REAL WAGES AND BUSINESS CYCLE ASYMMETRIES

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Abstract

The cyclicality of real wages has important implications for the validity of competing business cycle theories. However, the empirical evidence on the aggregate level is inconclusive. Using a threshold vector autoregressive model for the US and Germany to condition the relationship between real wages and business fluctuations on the phase of the cycle, it is demonstrated that the inconclusive evidence is not only caused by measurement problems, estimation method and composition bias as discussed in the literature. In addition, one should also consider whether the economy is in an upswing or a downswing. In general, the evidence for countercyclical wages is stronger in Germany than for the US, but taken together there is no clear systematic pattern.

JEL classification: C32, E32.

Keywords: threshold vector autoregressive model, real wages, business cycle.

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1 Introduction

In their paper on the cyclicality of real wages, Abraham and Haltiwanger (1995) point out that empirical evidence on whether real wages co-move with the business cycle is inconclusive.[1] Among the potential explanations for this finding they list measurement problems like the choice of the price index, and composition bias: because there are changes in labour quality over the business cycle (low skilled employment is more sensitive to business fluctuations), aggregate wage measures are not as volatile as wage measures on the individual level. In fact, using data from the Panel Study of Income Dynamics, Solon *et al.* (1994) find that US real wages are strongly procyclical. More recently, Liu (2003) comes to a similar conclusion in a cross-country study on the US, Canada and the United Kingdom. Another explanation is that the real wage is influenced by factors which can either lead to a pro- or a countercyclical response. This has recently been examined by Fleischmann (1999), who shows in a structural VAR framework that the reaction of real wages to technology and oil price shocks is procyclical, while the response to

[1] Building on Neftci (1978), Sargent (1978) shows that postwar US employment and real wages move countercyclical. Using a wholesale price index instead of the consumer price index, Geary and Kennan (1982) find that the relationship is insignificant. Bils (1985) analyzes panel data from the National Longitudinal Survey and finds that real wages are procycical. Other studies on the aggregate level cited by Abraham and Haltiwanger (1995) are Bodkin (1969) (procyclical real wage with consumer price index, countercyclical real wage with producer price index), Otani (1978) (procyclical real wage), Chirinko (1980) (countercyclical real wage), and Sumner and Silver (1989) (countercyclical real wage before the 70s, procyclical after).

labor supply and aggregate demand shocks is countercyclical.

The cyclicality of real wages has important implications for business cycle theory, as illustrated by Table 1 from Malley *et al.* (forthcoming). The table contains stylized expected patterns from competing models of the cycle.

Table 1: Expected Pattern of Responses to Technology Schocks

Model	ϵ	Y	L	w/p
RBC	+	+	+	+
Sticky Nominal Wages	+	+	+	0
Sticky Prices	+	+	-	-

Source: Malley *et al.* (forthcoming).

Following a positive technology shock ϵ, the standard real business cycle model (e.g. Kydland and Prescott, 1982; Long and Plosser, 1983; King and Plosser, 1984) predicts a positive response of output Y, labor L, and the real wage w/p. In other words, output and real wages move together. For New Keynesian type models with wage and price rigidities (see, e.g. Goodfriend and King, 1997; Rotemberg and Woodford, 1997; Galí, 1999), the outcome is different. In a model with sticky nominal wages, real wages do not change much in response to a technology shock. For the sticky price/imperfect competition model, we would expect a negative relationship between output and the real wage.[2]

For studies on the aggregate level, the common wisdom seems to be that "*correcting for all of the measurement problems, estimation problems, and composition problems does not lead to a finding of systematically procyclical or countercyclical real wages.*" (Abraham and Haltiwanger, 1995, p.1262). However, one can show that using frequency domain techniques instead of calculating correlation coefficients,[3] and focussing the analysis on business cycle frequencies, real wages in the US are strongly procyclical (Hart *et al.*, 2002). The approach adopted in this paper is different: if we accept the possibility that the real wage is influenced by factors which can either lead to a pro- or a countercyclical response, we can also expect different dynamics dependent on the phase of the business cycle, leading to an asymmetric relationship between the real wage and the cycle measure.

