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### A NOTE ON THE CYCLICAL BEHAVIOR OF SECTORAL EMPLOYMENT IN THE U.S.

Hiranya Nath\*

Sam Houston State University  
eco\_hkn@shsu.edu

#### Abstract

Using data for 14 major sectors of the U.S. private economy and the government from 1958 to 2014, this note examines the cyclical behavior of sectoral employment. In particular, it investigates if relative volatility and comovement of the cyclical component of sectoral employment with real GDP have changed over time. The cyclical components are extracted using the Hodrick-Prescott (H-P) filter and changes in cyclical properties are detected using rolling standard deviations and rolling correlations. The analysis suggests that these properties have changed substantially for a number of service sectors since the early 1980s. In particular, wholesale and retail trade, transportation and utility, information, financial activities, and professional and business services have experienced significant increases in relative volatility. Furthermore, while the positive correlation between the cyclical components of employment and real GDP has become stronger for wholesale trade, transportation and utility, financial activities, and professional and business services, it has become weaker for information services, leisure and hospitality, and other services. Finally, education and health sector employment has switched from being procyclical to countercyclical. Recognizing these changes is important and useful for future research on business cycle behavior of the labor market in the U.S. and for policy formulation.

*Keywords:* Cyclical behavior; sectoral employment; rolling standard deviation; rolling correlation; relative volatility; comovement

*JEL Codes:* E32, E24

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# A Note on the Cyclical Behavior of Sectoral Employment in the U.S.

## 1. Introduction

Over last several decades, there have been structural changes in the U. S. economy along with important labor market adjustments. For example, the share of services in total nonfarm employment has significantly increased and, correspondingly, the share of the goods-producing sector has declined. Within services, the growth of employment has not been uniform across different sectors. Given these, it is only natural to ask if there has been any change in the cyclical behavior of the labor market, particularly at disaggregated sectoral levels. Most business cycle research focuses on aggregate (average) fluctuations and often ignores sectoral heterogeneity that may be critical for understanding the labor market behavior at cyclical frequencies and may also be useful for formulating appropriate policies. There are only a handful of studies (e.g. Clark 1998; Stock and Watson 1999; Horensten 2000; Kim and Kim 2006; Malysheva and Sarte 2009; Cassou and Vazquez 2014) that examine the cyclical behavior of sectoral employment.

This note contributes to this literature by examining if cyclical employment properties have changed for 14 major sectors of the U.S. private nonfarm economy and government over nearly six decades. Following standard practices in the business cycle literature, the cyclical components of sectoral employment and aggregate output are extracted using the Hodrick-Prescott (H-P) filter and their relative volatility and comovement are measured. The novelty of this note lies in its use of rolling standard deviations and rolling correlations to detect changes in relative volatility and comovement of sectoral employment (with respect to aggregate output) at cyclical frequencies.

The analysis indicates that total private nonfarm employment has become more volatile relative to real GDP in recent years, driven primarily by similar volatility in several major service-producing

sectors. In particular, wholesale and retail trade, transportation and utility, information, financial activities, and professional and business services have experienced significant increases in relative volatility since the 1980s. Likewise, the positive comovement between the cyclical components of employment and real GDP has been stronger for a number of service sectors: wholesale trade, transportation and utility, financial activities, and professional and business services. In contrast, this correlation has become weaker for information services, leisure and hospitality, and other services. Furthermore, education and health sector employment has switched from being procyclical to countercyclical. The timing of these changes seem to have coincided with the period of so-called great moderation in the U.S. To the best of our knowledge, this is the first study to highlight these changes in the cyclical behavior of employment at disaggregated sectoral levels.

The rest of the paper is organized as follows. Section 2 briefly discusses the data. The cyclical properties of sectoral employment and an analysis of how they have changed over time are presented in section 3. Section 4 discusses the implications of the findings for business cycle research and their relevance for policy. The final section summarizes and concludes.

## 2. Data

Seasonally adjusted monthly data on employment are obtained from the Bureau of Labor Statistics (BLS) for 14 major sectors of the U.S. private nonfarm economy and government from January 1958 to June 2014.<sup>3</sup> Quarterly data on real GDP are obtained from the Bureau of Economic Analysis (BEA). Quarterly employment data are constructed as averages of months within each quarter.<sup>4</sup>

[Insert Table 1]

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<sup>3</sup> More disaggregated sectoral employment data are available only since 1990. Furthermore, data on average and total working hours data at the sectoral level are not consistently available for the sample period.

<sup>4</sup> This is similar to Malysheva and Sarte (2009).

Table 1 presents summary statistics for the 14 sectors, the government, and a few broad aggregate sectors. During the sample period, on an average, ‘durable goods’ and ‘retail trade’ accounted for the largest shares of total nonfarm employment. In general, most private services experienced increases in their employment shares with ‘professional and business services’, ‘education and healthcare services’, ‘leisure and hospitality’, and ‘other services’ recording the largest expansion. While durable goods sector was the largest employer in the beginning, ‘education and healthcare services’ has emerged as the largest private nonfarm employer by the end of the sample period.

### 3. The cyclical properties of sectoral employment

The Hodrick-Prescott (H-P) filter is applied to the logarithmic values of quarterly employment and real GDP data to extract their respective cyclical components.<sup>5</sup> To get a general sense of the cyclical movements of employment over the sample period, we plot the filtered cyclical components along with the cyclical component of real GDP for each sector and present them in Figure 1. As the figure indicates, relative employment volatility seems to have increased over last two decades for mining, construction, wholesale trade, transportation and utility, information, and professional and business services. In contrast, the employment volatility seems to have decreased in education and healthcare.

