms of GDP (Harvey, 1989). *Ad hoc* filters such as the Hodrick-Prescott (HP), Baxter-King (BK) or Christiano-Fitzgerald (CF) filters can also be applied to extract short- and long-run components of UK GDP. However, it is not recommended if the component is then used for further modeling, as it does not give any information on statistical inference.

The analysis is performed on seasonally adjusted data. To build model (1), a sequential testing procedure is used. The augmented Dickey-Fuller test with GLS detrending (ADF-GLS) is used to test for the unit roots in time series, while the KPSS test is applied to test for stationarity and confirm the results of the previous test. Both tests are said to have more power than the traditional augmented Dickey-Fuller test. The automatic lag-length selection procedure for the ADF-GLS test is applied. The lag-length depends on the significance of the last lag. Lag truncation for the KPSS test is 4. Because the article addresses the structure of the economy, it is crucial to test for possible structural breaks. As Perron (1989) states, they may cause a bias in the standard unit root tests toward the acceptance of the unit root hypothesis.

Similar to the suggestions in Perron (1997), three types of exogenous structural breaks in every time series are tested: the level change, slope change and additive outlier. The Saikkonen and Lütkepohl (2002) and Lanne *et al*. (2002) tests are used to confirm the hypothesis of a unit root in the case of the variables thus far found to be non-stationary in which the intervention analysis indicated a structural break. In the case of non-stationary time series, the Johansen trace test is used to test for a number of cointegrating relations. This gives a model that is a kind of a VAR model on differences, a vector error correction (VEC) model on differences and a VAR model on levels (see Seddighi *et al*., 2000). Next, information criteria are used to choose the optimal endogenous variables lag length *j*.

One way to include the non-stationary and cointegrated variables in the model is a VEC model developed by Lütkepohl (2005). It is of the form:

$$\begin{bmatrix}\Delta Y_t \\ \Delta\psi_t\end{bmatrix} = \tau + \Pi\begin{bmatrix}Y_{t-1} \\ \psi_{t-1} \\ F_{t-1}\end{bmatrix} + \sum_{k=1}^{p-1}\Gamma_k\begin{bmatrix}\Delta Y_{t-k} \\ \Delta\psi_{t-k}\end{bmatrix} + \begin{bmatrix}\upsilon_{Y,t} \\ \upsilon_{\psi,t}\end{bmatrix}, \qquad (3)$$

where $\Pi = \sum_{k=1}^{p} \mathrm{A}_k - I$, $\Gamma_k = -\sum_{l=k+1}^{p} \mathrm{A}_l$, $\Pi = \alpha\beta'$, α is a loading matrix, β is a cointegrating matrix, and both matrices have $n \times r$ dimentions with r as the cointegrating rank, and F_{t-1} is a vector of deterministic variables in the cointegrating equation, which may consist of a linear trend and a constant. τ, Γ_k, Π and E are parameter matrices.

In the VAR or VEC model building causality tests is applied to reveal instantaneous as well as lagged dependence. Two types of causality are tested: the instantaneous as well as Granger-causality, with the use of the methods proposed by Toda and Yamamoto (1995) as well as Dolado and Lütkepohl (1996). The results not only reveal information on the dependence between the business cycle and the structure of the UK economy, but also are used to impose specific instantaneous and long-run restrictions on the structural matrices of the models.

The structural restrictions imposed on the models are based on the Blanchard and Quah (1989) and Lütkepohl (2005) methods. As main emphasis has been put to short-run analysis, long-run restrictions are mostly used to identify models, with some noticeable exceptions. It assures that the short-run analysis is not biased by any assumptions. The innovation to the cyclical component of GDP in every model is interpreted as 'pure' cyclical shock. Innovations to the shares of GDP or employment are interpreted as sectoral shocks.

4. Data

The data come from the Eurostat database. Quarterly GDP for the period 1963Q1-2011Q4 and its components are taken as seasonally adjusted and adjusted by working days given in millions of pounds in chain-linked volumes. The structure of the economy is analyzed in two areas: goods market and labor market. The demand side of the goods market breaks down into final consumption expenditure, gross capital formation, and exports and imports of goods and services. The supply side is categorized by NACE Rev1.1 sections into:

- agriculture and fishing,
- industry (except construction),
- construction,
- wholesale and retail trade,
- hotels and restaurants and transport,
- financial intermediation and real estate,
- public administration and community services, and
- activities of households.

The reference years are 2005 and 2000 for the demand and supply time series, respectively. The labor market is addressed based on the NACE Rev1.1 sections too. To analyze the structure of the economy, not the level of variables, all components of GDP and employment are transformed into percentages.

The results of unit root and stationarity tests displayed in Table 1 indicate that GDP and nearly all of its components are I(1). There are some differences in the results of both tests that require a comment. The KPSS stationarity test indicates that the shares of employment and gross value added in public administration are trend-stationary. According to the ADF-GLS test they have unit roots. The standard ADF test confirms that the former is a trend-stationary I(0) process and the latter is a non-stationary I(1) process. This test also confirms the results of the KPSS test, in contrast to the ADF-GLS test, that consumption expenditure as a percentage of GDP is stationary. In addition, the KPSS test results, indicating that the percentage of employment in construction is I(1), is also confirmed by the standard ADF test. All non-stationary time series prove to have one unit root, i.e. to be I(1) processes according to the KPSS test. However, the ADF-GLS test states that some of them, including GDP, have more than one unit root, although the ADF test does not confirm this, indicating on $p = 1\%$ that all of the problematic time series are I(1). Moreover, checking for I(2) also fails, indicating integration of a higher order. This is strange as, since the work of

Dickey and Fuller (1979), it has been widely accepted that GDP has one unit root. Our result could be due to the occurrence of structural breaks. Having accounted for a structural break in 1973Q1 (see also Section 5), GDP proves to be I(1). In the case of other variables, accounting for a structural break do not change the result of the test, although in the case of expenditure components of GDP the test indicates this break is statistically significant.

Table 1. Unit root and stationarity tests.

