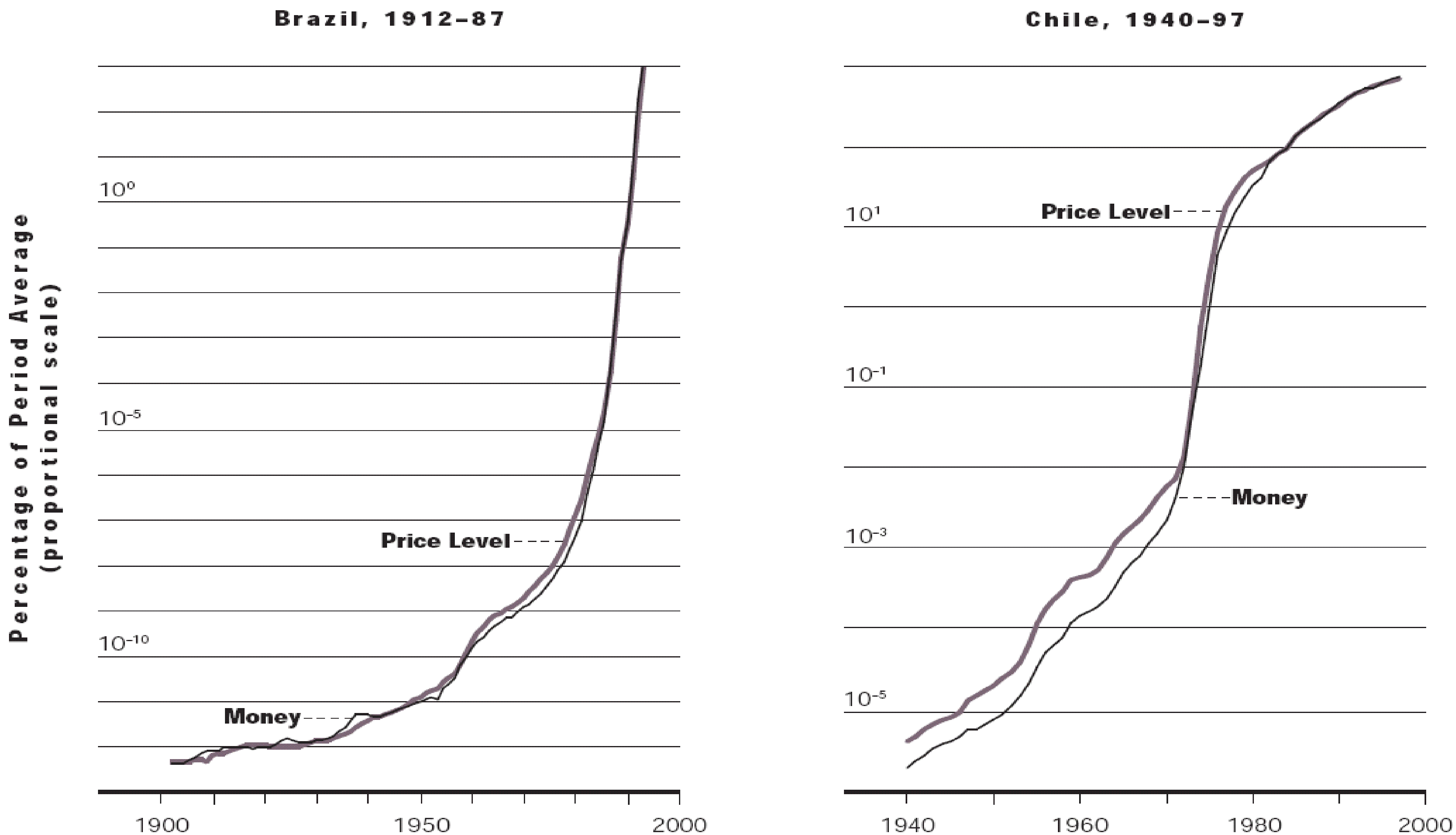
2. Observing Monetary Phenomena

John B. Taylor, April 29, 2013

Some Monetary Phenomena Are Easy to Observe



From Dwyer and Hafer FRB Atlanta, *Economic Review*, 2Q 1999

And Others Are Really Obvious To Everyone!

But more subtle facts are not so easy to uncover

- Time series analysis is needed
  - Stationarity, detrending
- Here we use
  - Multivariate time series
    - VARs, Impulse Responses, Granger Causality
  - Focus on relations between variables
  - Such as inflation, output or unemployment, and interest rate:

