

Business Cycles: Model versus Data

Thijs van Rens

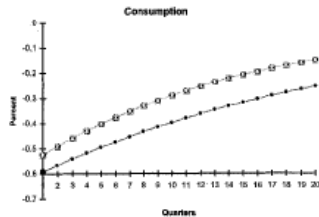
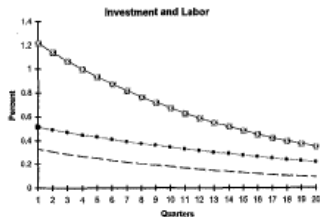
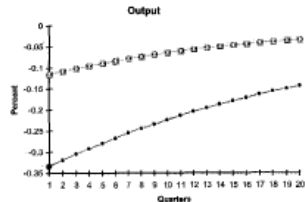
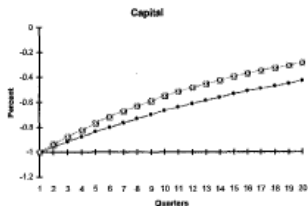
CREI, Universitat Pompeu Fabra and Barcelona GSE

Advanced Macro II

April 24, 2012

Predictions RBC model

IRF of the RBC model



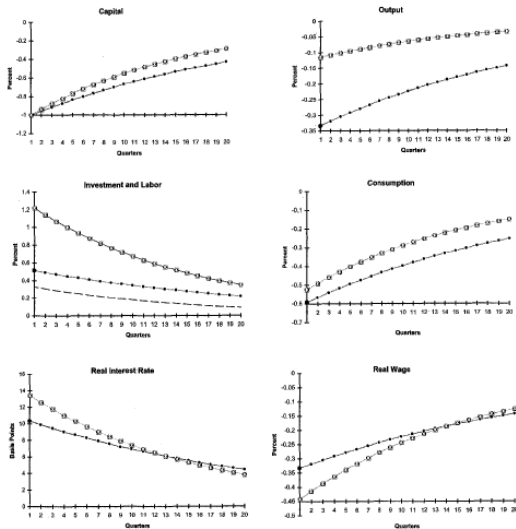


Fig. 6. Transitional dynamics: Basic RBC model (stars); fixed labor model (circles); dashes in mid left-hand panel represent labor response.

BC statistics simulated data from the RBC model

Table 3
Business Cycle Statistics for Basic RBC Model³⁵

	Standard Deviation	Relative Standard Deviation	First Order Auto-correlation	Contemporaneous Correlation with Output
Y	1.39	1.00	0.72	1.00
C	0.61	0.44	0.79	0.94
I	4.09	2.95	0.71	0.99
N	0.67	0.48	0.71	0.97
Y/N	0.75	0.54	0.76	0.98
w	0.75	0.54	0.76	0.98
r	0.05	0.04	0.71	0.95
A	0.94	0.68	0.72	1.00

Note: All variables have been logged (with the exception of the real interest rate) and detrended with the HP filter.

What are business cycles?

Business Cycle Expansions and Contractions - Mozilla Firefox

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http://wwwdev.nber.org/cycles/cyclesmain.html

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Business Cycle Expansions and Contractions

US Business Cycle Expansions and Contractions ¹

Contractions (recessions) start at the peak of a business cycle and end at the trough.

Please also see:

- [Latest announcement](#) from the NBER's Business Cycle Dating Committee, dated 12/01/08.
- [July 2003 announcement](#) of business cycle trough.
- [Press citations](#) on NBER Business Cycles

BUSINESS CYCLE REFERENCE DATES		DURATION IN MONTHS			
Peak	Trough	Contraction	Expansion	Cycle	
Quarterly dates are in parentheses		Peak to Trough	Previous trough to this peak	Trough from Previous Trough	Peak from Previous Peak
	December 1854 (IV)	--	--	--	--
June 1857(II)	December 1858 (IV)	18	30	48	--
October 1860(III)	June 1861 (III)	8	22	30	40
April 1865(I)	December 1867 (I)	32	46	78	54
June 1869(II)	December 1870 (IV)	18	18	36	50
October 1873(III)	March 1879 (I)	65	34	99	52
March 1892(I)	May 1895 (II)	38	36	74	101

Done

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Filtering

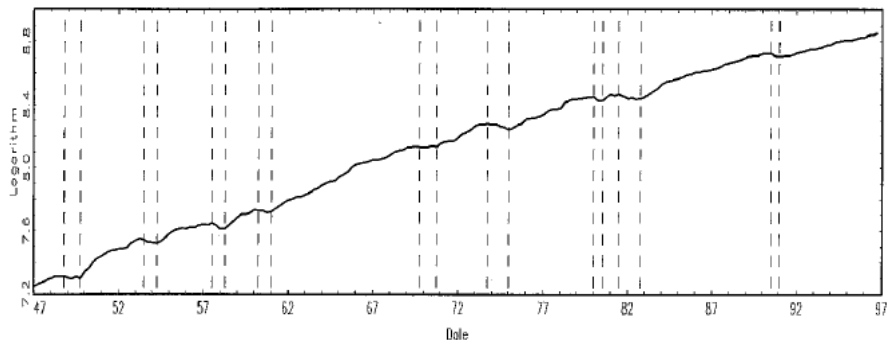


Fig. 2.1. Level of GDP.

Stock and Watson (1999)

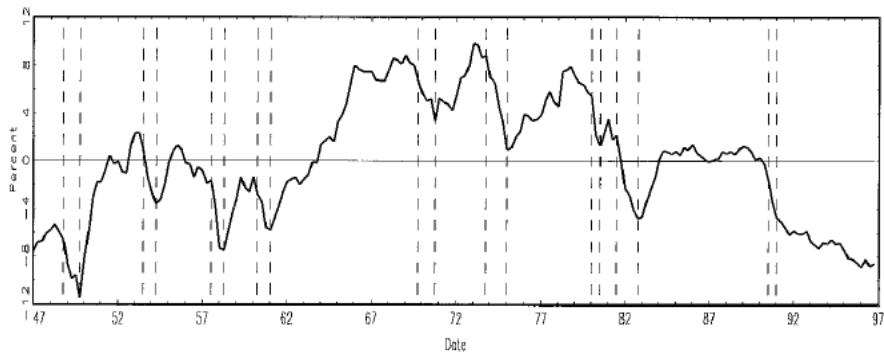


Fig. 2.2. Linearly detrended GDP.

Filtering

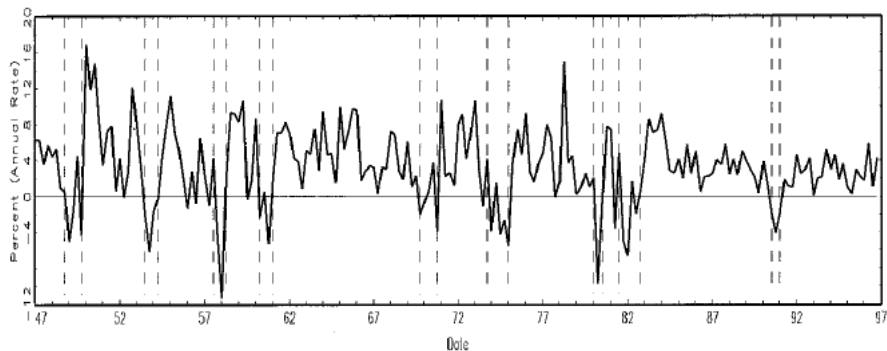
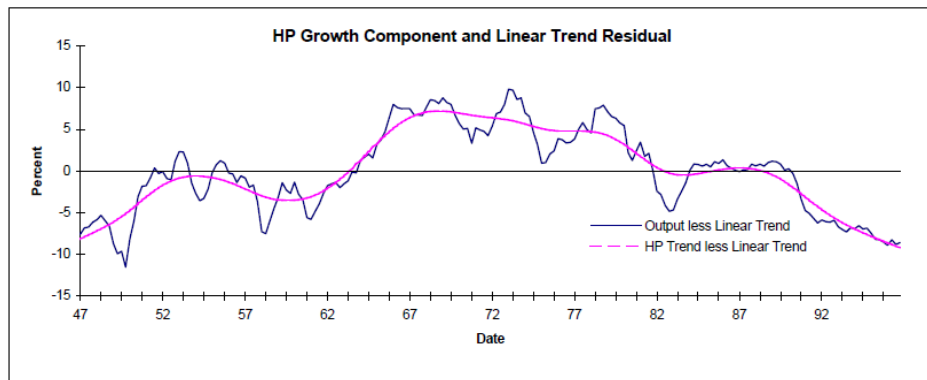