Time series	Test statistic					Level of integration
	ADF-GLS H_0:*Y*~I(1)	ADF-GLS H_0:d*Y*~I(1)	KPSS H_0:*Y*~I(0)	KPSS H_0:d*Y*~I(0)	Level shift H_0:*Y*~I(1)	
GDP	1.43	-0.28^{ADF}	3.90	0.19*	-0.64	I(1)
Cycle	-6.43***	-	0.05*	-	-	I(0)
$G_{consumption}$	-0.61^{ADF}	-0.33	0.14*	-	-	I(0)
$G_{capital}$	-0.34	-0.20^{ADF}	1.42	0.08*	-2.70* (1973Q1)	I(0)
$G_{foreign\ trade}$	-1.57	-1.13^{ADF}	2.07	0.07*	-1.70	I(1)
$G_{agriculture}$	-0.37	-2.45**	2.15	0.14*	-0.63	I(1)
$G_{industy}$	3.09	-3.97***	3.07	0.35**	0.54	I(1)
$G_{construction}$	0.13	-0.93^{ADF}	2.21	0.14*	-2.46	I(1)
G_{trade}	1.05	-3.52***	3.07	0.25*	0.21	I(1)
$G_{financial\ services}$	2.37	-1.66*	3.24	0.22*	0.99	I(1)
$G_{public\ services}$	0.23$^{ADF(*t)}$	-4.26***	0.15**$^{.\ t}$	-	-	I(0)^{t}
$L_{agriculture}$	-0.32	-1.02^{ADF}	2.40	0.19*	-0.56	I(1)
$L_{industry}$	0.14	-2.65***	2.53	0.69***	-2.35	I(1)
$L_{construction}$	-2.29**$_{non}^{.}$	-^{ADF}	0.76	0.13*	-2.54	I(1)
L_{trade}	-0.29	-8.32***	1.84	0.73***	-1.04	I(1)
$L_{financial\ services}$	-0.26	-1.89*	2.62	0.37**	-1.89	I(1)
$L_{public\ services}$	1.68	-2.90***	0.16$^{t.\ non}$	-	-0.44	I(1)

G – gross value added; L – employment; *** stationary at p=0.01; ** stationary at p=0.05; *stationary at p=0.10; ^{t} – trend-stationary; ^{non} – H_0 accepted in the ADF test; ^{ADF} – H_0 rejected in the ADF test with p<0.01; ^{0} concerns (details) the superscript given before the parenthesis.

Having confirmed the non-stationarity of almost all of the percentages, it seems obvious that the UK economy has strongly evolved since the 1960s. During this time, its structure changed in a stochastic manner and persistently, i.e. the long-run trend could have affected this structure.

5. Discussion of results

By looking at the structure of the UK economy with NBER recessions (contractions) in the background (Figures 1), we find certain regularities. The majority of them are known as *stylized facts*. Recession was almost always accompanied by a decrease in the share of gross capital formation in GDP, with the exception of the beginning of the 1970s when it slightly increased. In the mid-1970s it decreased by 3.9 percentage points, and in the beginning of 1980 by 2 pps. In the next more than 20 years the impact of recession on capital formation decreased to below 1 pps. In the 2008-2009 recession it decreased again by 4 pps. In addition, to the beginning of the 1970s the share of consumption expenditures increased almost proportionately to the decrease in the share of capital formation during the next two recessions. During the 1980s and 1990s it changed only slightly, while during the 2000s it increased again – by 1.2 and 2.5 pps, respectively. The share of trade balance increased during the recessions in the mid-1970s, early 1980s and 1990s, but the growth became smaller. During the 2008-2009 recession it increased by 1.5 pps, similar to the mid-1970s. During the early 1970s, the second recession of the 1980s and the early 2000s, it decreased.

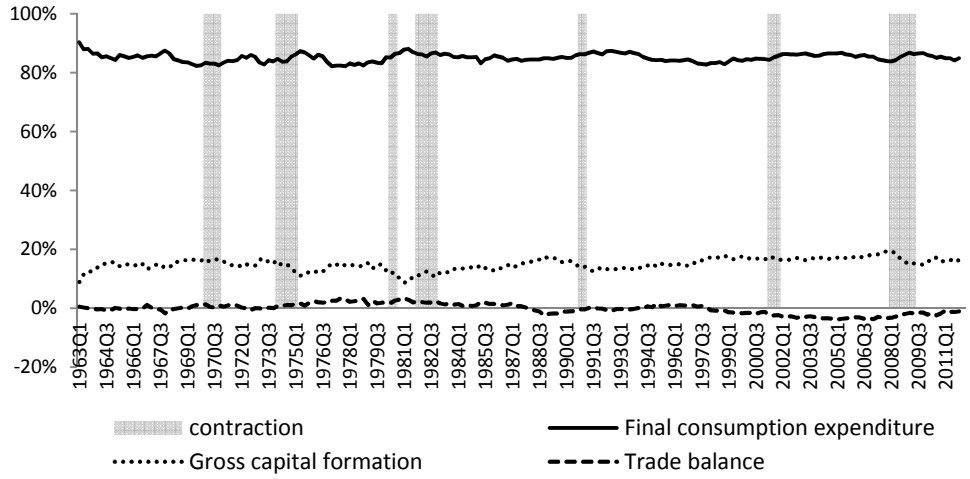


Figure 1. The UK expenditure structure and the NBER contractions.

As for the output structure, the share of industry in gross value added was found to be the most procyclical and largely substituted by public services, which appeared to be clearly countercyclical (Figure 2). The share of trade in GVA was slightly less procyclical, while the share of financial services held its position during recessions, being less countercyclical than

public services. The changes of the shares of industry and public services in GVA were the highest during the 1970s, and then were constantly decreasing, reaching the minimum during the 1990s, and again increasing during the 2000s. These sectors again became more cyclical during the last recession. In the case of trade and financial services such evidence was not found, and the cyclicality of the shares decreased in the beginning of the 1970s. The share of agriculture changed over the business cycle only slightly, showing no sign of the cyclicality.

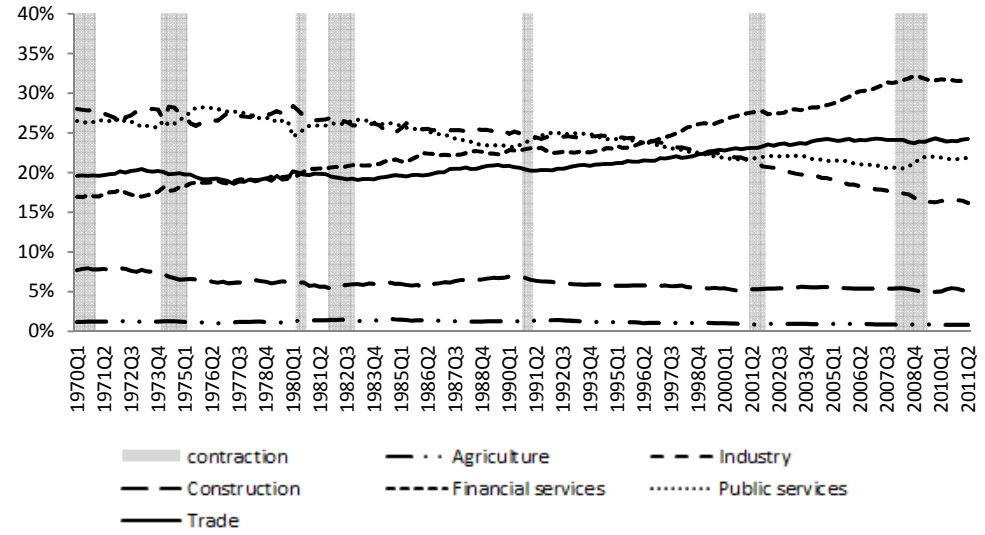


Figure 2. The UK output structure (by GVA) and the NBER contractions.