[Insert Figure 1]

Following standard practices, relative volatility is calculated as a ratio between the standard deviation of the cyclical component of sectoral employment and that of real GDP. Furthermore,

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<sup>5</sup> This filter was proposed by Hodrick and Prescott (1997). Band-pass (B-P) filters (as proposed by Baxter and King 1999 and Christiano and Fitzgerald 2003) are also applied. The relative volatility and comovement measures are not qualitatively different although there are some quantitative differences. The results with B-P filters can be obtained from the author.

cross-correlations of the cyclical components of sectoral employment with real GDP are calculated contemporaneously as well as up to 6 lags and leads.

[Insert Table 2]

Table 2 presents the relative volatility and comovement measures for each sector. Among the goods producing sectors, employment is relatively less volatile than real GDP only for the nondurable goods sector. In contrast, employment is relatively less volatile in most major services. Contemporaneous correlations suggest that most goods producing sectors, except mining, are strongly procyclical (as indicated by large positive correlation). The correlations at leads and lags indicate that the cyclical components of employment tend to lag real GDP (as indicated by maximum positive values of correlation coefficients at lags) for all sectors. These results are consistent with previous findings (e.g. Stock and Watson 1999).

### *3.1 Changes in the cyclical behavior of sectoral employment*

Have the cyclical properties of sectoral employment changed over time? In particular, have there been any changes in relative volatility and comovement of sectoral employment with respect to real GDP at cyclical frequencies? To address this question, rolling standard deviations and rolling correlations are computed with an arbitrarily chosen rolling window of 20 years.<sup>6,7</sup> We use the following formula to calculate rolling sample standard deviation:

$$\hat{\sigma}_{e_i,t}(n) = \sqrt{\frac{1}{n-1} \sum_{j=0}^{n-1} (e_{i,t-j}^c - \bar{e}_t^c(n))^2} \quad (1)$$

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<sup>6</sup> Any 20 year window during the sample period covers at least two recessionary cycles. For robustness, we also use an 8-year window and a 30-year window. The window-to-window fluctuations are large with shorter windows and small with longer windows. However, the long-run trends in these rolling volatility and comovement measures are similar across windows of different sizes.

<sup>7</sup> For a discussion on rolling analysis of time series and the formulae used here, see Zivot and Wang (2006).

where  $n$  is the width of a sub-sample or window ( $n = 80$  in our case as there are 80 quarters in 20 years);  $e_{i,t-j}^c$  is the cyclical component of employment in sector  $i$  in period  $t-j$  ( $j = 0, 1, 2, \dots, n-1$ ); and  $\bar{e}_t^c(n) = \frac{1}{n} \sum_{j=0}^{n-1} e_{i,t-j}^c$  is the rolling mean. Similarly, we calculate rolling standard deviation of the cyclical component of real GDP and take the ratios of these two rolling standard deviations to measure relative rolling volatility. Furthermore, we use the following formula to calculate rolling correlation coefficient:

$$\hat{\rho}_{e_i y, t}(n) = \frac{\hat{\sigma}_{e_i y, t}(n)}{\hat{\sigma}_{e_i, t}(n) \hat{\sigma}_{y, t}(n)} \quad (2)$$

where  $\hat{\sigma}_{e_i y, t}(n) = \frac{1}{n-1} \sum_{j=1}^{n-1} (e_{i,t-j}^c - \bar{e}_t^c(n))(y_{i,t-j}^c - \bar{y}_t^c(n))$  is the rolling covariance between the cyclical components of employment in sector  $i$  and of real GDP; and  $\hat{\sigma}_{e_i, t}(n)$  and  $\hat{\sigma}_{y, t}(n)$  are the rolling standard deviations of the cyclical components of sectoral employment and real GDP respectively. This methods essentially consider a sub-sample or window of 20 years (80 quarters) and compute standard deviations and contemporaneous cross-correlations for that sub-sample. Then they roll the window by excluding an observation at the beginning of the sample and including one at the end and compute standard deviations and cross-correlations. They repeat this process until all the observations are exhausted.

[Insert Figure 2]

Figure 2 plots the 20-year rolling standard deviations of the cyclical component of employment relative to that of real GDP for each of the 14 sectors, the total private nonfarm sector, and the government. Each point on the plot represents the cyclical employment volatility relative to real GDP for the 20 years until the period corresponding to that point. The following observations can be made. *First*, in general, private nonfarm employment has become relatively more volatile. A clear shift around 2002-03 indicates the onset of some changes in its cyclical behavior around the early 1980s. *Second*,

employment in wholesale and retail trade, transportation and utility, information, financial activities, professional and business services has become relatively more volatile than real GDP. In fact, that the shifts in employment volatility in these sectors coincide with a similar shift in the private nonfarm sector indicates that the higher total private nonfarm employment volatility in recent decades may have been driven by higher volatility in these services.

It may be argued that these increases in relative volatility are driven primarily by a larger drop in absolute volatility of real GDP during the period of great moderation that, studies show, began in the early 1980s. However, a closer look at absolute volatility of real GDP and of employment in different sectors reveals some interesting facts. For example, as it is well-established by now, the absolute volatility of real GDP (measured by rolling standard deviation in this note) had been falling since the mid-1980s until 2005-06 and since then it has slightly increased. In contrast, employment volatility has been rising almost constantly in sectors like ‘wholesale trade’ and ‘professional and business services’ that together accounted for about 18 percent of total nonfarm employment in 2014. Furthermore, the increases in absolute volatility of employment in certain sectors (e.g. transportation and utility, financial services, leisure and hospitality) during the recent recessionary cycle have been more pronounced and significantly larger than the moderate increase in real GDP volatility.

[Insert Figure 3]

Figure 3 presents the plots of rolling correlations of the cyclical sectoral employment with real GDP. In mining, the correlation has changed from being negative (countercyclical although not strong) to positive (procyclical). Employment in education and healthcare has changed from being procyclical to countercyclical. The same is true for employment in government. The procyclical behavior of employment has become stronger in wholesale trade, transportation and utility, financial activities, and professional and business services while it has been weaker in information services,

leisure and hospitality, and other services. In most cases a clear break can be detected around 2002-03 that indicates the beginning of some significant changes in the cyclical behavior in the early 1980s.

