Real Wages and the Business Cycle in Germany

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Outline

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Introduction

Relevance of an empirical analysis of the cyclical behavior of real wages

- Conflicting macroeconomic theories
  - anticyclical real wages, i.e. *Keynes (1936), Barro (1990), Christiano and Eichenbaum (1992)*
  - procyclical real wages, i.e. *Kydland and Prescott (1982), Barro and King (1984)*
  - procyclical or acyclical real wages, i.e. *Rotemberg and Woodford (1991)*
- Identification of the sources and features of wages and labor costs dynamics
  $\Rightarrow$ implications for monetary policy

Contribution of our study:

- The comovements between real wages and the cycle are analyzed not only in the time domain but also in the frequency domain
- Various methods are used to extract the cycle from the data in order to check the robustness of the results
- Both producer and consumer price index are used as a deflator in computing real wages
- Analysis is carried out for the whole economy
- Germany

Data

- Quarterly data from 1970.Q1 to 2009.Q1 (157 observations)
  - real GDP
  - consumer real wages
  - producer real wages
- Seasonal adjustment with the Census–X12–ARIMA procedure
- Data prior to 1991.Q1 refer to West Germany, linked to the data of unified Germany using annual averages for 1991
- All generated data are represented in logarithms

Stochastic properties

- Testing for unit roots:
  - Augmented Dickey-Fuller test (ADF test)
  - Phillips–Perron test

$\Rightarrow$ underlying processes are not covariance stationary

- Testing of the first differences for unit roots

$\Rightarrow$ all series are generated by I(1) processes

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1. Introduction

2. Data and stochastic properties of the series

3. Identification of the cyclical component
   - Linear trend
   - Beveridge-Nelson decomposition
   - Filters
   - Structural time series models

4. Comovements of real GDP and real wages
   - Time domain
   - Frequency domain

5. Conclusions

The general framework for the trend–cycle decomposition:

$$y_t = y_t^g + y_t^c + \varepsilon_t, \qquad t = 1, 2, ..., T \tag{1}$$

y_t: natural logarithm of the considered series
y_t^g: trend
y_t^c: cycle
ε_t: irregular component

- STSM: all three components explicitly modeled
- BK filter: implicitly modeled components, extraction of the cycle through an elimination of the trend and irregular movements
- HP filter and BN decomposition: ε_t not modeled, irregular movements assigned to the cycle

Linear trend

- Quandt–Andrews test on structural breaks
  $\Rightarrow$ in all cases, the hypothesis of no structural break is rejected, estimated break points:
  - 2002.Q4 for real GDP
  - 2003.Q1 for both real wages
- Estimation of the linear broken trend model (LBT) for all three series
- Residual of the estimated model as the cyclical component uncorrelated with the trend component
- Testing of the LBT cycles for unit roots
  $\Rightarrow$ not covariance stationary, therefore excluded from further analysis

Beveridge–Nelson decomposition

- Decomposition proposed by *Beveridge and Nelson (1981)*
- The examined series are assumed to underlie an I(1) process
- Trend as a prediction of future values of the series
- Trend is a random walk with drift
- Cycle is covariance stationary, correlated with trend

- **Advantages** in comparison to the linear trend model:
  - Suitable method for difference stationary processes
  - No assumptions with regard to the correlation between trend and cycle are required

- **Disadvantages**:
  - Various ARMA models can fit the data. However, this leads to various predictions and hence various trends and cycles
  - Variance of the trend can exceed variance of the series
  - Trend is a priori restricted to be a random walk

Filters

- Hodrick–Prescott (HP) filter and Baxter–King (BK) filter
- Linear filters often employed in macroeconomic applications in order to extract cycles
- HP (cyclical) filter eliminates lower "frequencies" and passes through higher "frequencies"
- BK (cyclical) filter eliminates "frequencies" outside a particular frequency band

- **Advantages**:
  - Render the data covariance stationary
  - Avoid modeling of the series

