

BUSINESS CYCLE BASICS

Emi Nakamura and Jon Steinsson

UC Berkeley

August 2025

- Trend vs. cycle decompositions
- Business cycle asymmetries: unemployment
- Is output trend or difference stationary?
- Welfare gains from stabilization policy
 - Lucas' Macroeconomic Priorities
 - Connection to asset pricing and equity premium puzzle
- Great Moderation

A cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals which merge into the expansion phase of the next cycle; this sequence of changes is recurrent but not periodic; in duration business cycles vary from more than one year to ten or twelve years; they are not divisible into shorter cycles of similar character with amplitudes approximating their own.

Burns and Mitchell, 1946, p. 3.

(Peak to trough analysis)

HOW TO DEFINE CYCLES?

- Peak-to-trough analysis
- Linear detrending
- First Differences (aka Growth Rate)
- Flexible detrending (e.g., HP Filter, Bandpass)

STOCK AND WATSON (1999): LEVEL OF GDP

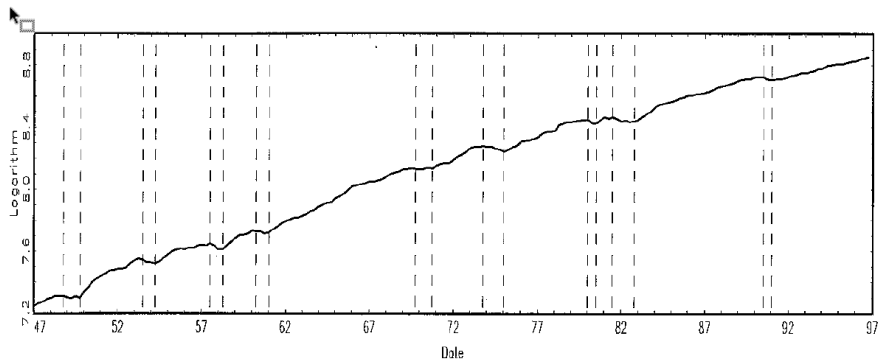


Fig. 2.1. Level of GDP.

STOCK AND WATSON (1999): LINEARLY DETRENDED

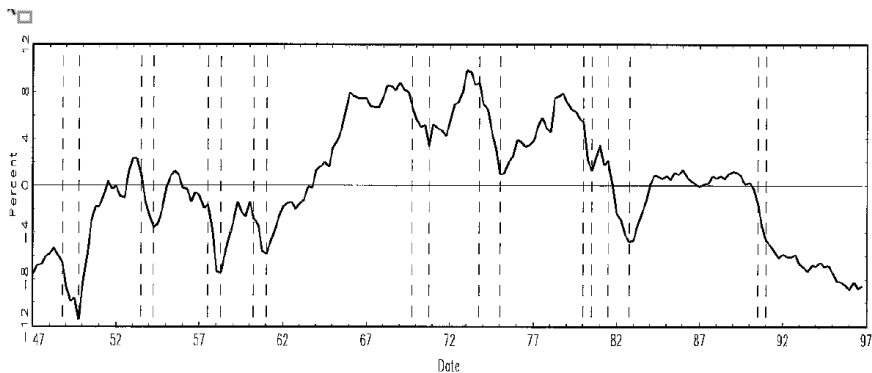


Fig. 2.2. Linearly detrended GDP.

STOCK AND WATSON (1999): GROWTH RATE

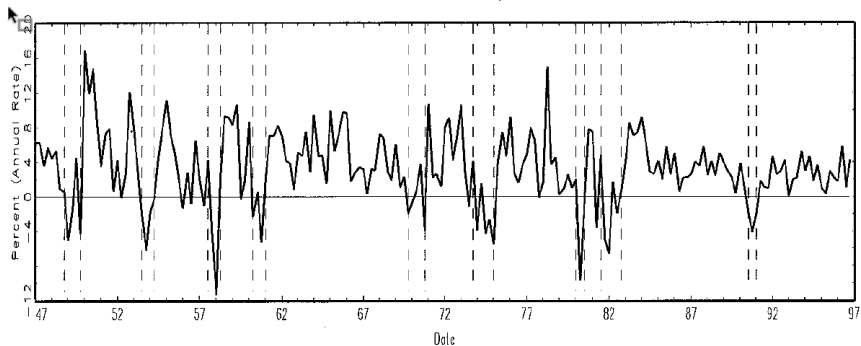


Fig. 2.3. Growth rate of GDP.

BAND PASS FILTER DEFINITION

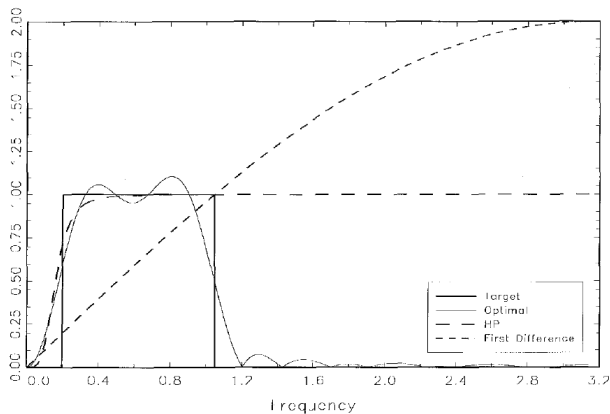


Fig. 2.4. Filter gains.