Although a deeper understanding of the above changes requires further investigation, their timing as detected in this study seems to have coincided with the beginning of great moderation.<sup>8</sup> However, a detailed exploration of the underlying factors or mechanism is beyond the scope of this note.

#### 4. Implications for business cycle research and policy

The findings presented in this note highlight two important aspects of the cyclical behavior of sectoral employment during the past six decades, which have clear implications for future business cycle research - particularly on labor market. First, there have been changes in relative volatility and comovement of employment with aggregate real GDP at cyclical frequencies for a number of sectors.<sup>9</sup> The fact that these changes seem to have occurred around the same time indicates that some aggregate factor(s) with effects across sectors may have driven these changes. Identifying that (those) factors would be an agenda item for future business cycle research. Although it would require extensive and in-depth investigation, some observations with regard to most sectors that experienced these changes may provide a direction. Due primarily to the advances in information and communication technologies, many service sector jobs have fundamentally changed. Since the 1990s, these jobs have been vulnerable to outsourcing, offshoring, and automation.<sup>10</sup> Second, the findings presented in this note also highlight that there is substantial heterogeneity not only in the cyclical properties but also, most importantly, in the changes of these properties across sectors. Thus, it is imperative that

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<sup>8</sup> For example, see Stock and Watson (2002)

<sup>9</sup> The business cycle literature has been using various nonlinear techniques to capture such changes. For an early discussion see, for example, Granger et al (1993).

<sup>10</sup> Technology-driven cyclical fluctuations are the mainstay of the real business cycle literature (see, for example, McGrattan 2008)



researchers consider heterogeneity in both while studying business cycle properties of sectoral employment.

The findings reported in this note are relevant for policy formulation as well. Since employment generation (alternatively, reduction in unemployment rate) is a primary goal of fiscal and monetary policy in the short-run, the changes in cyclical properties of sectoral employment provide important information to the policymakers. For example, that employment in a number of sectors, such as wholesale trade, professional and business services, and more recently, leisure and hospitality, has become more volatile would require the policymakers to think of appropriate fiscal and monetary policy incentives to counter such development. The policy measures that used to work before may not work again if the policymakers do not pay attention to these changes in cyclical properties. Furthermore, recognizing the differences in the changes across sectors is also important, particularly for those sectors that account for a large share of employment in the economy.

## 5. Concluding Remarks

Using data for 14 major sectors of the U.S. private nonfarm economy and the government from 1958 to 2014, this paper presents evidence to show that the cyclical properties of employment have changed for a number of service producing sectors since the 1980s. In particular, wholesale and retail trade, transportation and utility, information, financial activities, and professional and business services have experienced significant increases in relative volatility. Furthermore, while the positive correlation between the cyclical components of employment and real GDP has become stronger for wholesale trade, transportation and utility, financial activities, and professional and business services, this correlation has been weaker for information services, leisure and hospitality, and other services. Furthermore, education and health sector employment has switched from being procyclical to countercyclical. Recognizing these changes is important and useful for future research on business

cycle behavior of the labor market in the U.S. By highlighting the changes in relative volatility and comovements of the cyclical components of sectoral employment with that of real GDP, this research note makes a novel contribution to the existing literature on labor market behavior over business cycles. In our future research, we intend to explore the forces behind these changes and draw more specific policy implications.