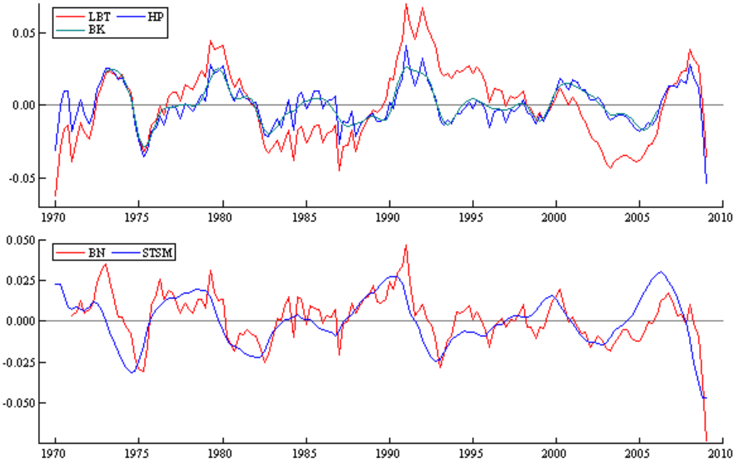
- **Disadvantage**: it has been shown that when applied to series generated by nonstationary processes both filters induce spurious cycles
  - HP critique: e.g. *Cogley and Nason (1995), Harvey and Jaeger (1993)*
  - *BK critique: e.g. Murray (2003)*

⇒ the results should be interpreted with some caution!

Structural time series models

- Are defined in terms of unobserved components that can, however, be directly interpreted (*Harvey, 1989*)
- **Advantages**:
  - In contrast to ad hoc filtering, they rely on stochastic properties of data
  - In contrast to ARIMA modeling, they do not aim at a parsimonious specification
- **Disadvantage**: problem of the "correct" model specification

Figure: Cycles of the real GDP



LBT:	Linear broken trend model	HP:	Hodrick–Prescott filter
BK:	Baxter–King filter	BN:	Beveridge–Nelson decomposition
STSM:	Structural time series model		

Figure: Cycles of the consumer real wage

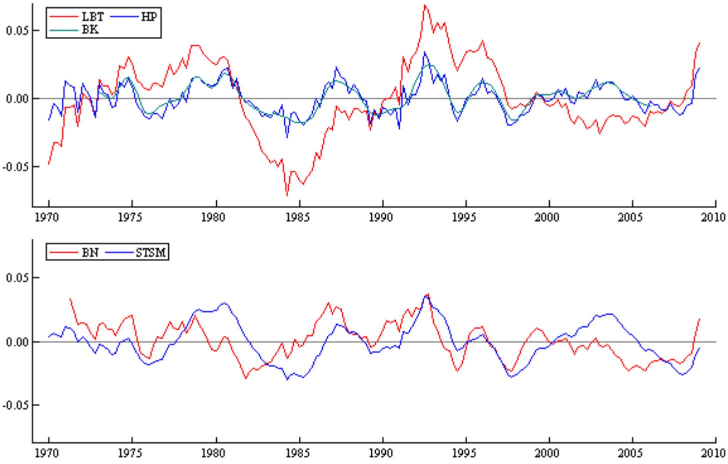


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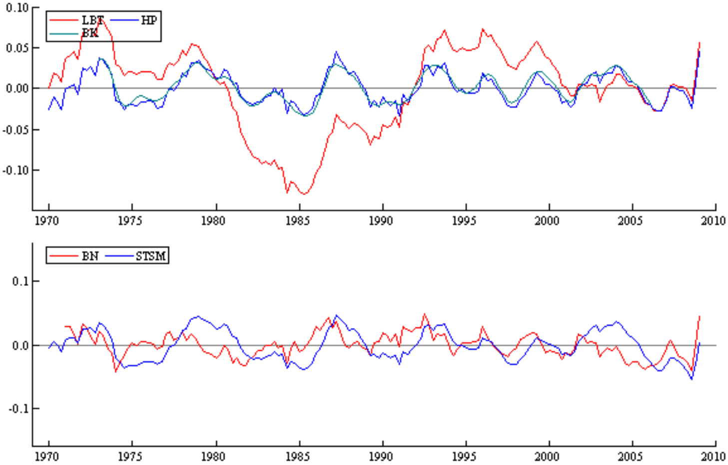
Figure: Cycles of the producer real wage



