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Determinants of Business Cycles in Small Scale Macroeconomic Models: The German Case

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Abstract

We identify measures of shocks to total factor productivity and preferences from two real business cycle models and subject them to Granger causality tests to see whether they can be considered exogenous to other plausible sources of the German business cycle. For West German data from 1960.i to 1989.iv we conclude that our measures of shocks are indeed exogenous. This contrasts with similar studies for other countries that question the exogeneity of either productivity or preference shocks. For the period 70.i to 01.iv we find that M3 Granger causes all of our shock measures. We attribute this to the breaks in our time series associated with the German reunification in 1990 and the European Monetary Union in 1999.

Keywords Real Business Cycles, Solow Residual, Granger Causality

JEL Classification E32, O47

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^dWe gratefully acknowledge the comments of two anonymous referees. All remaining errors are ours.

Appendix

Figure A.1: Time Path of Hours 1960-1989

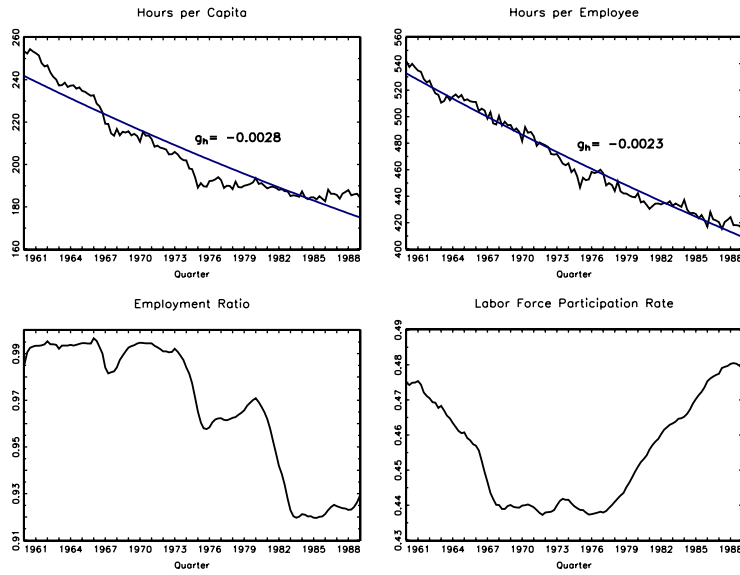


Figure A.2: Time Path of Hours 1976-1989

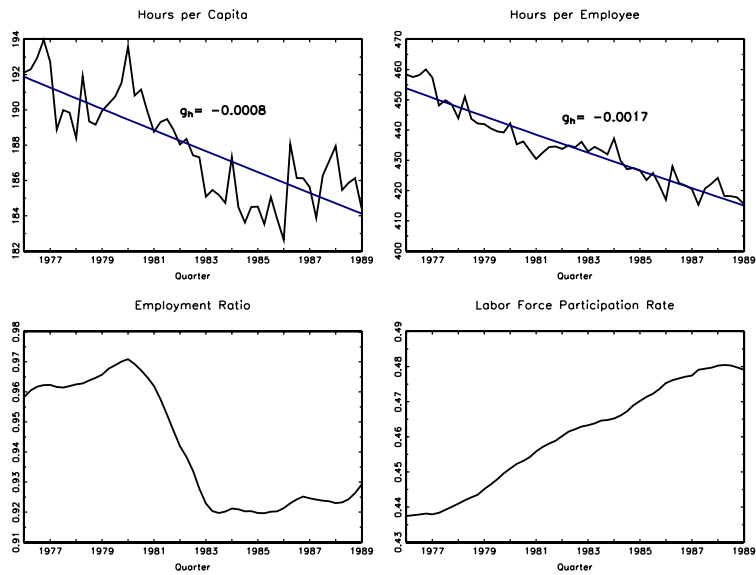


Figure A.3: Time Path of Hours 1971-2001

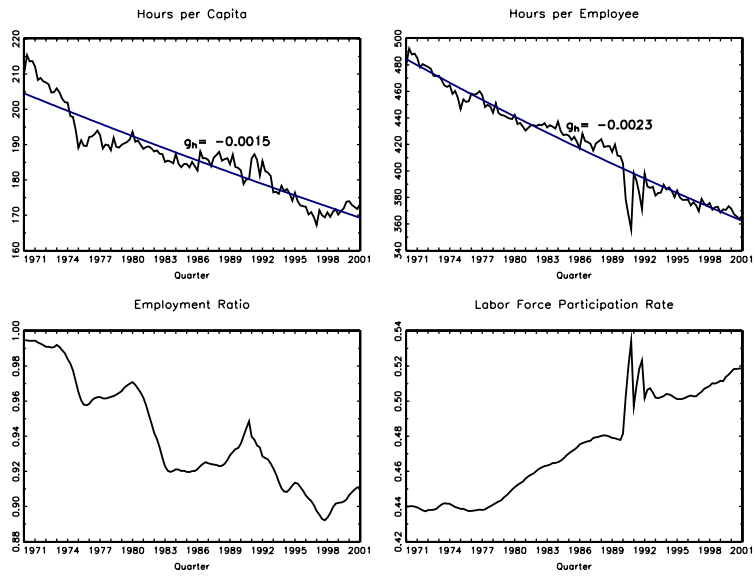


Figure A.4: Time Paths of Test Variables

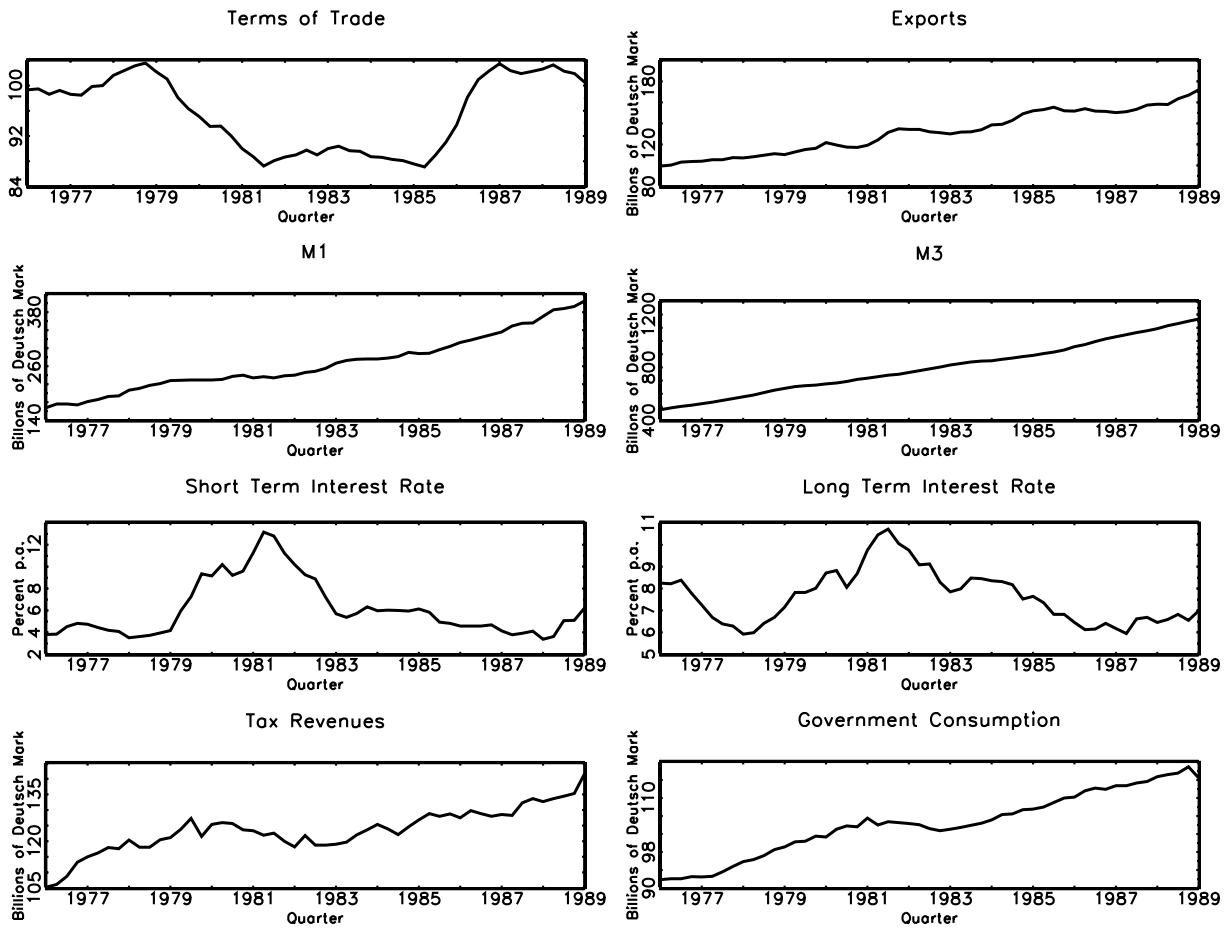


Table A.1:
Second Moments of Simulated Time Series

Variable	Empirical Time Series			Model One			Model Two		
	s_x	r_x	r_{xy}	s_x	r_x	r_{xy}	s_x	r_x	r_{xy}
Output	1.12	0.80	1.00	1.52	0.36	1.00	2.03	0.48	1.00
Consumption	1.25	0.85	0.82	1.01	0.22	0.88	1.02	0.23	0.88
Investment	2.71	0.80	0.80	4.97	0.48	0.97	8.18	0.57	0.98
Hours	0.77	0.31	0.37	1.70	0.64	0.81	1.92	0.60	0.88
Real Wage	1.24	0.91	0.47	0.99	0.17	0.14	1.08	0.11	0.37
Real Interest Rate	0.37	0.43	-0.11	1.65	0.64	0.72	1.52	0.63	0.05

Notes: s_x :=Standard deviation of HP-filtered time series of variable x , r_x :=first-order autocorrelation of variable x , r_{xy} :=cross-correlation of variable x with output.

The moments of the simulated series are averages over 500 simulations with 55 observations each.