## References

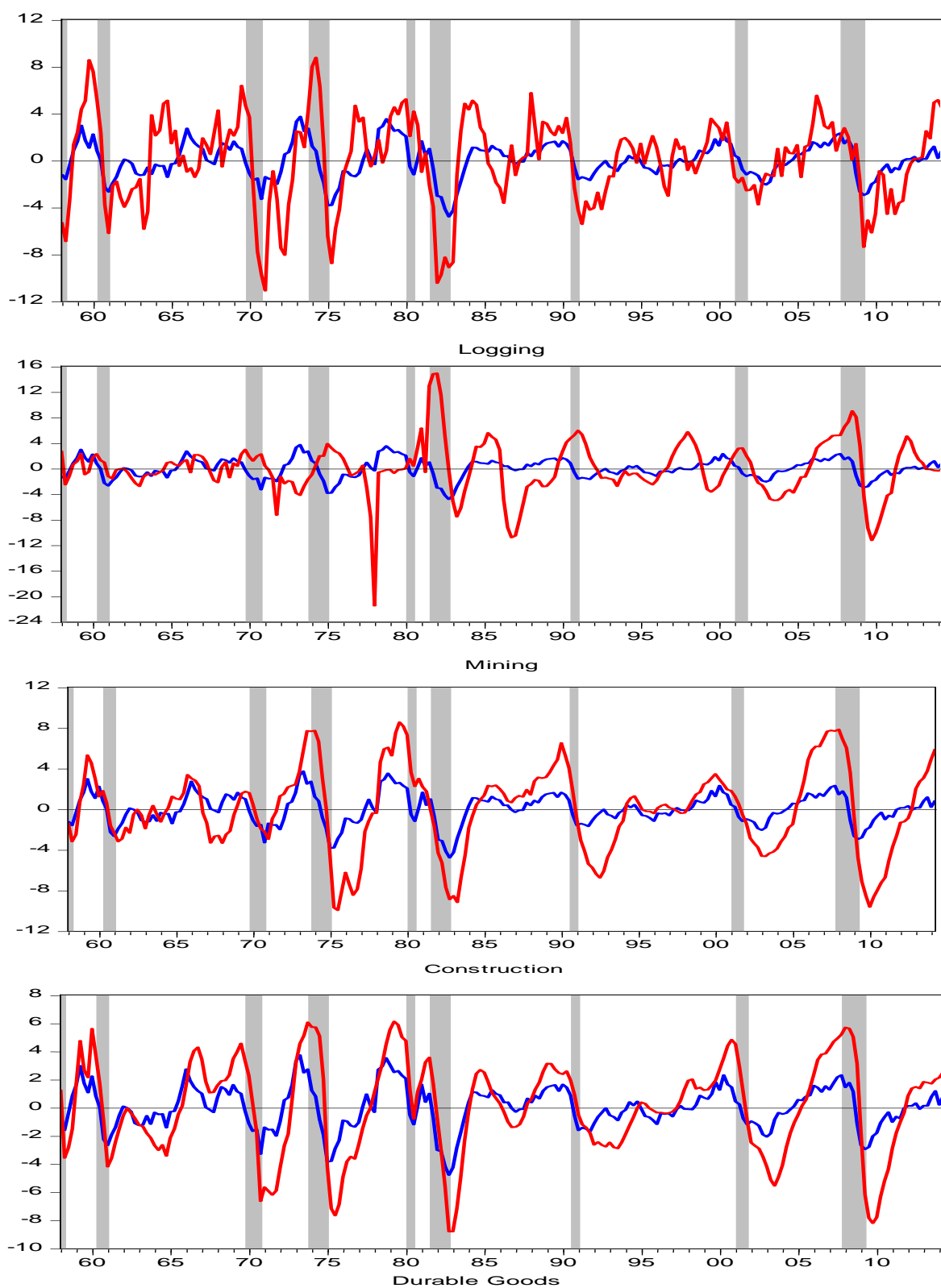
- Baxter, M., King, R. G. (1999). ‘Measuring business cycles: approximate band-pass filters for economic time series.’ *Review of Economics and Statistics* 81: 575 – 593.
- Cassou, S. P., Vazquez, J. (2014). ‘Employment comovements at the sectoral level over the business cycle’, *Empirical Economics* 46, 1301-1323
- Clark, T. E. (1998). ‘Employment Fluctuations in U.S. Regions and Industries: The Roles of National, Region-Specific, and Industry-Specific Shocks’, *Journal of Labor Economics* 16, 202-229
- Christiano, L., Fitzgerald, T. J. (2003). ‘The band-pass filter’, *International Economic Review* 44, 435-465.
- Granger, C. W., Terasvirta, T. Anderson, H. M. (1993). ‘Modeling Nonlinearity over the Business Cycle.’ In Stock, J. H., Watson, M. W. (eds). *Business Cycles, Indicators and Forecasting*. Chicago: University of Chicago Press, 311-326.
- Hodrick, R. J., Prescott, E. C. (1997). ‘Postwar U. S. business cycles: an empirical investigation’, *Journal of Money, Credit and Banking* 29, 1 – 16.
- Hornstein, a. (2000) “The business cycle and industry comovement.” *Federal Reserve Bank of Richmond Economic Quarterly* 86(1), 27-47
- Kim, K., Kim, Y.S. (2006). ‘How important is the intermediate input channel in explaining sectoral employment comovement over the business cycle?’ *Review of Economic Dynamics* 9, 659-682.
- Malysheva, N., Sarte, P.G. (2009). ‘Heterogeneity in Sectoral Employment and the Business Cycle’, *Federal Reserve Bank of Richmond Economic Quarterly* 95(4), 335 – 355
- McGrattan, E. (2008) ‘Real Business Cycles.’ In Durlauf, S. N. and Blume, L. E. *The New Palgrave Dictionary of Economics*, Second Edition, Palgrave Macmillan.
- Stock, J. H., Watson, M. W. (1999). ‘Business Cycle Fluctuations in US Macroeconomic Time Series’, in J. B. Taylor and M. Woodford (eds) *Handbook of Macroeconomics*, Vol. 1, 3 – 64
- Stock, J. H., Watson, M. W. (2002). ‘Has the Business Cycle Changed and Why?’ *NBER Macroeconomic Annual*, Vol. 17, 159-218.
- Zivot, E., Wang, J. (2006). *Modeling Financial Time Series with S-PLUS®*, New York, USA: Springer Science-Business Media, Inc.