Fig. 2.3. Growth rate of GDP.

Filtering



King and Rebelo (1999)

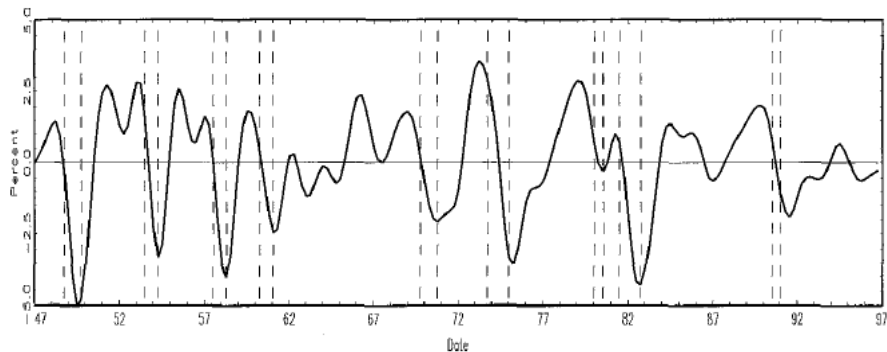
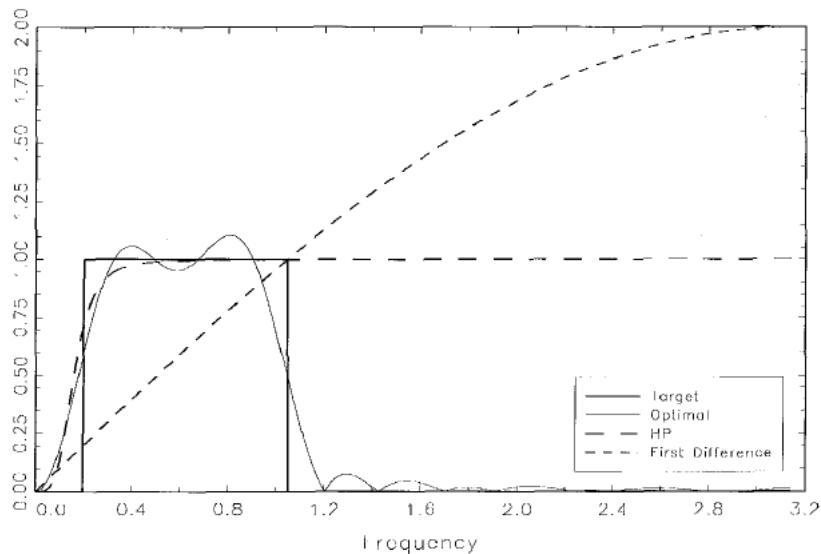


Fig. 2.5. Bandpass-filtered GDP (business cycle).

Filtering



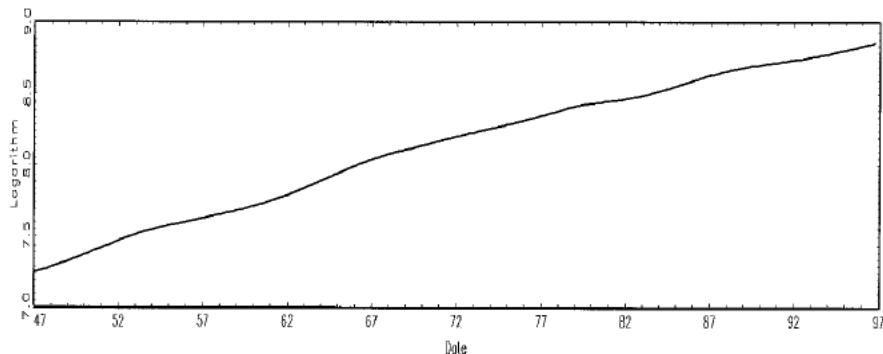


Fig. 2.6. Bandpass-filtered GDP (trend).

Filtering

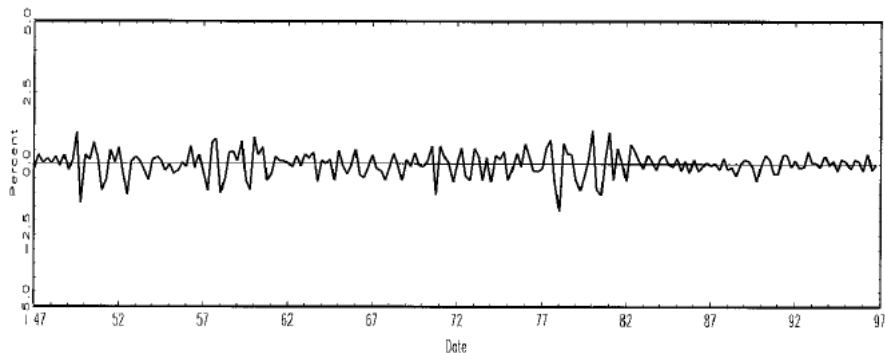


Fig. 2.7. Bandpass-filtered GDP (irregular).

Comovement variables over the BC

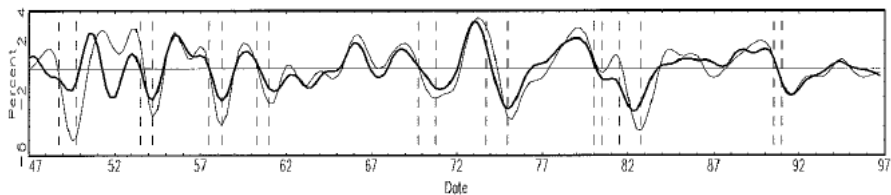


Fig. 3.9. Consumption (total).

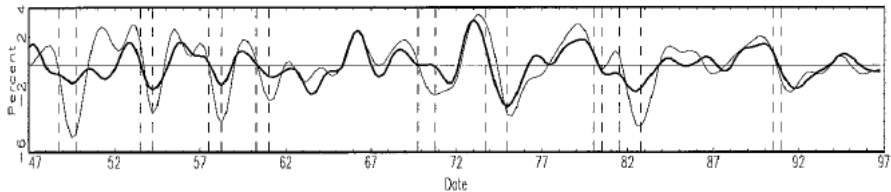


Fig. 3.10. Consumption (nondurables).