Raw data do not give any clear indication as to changes of the share of employment across branches of economic activity over the business cycle (see Figure 3). The share of employment in the industry fell over the years, and the importance of financial services grew. There is also an apparent growth of the share of public services, which significantly increased during the 2008-2009 recession, while the employment share of the rest of the branches in GVA decreased (with agriculture being the only exception).

The above picture of the structure of the UK economy gives only a general idea of the impact of recessions, i.e. classical cycles. In the next step, growth cycles were extracted with the use of BK filter. Correlation coefficients between the cyclical components of gross value added (GVA) and employment in sectors did not give any indication of possible leads or lags between them.

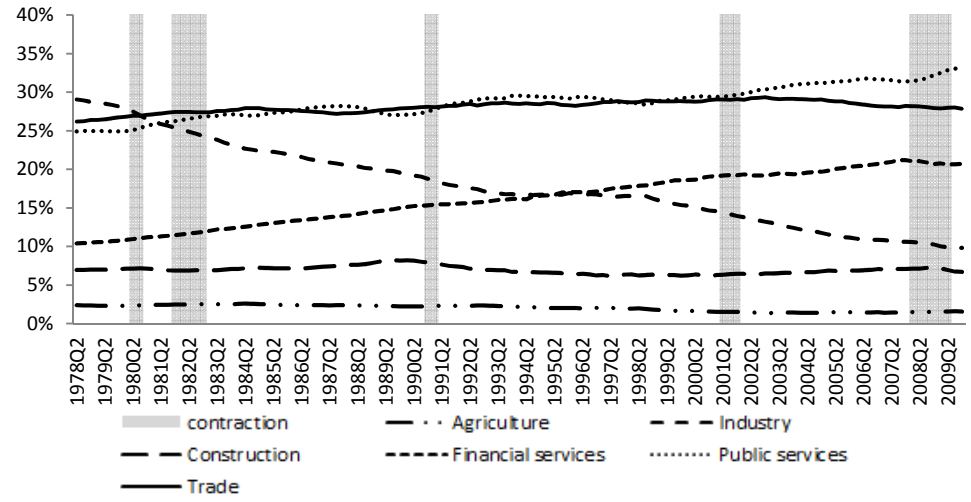


Figure 3. The UK output structure (by employment) and the NBER contractions.

In the first step of the modeling procedure the cyclical component of the UK GDP must be extracted. Because it is I(1), model (2.1) in the general case, i.e. with a stochastic level, slope and cycle, seems to be appropriate. However, several restrictions as well as extensions are also tested. Autoregressive terms are statistically highly insignificant. Higher orders of the slope and cycle are also rejected as insignificant and redundant. Hence, the intervention testing procedure is applied. The results reveal a few statistically significant additive outliers and level breaks. A general-to--specific procedure is applied to find the most suitable interventions. The goodness of fit of Models A-D is compared in Table 2.

Table 2. Comparison of the unobserved components models of UK GDP.

Model	Log-lik.	Prediction error variance	AIC	BIC	R_D^2	H(*h*)	Q(*p*,*q*)
Model A	901.12	9.49e-5	-9.20	-9.10	0.04	0.22	10.67
Model B	914.89	9.05e-5	-9.23	-9.10	0.08	0.28	10.05
Model C	900.56	9.56e-5	-9.19	-9.09	0.03	0.20	10.53
Model D	914.71	7.43e-5	-9.43	-9.29	0.25	0.27	10.05

Notes: model A: local linear trend with stochastic cycle; model B: local linear trend with stochastic cycle and interventions; model C: smooth trend with stochastic cycle; model D: smooth trend with stochastic cycle and interventions. For models A and C, the H(22) heteroscedasticity test critical value is F=2.05 at p=0.05, and for models B and D, the H(21) is F=2.08. Box-Ljung Q(12. 9) serial correlation test critical value χ^2=16.92 at p=0.05.

None of the models exhibit serial autocorrelation and heteroscedasticity of residuals. In all of the models, the standard R^2 coefficient is nearly 1. Models B and D seem the most appropriate according to log-likelihood, prediction error variance. Both information criteria AIC and BIC confirm that the best is Model D. In addition, the R_D^2 coefficient is the highest in this model. Based on this, the Model D estimates of the business cycle are chosen as the most appropriate.

Model A exhibits a 5.15-year cycle (Cycle 1) with frequency 0.31. The coefficient of determination recommended for UCM models by Harvey (1989, chap. 5) $R_D^2 = 0.04$ indicates that this model is only slightly better than a random walk with drift, a basic model describing GDP. The damping factor of the cycle equals 0.98, which means that it is close to a deterministic cycle (Figure 4). The amplitude of the cycle was considerably higher during the period 1960-1985 than later. In the beginning of 1980 it became smaller until the period 2007-2011, the period of the pre-crisis cyclical peak. In 2012Q1 the amplitude of the cycle was 9.26e-4. The estimated variance for the cyclical disturbance was 4.25e-6, while the variance of the irregular was 6.70e-6.

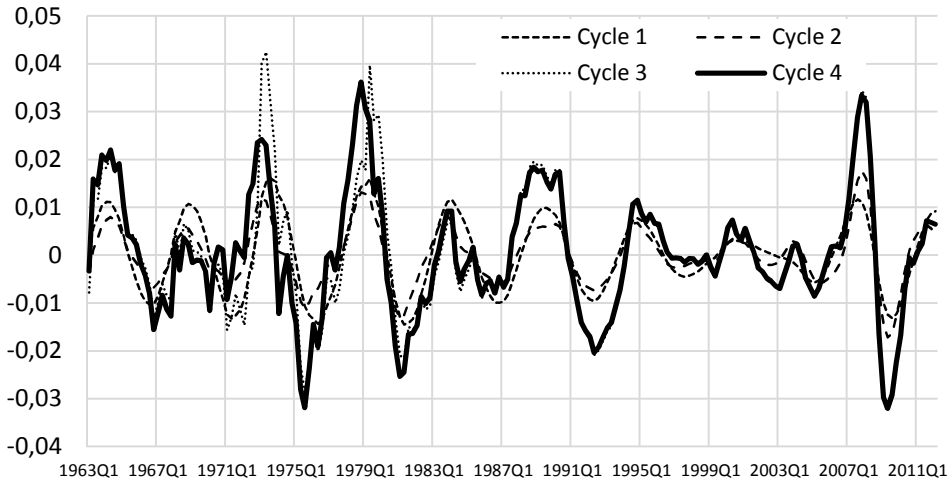
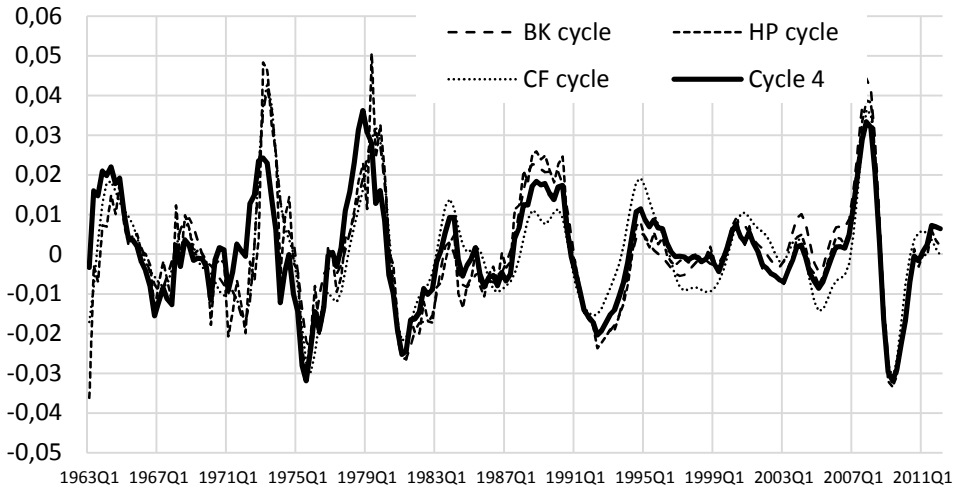