**Table 1.** Sectoral share (%) in total nonfarm employment: 1958:Q1 – 2014:Q2

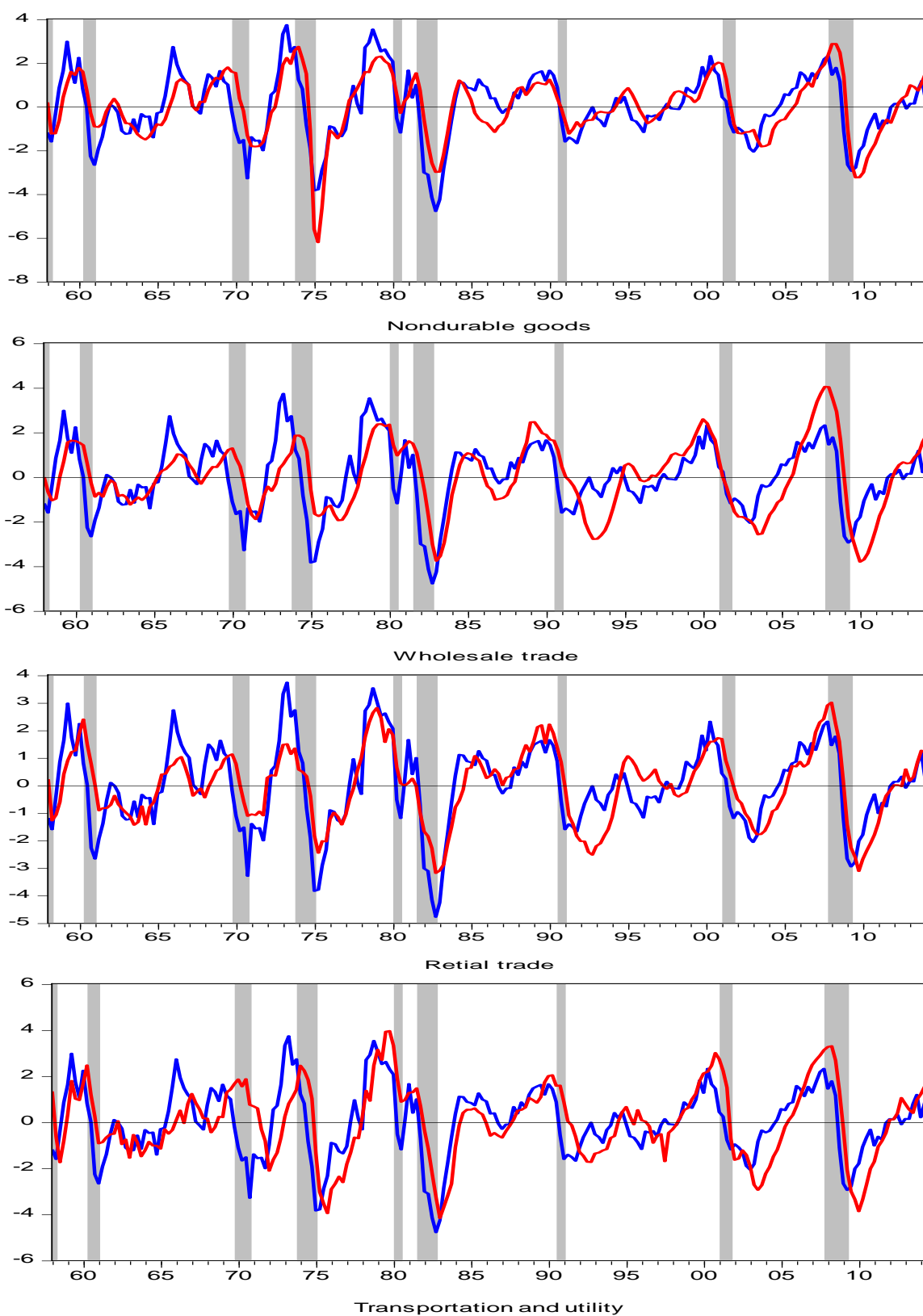
Sector	Mean	Standard deviation	Max	Min	Beginning of the sample period: (1958:Q1)	End of the sample period: (2014:Q2)
	(1)	(2)	(3)	(4)	(5)	(6)
Logging	0.09	0.04	0.18	0.04	0.17	0.04
Mining	0.76	0.28	1.44	0.38	1.44	0.61
Construction	4.96	0.41	5.78	4.18	5.53	4.34
Durable goods	11.23	3.81	17.12	5.41	16.82	5.52
Nondurable goods	7.24	2.72	12.05	3.23	12.03	3.23
Wholesale trade	4.71	0.27	5.11	4.19	4.94	4.23
Retail trade	11.21	0.62	12.19	10.15	10.22	11.07
Transportation and utility	4.11	0.50	5.61	3.63	5.61	3.72
Information	2.60	0.32	3.30	1.92	3.30	1.92
Financial activities	5.57	0.55	6.27	4.57	4.61	5.73
Professional and business services	9.69	2.31	13.83	6.68	6.68	13.83
Education and health services	9.48	3.11	15.48	5.18	5.18	15.46
Leisure and hospitality	8.09	1.28	10.54	6.27	6.27	10.54
Other services	3.30	0.72	4.16	2.03	2.03	3.98
Total private	83.05	0.90	84.83	80.66	84.83	84.20
Government	16.95	0.90	19.34	15.17	15.17	15.80
Goods-producing	24.29	6.99	36.19	13.65	35.99	13.73
Private service-providing	58.77	7.26	70.47	48.58	48.84	70.47

**Table 2.** Relative volatility and comovements of the cyclical components of sectoral employment with real GDP: 1958:Q1 – 2014:Q2