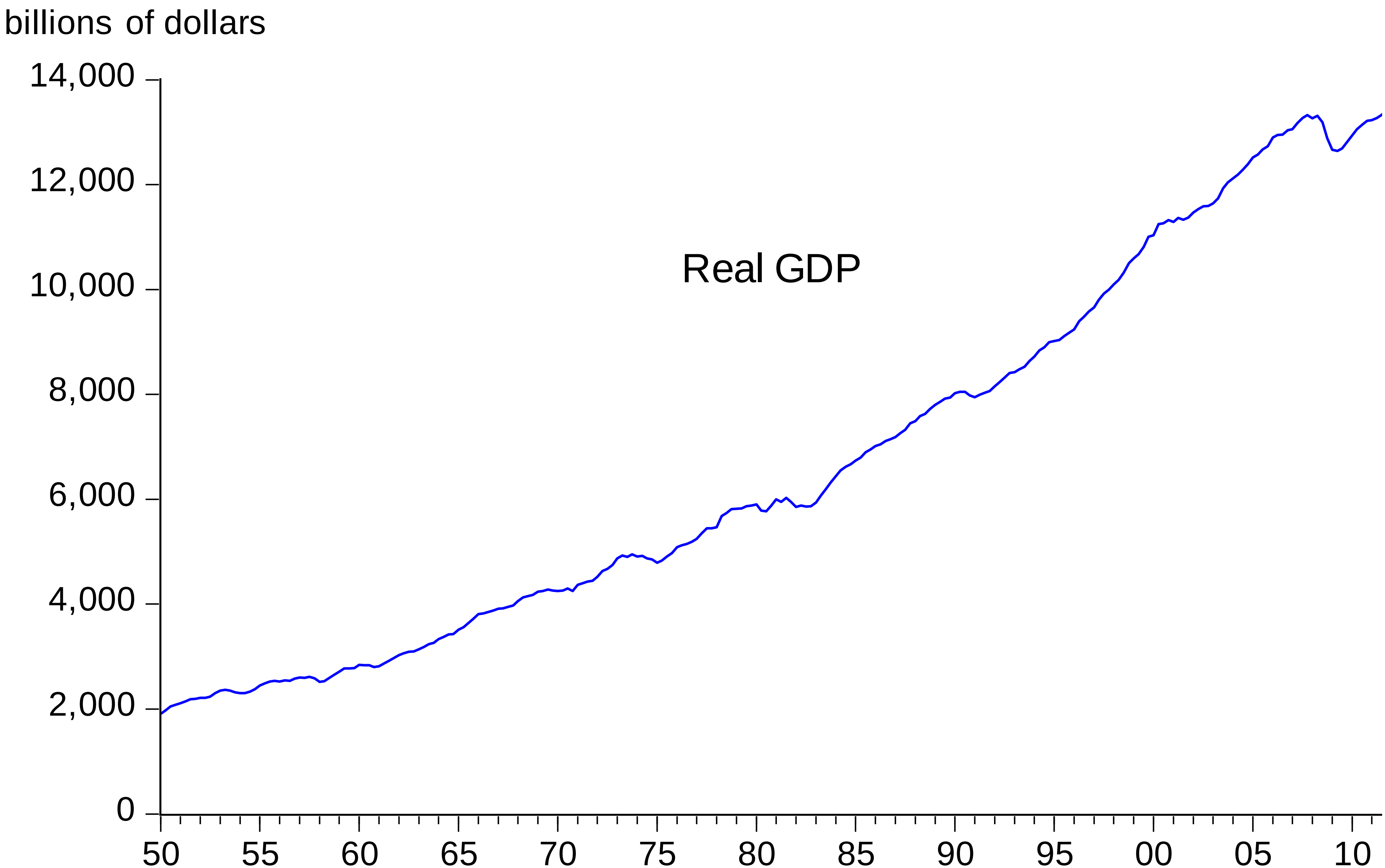
$$y_t = \begin{pmatrix} \pi_t \\ u_t \\ r_t \end{pmatrix}$$

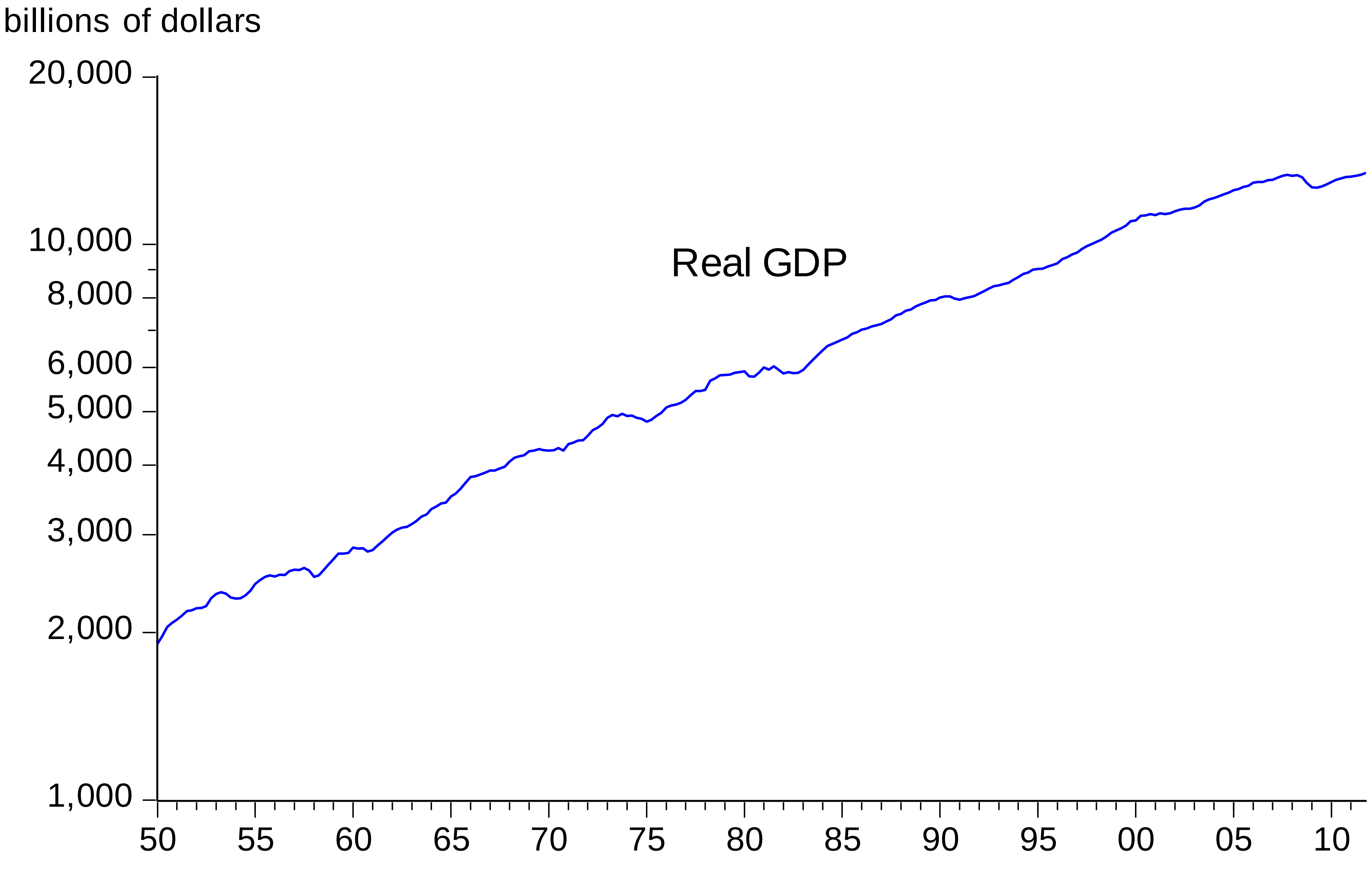
Recall alternative detrending methods to achieve stationarity