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Time domain

- Traditional approach to detect the cyclical behavior
- Sample **cross–correlations** as a measure of comovements
- Real GDP cycles as a reference for the business cycle
- Analyzed bandwidth: 12 leads and 12 lags

Definitions:

- The considered real wage is
  procyclical/countercyclical/acyclical
  if the estimated correlation coefficients are
  positive/negative/close to zero
  taking into account the lead–lag structure of the series
- The considered real wage is
  lagging/leading
  the cycle if the largest sample cross–correlation occurs at any
  lead/lag within a given band

Results for the consumer real wage:

- The consumer real wage is procyclical and lagging the business cycle
- The strongest reaction is observed between
  the 5th (BN and HP cycle) and 11th quarter (STSM cycle)

Frequency domain

- Provides additional insights into the cyclicality of real wages
- **Phase angle** as the main concept adopted here
- **Phase angle** gives information about the frequency by frequency correlation and lead–lag relationship between two processes

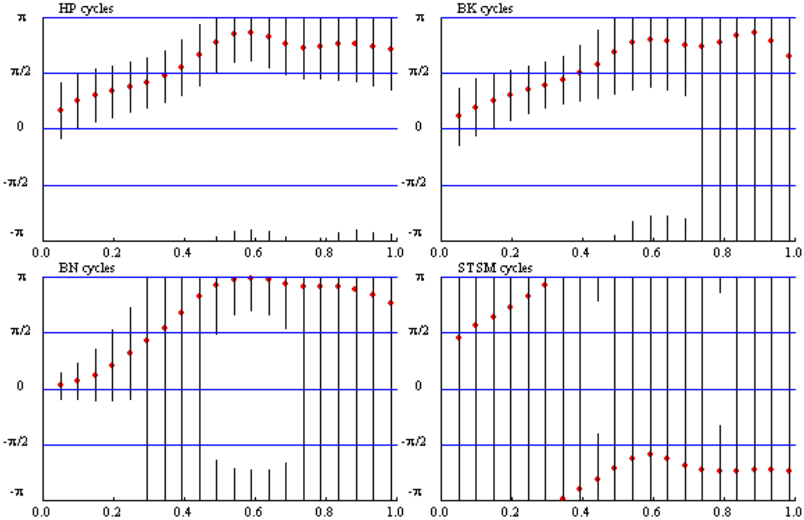
Definitions for the phase angle $\theta(\omega)$:

$\theta(\omega) > 0\ \ (< 0)$: component of real wage cycle with frequency ω lags (leads) the corresponding component of real GDP cycle

$|\theta(\omega)| < \pi/2$: component of real wage cycle with frequency ω is positively correlated with the corresponding component of real GDP cycle

$\pi/2 \leq |\theta(\omega)| \leq \pi$: component of real wage cycle with frequency ω is negatively correlated with the corresponding component of real GDP cycle

Figure: Phase angle: real GDP and consumer real wage cycles



Notes: The horizontal axis represents frequency ω.
red points: point estimates, black lines: 90% confidence intervals

HP, BK, BN cycles:

- Positive values at all frequencies suggesting lagging behavior of real wage
- Statistical significant positive values rather at lower business cycle frequencies (HP, BK: up to 0.45, BN: up to 0.2)
- Values in the interval $[0, \pi/2]$ at lower frequencies (up to about 0.35) suggesting procyclical pattern of real wage
- Statistical significant procyclical pattern up to frequency 0.25

STSM cycles:

- Positive values at lower frequencies, as in the case of the HP, BK and BN cycles
- However, there are not any statistical significant values in the whole frequency range

Results for the consumer real wage:

- Procyclical and lagging behavior of longer real wage cycles
- Countercyclical and also lagging behavior of shorter real wage cycles

Conclusions

- According to the results in the time domain, the consumer real wage displays a procyclical pattern and lags behind the business cycle though the contemporaneous correlation between the real GDP cycle and the real wage cycle is statistically insignificant
- The analysis of the phase angle in the frequency domain shows that the observed cyclicality depends on the frequency range under consideration
- At lower frequencies the consumer real wage is positively correlated with the business cycle, whereas at higher frequencies the correlation is negative
- The consumer real wage is lagging the real GDP at all frequencies
- Results for the consumer real wage are in line with nominal wage stickiness in the short run

Thank you for your attention!