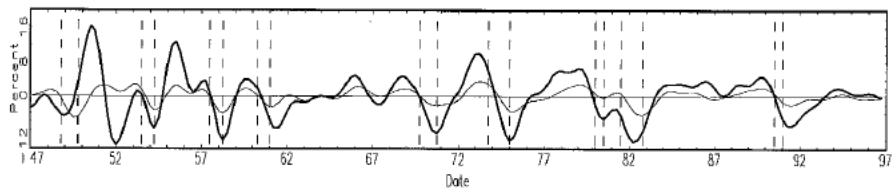


Fig. 3.13. Consumption (durables).

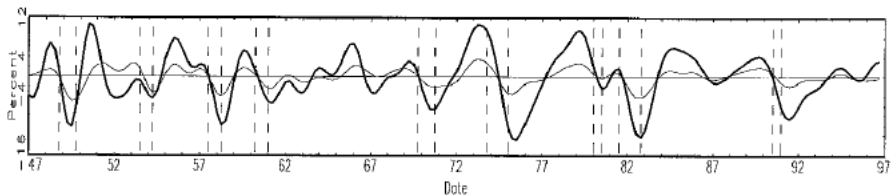


Fig. 3.14. Investment (total fixed).

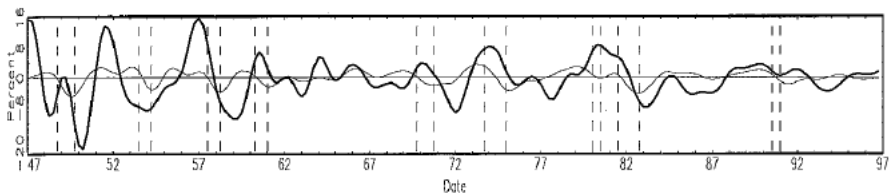


Fig. 3.19. Exports.

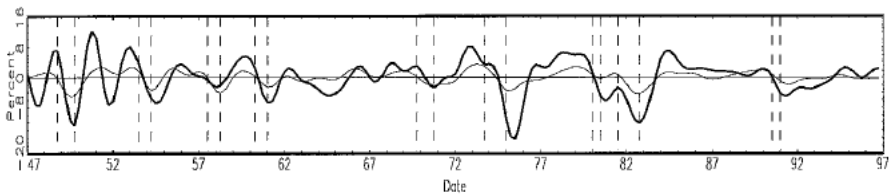


Fig. 3.20. Imports.

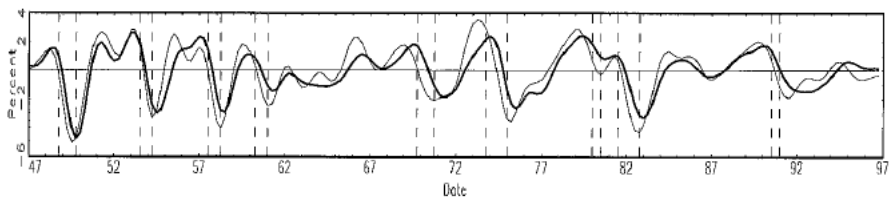


Fig. 3.25. Employment (total employees).

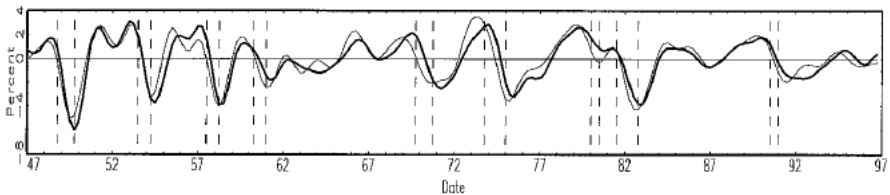


Fig. 3.26. Employment (total hours).

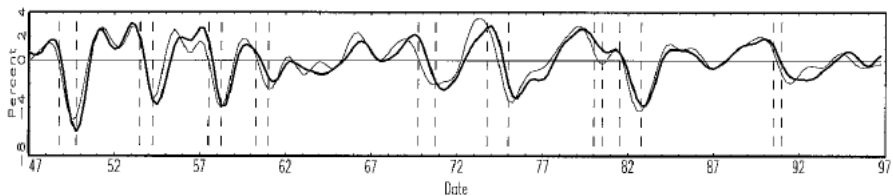


Fig. 3.26. Employment (total hours).

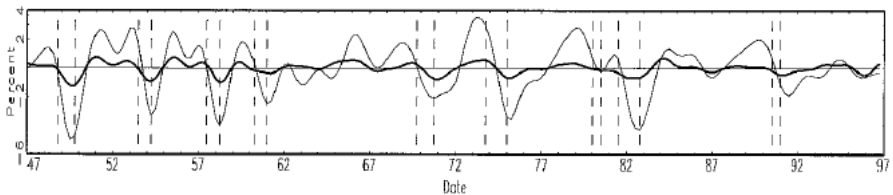


Fig. 3.27. Employment (average weekly hours).

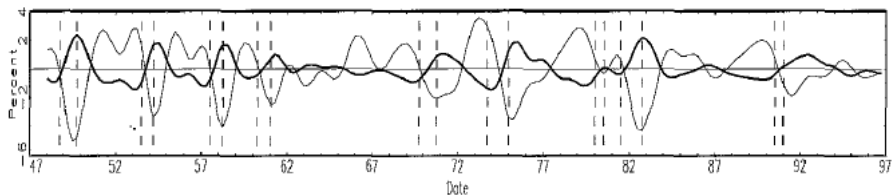


Fig. 3.28. Unemployment rate.

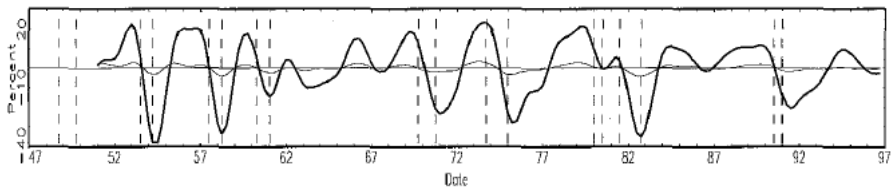


Fig. 3.29. Vacancies (Help Wanted index).

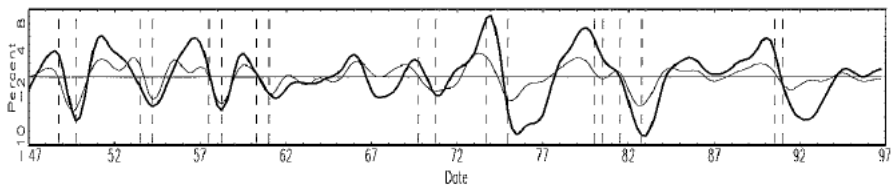


Fig. 3.1. Contract and construction employment.

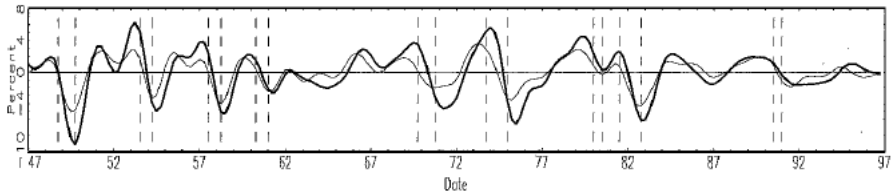


Fig. 3.2. Manufacturing employment.

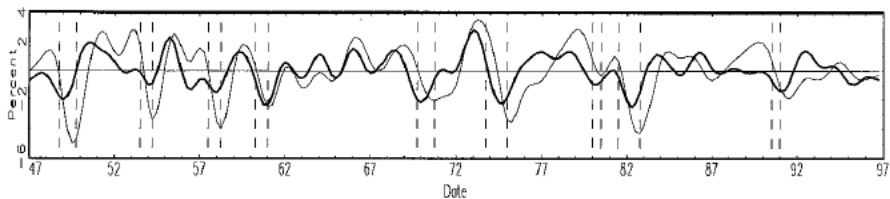


Fig. 3.33. Average labor productivity.