- First differencing
- Hodrick-Prescott filter

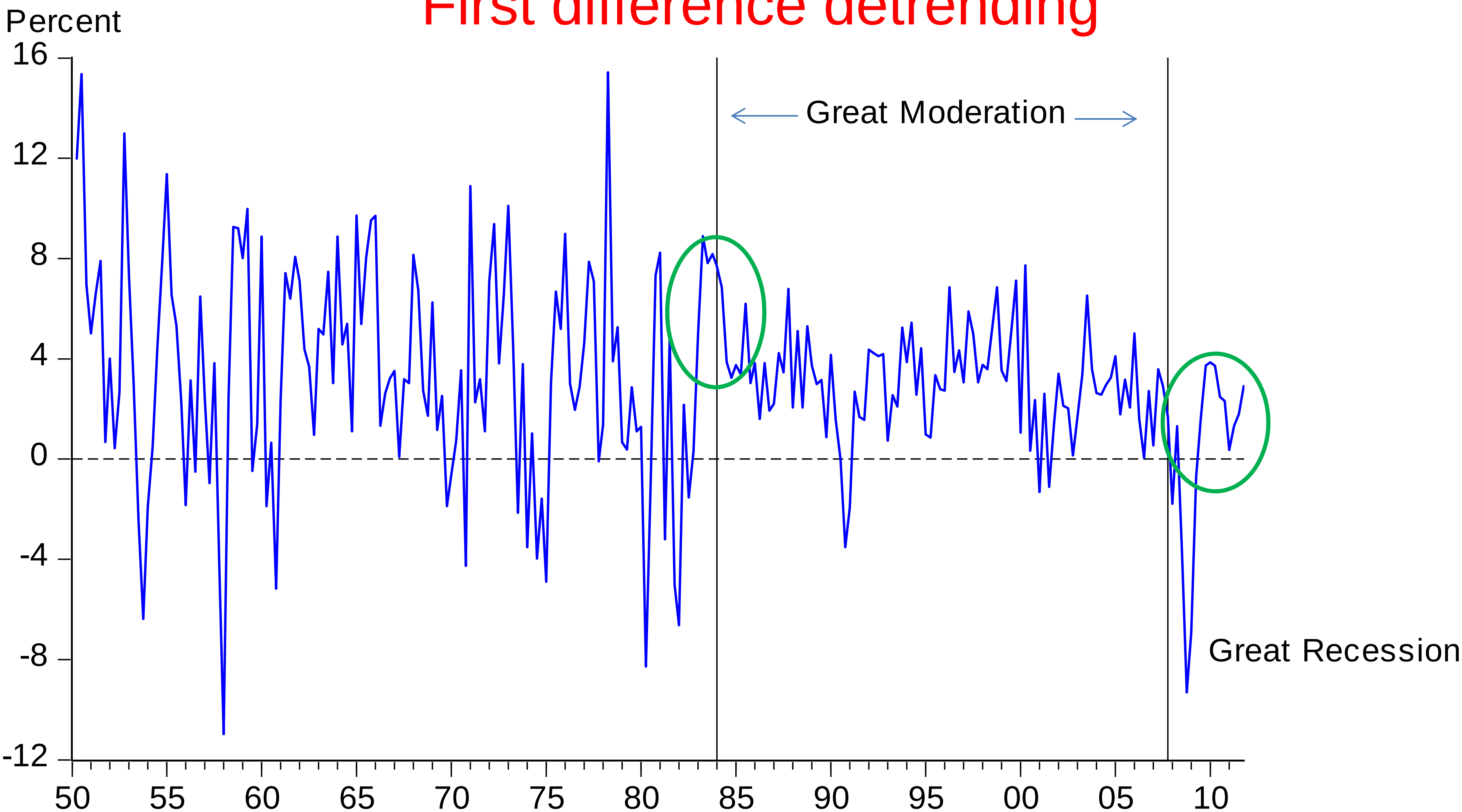
$$\sum_{t=1}^{T}(y_t - s_t)^2 + \lambda \sum_{t=2}^{T-1}((s_{t+1} - s_t) - (s_t - s_{t-1}))^2$$