It is a well known fact that business cycles are asymmetric. In the US, the average business cycle length after 1960 is about 75 months. An upswing takes on average 64 months, while the average downswing of the cycle is much shorter (11 months).[4] This difference between expansion and contraction

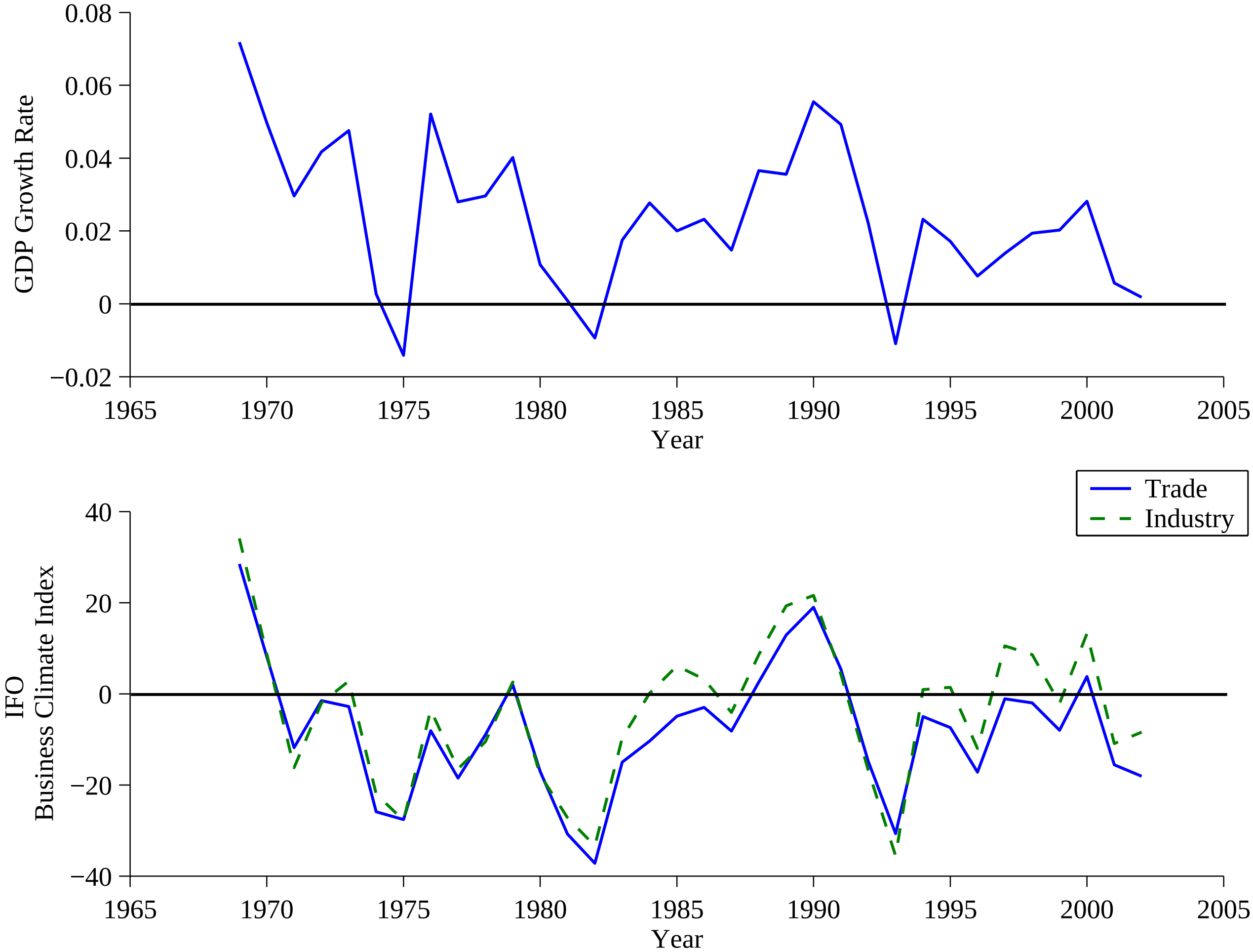
[2]Analyzing data from the NBER-CES/Census manufacturing industry productivity database, Malley *et al.* (forthcoming) find more support for RBC type models, implying a positive relationship between output and the real wage.

[3]The result in Abraham and Haltiwanger (1995) is based on correlation coefficients between real wages in manufacturing and employment/output, for different filtering techniques and quarterly and annual frequencies.

[4]See the US Business Cycle Expansions and Contractions (NBER) at http://www.nber.org/cycles.html/.

phases can also be seen when looking at business cycle measures for Germany (Figure 1).