Figure 4. The cyclical component of the UK GDP according to four unobserved components models.

In Model B interventions are tested and modeled. Finally, two statistically significant level changes are accepted. The level increases in 1973Q1 and decreases in 1979Q2. It was a period of high volatility for the UK cycles. The amplitude of Cycle 2 from Model B is smaller than Cycle 1 during the years 1960-2000. In the beginning of 2000 it became higher,

suggesting a higher volatility of the 2007-2009 crisis and pre-crisis period of expansion. The amplitude of the cycle in 2012Q1 equaled 0.01. The variance of cyclical disturbance was, however, two times higher, exceeding the variance of the irregular component. The periodicity of the cycle was found to be a little longer, equaling 5.43 years (0.29 in frequency units), and the cycle became more irregular and less deterministic (damping factor = 0.97).

Of all possible restrictions, the best results are given by imposing $\sigma_\eta^2 = 0$ and a smooth trend with the stochastic cycle (Model C and its variant – Model D – with two interventions introduced into Model B). For both models, the cyclical component is longer than for Models A and B, lasting 6.02 (0.26 in frequency units) for Cycle 3 and 6.32 years (0.25 in frequency units) for Cycle 4. They are also less deterministic, with damping factors of 0.92 for Model C and 0.93 for Model D. The cycles of the 1970s are found to be very volatile according to these models. The variance of disturbance of the cycle is the highest of all of the variances of component disturbances in both models. For Model C it equaled 4.01e-5; for Model D 3.22e-5. In the final period of estimation, 2012Q1, the amplitudes of the cycle are 6.87e-3 and 7.28e-3, respectively.



BK cycle: lag truncation = 12, period = 8-32 quarters
HP cycle: λ = 1600
CF cycle: asymmetric, GDP assumed I(1) with drift, period = 8-32 quarters.

Figure 4. The cyclical component of the UK GDP: Cycle 4 and *ad hoc* filters.

Cycle 4 can be compared to the most commonly used *ad hoc* filter estimates. Figure 5 shows that all of the cyclical components are quite similar.

In comparison to the HP cycle, the unobserved components cycle is slightly less volatile. The BK and CF estimates are smoother, though similar.

In the second step, three models of type (1) or (3) are built. To estimate the models one sectoral share must be dropped. From the first model trade balance is dropped, because its relation with the business cycle significantly varies in time. During some periods it is positive, while during others – negative. It would require a non-linear model to describe such behavior. From the second and third models agriculture is excluded as a non-cyclical sector. In the case of the model of the expenditure approach (Model 1A), according to the Johansen trace test, all null hypotheses are rejected (see Table 3). This indicates that the VAR model on levels would be appropriate, which confirms the previous tests, as all the variables are stationary. In Model 1B only Cycle 4 and $L_{\text{public services}}$ are stationary. The cointegration test indicates that, with a model including a deterministic trend, there is no stochastic long-run relationship (between the structure of the economy and the business cycle). In Model 1C all variables, with the exception of the estimator of the business cycle, are I(1), and the Johansen trace test indicates the existence of two cointegrating vectors.

Table 3. Johansen trace test for cointegration results.

Model	AIC	BIC	Det. var.	Rank 0 (H_0) [*p*-value]	Rank 1 (H_0) [*p*-value]	Rank 2 (H_0) [*p*-value]
Model 1A	2	2	const, t, 1973Q1	54.16 [0.0001]	25.67 [0.0033]	7.27 [0.0070]
Model 1B	2	1	const, t	102.29 [0.3127]	64.29 [0.7245]	42.01 [0.7755]
Model 1C	2	1	const, t	143.28 [0.0003]	88.30 [0.0522]	48.06 [0.5062]

Model 1A: G_{capital}, $G_{\text{consumption}}$, Cycle 4
Model 1B: Cycle 4, G_{industry}, $G_{\text{financial services}}$, $G_{\text{public services}}$, $G_{\text{construction}}$, G_{trade}
Model 1C: L_{industry}, $L_{\text{financial services}}$, $L_{\text{public services}}$, $L_{\text{construction}}$, L_{trade}, Cycle 4.

In Model 1A, for all instantaneous and lagged types of the causality test, H0 stating that there is no causality is rejected. Thus, the test results do not give any indication of possible structural restrictions. According to the autoregressive part of the model or the model in the reduced form, the business cycle has statistically significant influence on both the capital and consumption to GDP ratios up to the 2$^{\text{nd}}$ lag. In addition, both ratios have a significant impact on the cyclical fluctuations of GDP. The deterministic linear trend does not have a significant impact on the system. Thus, a visible

direction cannot be determined for the changes in the variables during the period.

The innovation to the cyclical component of GDP, interpreted as a business cycle shock, resulted in a rise in the share of investments and a fall in the share of consumption. This is understandable because investments are strongly procyclical and consumption is less procyclical. Thus, the structure of the economy changed in favor of capital over the business cycle. However, the reaction of the share of investments and consumption was not instantaneous. It occurred with one-quarter lag. The effects of the shock started to expire after 3 quarters, and after 6 they completely died out (Figure 5). These effects accounted for 4% of the variance of investments and 2% of the variance of consumption.