Also: Hodrick-Prescott (1981) Filter

BAND PASS FILTER

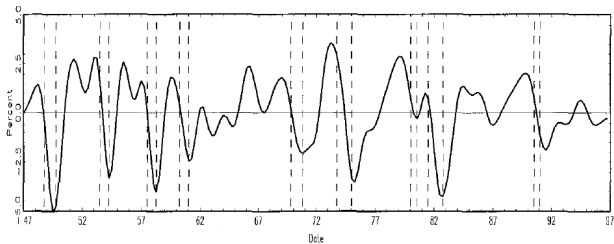
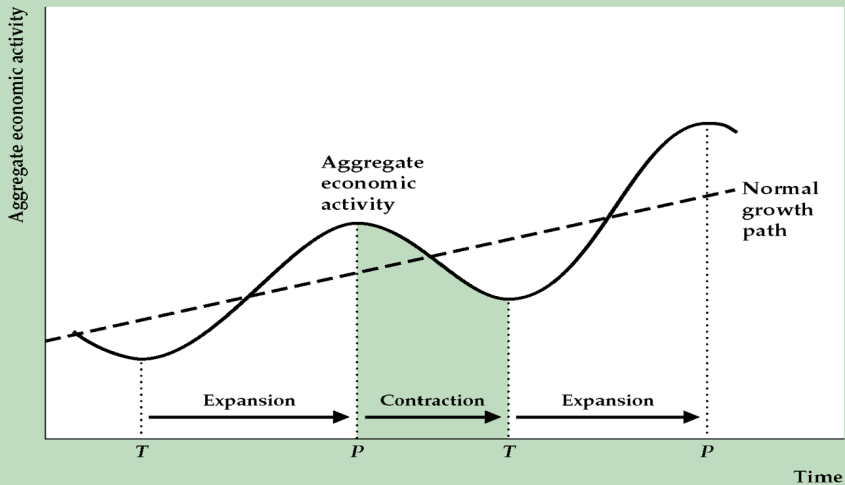


Fig. 2.5. Bandpass-filtered GDP (business cycle).

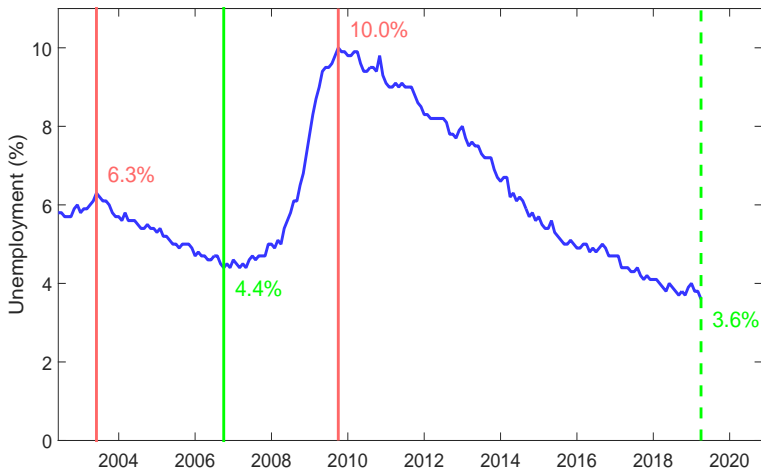
BUSINESS CYCLES: STANDARD VIEW



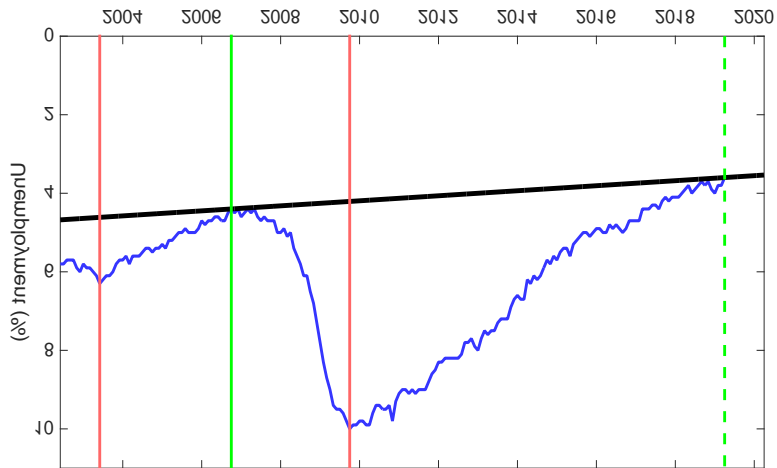
“Consider an elastic string stretched taut between two points on the underside of a rigid horizontal board and glued lightly to the board. Let the string be plucked at a number of points chosen more or less at random with a force that varies at random, and then held down at the lowest point reached. The result will be to produce a succession of apparent cycles in the string whose amplitudes depend on the force used in plucking the string.”

“Output is viewed as bumping along the ceiling of maximum feasible output except that every now and then it is plucked down by a cyclical contraction.”

THE LAST TROUGH-TO-PEAK-TO-TROUGH IN THE US



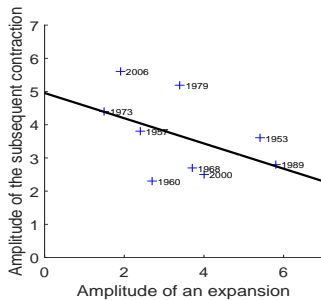
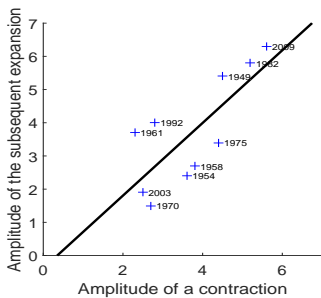
THROUGH THE LENS OF THE PLUCKING MODEL



FRIEDMAN 1964: IMPLICATION

- Plucking Model view: Contractions are drops below potential
- Plucking Property: One implication stressed by Friedman
 - Size of a contraction predicts the size of the following expansion
 - Size of an expansion doesn't predict the size of the following contraction

THE PLUCKING PROPERTY



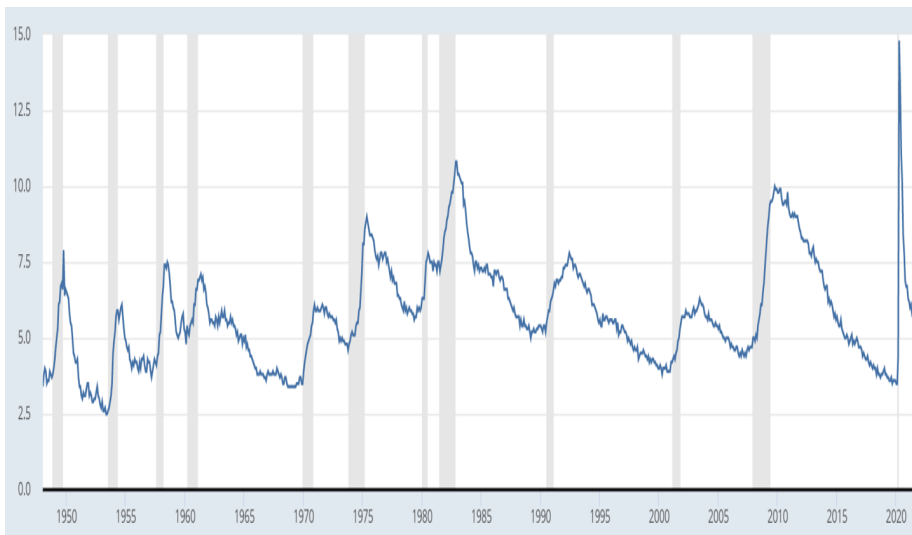
THE PLUCKING PROPERTY

	β	R^2
Subsequent expansion on contraction	1.09 (0.33)	0.58
Subsequent contraction on expansion	-0.38 (0.27)	0.22