The simulations use the parameters displayed in column two of Table ??, $\eta = 1.5$ and the estimated standard deviation of the growth rate of the productivity shock, $\sigma_\epsilon = 0.01006$ ($\sigma_\epsilon = 0.01027$ for model two) as well as the estimated parameters from AR(1)-processes fitted to the logarithmic deviation of the preference shock and the oil-price shock from its respective means, $\rho_\theta = 0.93$, $\sigma_\theta = 0.00996$ ($\rho_\theta = 0.86$, $\sigma_\theta = 0.00901$ for model two), $\rho_p = 0.95$, $\sigma_p = 0.14497$.

Table A.2:
Unit Root Tests 76.i-89.iv

Variable	Levels			First Differences	
	ADF	PP	KPSS	ADF	PP
Productivity Shock (1)	-1.449	-1.817	0.118	-2.958**	-8.680***
Productivity Shock (2)	-3.676**	-2.522	0.105	-3.886***	-7.376***
Preference Shock (1)	-2.012	-2.601	0.613**	-10.092***	-9.906***
Preference Shock (2)	-1.992	-2.445	0.268	-3.318**	-9.648***
Government Expenditures	-2.602	-1.518	0.097	-3.530**	-7.560***
Taxes	-2.322	-2.569	0.109	-7.769***	-7.757***
M1	-1.793	-2.149	0.109	-7.082***	-7.124***
M3	-2.424	-2.826	0.147**	-2.806*	-3.939***
Short-Term Interest Rate	-1.934	-1.847	0.136	-4.423***	-4.496***
Long-Term Interest Rate	-1.322	-1.821	0.201	-5.140***	-5.154***
Exports	-3.255*	-2.535	0.062	-5.977***	-5.847***
Terms of Trade	-0.776	-1.356	0.173**	-1.963	-3.373**
Oil Price	-1.812	-1.394	0.190	-4.752***	-4.525***