Figure 1: The German Business Cycle, 1969-2002



Notes:
Sources: (1) GDP (West Germany), 1969-2002, GGDC Total Economy Database, University of Groningen (http://www.eco.rug.nl/ggdc), in 1999 US dollars. (2) ifo business climate index, 1969-2002, Trade: wholesale and retail, Industry: manufacturing and construction. The index is based on a monthly survey of about 7000 enterprises on their assessment of the business climate (http://www.ifo.de, see also Section 2 for further details).

As pointed out by Koop and Potter (1999), the number of macroeconometric studies allowing for non-linearities is relatively low.[5] They explain the reluctance to use these techniques with the perceived weakness of the statistical evidence, the potential danger of data mining, and the lack of economic significance.[6] However, phenomena like the downward rigidity of nominal wages make it reasonable to suspect asymmetries in the relationship between the real wage and the cycle.

The approach adopted here is to estimate a threshold vector autoregressive model (TVAR), conditional on the phase of the business cycle,[7] using a grid-search based estimation strategy proposed by Tong (1990, p. 378-387). For each of the two subsamples, one obtains a VAR for which the implied cross correlation coefficients are calculated. The two data sets under analysis are for the US and for Germany, to compare two economies with very different labor market characteristics. The paper is structured as follows: Section 2 describes the data set, the methodology is explained in detail in Section 3, Section 4 discusses the results, and Section 5 conludes.

[5]As examples, Koop and Potter (1999) cite the Markov-switching model proposed by Hamilton (1989), and the studies by Beaudry and Koop (1993) and Pesaran and Potter (1997). Othe examples are DeLong and Summers (1986), Potter (1995), and Rothman (1991).

[6]Another reason is certainly the fact that macroeconomic time series are notoriously short.

[7]For a similar approach to study the dynamics of output and unemployment in the US see Altissimo and Violante (2001).

2 Data

To calculate correlations between the business cycle and the real wage, we need to find appropriate measures for both. As pointed out by Abraham and Haltiwanger (1995), differences in measurement potentially lead to different results with respect to real wage cyclicaltity. Therefore, given data availability, alternative measures are tried to check robustness. In the case of the US, both manufacturing output and employment are analyzed as cycle measures, in the case of Germany (West), the business cycle is also measured by the Ifo business climate index (see below).

The US data on wages and prices are monthly data from the Bureau of Labor Statistics, the observation period is 1956:01-1997:12.[8] Average hourly earnings A and average hourly earnings excluding overtime W are deflated using either the producer (PPI) or the consumer price index (CPI). These real wage measures are compared with cycles in employment and an index for manufacturing output (source: http://www.nber.org).

The Ifo business climate index is based on a monthly survey of about 7000 enterprises on their assessment of the business climate. Both the assessment of the current climate as well as the expectations for the next six

[8]Production workers in natural resources and mining and manufacturing, construction workers in construction, and nonsupervisory workers in the service-providing industries (source: http://www.bls.gov).

months are collected. The answers are converted to a seasonally adjusted index (base year: 1991), which can fluctuate between -100 (all firms are pessimistic) and +100 (all firms are optimistic). Both the current climate index ($IFO1$) and the expectations index ($IFO2$) are analyzed, in addition to the aggregate business climate index, which the Ifo institute calculates as a geometric average of the of the current and the expectations index ($IFO3$). The observation period is 1986:01-2003:07 (monthly data).[9]

To compare the results across different cycle measures, manufacturing output (Y) is also analyzed. The data are from the Bundesbank data base (1950:01-1998:02: CDRom Deutsche Bundesbank - 50 Jahre Deutsche Mark. Monetäre Statistiken 1948-1997. 1991.01-2002.12: Bundesbank Time Series Data Base (http://www.bundesbank.de), series UX01NA). The wage measures are gross earnings in manufacturing and mining per employee (W_1) and per hour (W_2) (Observation period: 1991:01-2002:12, source: Bundesbank Time Series Data Base (http://www.bundesbank.de), series US07RB, US08RB) To deflate gross earnings, the consumer price index (CPI) is used (1950:01-1998:02: CDRom Deutsche Bundesbank - 50 Jahre Deutsche Mark. Monetäre Statistiken 1948-1997.1991.01-2002.12: Bundesbank Time Series Data Base (http://www.bundesbank.de), series UUFA01.)

Since the observation period is rather short, the robustness of the re-

[9]I am grateful to the Ifo Institute for providing me with the data.

sults for West Germany is checked by analyzing a second data set (quarterly data).[10] The observation period is 1964:01-1996:04, the data are manufacturing output (Y), employment (N), an index of hourly earnings in manufacturing (W, 1985=100), and the consumer price index (CPI, 1991=100, source: OECD Statistical Compendium, 2003-1, Main Economic Indicators. The employment data are from the CDRom Deutsche Bundesbank - 50 Jahre Deutsche Mark. Monetäre Statistiken 1948-1997).