Tables and figures

Table: Estimation of segmented linear trend models for real GDP and real wages

regressor	GDP	consumer wage	producer wage
	coefficients [a]		
t	0.0057	0.0035	0.0052
	(104.21)	(59.19)	(46.87)
$S_{k,t}$	-0.0047	-0.0068	-0.0112
	(-10.49)	(-13.4)	(-11.77)
constant	5.544	2.385	2.173
	(1278.237)	(510.194)	(246.321)

[a] t-values in parentheses. Number of observations: 157. Break point $k = 132$ for real GDP and $k = 133$ for real wages.

Here: the assumed general model as in eq. (1) with

- $\varepsilon_t \sim \mathcal{NID}(0, \sigma_\varepsilon^2)$
- y_t^g as defined in *Koopman et al. (2009)*
- y_t^c as suggested in *Koopman et al. (2009), Koopman et al. (2008), Harvey and Streibel (1998)*

Model for the stochastic trend component y_t^g:

$$\begin{aligned} y_{t+1}^g &= y_t^g + \beta_t + \eta_t, & \eta_t &\sim \mathcal{NID}(0, \sigma_\eta^2) \\ \Delta^m \beta_{t+1} + \zeta_t &= (1 - L)^m \beta_{t+1} + \zeta_t, & \zeta_t &\sim \mathcal{NID}(0, \sigma_\zeta^2) \end{aligned} \tag{2}$$

β_t: slope of the trend
m: order of the slope ($m = 1, 2, 3, \ldots$)

Model for the cycle y_t^c:

$$\begin{bmatrix} y_{t+1}^c \\ y_{t+1}^{c*} \end{bmatrix} = \rho \begin{bmatrix} \cos(\omega) & \sin(\omega) \\ -\sin(\omega) & \cos(\omega) \end{bmatrix} \begin{bmatrix} y_t^c \\ y_t^{c*} \end{bmatrix} + \begin{bmatrix} \chi_t \\ \chi_t^* \end{bmatrix}, \qquad \begin{bmatrix} \chi_t \\ \chi_t^* \end{bmatrix} \sim \mathcal{NID}(\mathbf{0}, \sigma_\chi^2 \mathbf{I}_2), \tag{3}$$

y_t^{c*}: auxiliary variable
ω : frequency ($0 \leq \omega \leq \pi$)
ρ : damping factor ($0 \leq \rho \leq 1$)

- Starting point for all three series:
  - no variance restrictions
  - $m = 1$ local linear trend
- Results of the specification:
  - real GDP: $\sigma_\eta^2 = 0$, $m = 1$
  - real wage: $\sigma_\eta^2 = 0$, $m = 2$
- Diagnostic checking:
  - Ljung–Box autocorrelation test
  - Goldfeld–Quandt heteroscedasticity test
  - Bowman–Shenton normality test

$\Rightarrow$ the models are correctly specified

Table: Contemporaneous and largest sample cross–correlations between the real GDP cycle and the particular real wage cycle by various decomposition methods

GDP with	**methods**			
	BN	HP	BK	STSM
consumer real wage	0,1169 $0,4879^{*}(+6)$	0,0124 $0,4572^{*}(+6)$	0,1438 $0,6346^{*}(+5)$	$-0,1677^{*}$ $0,4099^{*}(+11)$
producer real wage	0,0279 $0,2718^{*}(+6)$	$-0,0423$ $0,2381^{*}(+7)$	0,0314 $0,315^{*}(+7)$	$-0,0362$ $0,2163^{*}(+10)$

Notes: " * " indicates statistical significance at the 5% level

Findings for the consumer real wage:

- Except for the STSM cycle, the estimates of the contemporaneuos cross–correlations are statistically insignificant at the 5% level
- Low practical significance, most apparent im the case of the HP cycle
- Leads of the real wage cycles: sample cross–correlations become significant and are positive (STSM cycle: not until the 6th lead)
- Lags of the real wage cycles: almost all sample cross–correlations are statistically insignificant in the case of the HP,BK and BN cycles

Producer real wage:

- All estimated contemporaneous cross–correlations are statistically insignificant at the 5% level
- Leads of the real wage cycles: similar pattern as in the case of the consumer real wage, but the sample cross–correlations are not as high
- Lags of the real wage cycles: almost all sample cross–correlations are statistically insignificant

⇒ summing–up:

- procyclical and lagging the cycle
- the strongest reaction observed between the 6th (BN cycle) and 10th quarter (STSM cycle)

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$\Rightarrow$ summing–up:

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Figure: Data in logarithms

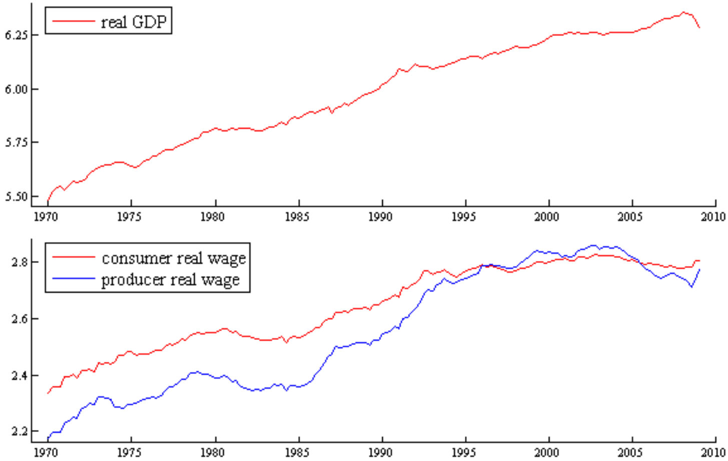
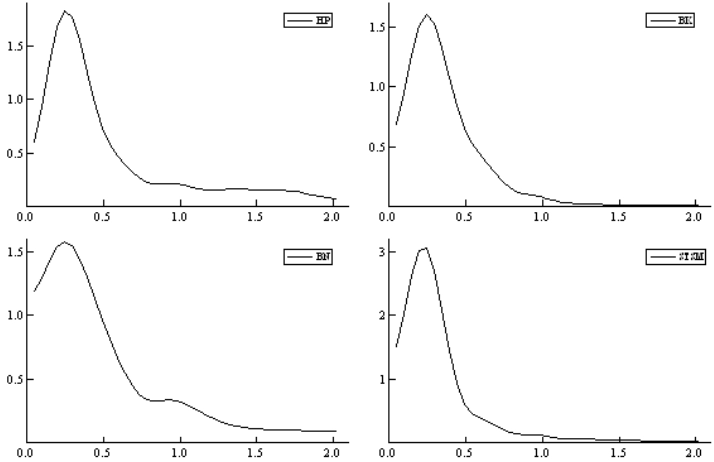
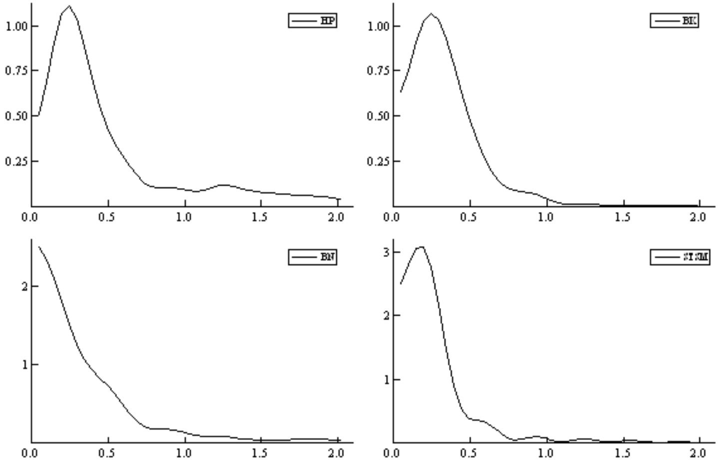


Figure: Spectra of the real GDP cycles



Notes: The horizontal axis represents frequency ω.
The values on the vertical axis have been multiplied by 10^4.