- Use economics to estimate trend (CBO)

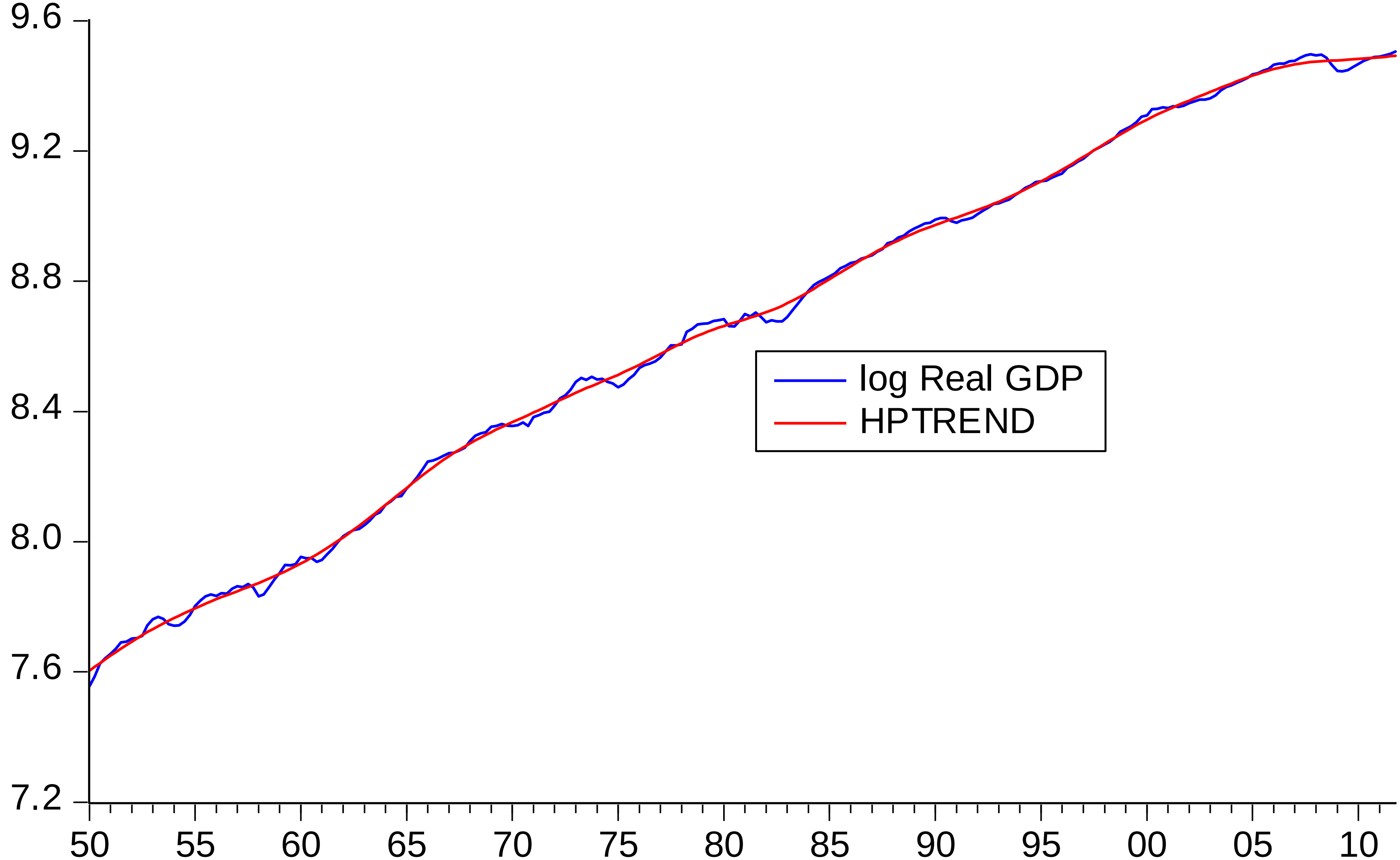

billions of dollars
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Real GDP
50
55
60
65
70
75
80
85
90
95
00
05
10