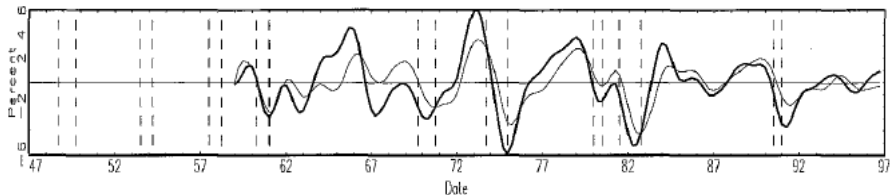


Fig. 3.32. Total factor productivity.

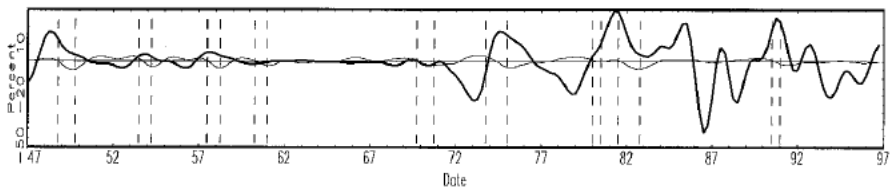


Fig. 3.36. Oil prices.

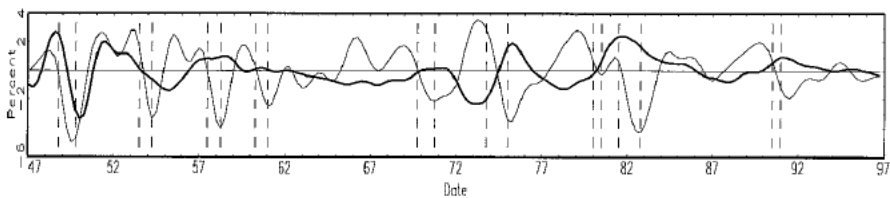


Fig. 3.37. GDP price deflator (level).

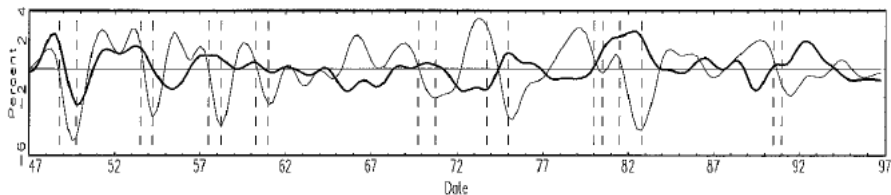


Fig. 3.43. Nominal wage rate (level).

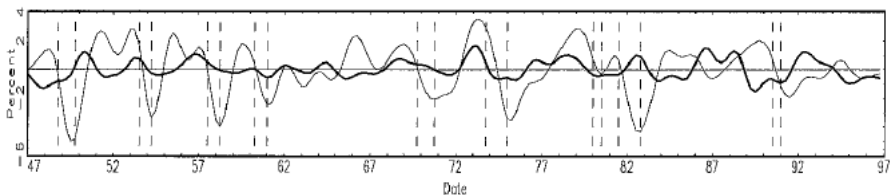


Fig. 3.44. Real wage rate (level).

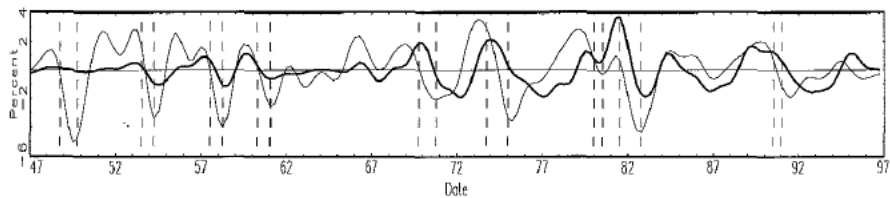


Fig. 3.48. Treasury Bill rate (3 month).

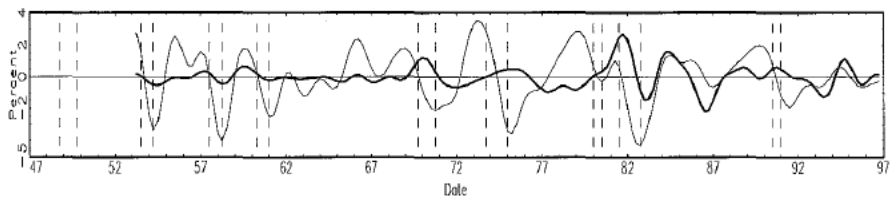


Fig. 3.49. Treasury Bond rate (10 year).

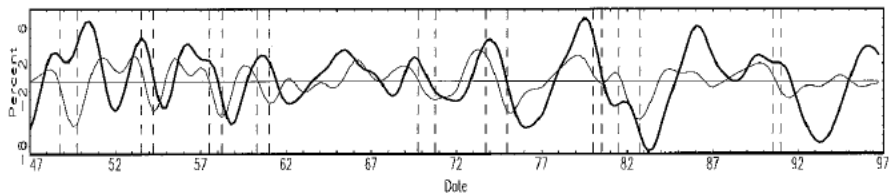


Fig. 3.60. Consumer credit.

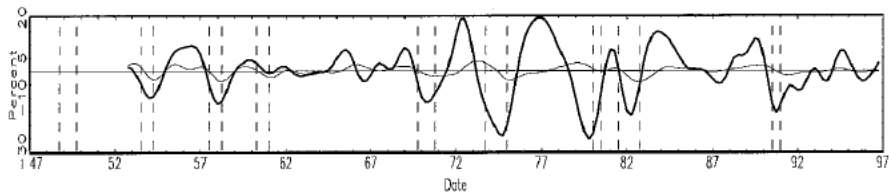


Fig. 3.61. Consumer expectations.

Romer fact #1: BC unequally spaced and sized

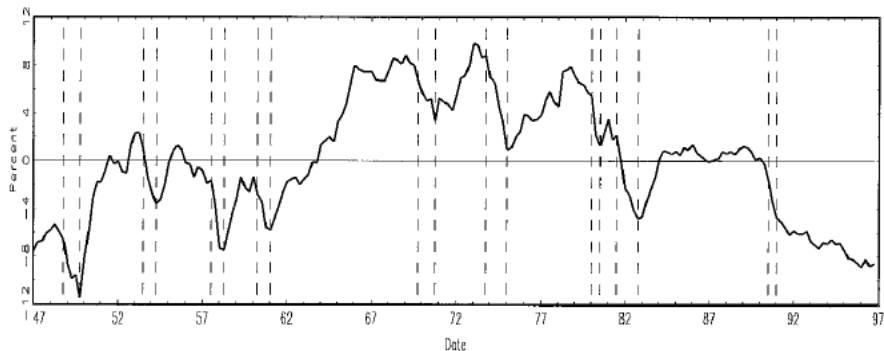


Fig. 2.2. Linearly detrended GDP.