Jackson and Tebaldi (2017)

- Forest fires: the longer the expansion, the more “underbrush” there are to burn during the contraction
- Recessions: Perhaps longer expansions beget larger contractions
- Aggregate data not supportive: Neither size nor duration of expansion predicts size of subsequent contraction
- Goes (slightly) the other way
 - Longest post-WW2 expansions (1961-1968, 1982-1989, 1992-2000) were followed by among the mildest recessions

UNEMPLOYMENT: UP THE ELEVATOR, DOWN THE STAIRS



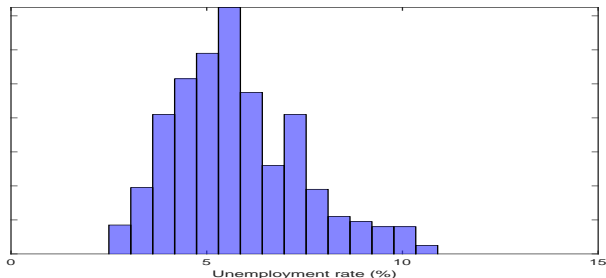
CONTRACTIONS ARE FASTER THAN EXPANSIONS

- Neftçi (1984)'s *"sudden jumps and slower drops"*

	pp/year
Speed of expansions	0.88
Speed of contractions	1.89
P-value for equal speed	0.002

POSITIVE SKEWNESS OF THE UNEMPLOYMENT RATE

- Sichel (1993)'s “deepness”: “*when troughs are deeper than peaks are tall*”



- Skewness of the unemployment rate = 0.63
- Reject [H_0 : No Skewness] at p-value = 0.071

COVID RECOVERY: WHY WAS THIS TIME SO FUNDAMENTALLY DIFFERENT?

Not well understood. Some ideas:

- Shock was (and expected to be) less persistent
 - Labor hoarding, temporary layoffs
- Shock involved “rationing” which led households to build up huge savings
 - Pent up demand for vacation travel, restaurants etc.
- Huge government stabilization policies (Fed, Treasury)

IS OUTPUT TREND OR DIFFERENCE STATIONARY?

Intellectual history:

- Big debate in macro in 1980's
(Nelson and Plosser, 1982; Watson, 1986;
Clark, 1987; Campbell and Mankiw, 1987)
- Important implications for business cycle theory
(Are recessions permanent?)

Papers:

- Cochrane (1988): US data on GNP, Variance ratios
- Cogley (1990)

SUPPOSE OUTPUT IS A RANDOM WALK?

$$\log Y_{t+1} = \mu + \log Y_t + \epsilon_{t+1}$$

- What does this imply about $\partial \log Y_{t+j} / \partial \epsilon_{t+1}$ as $j \rightarrow \infty$?

SUPPOSE OUTPUT IS A RANDOM WALK?

$$\log Y_{t+1} = \mu + \log Y_t + \epsilon_{t+1}$$

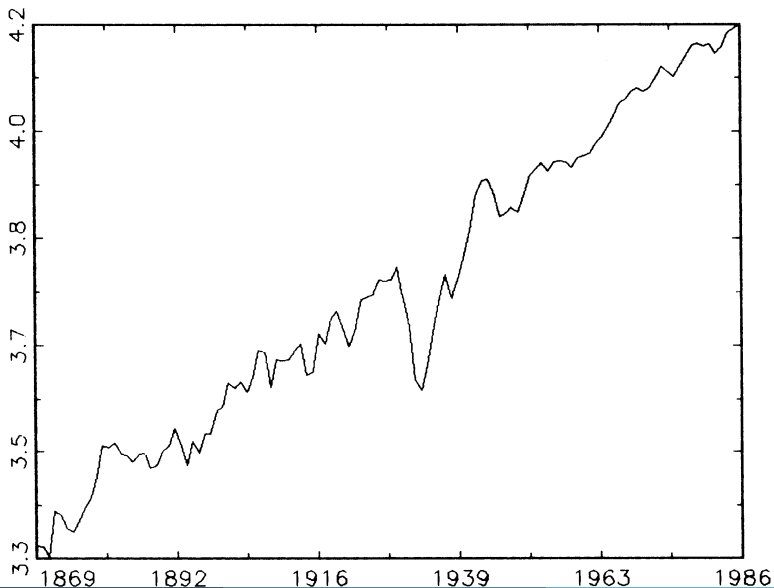
- What does this imply about $\partial \log Y_{t+j} / \partial \epsilon_{t+1}$ as $j \rightarrow \infty$?
 - $\partial \log Y_{t+j} / \partial \epsilon_{t+1} = 1$ for all j
- What does it imply about $\text{var}_t(\log Y_{t+j})$ as $j \rightarrow \infty$?

SUPPOSE OUTPUT IS A RANDOM WALK?

$$\log Y_{t+1} = \mu + \log Y_t + \epsilon_{t+1}$$

- What does this imply about $\partial \log Y_{t+j} / \partial \epsilon_{t+1}$ as $j \rightarrow \infty$?
 - $\partial \log Y_{t+j} / \partial \epsilon_{t+1} = 1$ for all j
- What does it imply about $\text{var}_t(\log Y_{t+j})$ as $j \rightarrow \infty$?
 - Goes to infinity!!
- But does US GDP look like a random walk with drift?

US GDP



SUPPOSE OUTPUT IS TREND STATIONARY?

- Trend stationary model:

$$\log Y_{t+1} = bt + \sum_{j=0}^{\infty} a_j \epsilon_{t-j}$$

($\sum_{j=0}^{\infty} a_j \epsilon_{t-j}$ stationary: a_j approaches zero for large j)

- How do long run forecasts change in response to ϵ_t ?