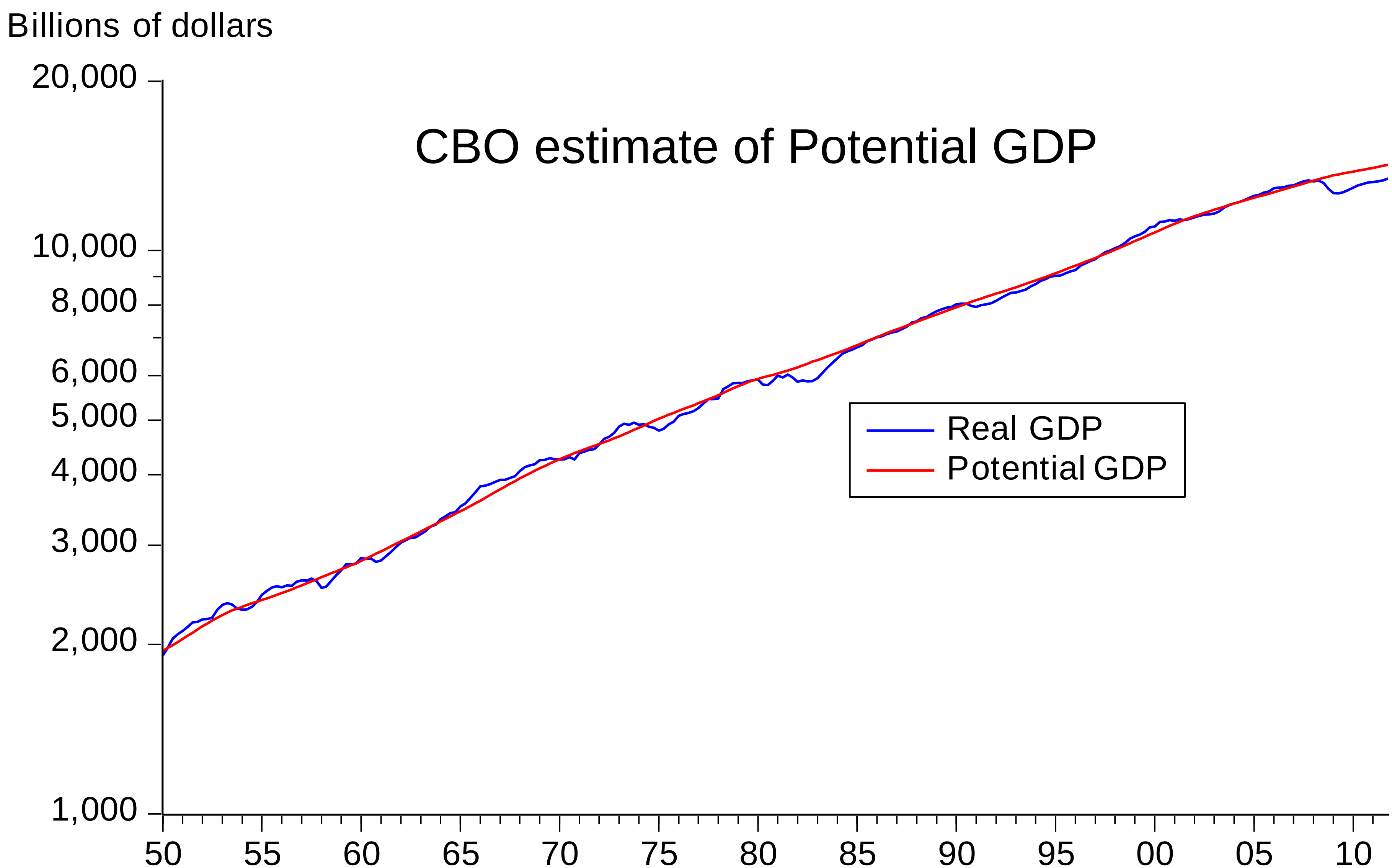

billions of dollars
20,000
10,000
8,000
6,000
5,000
4,000
3,000
2,000
1,000
Real GDP
50
55
60
65
70
75
80
85
90
95
00
05
10