Romer fact #2: patterns BC different from growth

TABLE 4.2 Behavior of the components of output in recessions

Component of GDP	Average share in GDP	Average share in fall in GDP in recessions relative to normal growth
Consumption		
Durables	8.5%	15.1%
Nondurables	25.4	10.3
Services	30.4	9.5
Investment		
Residential	4.8	10.7
Fixed nonresidential	10.6	20.3
Inventories	0.6	41.8
Net exports	-0.6	-11.4
Government purchases	20.3	3.8

Romer fact #3: BC asymmetric

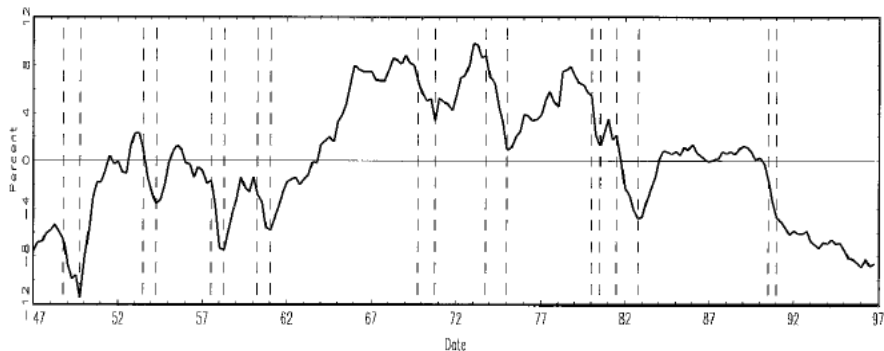


Fig. 2.2. Linearly detrended GDP.

Summarizing the BC facts (Romer)

TABLE 4.3 Behavior of some important macroeconomic variables in recessions

Variable	Average change in recessions	Number of recessions in which variable falls
Real GDP*	-3.9%	10/10
Employment*	-2.8%	10/10
Unemployment rate (percentage points)	+1.6	0/10
Average weekly hours, production workers, manufacturing	-2.2%	10/10
Output per hour, nonfarm business*	-1.7%	9/10
Inflation (GDP deflator; percentage points)	-0.1	4/10
Real compensation per hour, nonfarm business*	-0.6%	7/10
Nominal interest rate on 3-month Treasury bills (percentage points)	-1.5	9/10
Ex post real interest rate on 3-month Treasury bills (percentage points)	-1.2	7/10
Real money stock (M-2/GDP deflator)*†	-0.9%	3/7

*Change in recessions is computed relative to the variable's average growth over the full postwar period, 1947-2004.

† Available only beginning in 1959.

Summarizing the BC facts (Stock and Watson)

Table 2
Descriptive statistics for cyclical components of series, 1953–1996

Series	Std dev.	Cross correlations with output ($\text{corr}(x_{it}, y_{t+k})$)												
		-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6
Gross Domestic Product	1.66	-0.29	-0.18	0.03	0.33	0.66	0.91	1.00	0.91	0.66	0.33	0.03	-0.18	-0.29
<i>Sectoral employment</i>														
1. Contract and construction employment	3.75	0.02	0.20	0.39	0.58	0.73	0.80	0.77	0.65	0.44	0.19	-0.04	-0.23	-0.35
2. Manufacturing employment	2.61	-0.06	0.14	0.40	0.67	0.87	0.94	0.84	0.59	0.26	-0.06	-0.30	-0.43	-0.45
3. Finance, insurance and real estate employment	1.01	0.25	0.35	0.43	0.49	0.50	0.46	0.38	0.28	0.15	0.02	-0.10	-0.20	-0.28
4. Mining employment	3.79	0.13	0.19	0.25	0.28	0.25	0.16	-0.00	-0.20	-0.40	-0.53	-0.58	-0.55	-0.45
5. Government employment	0.82	0.51	0.53	0.49	0.43	0.35	0.29	0.23	0.15	0.04	-0.08	-0.21	-0.31	-0.37
6. Service employment	0.83	0.20	0.33	0.49	0.63	0.71	0.69	0.55	0.34	0.08	-0.15	-0.33	-0.44	-0.50
7. Wholesale and retail trade employment	1.20	-0.01	0.21	0.45	0.68	0.83	0.87	0.79	0.60	0.35	0.10	-0.10	-0.24	-0.32
8. Transportation and public utility employment	1.54	0.23	0.42	0.61	0.77	0.83	0.76	0.56	0.26	-0.06	-0.33	-0.49	-0.53	-0.50
<i>NIPA components</i>														
9. Consumption (total)	1.26	-0.39	-0.28	-0.07	0.21	0.51	0.76	0.90	0.89	0.75	0.53	0.29	0.09	-0.06
10. Consumption (nondurables)	1.11	-0.36	-0.24	-0.02	0.25	0.52	0.74	0.83	0.80	0.65	0.43	0.21	0.02	-0.12
11. Consumption (services)	0.64	-0.13	-0.00	0.14	0.31	0.49	0.66	0.78	0.80	0.70	0.51	0.27	0.05	-0.12
12. Consumption (nondurables + services)	0.78	-0.28	-0.15	0.05	0.29	0.55	0.75	0.87	0.85	0.71	0.49	0.25	0.03	-0.13
13. Consumption (durables)	4.66	-0.46	-0.38	-0.19	0.09	0.42	0.70	0.85	0.86	0.73	0.53	0.32	0.15	0.03
14. Investment (total fixed)	4.97	-0.34	-0.19	0.04	0.32	0.61	0.82	0.89	0.83	0.65	0.41	0.18	-0.00	-0.13
15. Investment (equipment)	5.25	-0.06	0.16	0.41	0.65	0.84	0.92	0.88	0.73	0.49	0.23	-0.01	-0.20	-0.31
16. Investment (nonresidential structures)	4.67	0.20	0.40	0.58	0.70	0.74	0.67	0.52	0.30	0.07	-0.14	-0.30	-0.40	-0.44
17. Investment (residential structures)	10.04	-0.49	-0.48	-0.37	-0.18	0.09	0.38	0.62	0.77	0.78	0.69	0.53	0.36	0.20
18. Change in bus. inventories (rel. to trend GDP)	0.38	-0.58	-0.50	-0.32	-0.04	0.28	0.57	0.73	0.72	0.56	0.32	0.08	-0.08	-0.15

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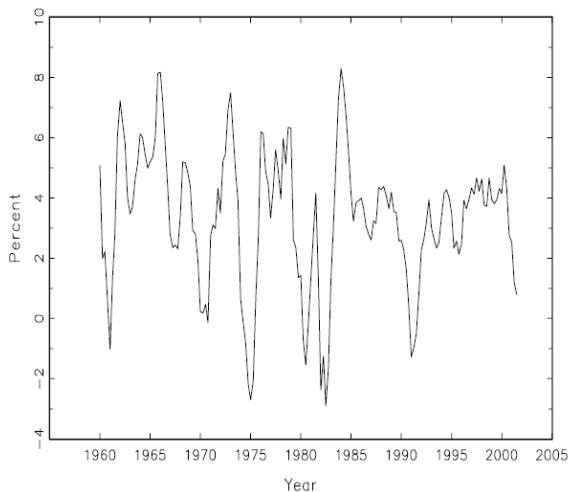
Summarizing the BC facts (King and Rebelo)

Table 1
Business Cycle Statistics for the U.S. Economy

	Standard Deviation	Relative Standard Deviation	First Order Auto-correlation	Contemporaneous Correlation with Output
Y	1.81	1.00	0.84	1.00
C	1.35	0.74	0.80	0.88
I	5.30	2.93	0.87	0.80
N	1.79	0.99	0.88	0.88
Y/N	1.02	0.56	0.74	0.55
w	0.68	0.38	0.66	0.12
r	0.30	0.16	0.60	-0.35
A	0.98	0.54	0.74	0.78

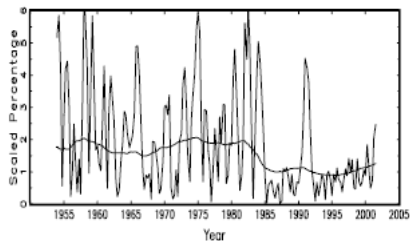
Changes in BC facts

Figure 1: Annual Growth Rates in GDP

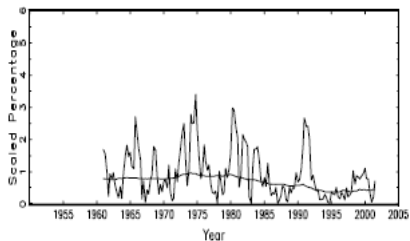


Stock and Watson (2002). Has the Business Cycle Changed and Why?