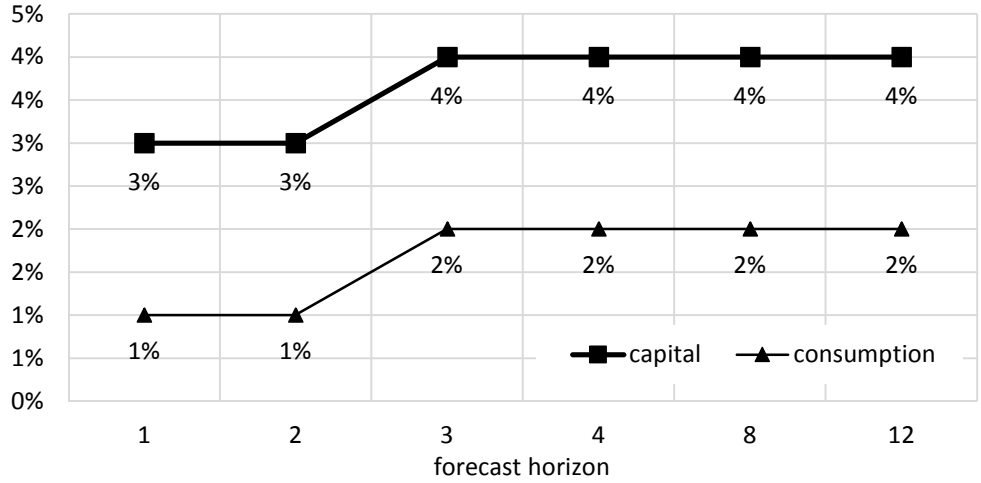


Figure 5. Influence of the business cycle on the variance of investments and consumption.

The changes in the share of investments instantaneously and positively affected the business cycle. The share of consumption affected the business cycle less visibly and negatively but still instantaneously (Figure 6). The effects of the innovation to the share of investments on the business cycle lasted approximately 8 quarters, and the effects of innovation to the share of consumption were expiring very slowly and completely died out after approximately 28 quarters. Therefore, the deficit of investments in relation to consumption over the business cycle can have long-lasting negative effects. The capital share had significant meaning for the business cycle, as it accounted for approximately one-third of the forecast error variance of the business cycle, with the weakest impact in the first quarter after the shock.

The consumption share had some meaning only in the first quarter after the shock; then, the influence was marginal.

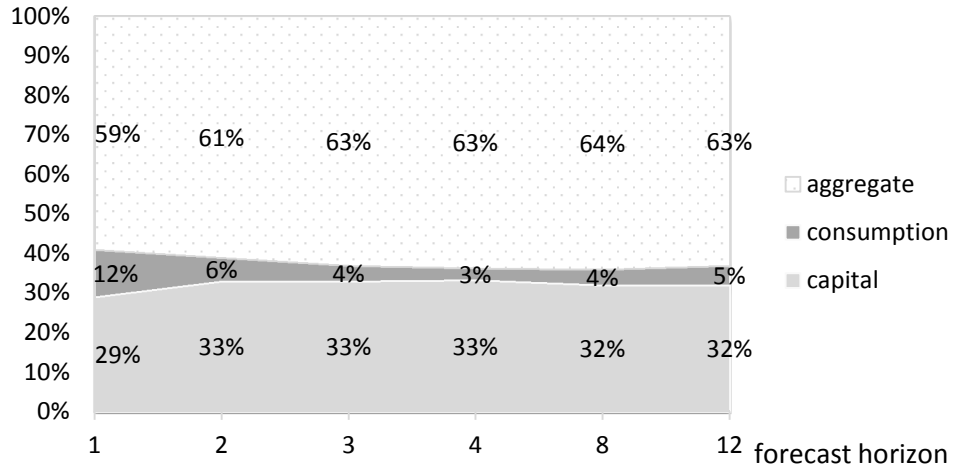


Figure 6. Variance decomposition of the business cycle (by expenditure type).

Next, VAR(2) Model 1B is built on first differences (lag 2 indicates the majority of the information criteria). An instantaneous causality test indicates a relationship between all of the variables in the system. However, the shares of all analyzed branches of the economy do not Granger-cause the others, that is, if the lagged relations are taken into account. Only the cyclical component influences all of them. Having imposed some exclusion restrictions in the reduced form, the model is estimated.

The impact of cyclical fluctuations on the system turned out to be significant for the most part in the short-run. The cyclical shock affected the share of GVA in construction and financial services simultaneously. The effects on construction were the strongest after 4 quarters, and then they died out very slowly (Figure 7). This may indicate that the entrepreneurs noted the changing business cycle phase, but their reaction was distributed in time according to long-run investment outlays and the investment cycle. That is why construction may be seen as a slowly-reacting and sometimes lagging sector. The business cycle explained only up to 5% of the error variance of the GVA share in this sector (Figure 8), because investment-pulled construction is mainly dependent on financial services and industry. The effect of the cyclical shock on financial services was the fastest, though negative. The peak of influence occurred after 1 quarter. The negative effect was a result of the weak cyclicality of this sector. The adjustments of financial services, mainly through monetary policy actions such as an increase in

interest rates, provide fast reactions of these services, but after two years they significantly diminished. The business cycle affected industry to a higher extent than other sectors, with the exception of the long-lasting effects on public services. This is why, in comparison to other sectors, industry is procyclical. However, it reacted with a 2-quarter lag and died out after 3 years. The negative effect of the business cycle shock on the share of public services was lagged and persistent. It also turned out to be an important factor in explaining its error variance. This effect may remain several years in political decisions. The effects of the business cycle on trade were marginal, occurred only after 8 lags and died out very slowly.

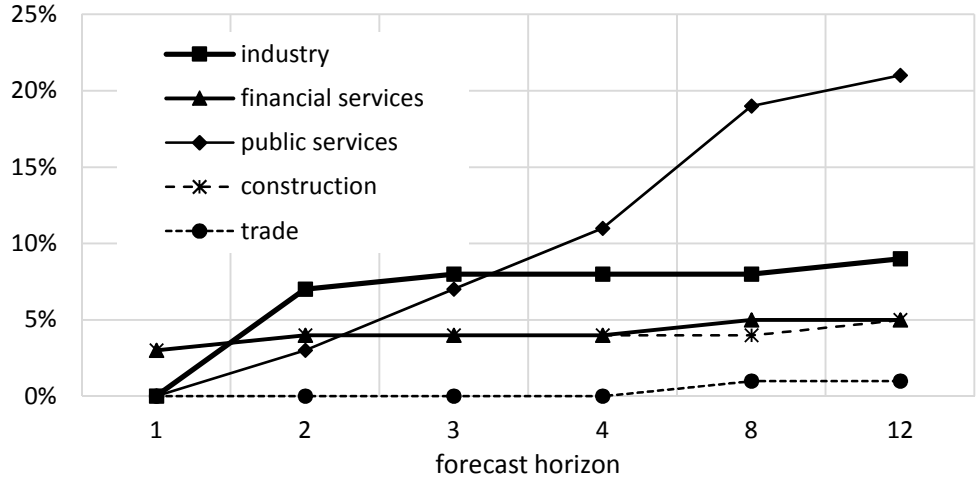


Figure 7. Influence of the business cycle on the variance of production of the UK branches.