Notes:

ADF: The augmented Dickey-Fuller t-statistic. The estimated model is

$$\Delta x_t = m + bt + rx_{t-1} + \sum_{i=1}^q a_i \Delta x_{t-i} + \epsilon_t \quad (i)$$

and the true process is

$$\Delta x_t = \mu + \sum_{i=1}^q \alpha_i \Delta x_{t-i} + \epsilon_t, \quad (ii)$$

where x_t refers to log of the variable in column 1, except in the case of interest rates. q in equation (i) was chosen to minimize the Schwarz information criterium over $p = 1, 2, \dots, \bar{p}$, $\bar{p} = [12(T/100)^{1/4}]$, where $[z]$ denotes the integer part of z and T denotes the sample size, respectively (see Hayashi, 2000, p. 594 on this choice of \bar{p}). The test statistic is the t-statistic of the estimated r . Critical values are from MacKinnon (1991).

PP: Phillips-Peron Z_t statistic with lag truncation parameter equal to 7. The estimated model and the true process are as in (i) and (ii). The critical values are the same as those of the ADF-t statistic.

KPSS: Kwiatkowski-Phillips-Schmidt-Shin statistic of the null of stationarity. The bandwidth parameter was set to 7, critical values are taken from Kwiatkowski et al. (1992), Table 1.

The ADF-t and PP tests for the first differences of the variables in column 1 estimate the model (i) without the time trend bt and assume (ii) without the drift term μ .

*, **, or *** denote rejection of the null at the 10%, 5%, or 1% level.

Table A.3:
Unit Root Tests 60.i-89.iv

Variable	Levels			First Differences	
	ADF	PP	KPSS	ADF	PP
Productivity Shock (1)	-1.011	-1.230	0.381 ^{***}	-3.730 ^{***}	-10.838 ^{***}
Productivity Shock (2)	0.016	-0.427	0.381 ^{***}	-5.823 ^{***}	-10.258 ^{***}
Preference Shock (1)	-1.911	-1.973	1.459 ^{***}	-4.342 ^{***}	-13.081 ^{***}
Preference Shock (2)	-2.803	-2.775	1.106 ^{***}	-4.950 ^{***}	-12.763 ^{***}
Government Expenditures	-0.682	-0.682	0.374 ^{***}	-9.745 ^{***}	-10.149 ^{***}
Taxes	-2.742	-2.699	0.347 ^{**}	-13.117 ^{***}	-13.049 ^{***}
M1	-2.103	-2.232	0.196 ^{**}	-4.566 ^{***}	-13.242 ^{***}
M3	0.463	0.297	0.388 ^{***}	-1.831	-4.924 ^{***}
Short-Term Interest Rate	-4.335 ^{***}	-2.911	0.211	-4.986 ^{***}	-7.646 ^{***}
Long-Term Interest Rate	-2.506	-2.261	0.326	-7.311 ^{***}	-7.226 ^{***}
Exports	-0.510	-1.396	0.372 ^{***}	-2.404	-12.089 ^{***}
Terms of Trade	-1.914	-1.869	0.202 ^{**}	-3.354 ^{**}	-8.047 ^{***}
Oil Price	-1.874	-1.572	1.243 ^{***}	-7.729 ^{***}	-7.475 ^{***}