Figure: Spectra of the consumer real wage cycles



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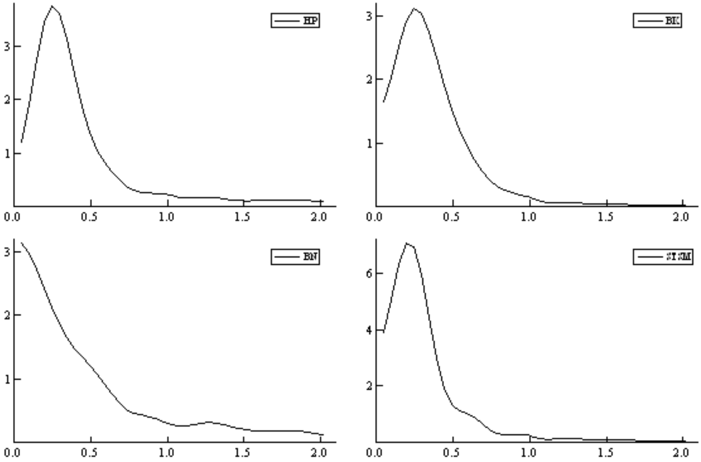

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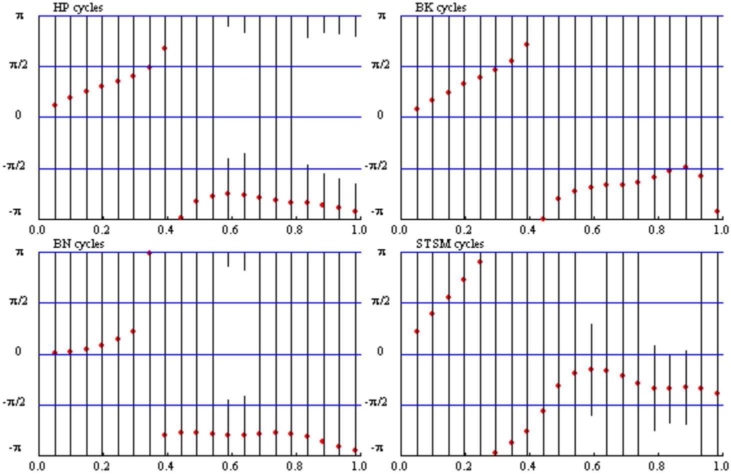
Producer real wage

Figure: Phase angle: real GDP and producer real wage cycles



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red points: point estimates, black lines: 90% confidence intervals

Modifications and new results

1. **Initial general model for the stochastic trend component** y_t^g:

$$
\begin{aligned}
y_{t+1}^g &= y_t^g + \beta_t + \eta_t, & \eta_t &\sim \mathcal{NID}(0, \sigma_\eta^2) \\
\beta_{t+1} &= \beta_t + \zeta_t, & \zeta_t &\sim \mathcal{NID}(0, \sigma_\zeta^2),
\end{aligned}
\tag{4}
$$

2. The initial specification seems to be inappropriate for the real wages
3. Low variances of the cycle components with at the same time high variances of the irregular components as an indicator of possibly omitted informations
4. Hartz reforms starting from January 1, 2003 as an event with a great impact on the German labor market
5. Initial model extended by a slope intervention variable from 2003.Q1 on to take account of the additional information