Out of the shares of the five sectors, public services and financial services had a significant meaning for the business cycle. Financial services expansion made a visible and positive impact. Moreover, the effect was instantaneous. Public services expansion diminished the short-run growth, which militates against expansionary government policy. We can also observe some negative 'long-run' effects. If the share of GVA in industry had increased, the economic growth in the short run would have generally been slower. Only initially it affected the business cycle in a positive way. The UK economy take an advantage when locating direct investments abroad, which significantly reduces labor costs. Construction sector expansion would not have had much impact on the short-run growth. Similarly, the expansion of trade would have been slight and negative.

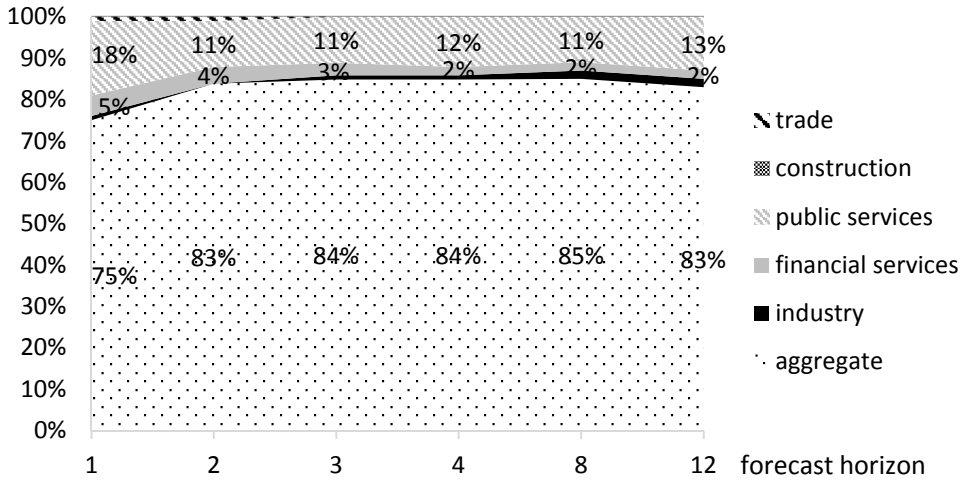


Figure 8. Variance decomposition of the business cycle (by branches).

Another Model (1C) is based on the structure of the UK economy from the point of view of employment in the branches. After some preliminary estimations, it was found that the most suitable model with respect to the assumptions of the error term was the model with 1-lag length in the autoregressive part. Thus, SVEC(1) model type (3) with 2 cointegrating vectors was chosen. In the case of the most of the causality test results, H0 was rejected at p=0.05, indicating that there may be instantaneous as well as lagged causality between the variables of the system. The outlying results of the lagged type of the test indicated that employment in trade and the business cycle did not Granger-cause the rest of the variables, although the other test results indicated that there might have been instantaneous relations.

The first cointegrating relation is the share of employment in industry. According to this, in the long-run, there is a significant negative relationship between the share of industry in the UK economy and construction and trade. There also might be some positive structural interdependence with the business cycle, which turned out to be statistically significant. It may possibly indicate some long-run effects of the business cycle. The second cointegrating vector is the relation of the share of employment in financial services. In the long-run, it is negatively related to public services and positively related to construction and trade. In the case of both variables, the deterministic trend turned out to be statistically significant, indicating that since the late 1970s, both shares of employment – industry and financial services – also changed significantly in a deterministic way.

On the basis of Granger-causality tests restrictions (4) are imposed. At the beginning, the restriction of no long-run impact of the share of

employment in trade on all of the variables is imposed. In addition to this, no long-run impact of the business cycle is allowed, with the exception of the share of industry and financial services. Also no long-run impact of the share of financial services on the business cycle is imposed. Such restrictions are implied by the previous results (i.e. meaningless and negligible long-run impact of trade and financial services). Also, the business cycle should have a transitory effect on the variables of the system. Short-run restrictions are imposed on the basis of the *t*-values, calculated with the use of bootstrapped standard errors. No impact of financial services on the share of administration and construction is allowed. Similarly, no influence of the share of administration on construction and trade, and no influence of construction and trade on the business cycle is assumed. The insignificance of these parameters means that lags in reaction to sectoral shocks between sectors are identified. The structural matrices are as follows:

$$\mathbf{B} = \begin{bmatrix} * & * & * & * & * & * \\ * & * & * & * & * & * \\ * & 0 & * & * & * & * \\ * & 0 & 0 & * & * & * \\ * & * & 0 & 0 & * & * \\ * & * & * & * & 0 & * \end{bmatrix}, \Xi\mathbf{B} = \begin{bmatrix} * & * & * & * & 0 & * \\ * & * & * & * & 0 & * \\ * & * & * & * & 0 & 0 \\ * & * & * & * & 0 & 0 \\ * & * & * & * & 0 & 0 \\ * & 0 & * & * & 0 & 0 \end{bmatrix}, \tag{4}$$

where * means that no restriction is imposed.

The business cycle did not affect the employment shares profoundly. The cyclical shock from aggregate economic activity influenced the share of employment in industry positively and contemporaneously. Although at first it was only marginal, it was the highest amongst all the sectors. Its influence increased, reaching a peak after 8 quarters (Figure 9). The effects on the share of financial sector employment was also simultaneous and, at first, positive but small. After 4 quarters it became negative for the next 3 years. The influence on construction and public services was even smaller and died out very fast. The share of construction behaved in a manner that is quite the opposite. Its reaction for the first 3 quarters was significantly negative but subsequently became positive for over 2 years. The business cycle in a negative way influenced the share of employment in the public services for 2.5 years. Shorter, though still negative, was the effect of the cyclical shock on the share of employment in trade. It might have been a result of insignificant reaction of GVA in this sector. This lasted 5 quarters and expired after this period. These results somewhat resemble those of Mulligan (2002).

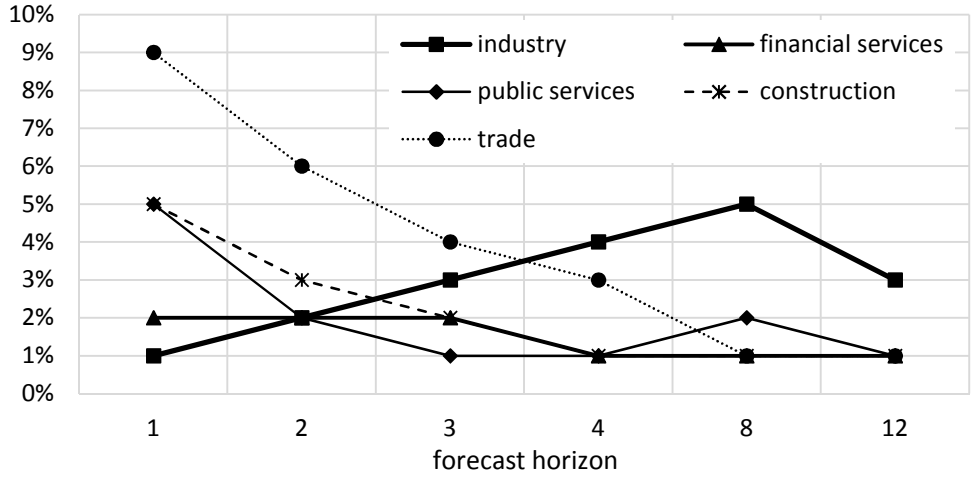


Figure 9. Influence of the business cycle on the variance of production of the UK branches.