Notes: See Table A.2

Table A.4:
Unit Root Tests 70.i-01.iv

Variable	t-Statistic	Variable	t-Statistic
Productivity Shock (1)	-2.552	Productivity Shock (M2)	-2.522
Preference Shock (1)	-2.131	Preference Shock (M2)	-1.999
Government Expenditures	-2.847	Taxes	-3.352
M1	-2.785	M3	-2.456
Short-Term Interest Rate	-3.478*	Long Term Interest Rate	-2.988
Exports	-2.151	Terms of Trade	-2.589
Oil Price	-2.650		

Notes:

a) The estimated model is

$$\tilde{x}_t = r\tilde{x}_{t-1} + \sum_{i=1}^q a_i \Delta \tilde{x}_{t-i} + \epsilon_t, \quad (i)$$

where \tilde{x}_t is the OLS-residual from the regression

$$x_t = c + \delta d_t + \beta t + \eta_t.$$

The dummy variable d_t is zero for quarters 70.i through 90.iv and one for the remaining quarters. Columns 2 and 3 report the t-statistic of $H_0 : r = 1$. For our sample size and choice of the breakpoint the 10%, 5%, and 1% critical values are -3.46,-3.76, and -4.32, respectively (see, Perron (1989), Table IV.B).

b) *, **, or *** denote rejection of the null at the 10%, 5%, or 1% level.

Table A.5:
Cointegration Tests 60.i-89.iv

Variable	Model One Shock Measures							
	Productivity				Preferences			
	AIC		HQ		AIC		HQ	
	q	r_1, r_2	q	r_1, r_2	q	r_1, r_2	q	r_1, r_2
Government Expenditures	7	1,1	5	1,1	5	2,0	1	1,1
Taxes	6	1,1	1	2,2	4	0,0	1	0,0
M1	6	0,0	6	0,0	7	0,0	6	0,0
M3	6	0,0	6	0,0	8	2,2	6	2,0
Short-Term Interest Rate	6	0,0	5	2,0	5	1,1	5	1,1
Long-Term Interest Rate	6	0,0	5	0,0	4	0,0	2	1,0
Exports	6	0,0	6	0,0	6	1,0	5	0,0
Terms of Trade	6	0,0	6	0,0	6	0,0	6	0,0
Oil Price	5	1,1	2	1,1	4	0,0	2	0,0

Variable	Model Two Shock Measures							
	Productivity				Preferences			
	AIC		HQ		AIC		HQ	
	q	r_1, r_2	q	r_1, r_2	q	r_1, r_2	q	r_1, r_2
Government Expenditures	8	2,2	1	2,2	5	2,0	1	1,0
Taxes	5	1,1	1	2,2	4	0,0	4	0,0
M1	6	0,0	6	0,0	6	1,1	6	1,1
M3	6	0,0	6	0,0	6	2,0	6	2,0
Short-Term Interest Rate	5	2,0	5	2,0	5	1,1	5	1,1
Long-Term Interest Rate	6	2,0	2	0,0	4	0,0	4	0,0
Exports	5	0,0	5	0,0	6	1,0	5	0,0
Terms of Trade	6	0,0	6	0,0	6	0,0	6	0,0

Notes:

AIC and HQ refer to the Akaike and the Hannan-Quinn information criterion, respectively. q is the number of lags in the estimated model selected by AIC or HQ. r_1 (r_2) indicates the cointegrating rank according to the Johansen trace (maximum Eigenvalue) test.

Table A.6:
Cointegration Tests 76.i-89.iv

Variable	Model One Shock Measures							
	Productivity				Preferences			
	AIC		HQ		AIC		HQ	
	q	r_1, r_2	q	r_1, r_2	q	r_1, r_2	q	r_1, r_2
Government Expenditures	8	0,0	1	0,0	5	0,0	5	0,0
Taxes	8	0,0	5	0,0	4	0,0	1	0,0
M1	8	1,1	1	0,0	4	0,0	1	0,0
M3	8	1,1	5	0,0	5	0,0	5	0,0
Short-Term Interest Rate	5	0,0	5	0,0	2	0,0	2	0,0
Long-Term Interest Rate	5	0,0	1	0,0	3	0,0	1	0,0
Exports	5	0,0	5	0,0	8	0,0	2	0,0
Terms of Trade	6	0,0	6	0,0	6	0,0	5	0,0
Oil Price	5	0,0	2	0,0	4	0,0	2	0,0