3 Method

The results in Section 4 are based on a Threshold VAR (TVAR) model for the business cycle measure (percentage changes in output Y, employment N, or business cycle index IFO) and the percentage change in the real wage RW:

$$\mathbf{X_t} = \begin{pmatrix} Y_t \\ \\ RW_t \end{pmatrix} = \begin{cases} \mathbf{c}_1 + \sum_{j=1}^{p_1} \mathbf{A}_j \mathbf{X}_{t-j} + \boldsymbol{\epsilon}_t & \text{if } X_{1,t-d} \leq 0; \\ \\ \mathbf{c}_2 + \sum_{j=1}^{p_2} \mathbf{B}_j \mathbf{X}_{t-j} + \boldsymbol{\eta}_t & \text{else} \end{cases} . \qquad (1)$$

Whenever the growth rate representing the cycle at time $t - d$ is less than or equal to zero, the economy is deemed to be in a recession, and the first

[10]Note that the second data set does not cover more observations. However, since the time span is longer (1964-1996), it covers more realisations of the business cycle.

model is active. In the case the growth rate is positive, the second model describes the dynamic interaction between cycle and real wage. Note that d is set to zero because of the small sample size for West Germany.

The TVAR model in equation (1) is estimated adopting the strategy set out in Tong (1990, p. 378-387). For a fixed threshold lag d and fixed VAR orders p_1 and p_2, the parameter matrices

$$\mathbf{A} = \begin{pmatrix} \mathbf{c}_1 & \mathbf{A}_1 & \dots & \mathbf{A}_{p_1} \end{pmatrix}, \mathbf{B} = \begin{pmatrix} \mathbf{c}_1 & \mathbf{B}_1 & \dots & \mathbf{B}_{p_2} \end{pmatrix}$$

and the error variance-covariance matrices $\hat{\mathbf{\Sigma}}_1$ and $\hat{\mathbf{\Sigma}}_2$ are estimated using least squares. The VAR orders are determined by minimizing the Akaike information criterion (AIC), given d:[11]

$$AIC_{j,d} = N_j \ln |\tilde{\mathbf{\Sigma}}_j| + 2n(p_j + 1), j = 1, 2,$$

where n is the row dimension of $\mathbf{X}_t$, and N_j is the effective sample size. The matrix $\tilde{\mathbf{\Sigma}}_j$ is the LS estimator with degrees of freedom adjustment

[11]For the US data, the maximum lag is set to 10. Due to the small size of the West german sample, the maximum lag is set to 5, both for the quarterly and the monthly frequency.

(Lütkepohl, 1991, p. 128)

$$\tilde{\mathbf{\Sigma}}_j = \frac{N_j - p_j n - 1}{N_j} \hat{\mathbf{\Sigma}}$$

Let

$$NAIC_d = \frac{(AIC_{1,d} + AIC_{2,d})}{N_1 + N_2}$$

denote the average of the two minimum AIC values obtained for a given d. Minimizing $NAIC_d$ w.r.t. d gives the minimum AIC estimates for the TVAR. Because the purpose of this exercise is to examine differences in the cross-correlations dependent on the phase of the business cycle, the parameter space is restricted to stationary solutions. To ensure that the estimated system is stationary, we calculate the roots of the characteristic polynomial $|\mathbf{F}_j - \lambda \mathbf{I}| = 0$, where $\mathbf{F}_j$ is the companion matrix of the parameter matrices of the two models, and check whether the moduli are inside the unit circle (Lütkepohl, 1991, p. 9-13).

Once the representative model is found, the cross corellation matrices can be obtained from the covariance matrices $\mathbf{\Gamma}(\tau)$ calculated using the Yule-

Walker equations

$$\mathbf{\Gamma}(0) = \sum_{j=1}^{p_1} \mathbf{A}_j \mathbf{\Gamma}(-j) + \mathbf{\Sigma}_1;$$
$$\mathbf{\Gamma}(0) = \sum_{j=1}^{p_2} \mathbf{B}_j \mathbf{\Gamma}(-j) + \mathbf{\Sigma}_2;$$

and for $\tau > 0$,

$$\mathbf{\Gamma}(\tau) = \sum_{j=1}^{p_1} \mathbf{A}_j \mathbf{\Gamma}(\tau - j);$$
$$\mathbf{\Gamma}(\tau) = \sum_{j=1}^{p_2} \mathbf{B}_j \mathbf{\Gamma}(\tau - j).$$

The first p_j covariance matrices needed as starting values for the recursion are derived from the VAR(1) representation of the two models(Lütkepohl, 1991, p. 23-25). As Tong (1990, Theorem 5.7 and 5.8) points out, approximate standard errors can be obtained from standard regression theory, conditional on the threshold lag d and the VAR orders p_1 and p_2. Significance of the cross-correlations is established by calculating standard errors from a parametric bootstrap of the two models (2000 replications).