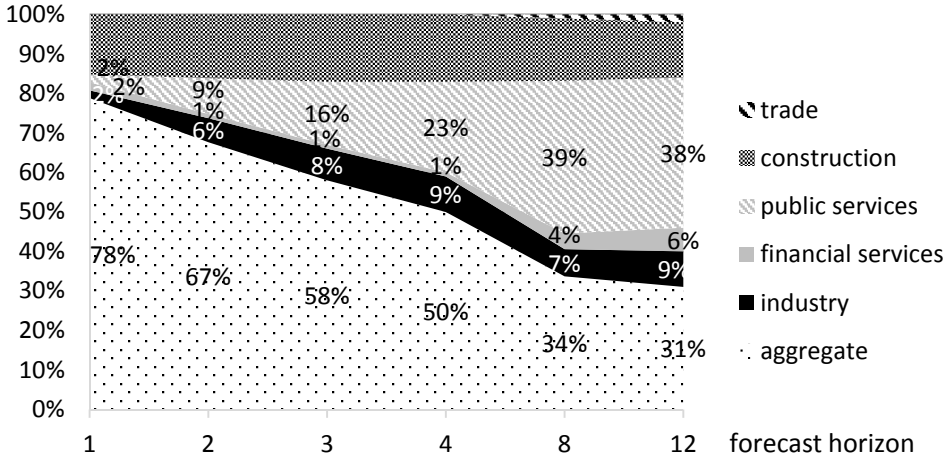


Figure 10. Variance decomposition of the business cycle (by branches).

Although the shares of employment poorly explain the variance of the business cycle, some influence can be seen. Similarly to GVA, public services employment has a significant negative impact on the future business cycle, which can be called a 'long-run impact'. There is a smaller, positive and long-lasting impact of employment in construction on the business cycle. The increase in the share of employment in construction would be a factor behind short-run growth acceleration. The effects of these two sectors are significant. The increase in the share of employment in industry in a direct investment-oriented economy such as the UK would decrease the cyclical

expansion in the first year. The positive effect of accelerating economic growth would occur 5-16 quarters after the shock. However, some negative long-run effects may subsequently occur. This indicates that in the UK economy market services employment is more growth-accelerating than employment in industry.

6. Conclusions

This article contributes to the literature on the heterogeneity of the business cycle from the point of view of economy sectors. The innovation of the paper is the analysis of the interrelation of the business cycle and the structure of the economy. The analysis presents empirical examples supporting the theories of the heterogeneity of the business cycle and the relationship between economic fluctuations and structural changes. It was found that the business cycle both influences and is influenced by the structure of the economy. Not only crises affect the structure of the economy but also fluctuations with a narrower amplitude. The effect is not profound, but in many cases significant. Significant interdependence of cyclical and structural changes was found particularly when sectoral gross value added was analyzed. From the point of view of sectoral employment, only a few significant relations were identified.

Aggregate shocks are the ones that drive business cycles. However, some of the sectoral shocks also have significant meaning for fluctuations. The effects of the share of investments on fluctuations are instantaneous and large. Capital shortage over the business cycle may have severe effects in diminishing economic growth. The impact of fluctuations on employment shares were generally lagged but more persistent than that on gross value added. A rise in the employment shares of public services and industry negatively affects the business cycle, while the employment shares of construction and market services affect it positively. Contrary to the popular belief, financial services and construction sectors are the ones that react first to a business cycle shock. Then industry and public services follow, which are influenced the hardest. Trade lags and responds to a very small extent. The financial services and public services shares in GVA have significant impact on fluctuations. The higher the share of public services in the economy, the lower the economic growth. Financial services share positively affects the business cycle.

Transitions between sectors of the economy over the business cycle have important implications. The most visible is improvement of forecasting of business cycle turning points, and classification of structural changes. Recognition of employment flows between sectors can contribute to the

knowledge on the short-run job-to-job transitions, which influences labor market stickiness. This may direct labor market policy, e.g. unemployment support and demand for training in different business cycle phases. Flows of gross value added between sectors may be taken into account in setting interest rates and financial sector instruments, as they may be more accurately adjusted to particular sectors. Sectoral shifts also result in tax inflow and government expenditure changes, as sectors differ in their participation in fiscal policy measures. Taking this into account may improve government budget predictability.

The United Kingdom is a representative of a developed market economy. The analyzed period was also generic. It contained various macroeconomic breakthroughs as well as periods of relative stability. That is why I argue that major conclusions of this article are universal. However, the UK has its own specificity, e.g. liberal law, developed financial services and foreign direct investment capital inflows. It may determine roles of some sectors of this economy, while in other types of economies, e.g. other European developed countries with more social law or middle-developed countries, their significance could be different. Future research should focus on how certain factors affect these relations. Also, non-linear relations may be taken into account, esp. in the case of foreign trade. Additionally, different or more disaggregated sectors may be analyzed.

References

Alexopoulos, M., 2007. A monetary business cycle model with unemployment, *Journal of Economic Dynamics and Control*, 31 (12), 3904-3940.

Ashcroft, B., Love, J., Malloy, E., 1991. New firm formation in the British counties with special reference to Scotland, *Regional Studies*, 25 (5), 395-409.

Backus, D. K., Kehoe, P. J., Kydland, F. E., 1992. International real business cycles, *Journal of Political Economy*, 100 (4), 745-775.

Backus, D. K., Kehoe, P. J., 1992. International evidence on the historical properties of business cycles, *American Economic Review*, 82 (4), 864-88.

Basu, S., Fernald, J., Kimball, M., 2006. Are technology improvements contractionary?, *American Economic Review*, 96 (5), 1418-1448.

Baxter, M., King, R., 1999. Measuring business cycles: Approximate band-pass filters for economic time series, *Review of Economics and Statistics*, 81 (4), 575-593.

Blackburn, K., Ravn, M. O., 1992. Business cycles in the United Kingdom: Facts and fictions, *Economica*, 59 (236), 383-401.

Blanchard, O. J., Quah, D., 1989. The dynamic effects of aggregate demand and supply disturbances, *American Economic Review*, 79 (4), 655-673.

Buch, C., M., Lipponer, A., 2005. Business cycles and FDI: Evidence from German sectoral data, *Review of World Economics*, 141 (4), 732-759.

Burns, A. F., Mitchell, W. C., 1946. *Measuring business cycles*, New York: National Bureau of Economic Research.