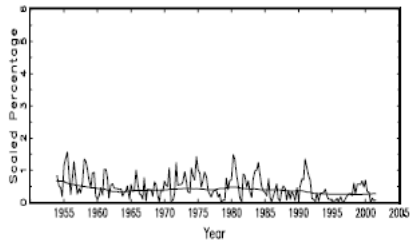
A. GDP



B. Consumption
(Weight = 0.64)



C. Consumption - Durables
(Weight = 0.08)



D. Consumption - Nondurable
(Weight = 0.24)

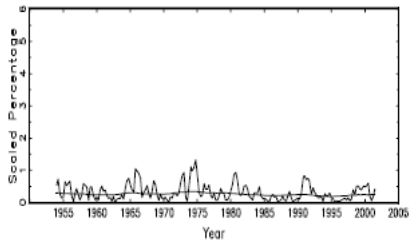


Table 2
Standard Deviations, by Decade, of Annual Growth Rates or Changes of 22
Macroeconomic Time Series

Series	Standard Deviation 1960-2001	Standard Deviation, relative to 1960 - 2001			
		1960- 1969	1970- 1979	1980- 1989	1990- 2001
GDP	0.023	0.98	1.18	1.14	0.67
consumption	0.019	0.97	1.17	1.07	0.78
consumption – durables	0.066	0.87	1.18	1.13	0.79
consumption – nondurables	0.018	1.06	1.22	0.81	0.87
consumption – services	0.012	1.07	0.84	1.20	0.88
investment (total)	0.104	0.82	1.15	1.22	0.77
fixed investment – total	0.067	0.77	1.29	1.04	0.84
nonresidential	0.067	0.87	1.17	1.06	0.89
residential	0.134	0.78	1.25	1.23	0.65
Δ inventory investment/GDP	0.006	1.12	0.92	1.22	0.71
exports	0.064	1.07	1.13	1.12	0.66
imports	0.072	0.87	1.24	1.14	0.70
government spending	0.025	1.40	1.00	0.85	0.65
<i>Production</i>					
goods (total)	0.036	0.97	1.13	1.13	0.76
nondurable goods	0.073	1.00	1.14	1.16	0.68
durable goods	0.025	0.92	1.16	1.22	0.65
services	0.011	1.41	0.52	1.01	0.87
structures	0.062	0.73	1.33	1.11	0.73
nonagricultural employment	0.017	0.94	1.21	1.09	0.73
price inflation (GDP deflator)	0.004	0.69	1.51	1.06	0.50
90-day T-bill rate	1.704	0.51	1.10	1.43	0.75
10-year T-bond rate	1.223	0.43	0.65	1.67	0.82

Notes: NIPA series are annual growth rates, except for the change in inventory investment, which is the annual difference of the quarterly change in inventories as a fraction of GDP. Inflation is the four-quarter change in the annual inflation rate, and interest rates are in four-quarter changes.

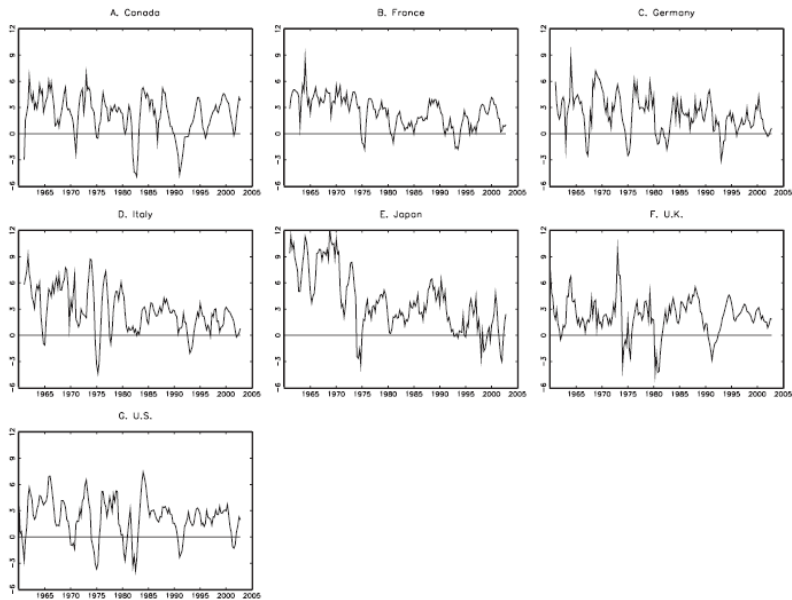


FIGURE 1. Four-quarter growth rates of GDP.

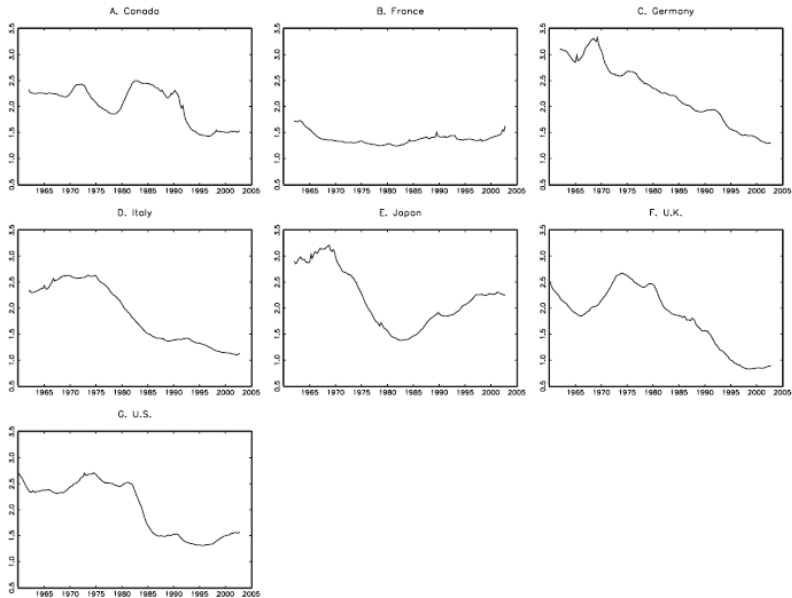


FIGURE 4. Estimated instantaneous standard deviation of four-quarter GDP growth.

TABLE 1. Standard deviation of four-quarter percentage growth of per capita GDP in the G7 by decade.