4 Results

The correlation coefficents implied by the models fitted to the three data sets are displayed in Tables 2 and 3. More detailed estimation results can be found in Table 4. This table contains the two VAR orders p_1 and p_2, as well as the effective sample sizes N_1 and N_2. The maximum absolute eigenvalues and the maximum period length calculated from the roots of the characteristic polynomial help to judge differences in the dynamics during different phases of the business cycle. For example, when using output as measure for the cycle in the US case, the average maximum cycle length during an upswing is estimated as 67.8 months, while it is 26.3 months during a downswing. Especially the result for the downswing is very close to the business cycle duration in the US. As discussed above, the NBER calculates an average duration of the contraction phase of 11 months for the period after 1960. This is almost exactly half the cycle length estimated for the downswing. With German monthly output data, the average maximum cycle length in an upswing is 68.9 months, and 23 months in a downswing, which is very close to the outcome for the US. Using the monthly Ifo indices as cycle measure results in shorter cycles (33.1 months in an upswing, 20 months in a downswing). In the case of the US, the maximum absolute eigenvalues do not depend on the phase of the business cycle. On average, they are 0.95

in an uspwing and 0.97 in a downswing. For the German monthly output series, the averages are lower, but also very close (0.88 in an upswing and 0.86 in a downswing). Using the Ifo indices produces different results: one obtains an average of 0.94 in an upswing and 0.85 in a downswing.

Turning to the correlations, the first striking difference between real wage cyclicality in Germany and the US is that for Germany, there is much less evidence of asymmetric correlations. In the US, both average hourly earnings and average hourly earnings excluding overtime show procyclical behavior in an upswing if output is used as a measure for the cycle, and if the nominal wage is deflated using the CPI. With PPI as deflator, real wages fluctuate countercyclically during a downswing. With employment as cycle measure, there is some evidence of weak procyclical fluctuations when looking at average hourly earnings. With the exception of average hourly earnings excluding overtime deflated with PPI, which are countercyclical during a downswing, all the other results point towards acyclical fluctuations.

Given the stylized model predictions from Table 1, one can conclude that the relationship between business cycles and real wages in the US are best characterized by models with sticky nominal wages, while there is also some evidence of RBC type fluctuations.[12] A sticky price model which predicts a countercyclical relationship fits only for wages excluding overtime deflated

[12]This is in line with the results reported in Malley *et al.* (forthcoming).

with PPI during a contraction of the economy.

Table 2: Correlation between Real Wage and Business Cycle Measures (USA)

	Y		N	
	Upswing	Downswing	Upswing	Downswing
A/CPI	0.52	0.14	0.23	0.28
	(0.08)	(0.08)	(0.10)	(0.10)
A/PPI	0.20	−0.47	−0.04	−0.06
	(0.11)	(0.11)	(0.12)	(0.11)
W/CPI	0.34	−0.06	0.08	−0.16
	(0.10)	(0.08)	(0.13)	(0.08)
W/PPI	0.08	−0.65	−0.15	−0.35
	(0.13)	(0.12)	(0.13)	(0.09)

Notes:
A: average hourly earnings, W: average hourly earnings excluding overtime, CPI: consumer price index, PPI: producer price index, Y: output, N: employment.
The figures in brackets are bootstrap standard errors.

With the results for West Germany, the case for a countercyclical relationship is much stronger: 50 per cent of the real wage / cycle measure pairs show a negative correlation. In two cases, there is a significant positive correlation, but just during a contraction. Based on these results on can conclude that Germany is better characterized by New Keynesian type models than the US. This conclusion is obviously in line with the institutional differences between the two labor markets.