Burren, D., Neusser, K., 2013. The role of sectoral shifts in the decline of real GDP volatility, *Macroeconomic Dynamics*, 17 (3), 477-500.

Caporale, G. M., 1997. Common features and output fluctuations in the United Kingdom, *Economic Modelling*, 14 (1), 1-9.

Cheng, S., 2011. Business cycle, industrial composition, or regional advantage? A decomposition analysis of new firm formation in the United States, *Annals of Regional Science*, 47 (1), 147-167.

Cheung, Y. W., Westermann, F., 2003. Sectoral trends and cycles in Germany, *Empirical Economics*, 28 (1), 141-156.

Canova, F., 1998. Detrending and business cycle facts, *Journal of Monetary Economics*, 41 (3), 475-512.

Cubadda, G., Savio, G., Zelli, R., 2002. Seasonality, productivity shocks, and sectoral comovements in a real business cycle model for Italy, *Macroeconomic Dynamics*, 6 (3), 337-356.

Dickey, D. A., Fuller, W. A., 1979. Estimators for autoregressive time series with a unit root, *Journal of the American statistical Association*, 74 (366), 427-431.

Dolado, J. J., Lütkepohl, H., 1996. Making Wald tests work for cointegrated VAR systems, *Econometric Reviews*, 15 (4), 369-386.

Durlauf, S. N., 1989. Output persistence, economic structure, and the choice of stabilization policy, *Brookings Papers on Economic Activity*, 2, 69-136.

Eickmeier, S., 2007. Business cycle transmission from the US to Germany - A structural factor approach, *European Economic Review*, 51 (3), 521-551.

Engle, R. F., Issler, V., 1995. Estimating common sectoral cycles, *Journal of Monetary Economics*, 35 (1), 83-113.

Fukuda, K., 2008. Differentiating between business cycles and growth cycles: evidence from 15 developed countries, *Applied Economics*, 40 (7), 875-883.

Galí, J., 2008. *Monetary policy, inflation, and the business cycle: An introduction to the new Keynesian framework*, Princeton: Princeton University Press.

Harvey, A. C., 1989. *Forecasting structural time series models and the Kalman filter*, Cambridge: Cambridge University Press.

Harvey, A. C., Mills, T. C., 2002. Common features in UK sectoral output, *Economic Modelling*, 19 (1), 91-104.

Hornstein, A., Praschnik, J., 1997. Intermediate inputs and sectoral comovement in the business cycle, *Journal of Monetary Economics*, 40 (3), 573-595.

Hornstein, A., 2000. The business cycle and industry comovement, *Federal Reserve Bank of Richmond Economic Quarterly*, 86 (1), 27-48.

Hughes, A., M., 1997. The recession of 1990: An Austrian explanation, *Review of Austrian Economics*, 10 (1), 107-123.

Jaimovich, N., Siu, H. E., 2012. *The trend is the cycle: Job polarization and jobless recoveries*, National Bureau of Economic Research Working Paper No. 18334.

Kydland, F. E., Prescott, E. C., 1990. Business cycles: Real facts and a monetary myth, *Federal Bank of Minneapolis Quarterly Review*, 14 (2), 3-18.

Lanne, M., Lütkepohl, H., Saikkonen, P., 2002. Comparison of unit root tests for time series with level shifts, *Journal of Time Series Analysis*, 23 (6), 667-685.

Leamer, E. E., 2008. *What's a recession, anyway?*, National Bureau of Economic Research Working Paper 14221.

Liu, T., Spector, L. C., 2005. Dynamic employment adjustments over business cycles, *Empirical Economics*, 30 (1), 151-169.

Long, J. B., Plosser, C. I., 1983. Real business cycles, *Journal of Political Economy*, 91 (1), 39-69.

Lucas, R E., 1977. Understanding business cycles, *Carnegie-Rochester Conference Series on Public Policy*, 5, 7-29.

Lütkepohl, H., 2005. *New introduction to multiple time series analysis*, Berlin: Springer-Verlag.

Mills, T. C., 2003. *Modelling trends and cycles in economic time series*, New York: Palgrave Macmillan.

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

Montgomery, M., R., 2006. Austrian persistence? Capital-based business cycle theory and the dynamics of investment spending, *Review of Austrian Economics*, 19 (1), 17-45.

Mulligan, R., F., 2002. A Hayekian analysis of the term structure of production, *The Quarterly Journal of Austrian Economics*, 5 (2), 17-33.

Pater, R., 2011. Wskaźniki wyprzedzające dla rynku pracy, *Prace i Materiały Instytutu Rozwoju Gospodarczego SGH*, 87, 117-140.

Perez, P. J., 2001. *Cyclical properties in the main western economies*, University of Manchester Discussion Paper Series No. 33.

Perron, P., 1989. The great crash, the oil price shock, and the unit root hypothesis: Erratum, *Econometrica*, 61 (2), 248-249.

Perron, P., 1997. Further evidence on breaking trend functions in macroeconomic variables, *Journal of Econometrics*, 80 (2), 355-385.

Rebelo, S., 2005. Real business cycle models: Past, present, and future, *Scandinavian Journal of Economics*, 107 (2), 217-238.

Saikkonen, P., Lütkepohl, H., 2002. Testing for a unit root in a time series with a level shift at unknown time, *Econometric Theory*, 18 (2), 313-348.

Saroliya, G., 2007. The New Keynesian business cycle achievements and challenges, *Portuguese Economic Journal*, 6 (2), 95-116.

Seddighi, H. R., Lawler, K. A., Katos, A. V., 2000. *Econometrics. A practical approach*, London and New York: Routledge.

Shea, J., 2002. Complementarities and comovements, *Journal of Money, Credit and Banking*, 34 (2), 412-433.

Skrzypczyńska, M., 2012. Cykl koniunkturalny w Polsce – analiza sektorowa, *Bank i Kredyt*, 44 (2), 175-206.

Stockman, A. C., 1988. Sectoral and national aggregate disturbances to industrial output in seven European countries, *Journal of Monetary Economics*, 21 (2-3), 387-409.

Tang, J. H., 2007. Gross job flows and technology shocks in nondurable and durable goods sectors, *Journal of Macroeconomics*, 29 (2), 326-354.

Toda, H. Y., Yamamoto, T., 1995. Statistical inference in vector autoregressions with possible integrated processes, *Journal of Econometrics*, 66 (1-2), 225-250.

Veldkamp, L., Wolfers, J., 2007. Aggregate shocks or aggregate information? Costly information and business cycle comovement, *Journal of Monetary Economics*, 54 (Supplement), 37-55.

Yang, J-M., Kim, T-W., 2005. A search for leading sectors over the business cycle: The case of Korea, *Japan and the World Economy*, 17 (4), 480-495.

Zarnowitz, V., Ozyildirim, A., 2006. Time series decomposition and measurement of business cycles, trends and growth cycles. *Journal of Monetary Economics*, 53 (7), 1717-1739.