SUPPOSE OUTPUT IS TREND STATIONARY?

- Trend stationary model:

$$\log Y_{t+1} = bt + \sum_{j=0}^{\infty} a_j \epsilon_{t-j}$$

($\sum_{j=0}^{\infty} a_j \epsilon_{t-j}$ stationary: a_j approaches zero for large j)

- How do long run forecasts change in response to ϵ_t ?
 - Invariant to shocks!
- $\text{var}_t(\log Y_{t+j}) \rightarrow \sum_{j=0}^{\infty} a_j^2 \sigma$ as $j \rightarrow \infty$

VARIANCE RATIOS FOR CONSUMPTION GROWTH

- Cochrane (1988) advocated using variance ratios:

$$VR_{i,k} = \frac{1}{k} \frac{\text{var}(Y_{i,t} - Y_{i,t-k})}{\text{var}(Y_{i,t} - Y_{i,t-1})}$$

VARIANCE RATIOS FOR CONSUMPTION GROWTH

- Cochrane (1988) advocated using variance ratios:

$$VR_{i,k} = \frac{1}{k} \frac{\text{var}(Y_{i,t} - Y_{i,t-k})}{\text{var}(Y_{i,t} - Y_{i,t-1})}$$

- Random walk: $VR_{i,k} = 1$ for all k
- Trend stationary: $VR_{i,k} \rightarrow 0$ as $k \rightarrow \infty$
- Positively autocorrelated growth: $VR_{i,k} > 1$ for large k

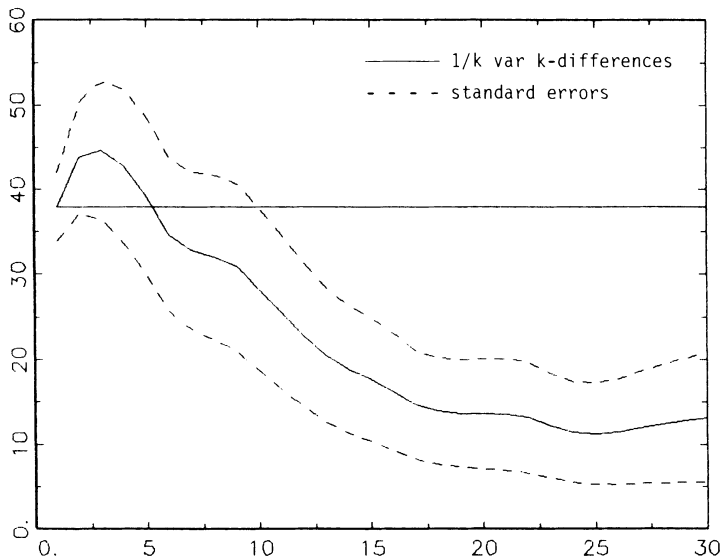


FIG. 1.— $1/k$ times the variance of k -differences of log real per capita GNP, 1869–1986, with asymptotic standard errors.

- Extends Cochrane's estimation approach to 9 OECD countries for 1871-1985
- Critiques small sample properties of Cochrane's asymptotic standard errors

Log Per Capita Consumption in France

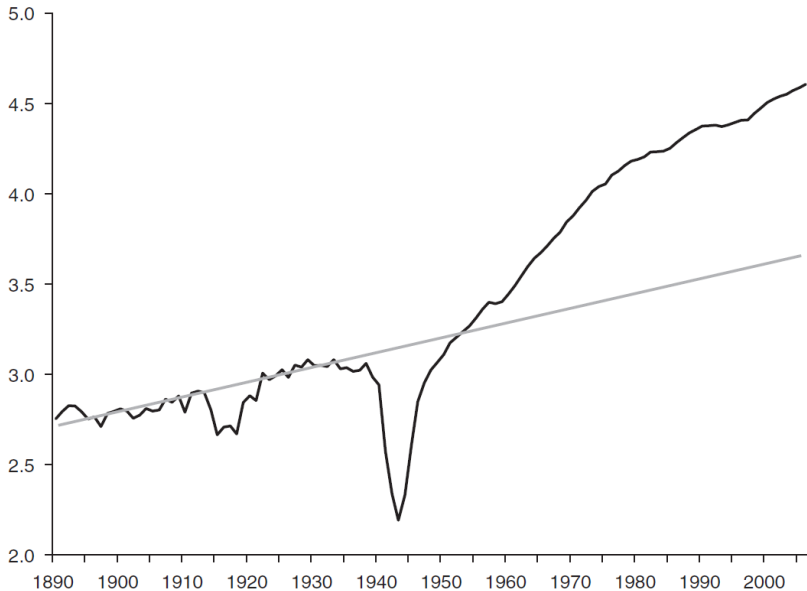


TABLE 2
ESTIMATES OF THE VARIANCE RATIO: PER CAPITA OUTPUT GROWTH, 1871–1985

	\hat{V}^f		\hat{V}^*	
	$k = 15$	$k = 20$	$k = 15$	$k = 20$
Australia	1.15 (.63, 3.2)	1.21 (.64, 4.1)	1.25	1.40
Canada	.64 (.35, 1.8)	.64 (.34, 2.2)	.72	.77
Denmark	.92 (.51, 2.6)	.97 (.51, 3.3)	1.00	1.09
France	1.57 (.86, 4.4)	1.55 (.82, 4.9)	1.78	1.84
Italy	1.60 (.88, 4.5)	1.80 (.96, 6.1)	1.75	2.02
Norway	1.21 (.67, 3.4)	1.39 (.74, 4.7)	1.24	1.39
Sweden	.90 (.50, 2.5)	.89 (.47, 3.0)	.99	.97
United Kingdom	.77 (.43, 2.2)	.85 (.45, 2.9)	.94	1.03
United States:				
GDP	.48 (.27, 1.4)	.36 (.19, 1.2)	.62	.51
GNP	.49 (.27, 1.4)	.41 (.22, 1.4)	.60	.53