Variable	Model Two Shock Measures							
	Productivity				Preferences			
	AIC		HQ		AIC		HQ	
	q	r_1, r_2	q	r_1, r_2	q	r_1, r_2	q	r_1, r_2
Government Expenditures	1	0,0	1	0,0	8	1,1	5	0,0
Taxes	5	0,0	1	0,0	4	0,0	1	0,0
M1	1	0,1	1	0,1	4	0,0	1	0,0
M3	8	1,1	8	1,1	5	0,0	5	0,0
Short-Term Interest Rate	5	0,0	5	0,0	2	0,0	2	0,0
Long-Term Interest Rate	1	0,0	1	0,0	3	2,0	1	0,0
Exports	5	0,0	1	0,0	8	0,0	2	0,0
Terms of Trade	6	0,0	6	0,0	6	0,0	5	1,1

Notes: See Table A.5.

Table A.7:
Cointegration Tests 70.i-01.iv

Variable	Model One Shock Measures							
	Productivity				Preferences			
	AIC		HQ		AIC		HQ	
	q	r_1, r_2	q	r_1, r_2	q	r_1, r_2	q	r_1, r_2
Government Expenditures	7	1,1	4	1,1	5	1,1	1	1,1
Taxes	2	1,1	2	1,1	8	1,1	1	1,1
M1	6	1,1	3	1,1	4	0,0	4	0,0
M3	6	1,1	3	2,2	4	0,0	4	0,0
Short-Term Interest Rate	2	1,1	2	1,1	5	1,1	2	1,1
Long-Term Interest Rate	2	1,1	2	1,1	4	1,0	2	1,1
Exports	5	0,0	5	0,0	5	0,0	5	0,0
Terms of Trade	6	1,1	2	0,0	6	0,0	6	0,0
Oil Price	6	0,0	2	0,0	6	0,0	5	0,0

Variable	Model Two Shock Measures							
	Productivity				Preferences			
	AIC		HQ		AIC		HQ	
	q	r_1, r_2	q	r_1, r_2	q	r_1, r_2	q	r_1, r_2
Government Expenditures	5	1,1	4	1,1	7	1,1	2	2,0
Taxes	6	1,1	2	1,1	8	2,2	1	2,0
M1	3	1,1	3	1,1	4	0,0	4	0,0
M3	3	1,1	3	1,1	4	1,1	4	1,1
Short-Term Interest Rate	2	1,1	2	1,1	2	1,1	2	1,1
Long-Term Interest Rate	2	1,1	2	1,1	4	1,1	2	1,1
Exports	5	1,1	5	1,1	5	0,1	5	0,1
Terms of Trade	7	1,1	2	0,0	6	0,0	2	0,0

Notes: See also Table A.5. Since all tests were performed with a dummy variable that accounts for the break in 1991, the critical values for the Johansen tests are at best indicative of the existence of cointegration.

Table A.8:
Multivariate Granger Causality Tests 70.i-01.iv: Error Correction, r=1

Shock	q	M1→	→M1	M3→	→M4
Productivity shock (1)	3.00	0.41	0.14	0.00	0.23
Productivity shock (2)	3.00	0.12	0.19	0.00	0.42
Preference shock (1)	4.00	0.59	0.88	0.00	0.98
Preference shock (2)	4.00	0.17	0.82	0.00	0.96

Notes: q denotes the lag length of the estimated VAR in levels. In all four tests both the AIC and the HQ criterium selected the same lag length. The column labeled M1→ (M3→) displays the marginal level of significance for the null that M1 (M3) Granger causes the shock in column 1. The column labeled →M1 (→M3) displays the marginal level of significance for the null that the shock from column 1 Granger causes M1 (M3).