Model for the cycle y_t^c:

$$\begin{bmatrix} y_{t+1}^c \\ y_{t+1}^{c*} \end{bmatrix} = \rho \begin{bmatrix} \cos(\omega) & \sin(\omega) \\ -\sin(\omega) & \cos(\omega) \end{bmatrix} \begin{bmatrix} y_t^c \\ y_t^{c*} \end{bmatrix} + \begin{bmatrix} \chi_t \\ \chi_t^* \end{bmatrix}, \qquad \begin{bmatrix} \chi_t \\ \chi_t^* \end{bmatrix} \sim \mathcal{NID}(\mathbf{0}, \sigma_\chi^2 \mathbf{I}_2), \tag{5}$$

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Figure: Cycles of the real GDP

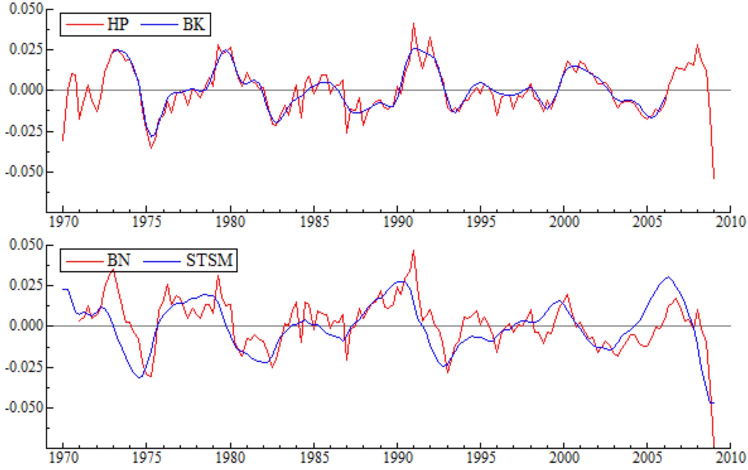

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Figure: Cycles of the consumer real wage

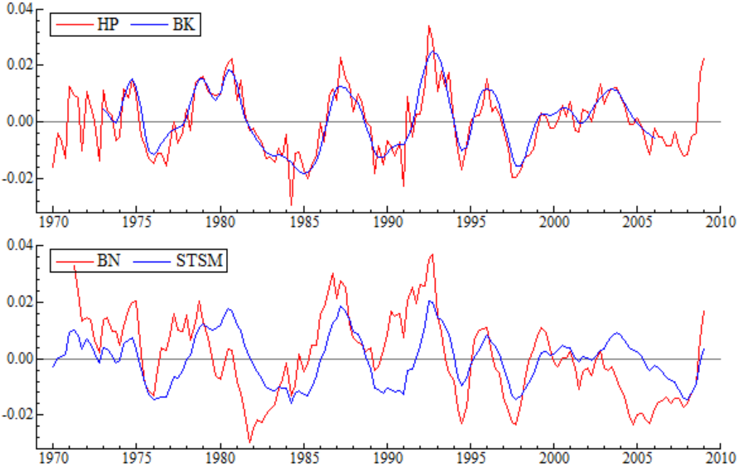

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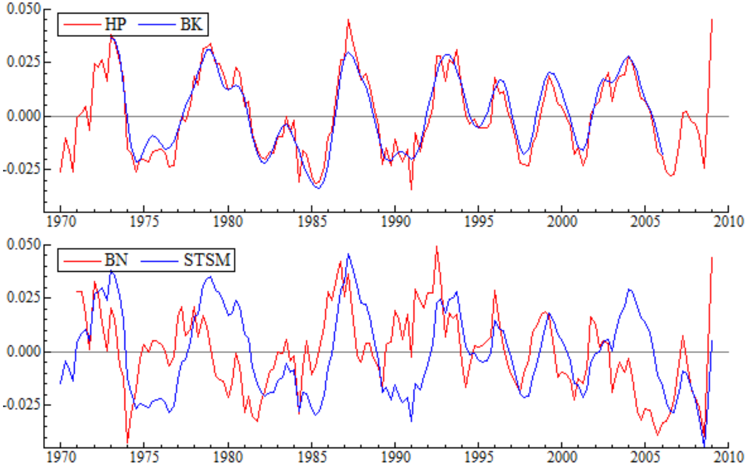
Figure: Cycles of the producer real wage