	1960–1969	1970–1979	1980–1989	1990–2002
Canada	1.83	1.82	2.67	2.24
France	1.24	1.66	1.27	1.43
Germany	2.56	2.13	1.67	1.53
Italy	2.34	3.14	1.33	1.30
Japan	2.19	3.16	1.57	2.08
UK	1.84	2.48	2.51	1.60
US	2.09	2.74	2.66	1.47

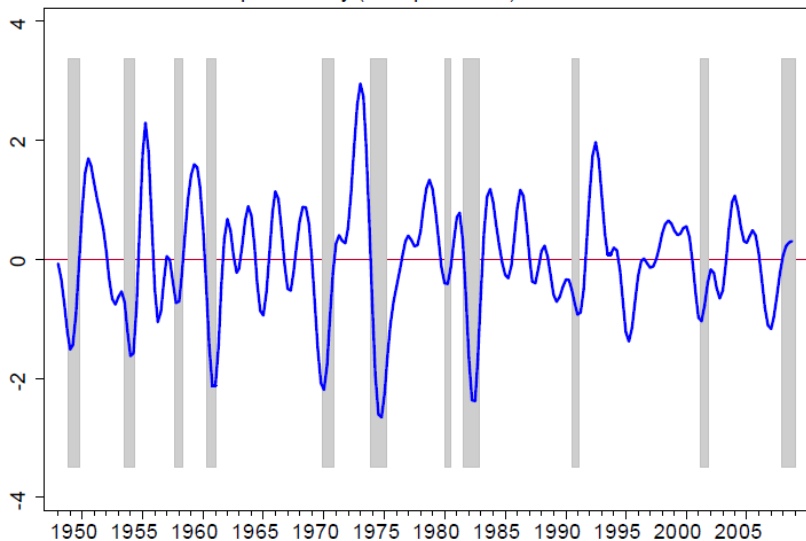
Notes: Entries are the standard deviation of $100 \ln(GDP_t / GDP_{t-4})$.

TABLE 2. Test for breaks in autoregressive parameters.

	Conditional mean			Conditional variance: break model			Conditional variance: Trend + break model		
	<i>p</i>	Break date	67% confidence interval	<i>p</i>	Break date	67% confidence interval	<i>p</i> : trend	<i>p</i> : break	Break date
Canada	0.00	1972:4	1972:2–1973:2	0.00	1991:2	1990:4–1993:1	0.00	0.25	
France	0.00	1974:1	1973:3–1974:3	0.03	1968:1	1967:3–1970:3	0.92	0.65	
Germany	0.39			0.00	1993:1	1992:3–1995:2	0.49	0.91	
Italy	0.00	1979:4	1979:2–1980:2	0.00	1980:1	1979:3–1982:4	0.00	0.27	
Japan	0.00	1973:1	1972:3–1973:3	0.32			0.34	0.11	
UK	0.00	1980:1	1979:3–1980:3	0.00	1980:1	1979:4–1982:1	0.00	0.00	1970:4
US	0.99			0.00	1983:2	1982:4–1985:3	0.67	0.01	1983:2

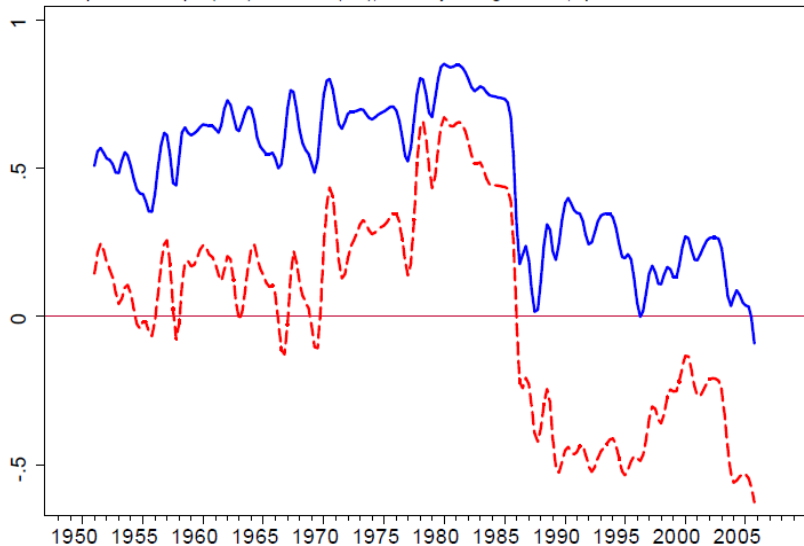
Notes: These results are based on AR(4) models estimated using $\Delta \ln(GDP_t/GDP_{t-1})$. The results shown in the columns labels “Conditional Mean” refer to changes in the AR coefficients, and the results shown in the columns labeled “Conditional Variance” refer to changes in the variance of the AR innovations. The “break model” allows a one-time break in the variance; the “Trend + break model” allows the variance to contain a linear trend and a one-time break. Columns labeled “*p*” are the *p*-value of the test statistic under the null hypothesis of no-change; “Break date” is the estimated date of a one-time shift in the parameters (reported only if the *p*-value is less than 5%); and the confidence interval is for the break date.

Labor productivity (bandpass filter)



Galí and van Rens

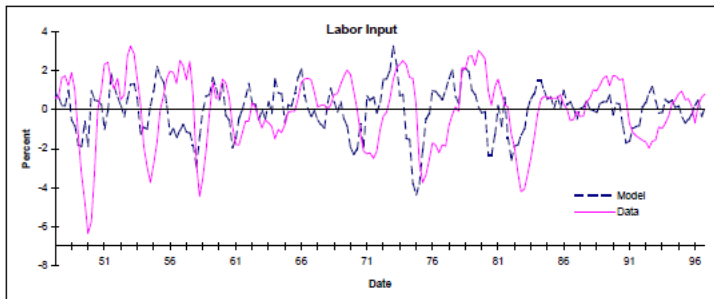
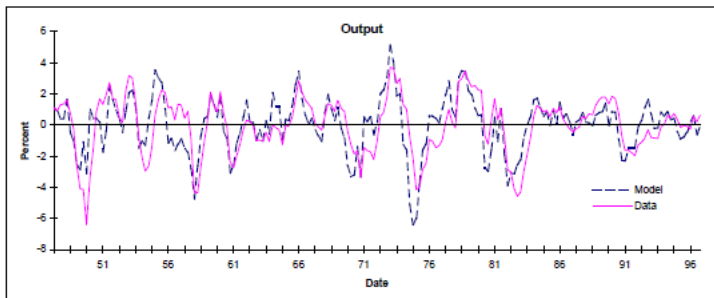
Correl prod with output (blue) and hours (red), cntnd 6-yr rolling window , bp



Can model match the facts?

Table 2
Calibration of Baseline Model

σ	b	θ	η	γ	α	δ	ρ	σ_{ε}
1	0.984	3.48	1	1.004	0.667	0.025	0.979	0.0072



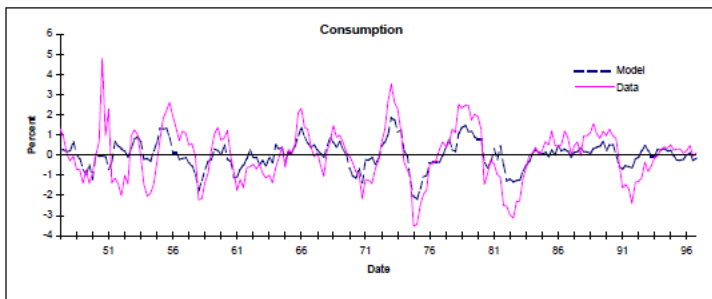
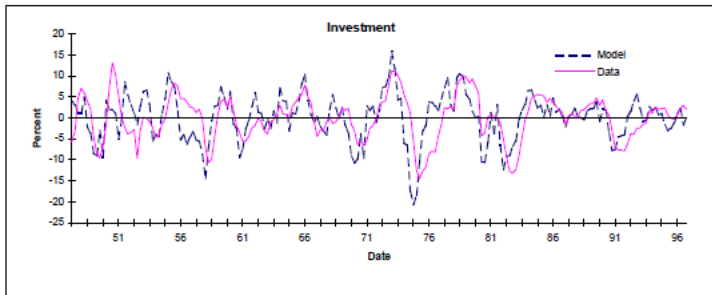