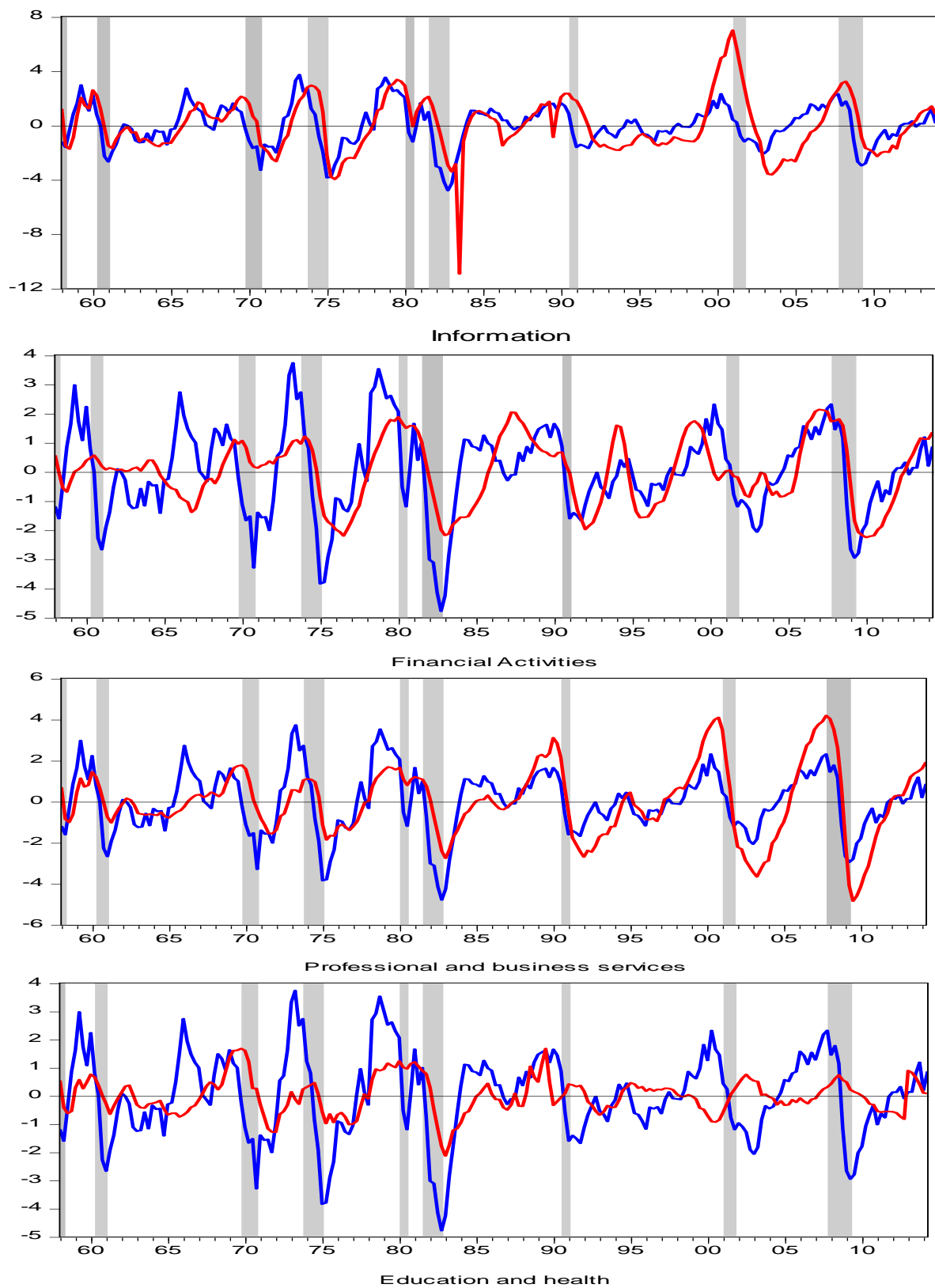
Sector	Relative volatility	Correlation of the cyclical component of real GDP ( $y_t$ ) with that of employment ( $e_{t+k}$ ) at various lags and leads												
		(-6)	(-5)	(-4)	(-3)	(-2)	(-1)	(0)	(+1)	(+2)	(+3)	(+4)	(+5)	(+6)
Logging	2.44	-0.04	0.02	0.11	0.24	0.41	0.55	0.63	0.62	0.52	0.38	0.21	0.06	-0.09
Mining	2.75	-0.31	-0.36	-0.39	-0.36	-0.27	-0.13	0.07	0.18	0.27	0.33	0.34	0.29	0.23
Construction	2.70	-0.17	-0.05	0.09	0.26	0.45	0.63	0.77	0.81	0.78	0.68	0.54	0.38	0.20
Durable goods	2.22	-0.30	-0.19	-0.05	0.13	0.36	0.60	0.81	0.89	0.86	0.75	0.57	0.37	0.17
Nondurable goods	0.94	-0.24	-0.14	-0.01	0.18	0.40	0.63	0.80	0.84	0.77	0.60	0.40	0.20	0.02
Wholesale trade	1.04	-0.31	-0.22	-0.09	0.08	0.26	0.46	0.64	0.75	0.78	0.74	0.63	0.50	0.34
Retail trade	0.87	-0.17	-0.04	0.11	0.27	0.46	0.64	0.79	0.83	0.79	0.68	0.52	0.35	0.18
Transportation and utility	1.07	-0.31	-0.22	-0.12	0.02	0.21	0.43	0.65	0.78	0.82	0.78	0.68	0.54	0.37
Information	1.36	-0.41	-0.33	-0.23	-0.07	0.13	0.36	0.58	0.71	0.76	0.73	0.64	0.51	0.37
Financial activities	0.76	-0.17	-0.08	0.02	0.13	0.26	0.38	0.49	0.56	0.58	0.56	0.52	0.45	0.36
Professional and business services	1.13	-0.24	-0.14	-0.01	0.15	0.33	0.51	0.66	0.73	0.72	0.65	0.53	0.40	0.25
Education and healthcare services	0.43	-0.43	-0.37	-0.29	-0.16	-0.01	0.16	0.33	0.44	0.50	0.51	0.49	0.45	0.38
Leisure and hospitality	0.77	-0.19	-0.06	0.07	0.24	0.42	0.61	0.76	0.81	0.78	0.68	0.54	0.37	0.21
Other services	0.59	-0.37	-0.31	-0.22	-0.09	0.07	0.26	0.44	0.55	0.60	0.60	0.55	0.47	0.38
Total private	1.03	-0.31	-0.19	-0.04	0.15	0.37	0.61	0.81	0.89	0.87	0.77	0.61	0.43	0.24
Government	0.49	-0.36	-0.29	-0.20	-0.10	0.00	0.09	0.17	0.25	0.33	0.42	0.48	0.53	0.55
Total nonfarm	0.88	-0.33	-0.21	-0.06	0.13	0.36	0.60	0.80	0.89	0.88	0.79	0.64	0.47	0.29
Goods producing	1.86	-0.27	-0.16	-0.02	0.16	0.38	0.62	0.82	0.89	0.86	0.74	0.57	0.38	0.18
Private service providing	0.74	-0.30	-0.18	-0.04	0.13	0.34	0.55	0.74	0.83	0.84	0.77	0.64	0.49	0.33



**Figure 1.** H-P filtered cyclical components of real GDP and employment: 1958 - 2014  
 Real GDP \_\_\_\_\_ Employment \_\_\_\_\_