First difference detrending

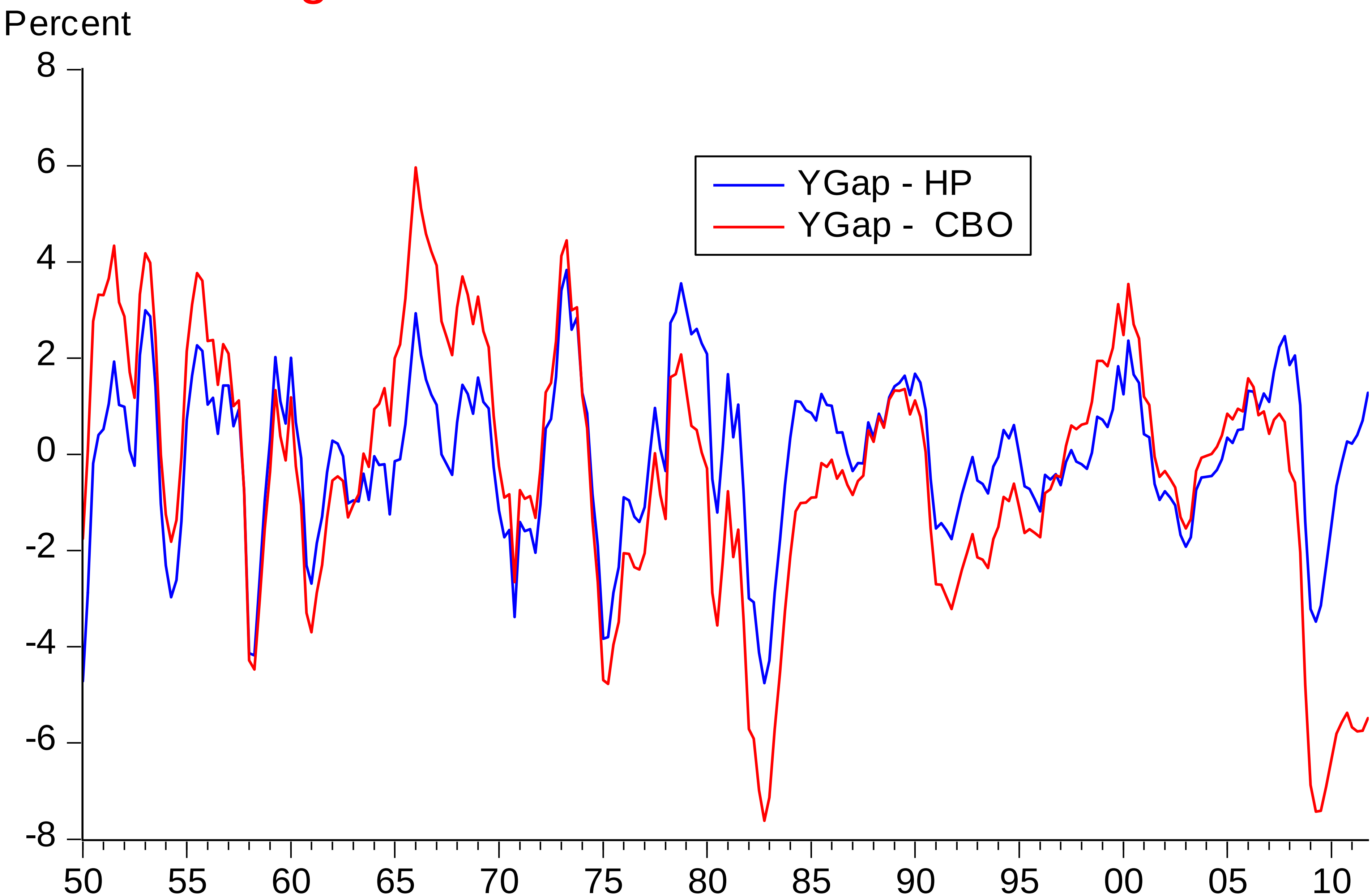


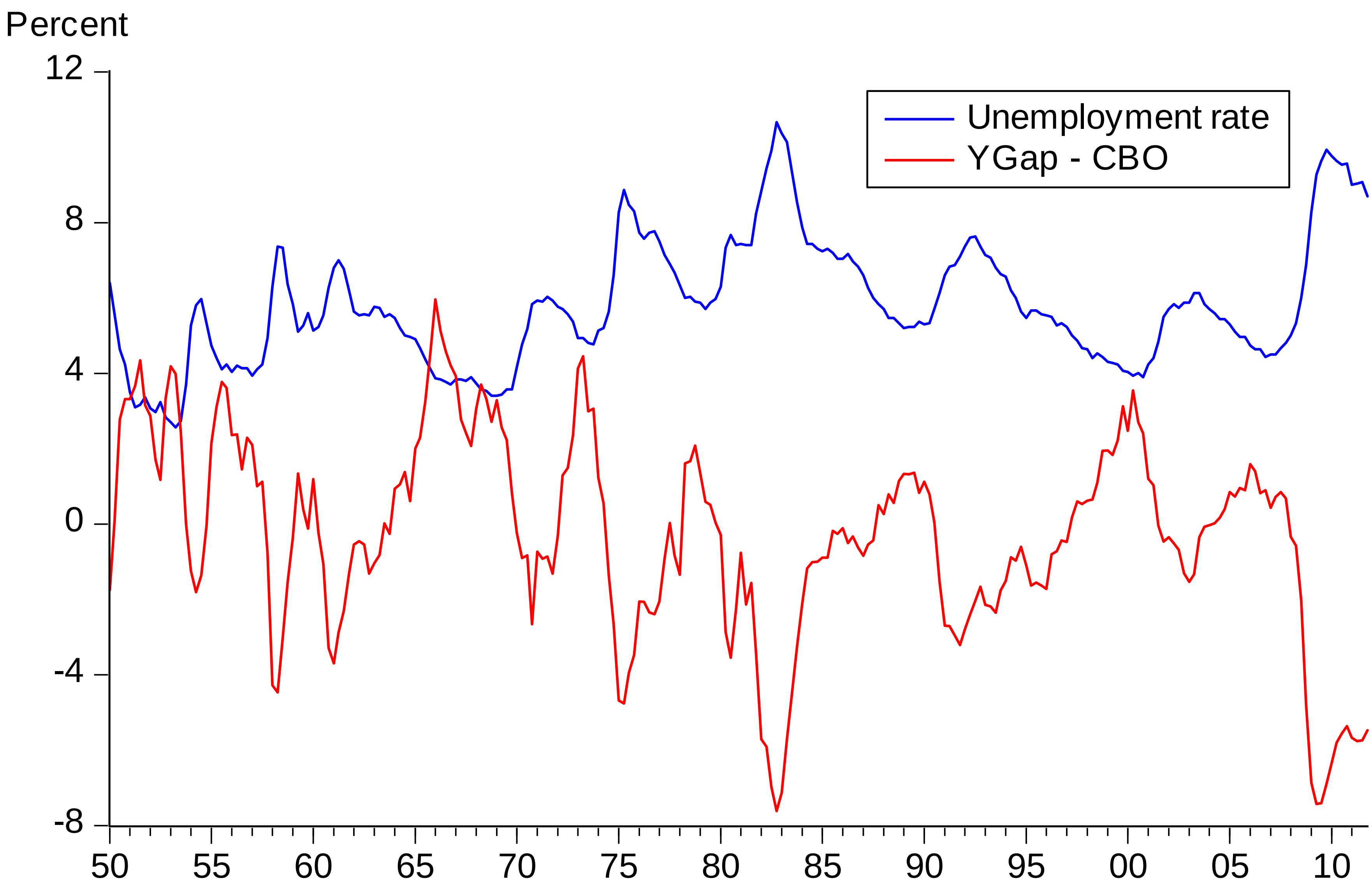
Growth rate of Real GDP

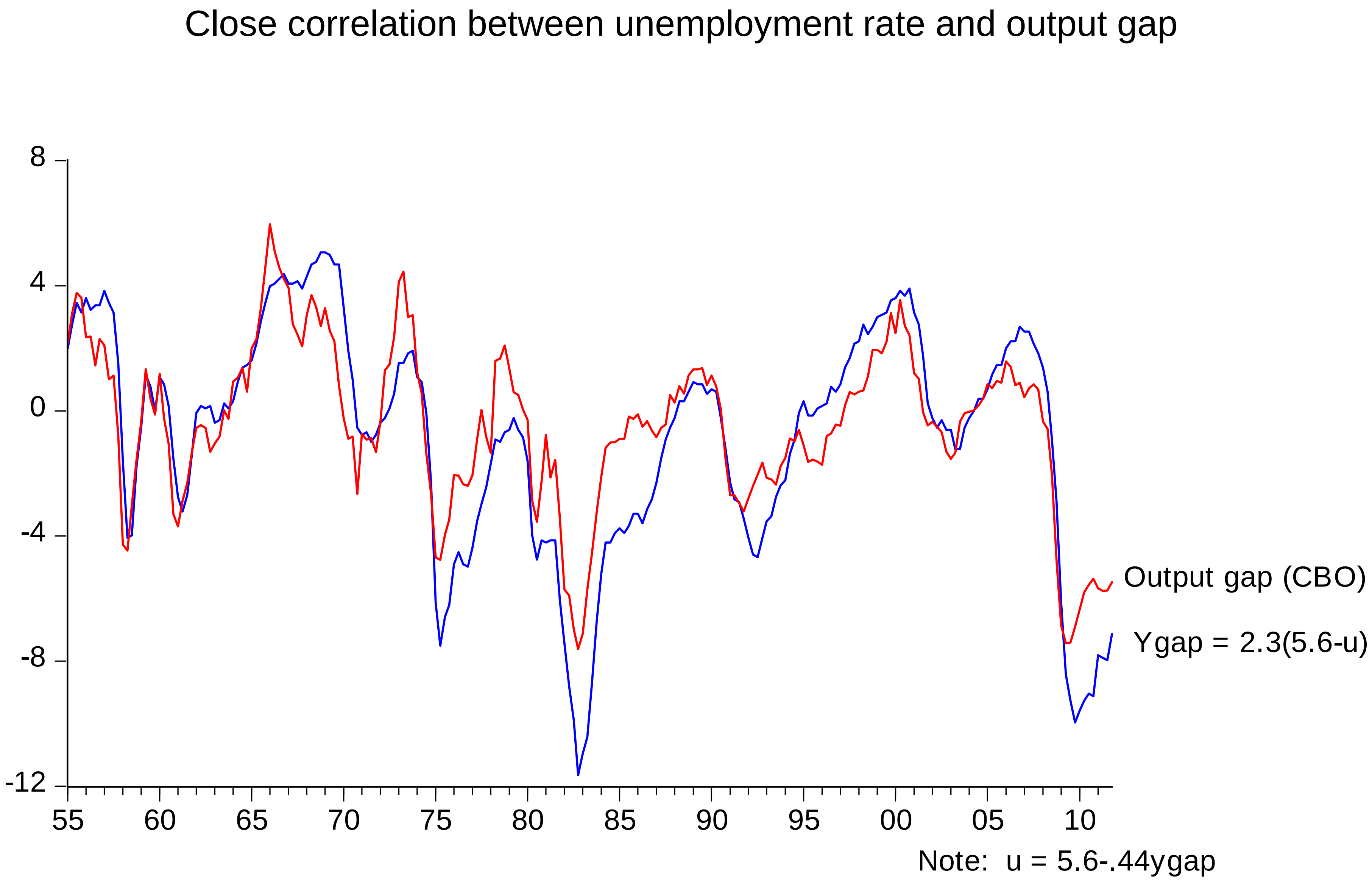

9.6
9.2
8.8
8.4
8.0
7.6
7.2
50
55
60
65
70
75
80
85
90
95
00
05
10
log Real GDP
HPTREND


Billions of dollars
CBO estimate of Potential GDP
20,000
10,000
8,000
6,000
5,000
4,000
3,000
2,000
1,000
50
55
60
65
70
75
80
85
90
95
00
05
10
Real GDP
Potential GDP

Note big differences between HP filter and CBO




Percent
12
8
4
0
-4
-8
50
55
60
65
70
75
80
85
90
95
00
05
10
Unemployment rate
YGap - CBO



Close correlation between unemployment rate and output gap
8
4
0
-4
-8
-12
55
60
65
70
75
80
85
90
95
00
05
10
Output gap (CBO)
Ygap = 2.3(5.6-u)
Note: u = 5.6-.44ygap

VARs and impulse response functions

$$VAR(1) \quad y_t = A_1 y_{t-1} + u_t \quad Eu_t = 0, Eu_t u_t^{'} = \Sigma, \quad Eu_t u_s^{'} = 0 \;\; for \;\; t \neq s$$

$$VAR(p) \quad y_t = A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-p} + u_t$$