Table 3
Business Cycle Statistics for Basic RBC Model³⁵

	Standard Deviation	Relative Standard Deviation	First Order Auto-correlation	Contemporaneous Correlation with Output
Y	1.39	1.00	0.72	1.00
C	0.61	0.44	0.79	0.94
I	4.09	2.95	0.71	0.99
N	0.67	0.48	0.71	0.97
Y/N	0.75	0.54	0.76	0.98
w	0.75	0.54	0.76	0.98
r	0.05	0.04	0.71	0.95
A	0.94	0.68	0.72	1.00

Note: All variables have been logged (with the exception of the real interest rate) and detrended with the HP filter.

Table 1
Business Cycle Statistics for the U.S. Economy

	Standard Deviation	Relative Standard Deviation	First Order Auto-correlation	Contemporaneous Correlation with Output
Y	1.81	1.00	0.84	1.00
C	1.35	0.74	0.80	0.88
I	5.30	2.93	0.87	0.80
N	1.79	0.99	0.88	0.88
Y/N	1.02	0.56	0.74	0.55
w	0.68	0.38	0.66	0.12
r	0.30	0.16	0.60	-0.35
A	0.98	0.54	0.74	0.78

Table 3
Business Cycle Statistics for Basic RBC Model³⁵

	Standard Deviation	Relative Standard Deviation	First Order Auto-correlation	Contemporaneous Correlation with Output
Y	1.39	1.00	0.72	1.00
C	0.61	0.44	0.79	0.94
I	4.09	2.95	0.71	0.99
N	0.67	0.48	0.71	0.97
Y/N	0.75	0.54	0.76	0.98
w	0.75	0.54	0.76	0.98
r	0.05	0.04	0.71	0.95
A	0.94	0.68	0.72	1.00

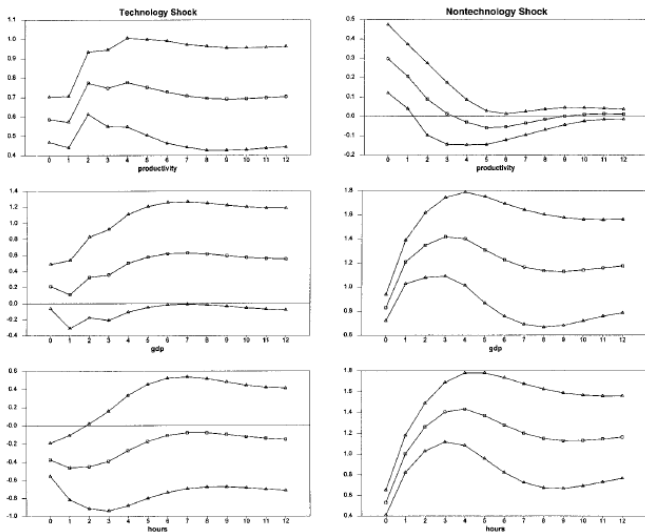


FIGURE 2. ESTIMATED IMPULSE RESPONSES FROM A BIVARIATE MODEL: U.S. DATA, FIRST-DIFFERENCED HOURS (POINT ESTIMATES AND ± 2 STANDARD ERROR CONFIDENCE INTERVALS)

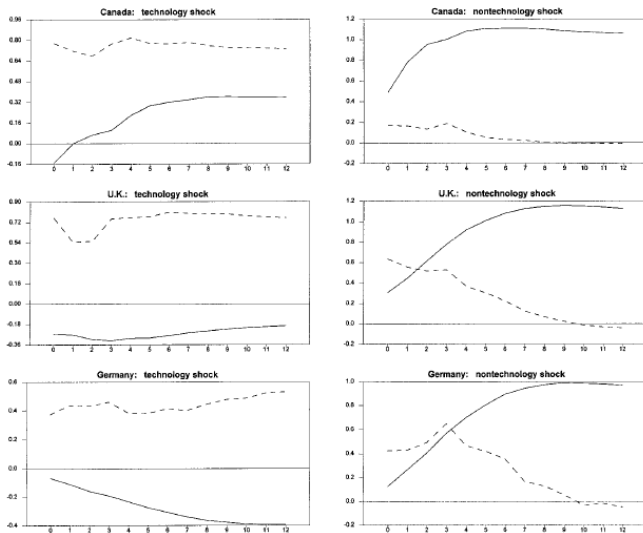


FIGURE 5. ESTIMATED IMPULSE RESPONSES OF EMPLOYMENT (SOLID LINE) AND PRODUCTIVITY (DASHED LINE) FOR OTHER INDUSTRIALIZED ECONOMIES

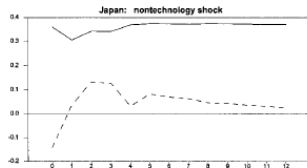
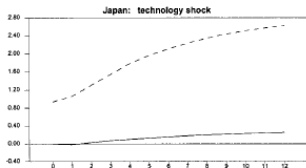
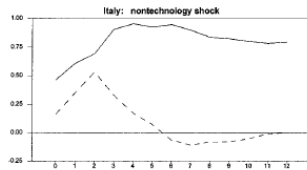
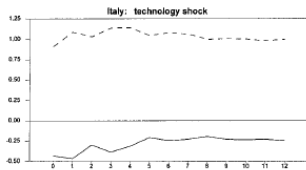
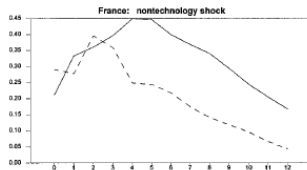
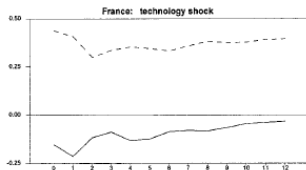


FIGURE 5. *Continued*

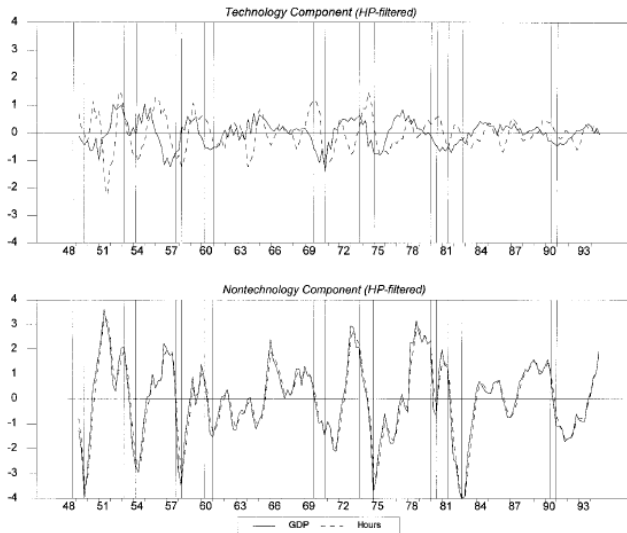


FIGURE 6. ESTIMATED TECHNOLOGY AND NONTECHNOLOGY COMPONENTS OF U.S. GDP AND HOURS