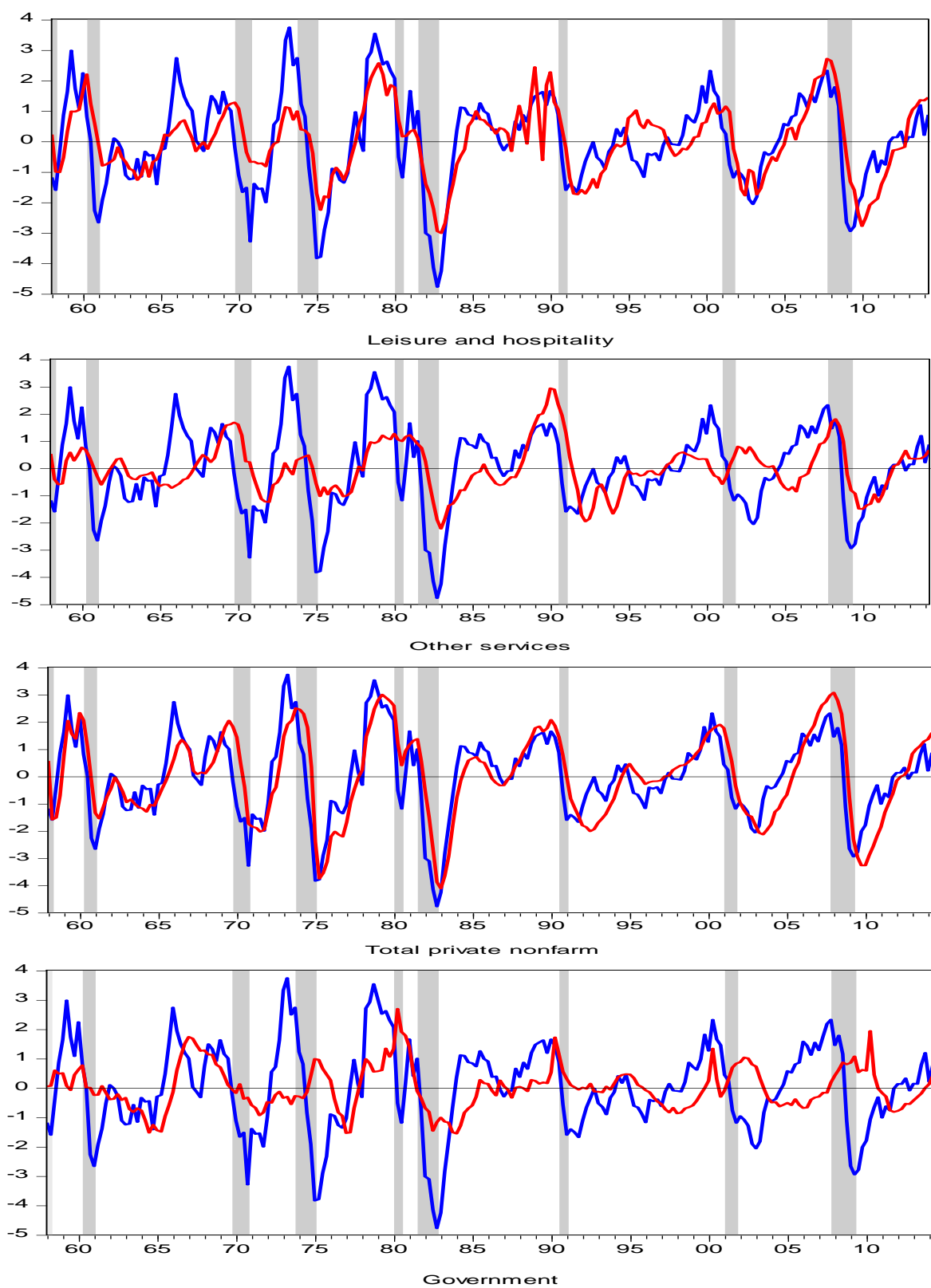


**Figure 1.(contd.)** H-P filtered cyclical components of real GDP and employment:1958-2014  
 Real GDP \_\_\_\_\_ Employment \_\_\_\_\_