Table 3: Correlation between Real Wage and Business Cycle Measures (West Germany)

quarterly data	Y		N	
	Upswing	Downswing	Upswing	Downswing
E_1/CPI	0.20	−0.38	0.07	−0.17
	(0.16)	(0.10)	(0.19)	(0.10)
monthly data	$E2/CPI$		$E3/CPI$	
	Upswing	Downswing	Upswing	Downswing
Y	−0.01	0.41	−0.31	−0.02
	(0.12)	(0.07)	(0.13)	(0.09)
$IFO1$	−0.40	0.07	−0.79	−0.37
	(0.11)	(0.11)	(0.08)	(0.10)
$IFO2$	−0.18	0.46	−0.68	−0.19
	(0.13)	(0.11)	(0.12)	(0.13)
$IFO3$	−0.35	−0.24	−0.50	−0.29
	(0.12)	(0.12)	(0.12)	(0.11)

Notes: Y: output; $IFO1$: current climate index, $IFO2$: expectations index; $IFO3$: composite index; CPI: consumer price index; E_1: hourly earnings (quarterly data); E_2: earnings per employee (monthly data); E_2: earnings per hour (monthly data).
The figures in brackets are bootstrap standard errors.

5 Conclusions

The paper analyzes the cyclicality between real wages and the business cycle by looking at data sets for the US and for Germany. Using a threshold vector autoregressive model to calculate correlation coefficients dependent on the phase of the cycle, it is demonstrated that the result does not only depend on measurement problems, estimation method and composition bias, but also on whether the economy is in an upswing or a downswing: if there is asymmetry in the relationship between the real wage and the cycle, significant correlations might cancel out if calculated without conditioning on the phase of the cycle. In general, the evidence for countercyclical real wages is stronger for Germany than for the US, but taken together, there is no systematic pattern.

An interesting extension would be to look not just for differences in the cyclicality of the real wage conditional on the phase of the business cycle, but to see whether there are changes over time. It is striking that studies with observation periods up to the 70s find countercyclical results (e.g. Sargent, 1978; Neftci, 1978), while more recent work concludes that the evidence for procyclical real wages is much stronger. Identifying the transition from one regime to the other and comparing it across countries could help in further understanding the interaction between the real wage and the business cycle.

Appendix

Table 4: Estimation Results, USA and West Germany

Business Cycle	Real Wage	p_1	p_2	$\|\lambda_1\|$	$\|\lambda_2\|$	P_1	P_2	N_1	N_2
USA, monthly data									
Y	A/CPI	10	7	0.93	0.89	67.23	20.75	460	59
	A/PPI	10	9	0.93	0.98	65.59	30.47	460	47
	W/CPI	10	7	0.93	0.91	71.92	21.78	460	59
	W/PPI	10	9	0.94	0.99	66.43	32.13	460	47
N	A/CPI	10	10	0.97	0.99	68.88	31.63	387	115
	A/PPI	10	8	0.97	0.99	73.94	61.69	387	131
	W/CPI	10	10	0.96	0.99	71.87	36.15	387	115
	W/PPI	10	8	0.98	0.99	75.48	71.75	387	131
Germany, quarterly data									
Y	E_1/CPI	3	3	0.89	0.73	14.27	23.15	137	18
N	E_1/CPI	3	3	0.84	0.92	24.63	10.48	111	44
Germany, monthly data									
Y	E_2/CPI	3	3	0.88	0.85	3.06	20.86	106	29
	E_3/CPI	3	3	0.87	0.87	134.82	25.20	106	29
$IFO1$	E_2/CPI	5	3	0.93	0.89	37.91	18.28	84	59
	E_3/CPI	5	3	0.94	0.89	36.75	16.88	84	59
$IFO2$	E_2/CPI	5	3	0.98	0.89	34.45	27.11	76	67
	E_3/CPI	5	3	0.99	0.88	34.43	27.51	76	67
$IFO3$	E_2/CPI	5	2	0.89	0.77	26.23	16.07	87	61
	E_3/CPI	5	3	0.92	0.79	28.93	13.90	87	57

Notes:
Y: output; N: employment; $IFO1$: current climate index, $IFO2$: expectations index; $IFO3$: composite index.
CPI: consumer price index, PPI: producer price index.
A: average hourly earnings (USA), W: average hourly earnings excluding overtime (USA); E_1: hourly earnings (West Germany, quarterly data); E_2: earnings per employee (West Germany, monthly data); E_2: earnings per hour (West Germany, monthly data).
p_1, p_2: VAR orders; $|\lambda_1|, |\lambda_2|$ maximum absolute eigenvalue; P_1, P_2: maximum period length; N_1, N_2: effective sample sizes.

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