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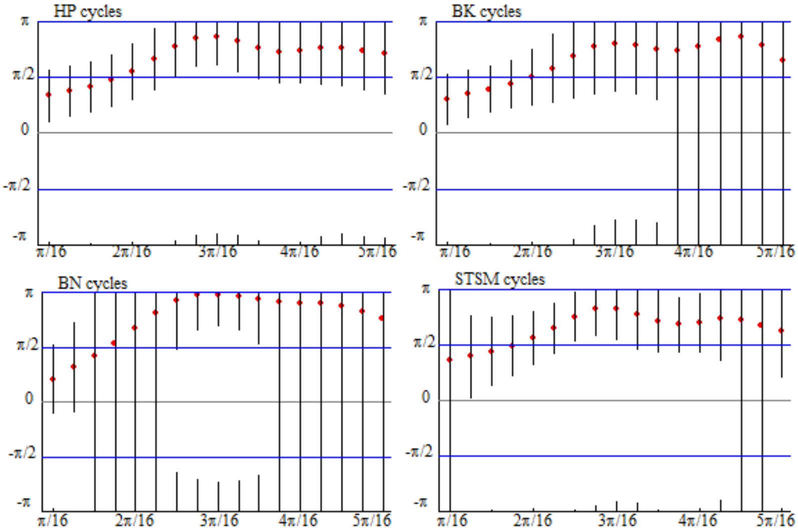
producer real wage	0.0279	-0.0423	0.0314	0.0069
	$0.2718^{*}(+6)$	$0.2381^{*}(+7)$	$0.315^{*}(+7)$	$0.1806^{*}(+11)$

Notes: " * " indicates statistical significance at the 5% level

Figure: Phase angle: real GDP and consumer real wage cycles



Notes: The horizontal axis represents the (angular) frequency ω.

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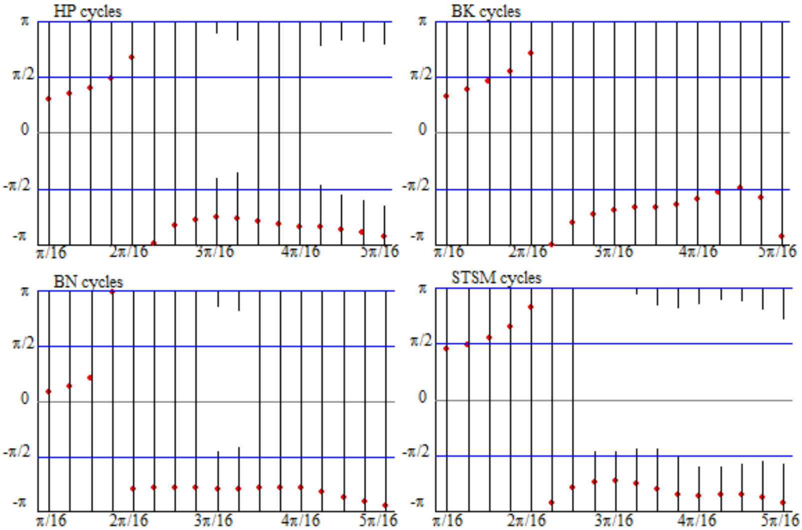

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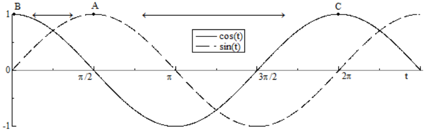
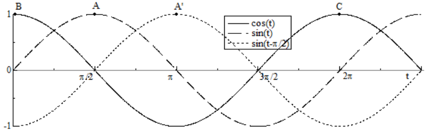
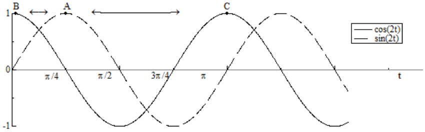
Figure: Examples of phase shifts between cyclical components



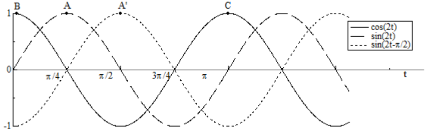
(a)



(b)



(c)



(d)