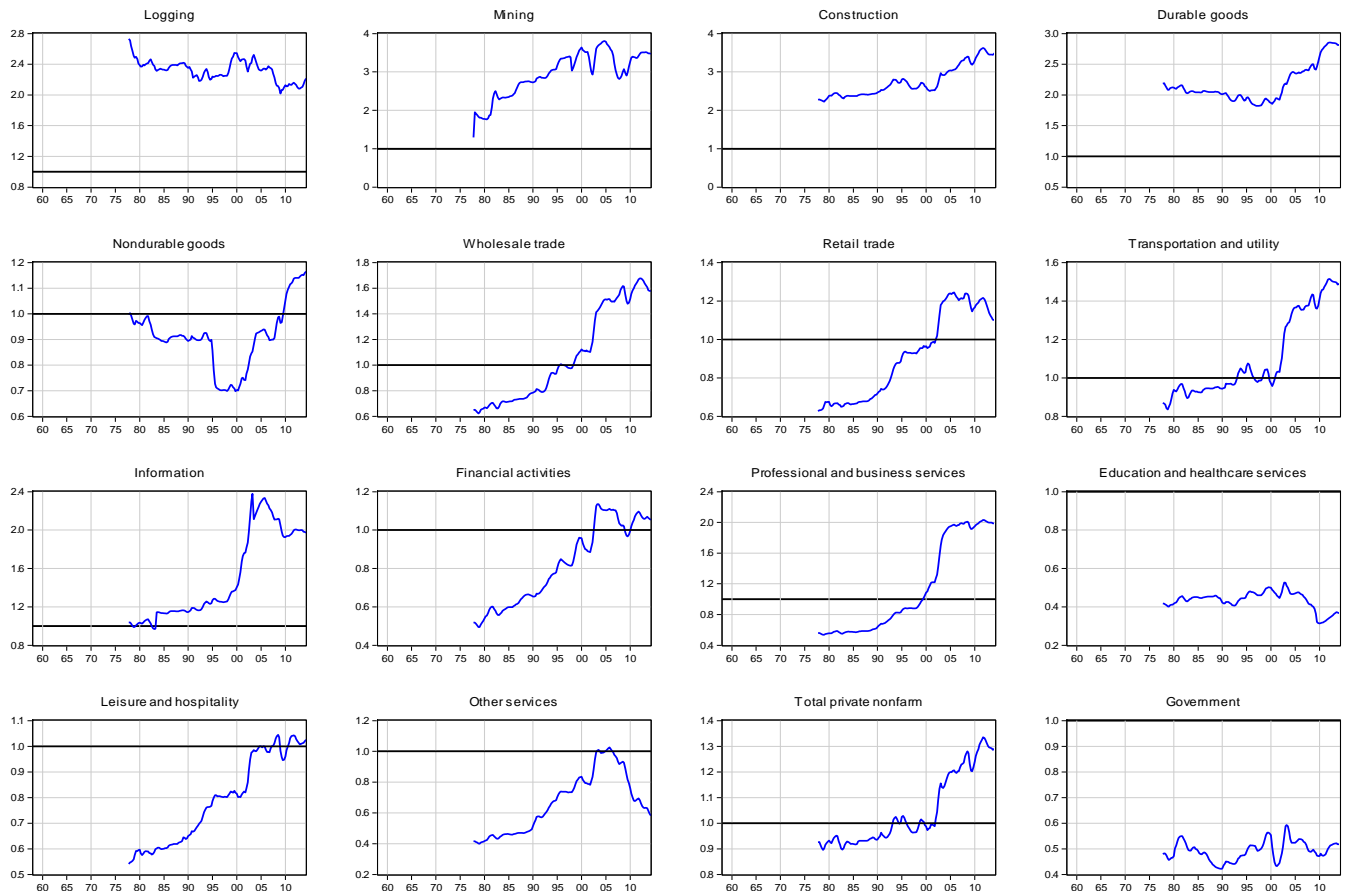


**Figure 1.(contd.)** H-P filtered cyclical components of real GDP and employment:1958-2014  
 Real GDP \_\_\_\_\_ Employment \_\_\_\_\_

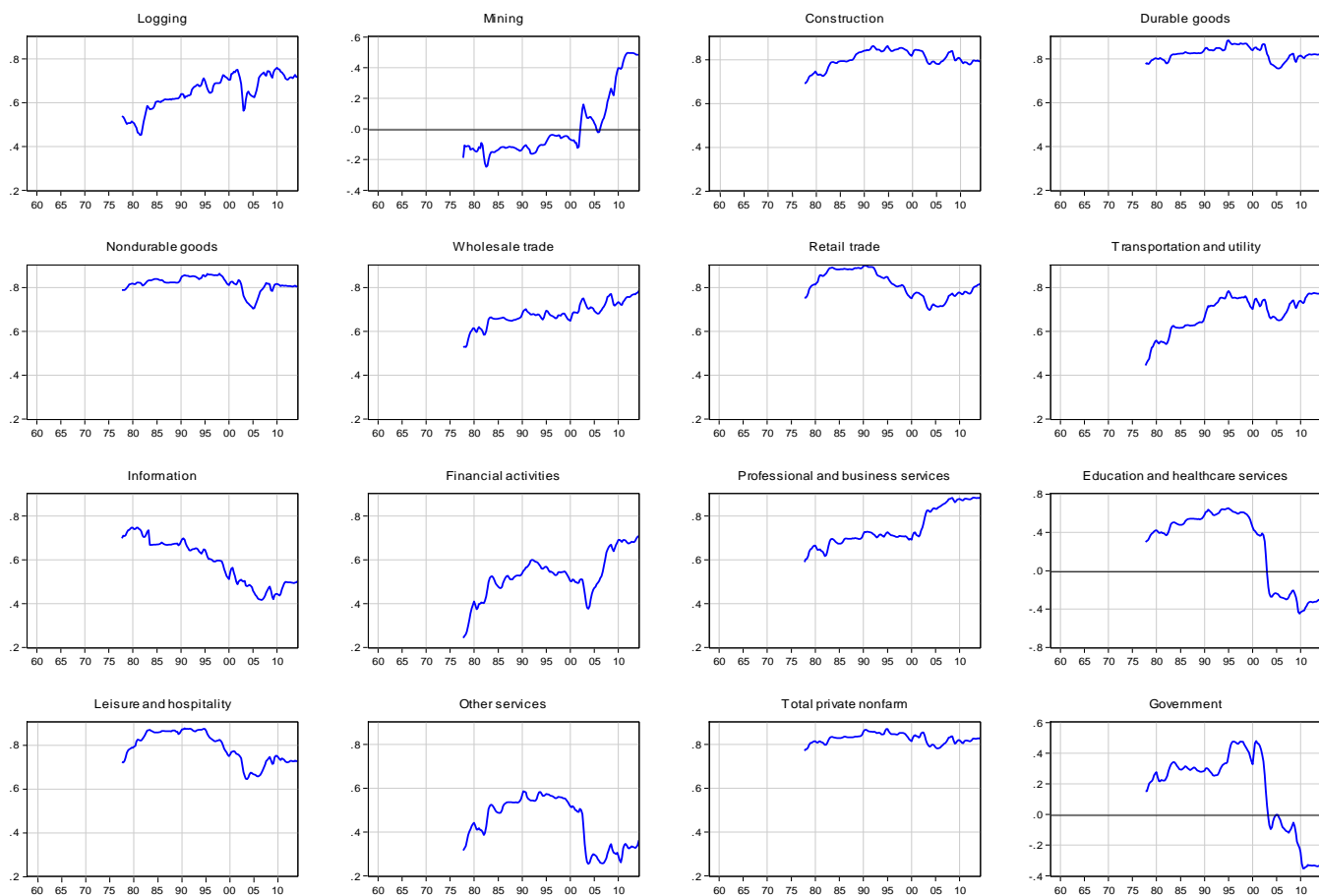




**Figure 1.** (contd.) H-P filtered cyclical components of real GDP and employment: 1958 - 2014  
Real GDP \_\_\_\_\_ Employment \_\_\_\_\_



**Figure 2.** Rolling standard deviation of the cyclical components of sectoral employment relative to that of real GDP (20-year rolling window)



**Figure 3.** Rolling correlations between the cyclical components of sectoral employment and that of real GDP (20-year rolling window)