NOTE.—Approximate 90 percent confidence intervals are shown in parentheses

TABLE 4
CORRELATIONS OF ANNUAL AND LONG-TERM GROWTH, 1871–1985

	Australia	Canada	Denmark	France	Italy	Norway	Sweden	United Kingdom	United States
Australia	1.0	.25	-.11	-.05	.17	-.10	.10	.35	.20
Canada	.50	1.0	-.04	-.11	.13	-.01	.07	.33	.40
Denmark	.18	-.05	1.0	.44	.16	.41	.42	-.16	.01
France	.17	-.08	.87	1.0	.45	.44	.24	-.04	-.28
Italy	.34	.01	.71	.77	1.0	.11	.01	.28	-.05
Norway	.25	-.11	.57	.71	.65	1.0	.53	.01	-.09
Sweden	.21	-.13	.68	.78	.60	.52	1.0	.05	.15
United Kingdom	.43	.33	.24	-.17	.38	.26	.29	1.0	.36
United States	.28	.60	-.21	-.29	-.26	-.27	-.18	.24	1.0

NOTE.—The values above the diagonal are the correlations of yearly output growth across countries. The values below the diagonal are coherencies at frequency zero, which are equal to the correlations of long growth cycles across countries.

WELFARE GAINS FROM STABILIZATION POLICY

- Robert Lucas' thought experiment
- Macroeconomic Priorities (Lucas, 2003)
- Famously led Lucas to stop working on business cycles and start working on growth

WELFARE GAINS FROM STABILIZATION POLICY

- Imagine that we could magically eliminate all consumption variation around trend
- Consumer's stochastic consumption stream:

$$c_t = A e^{\mu t} e^{-(1/2)\sigma^2} \epsilon_t$$

- $\log(\epsilon_t) \sim N(0, \sigma^2)$ implies useful fact:

$$E(e^{-(1/2)\sigma^2} \epsilon_t) = 1$$

- Consumer's utility function

$$E \left\{ \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\gamma}}{1-\gamma} \right\}$$

- β is subjective discount factor, γ coefficient of risk aversion

WELFARE GAINS FROM STABILIZATION POLICY

$$E \left\{ \sum_{t=0}^{\infty} \beta^t \frac{((1 + \lambda)c_t)^{1-\gamma}}{1 - \gamma} \right\} = \sum_{t=0}^{\infty} \beta^t \frac{(Ae^{\mu t})^{1-\gamma}}{1 - \gamma}$$

$$\lambda \simeq \frac{1}{2} \gamma \sigma^2$$

- For 1947-2001, the standard deviation of the log of U.S. real, per capita consumption about a linear trend: 0.032.
- Estimates of γ from macro and public finance: 1-4

$$\lambda = \frac{1}{2} (0.032)^2 = 0.0005$$

WELFARE GAINS FROM STABILIZATION POLICY

- Conclusion: Welfare gains from stabilization policy are trivial.
- Is this convincing?

WELFARE GAINS FROM STABILIZATION POLICY

- Conclusion: Welfare gains from stabilization policy are trivial.
- Is this convincing?
 - Trend vs. difference stationary consumption
 - Disasters, long-run risks
 - Uninsurable risks
 - Inequality and heterogeneity

Deeply connected to “equity premium puzzle”

DIGRESSION: CONSUMPTION BASED ASSET PRICING

- Consumption based asset pricing starts from the Consumption Euler equation:

$$U'(C_t) = \beta E_t[(1 + R_{i,t+1})U'(C_{t+1})]$$

- A little manipulation yields:

$$1 = E_t \left[(1 + R_{i,t+1}) \frac{\beta U'(C_{t+1})}{U'(C_t)} \right]$$

$$1 = E_t[(1 + R_{i,t+1})M_{t+1}]$$

- where M_{t+1} is call the stochastic discount factor

- Now suppose that

$$U(C_t) = \frac{C_t^{1-\gamma} - 1}{1-\gamma}$$

- This implies:

$$U'(C_t) = C_t^{-\gamma}$$

$$M_{t+1} = \frac{\beta U'(C_{t+1})}{U'(C_t)} = \beta \left(\frac{C_{t+1}}{C_t} \right)^{-\gamma}$$

EULER EQUATION WITH POWER UTILITY

$$1 = E_t[(1 + R_{i,t+1})M_{t+1}]$$

$$1 = E_t[(1 + R_{i,t+1})]^\beta \left(\frac{C_{t+1}}{C_t} \right)^{-\gamma}$$

Taking logs and assuming log-normality:

$$0 = E_t r_{i,t+1} + \log \beta - \gamma E_t \Delta C_{t+1} + \frac{1}{2} [\sigma_i^2 + \gamma^2 \sigma_c^2 - 2\gamma \sigma_{ic}]$$

And for risk-free rate:

$$0 = r_{f,t+1} + \log \beta - \gamma E_t \Delta C_{t+1} + \frac{1}{2} \gamma^2 \sigma_c^2$$

Combining these last two yields:

$$E_t r_{i,t+1} - r_{f,t+1} + \frac{1}{2} \sigma_i^2 = \gamma \sigma_{ic}$$

$$E_t r_{i,t+1} - r_{f,t+1} + \frac{1}{2} \sigma_i^2 = \gamma \sigma_{ic}$$

- Equity premium is a function of covariance between consumption growth and return on equity
- What is the intuition for this?

$$E_t r_{i,t+1} - r_{f,t+1} + \frac{1}{2} \sigma_i^2 = \gamma \sigma_{ic}$$

Suppose equity returns and consumption growth are perfectly correlated:

$$E_t r_{i,t+1} - r_{f,t+1} + \frac{1}{2} \sigma_i^2 = \gamma \sigma_i \sigma_c$$

Table 5
The equity premium puzzle^a

Country	Sample period	\overline{aer}_e	$\sigma(er_e)$	$\sigma(m)$	$\sigma(\Delta c)$	$\rho(er_e, \Delta c)$	$\text{Cov}(er_e, \Delta c)$	RRA(1)	RRA(2)
USA	1947.2–1996.3	7.852	15.218	51.597	1.084	0.193	3.185	246.556	47.600
AUL	1970.1–1996.2	3.531	23.194	15.221	2.142	0.156	7.725	45.704	7.107
CAN	1970.1–1996.2	3.040	16.673	18.233	2.034	0.159	5.387	56.434	8.965
FR	1973.2–1996.2	7.122	22.844	31.175	2.130	-0.047	-2.295	< 0	14.634
GER	1978.4–1996.2	6.774	20.373	33.251	2.495	0.039	1.974	343.133	13.327
ITA	1971.2–1995.2	2.166	27.346	7.920	1.684	0.002	0.088	2465.323	4.703
JPN	1970.2–1996.2	6.831	21.603	31.621	2.353	0.100	5.093	134.118	13.440
NTH	1977.2–1996.1	9.943	15.632	63.607	2.654	0.023	0.946	1050.925	23.970
SWD	1970.1–1994.4	9.343	23.541	39.688	1.917	0.003	0.129	7215.176	20.705
SWT	1982.2–1996.2	12.393	20.466	60.553	2.261	-0.129	-5.978	< 0	26.785
UK	1970.1–1996.2	8.306	21.589	38.473	2.589	0.095	5.314	156.308	14.858
USA	1970.1–1996.3	5.817	16.995	34.228	0.919	0.248	3.875	150.136	37.255
SWD	1920–1993	6.000	18.906	31.737	2.862	0.169	9.141	65.642	11.091
UK	1919–1993	8.677	21.706	39.974	2.820	0.355	21.738	39.914	14.174
USA	1891–1994	6.258	18.534	33.767	3.257	0.497	30.001	20.861	10.366

^a \overline{aer}_e is the average excess log return on stock over a money market instrument, plus one half the variance of this excess return: $\overline{aer}_e = \overline{r_e - r_f} + \sigma^2(r_e - r_f)/2$. It is multiplied by 400 in quarterly data and 100 in annual data to express in annualized percentage points. $\sigma(er_e)$ and $\sigma(\Delta c)$ are the standard deviations of the excess log return $er_e = r_e - r_f$ and consumption growth Δc , respectively, multiplied by 200 in quarterly data and 100 in annual data to express in annualized percentage points. $\sigma(m) = 100\overline{aer}_e/\sigma(er_e)$ is calculated from equation (12) as a lower bound on the standard deviation of the log stochastic discount factor, expressed in annualized percentage points. $\rho(er_e, \Delta c)$ is the correlation of er_e and Δc . $\text{Cov}(er_e, \Delta c)$ is the product $\sigma(er_e)\sigma(\Delta c)\rho(er_e, \Delta c)$. RRA(1) is $100\overline{aer}_e/\text{Cov}(er_e, \Delta c)$, a measure of risk aversion calculated from equation (16) using the empirical covariance of excess stock returns with consumption growth. RRA(2) is $100\overline{aer}_e/\sigma(er_e)\sigma(\Delta c)$, a measure of risk aversion calculated using the empirical standard deviations of excess stock returns and consumption growth, but assuming perfect correlation between these series.

Abbreviations: AUL, Australia; CAN, Canada; FR, France; GER, Germany; ITA, Italy; JPN, Japan; NTH, Netherlands; SWD, Sweden; SWT, Switzerland; UK, United Kingdom; USA, United States of America.

Table 5 Long-Period Averages of Rates of Return						
Country	Start	Stocks	Bills	Start	Bonds	Bills
Part 1: OECD countries						
Australia	1876	0.1027 (0.1616)	0.0126 (0.0566)	1870	0.0352 (0.1157)	0.0125 (0.0569)
Belgium	--	--	--	1870	0.0291 (0.1584)**	0.0179 (0.1447)**
Canada	1916	0.0781 (0.1754)	--	1916	0.0392 (0.1199)	--
Denmark	1915	0.0750 (0.2300)	0.0265 (0.0652)	1870	0.0392 (0.1137)	0.0317 (0.0588)
Finland	1923	0.1268 (0.3155)	0.0128 (0.0935)	--	--	--
France	1870	0.0543 (0.2078)*	-0.0061 (0.0996)*	1870	0.0066 (0.1368)	-0.0079 (0.1000)
Germany	1870	0.0758 (0.2976)	-0.0153 (0.1788)	1924	0.0402 (0.1465)	0.0158 (0.1173)
Italy	1906	0.0510 (0.2760)	-0.0112 (0.1328)	1870	0.0173 (0.1879)	0.0046 (0.1191)
Japan	1894	0.0928 (0.3017)	-0.0052 (0.1370)	1883	0.0192 (0.1820)	0.0043 (0.1475)
Netherlands	1920	0.0901 (0.2116)**	0.0114 (0.0474)**	1881	0.0308 (0.1067)	0.0118 (0.0512)
New Zealand	1927	0.0762 (0.2226)	0.0234 (0.0529)	1926	0.0276 (0.1209)	0.0240 (0.0529)
Norway	1915	0.0716 (0.2842)	0.0098 (0.0782)	1877	0.0280 (0.1130)	0.0204 (0.0709)
Spain	1883	0.0610 (0.2075)†	0.0173 (0.0573)†	--	--	--
Sweden	1902	0.0923 (0.2347)	0.0180 (0.0719)	1922	0.0292 (0.0941)	0.0176 (0.0448)
Switzerland	1911	0.0726 (0.2107)††	0.0083 (0.0531)††	1916	0.0218 (0.0717)	0.0065 (0.0545)
U.K.	1870	0.0641 (0.1765)	0.0179 (0.0624)	1870	0.0280 (0.1049)	0.0179 (0.0624)
U.S.	1870	0.0827 (0.1866)	0.0199 (0.0482)	1870	0.0271 (0.0842)	0.0199 (0.0482)
Part 2: Non-OECD countries						
Chile	1895	0.1430 (0.4049)	-0.0094 (0.1776)	--	--	--
India	1921	0.0514 (0.2341)***	0.0133 (0.0835)***	1874	0.0191 (0.1147)	0.0240 (0.0785)
South Africa	1911	0.0890 (0.2006)	--	1911	0.0248 (0.1165)	--
Overall means†††	--	0.0814 (0.2449)	0.0085 (0.0880)	--	0.0266 (0.1234)	0.0147 (0.0805)

*missing 1940-41, **missing 1945-46, †missing 1936-40, ††missing 1914-16, ***missing 1926-27

†††Averages of means and standard deviations for 17 countries with stock and bill data and 15 countries with bond and bill data

- Volatility of consumption seems to be relatively modest
- World seems to be a relatively safe place
- People must be very risk averse to not want to bid up prices of stocks

- Consider the following gamble: I flip a coin and ...
 - If it comes up heads, I multiply your lifetime income by 1 million
 - If it comes up tails, I reduce your lifetime income by 10%

- Consider the following gamble: I flip a coin and ...
 - If it comes up heads, I multiply your lifetime income by 1 million
 - If it comes up tails, I reduce your lifetime income by 10%
- If you accept, your CRRA is less than 10

- Consider the following gamble: I flip a coin and ...
 - If it comes up heads, I multiply your lifetime income by 1 million
 - If it comes up tails, I reduce your lifetime income by 10%
- If you accept, your CRRA is less than 10
- What about 20% reduction? If yes, $\text{CRRA} < 5$

- Consider the following gamble: I flip a coin and ...
 - If it comes up heads, I multiply your lifetime income by 1 million
 - If it comes up tails, I reduce your lifetime income by 10%
- If you accept, your CRRA is less than 10
- What about 20% reduction? If yes, $CRRA < 5$
- What about 30% reduction? If yes, $CRRA < 3$

- Consider the following gamble: I flip a coin and ...
 - If it comes up heads, I multiply your lifetime income by 1 million
 - If it comes up tails, I reduce your lifetime income by 10%
- If you accept, your CRRA is less than 10
- What about 20% reduction? If yes, $CRRA < 5$
- What about 30% reduction? If yes, $CRRA < 3$
- What about 50% reduction? If yes, $CRRA < 2$

Empirical observation:

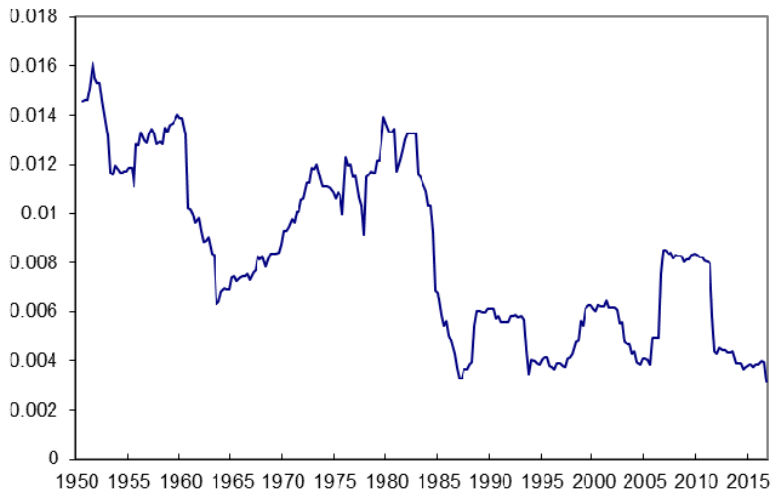
- Rolling window quarterly standard deviation of output shows sharp drop in 1984!

Note: This is the “classic” graph but perhaps it is misleading (more on this later...)

Early papers:

- McConnell and Perez-Quiros (2000)
- Blanchard and Simon (2001)
- Stock and Watson (2002))

Twenty Quarter St.Dev. of Real GDP Growth



EARLY WORK: MCCONNELL AND PEREZ-QUIROS (2000)

- Sharp decline in volatility in 1984Q1
- Possible hypotheses:
 - Shift toward service sector
 - Better monetary policy
- But largest declines in durable goods: production but not sales (i.e. role of inventories)
 - Conclude that inventory management was important

McCONNELL AND PEREZ-QUIROS (2000)

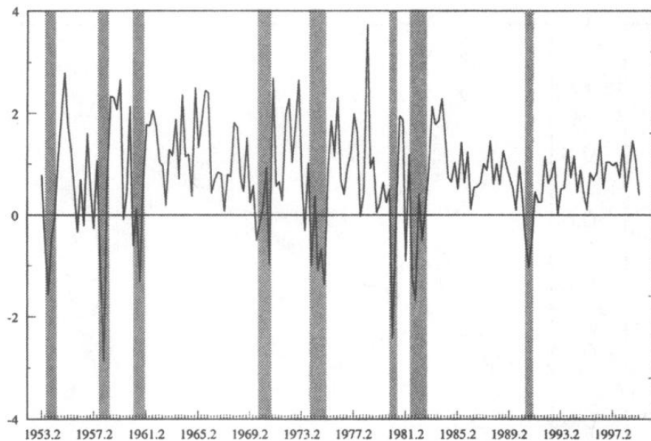


FIGURE 1. U.S. REAL GDP GROWTH: 1953:2 TO 1999:2

- Longer-term trend in volatility over the twentieth century
- Confounding factors:
 - World Wars
 - Much more volatile data before modern national accounts (Romer (1986))
- Nevertheless, it appears there has been a “long and large decline” in macro volatility over the post-WWII period
 - Exact timing varies across countries

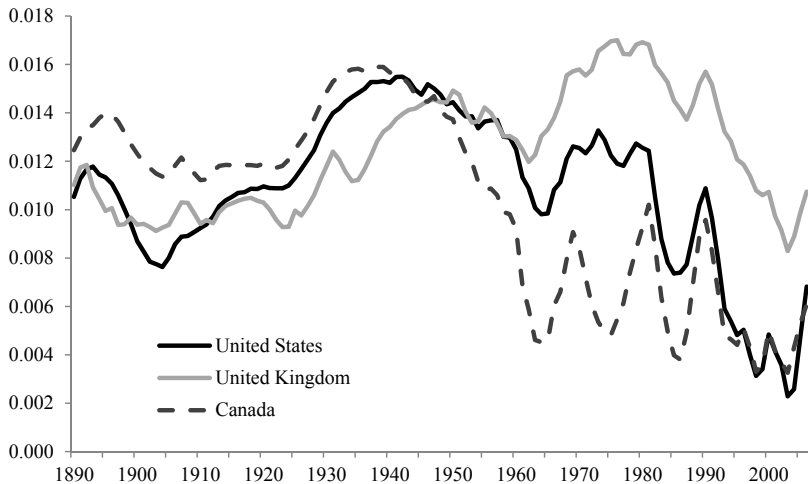


FIGURE IV
Stochastic Volatility for the United States, the United Kingdom and Canada

Figure from Nakamura et al. (2013)

Comprehensive view of the evidence:

- Broad decline in volatility across sectors
- Associated with declines in conditional variances, not means (based on ARIMA type model)
- Break rather than trend
 - Formally test for break date (as in Bai, Lumsdaine, Stock, 1998)
- Break date around 1984
- Much less support for “inventories” view when focusing on annual data

Table 7 STANDARD DEVIATIONS OF GROWTH OF PRODUCTION, SALES, AND INVENTORIES

Series	One-quarter growth			Four-quarter growth		
	$S_{1960-1983}$	$S_{1984-2001}$	$S_{1984-2001}/S_{1960-1983}$	$S_{1960-1983}$	$S_{1984-2001}$	$S_{1984-2001}/S_{1960-1983}$
	GDP	4.32	2.18	.51	2.71	1.59
Total goods:						
Production	7.78	4.58	.59	4.12	2.87	.70
Sales	5.14	3.93	.76	3.05	2.01	.66
$\Delta I/\text{sales}$	6.22	4.50	.72	2.09	1.95	.94
Durable goods:						
Production	17.25	8.06	.47	8.46	5.28	.62
Sales	9.86	7.83	.79	5.67	3.67	.65
$\Delta I/\text{sales}$	12.10	8.17	.68	4.15	3.15	.76
Nondurable goods:						
Production	7.41	4.69	.63	2.96	1.81	.61
Sales	4.50	2.88	.64	2.35	1.41	.60
$\Delta I/\text{sales}$	6.55	3.97	.61	1.89	1.59	.84
Services production	1.71	1.38	.81	1.18	0.80	.68
Structures production	11.80	6.71	.57	7.16	4.79	.67

Notes: $S_{1960-1983}$ denotes the standard deviation computed using the 1960-1983 data, etc. One-quarter growth rates are computed as $400\ln(X_t/X_{t-1})$, where X_t is sales (etc.), except for $\Delta I/\text{sales}$, which is computed as 400 times its quarterly first difference ($400\Delta X_t$). Four-quarter growth rates are computed as $100\ln(X_t/X_{t-4})$, except for $\Delta I/\text{sales}$, which is computed as 100 times its fourth difference [$100(X_t - X_{t-4})$].

WHY DID THE GREAT MODERATION OCCUR?

Stock and Watson consider several hypotheses

- Inventories (McConnell and Perez-Quiros, 2000)
 - But little evidence in annual (as opposed to quarterly) data
- Sectoral Shift to less volatile service sector
 - Not large enough (but ignores feedback)
- Weaker propagation of shocks
 - Inconsistent with VAR evidence (see next slide)
- Changes in residential housing market
 - Big drop in volatility and changes in institutions, but occurred gradually!
 - Might be a candidate

What is left? Smaller shocks!

STOCK AND WATSON: SHOCKS NOT PROPAGATION!

Table 5 IMPLIED STANDARD DEVIATIONS OF FOUR-QUARTER GDP GROWTH FROM SUBSAMPLE VARs

$$X_t = \Phi(L)X_{t-1} + u_t, \quad \text{Var}(u_t) = \Sigma$$

First sample period: 1960–1983 [estimated parameters $\hat{\Phi}_1(L)$ and $\hat{\Sigma}_1$]

Second sample period: 1984–2001 [estimated parameters $\hat{\Phi}_2(L)$ and $\hat{\Sigma}_2$]

(a) Four-Variable Benchmark Specification [VAR(4) with GDP Growth, Change in Inflation, Federal Funds Rate, and the Growth Rate of Real Commodity Prices]

Variable	Sample standard deviation		Standard deviation of four-quarter GDP growth implied by the VAR			
	1960–1983	1984–2001	$\sigma(\hat{\Phi}_1, \hat{\Sigma}_1)$	$\sigma(\hat{\Phi}_2, \hat{\Sigma}_2)$	$\sigma(\hat{\Phi}_1, \hat{\Sigma}_2)$	$\sigma(\hat{\Phi}_2, \hat{\Sigma}_1)$
GDP growth	2.71	1.59	2.76	1.43	1.48	2.63
Inflation	1.49	0.59	1.52	0.57	0.95	0.92
Federal funds rate	2.64	1.47	2.67	1.48	1.35	3.03

- Identified productivity and commodity price shocks (20-30%)
- Changes in Monetary Policy (10-25%)
 - Change in Taylor rule
 - Estimate structural model, allowing Taylor rule to change
 - Lucas critique?
- Unknown sources of “Good Luck” (40-60%)
- Has our good luck ended?

- Argue for demographic explanation for Great Moderation
- Key insight: Population is aging in many countries
- ...And volatility of hours worked much higher for certain age groups
 - Consider age groups 15-19, 20-24, 25-29,...,60-64
 - U-shaped pattern in cyclical volatility by age

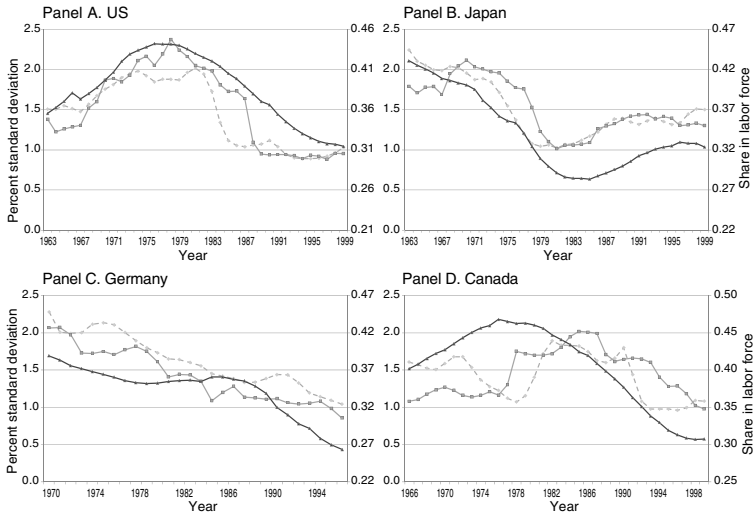


FIGURE 2. DEMOGRAPHICS AND BUSINESS CYCLE VOLATILITY, G7 COUNTRIES, PART 1

Notes: Dark, triangle-hatched line: volatile-age labor force share. Light, square-hatched line and light, dashed line: two measures of business cycle volatility. See text for detailed description of variables.