Infinite MA (or impulse response function) :

$$y_t = u_t + \Theta_1 u_{t-1} + \Theta_2 u_{t-2} + \ldots$$

where Θ_i are functions of the $A's$

$Example \;\; for \; VAR(1) : \Theta_i = A_1^i$

$for \; VAR(2) : \Theta_1 = A_1, \Theta_2 = A_1 \Theta_1 + A_2, \Theta_i = A_1 \Theta_{i-1} + A_2 \Theta_{i-2}, i = 3,4,\ldots$

$A's$ can be estimated with OLS, and $\Theta's$ can then be calculated

Granger-causality

Consider two variables: π_t and y_t. Then

y is said to Granger – cause π if

$$\sigma^2_{prediction}(\pi_t \mid \pi_{t-1}, \pi_{t-2}, \dots y_{t-1}, y_{t-2}, \dots) < \sigma^2_{prediction}(\pi_t \mid \pi_{t-1}, \pi_{t-2}, \dots)$$

To show how to construct a test, consder a VAR

$$\pi_t = a_{11}\pi_{t-1} + a_{12}\pi_{t-2} + b_{11}y_{t-1} + b_{12}y_{t-2} + u_{1t}$$

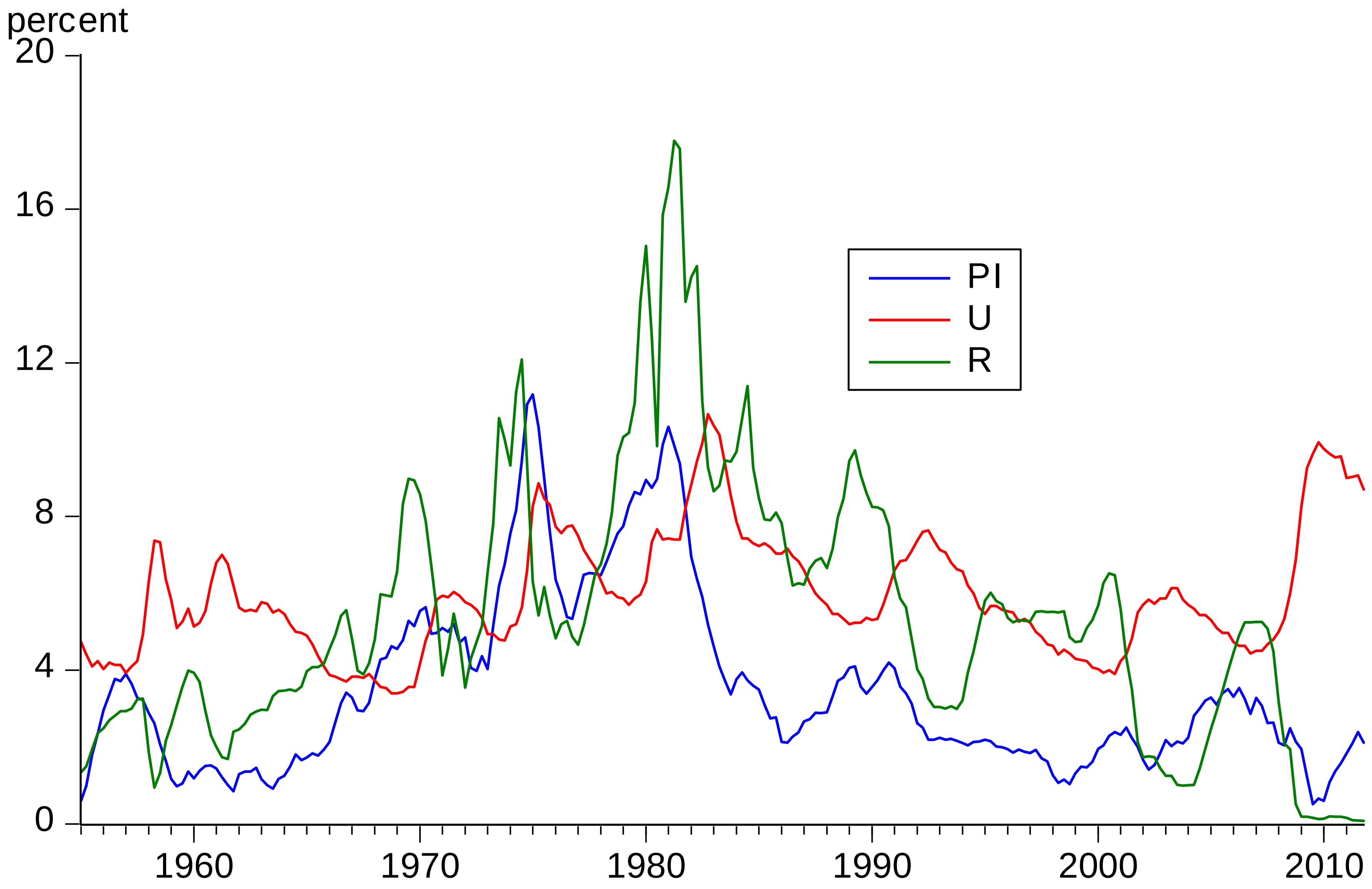
$$y_t = a_{21}\pi_{t-1} + a_{22}\pi_{t-2} + b_{21}y_{t-1} + b_{22}y_{t-2} + u_{2t}$$

and the null hypotheses:

$H_0 : b_{11} = b_{12} = 0 \Leftrightarrow y$ does not Granger cause π

$H_0 : a_{21} = a_{22} = 0 \Leftrightarrow \pi$ does not Granger cause y

which can be tested with F – statistics. Note that both can be rejected indicating that both variables Granger - cause the other.

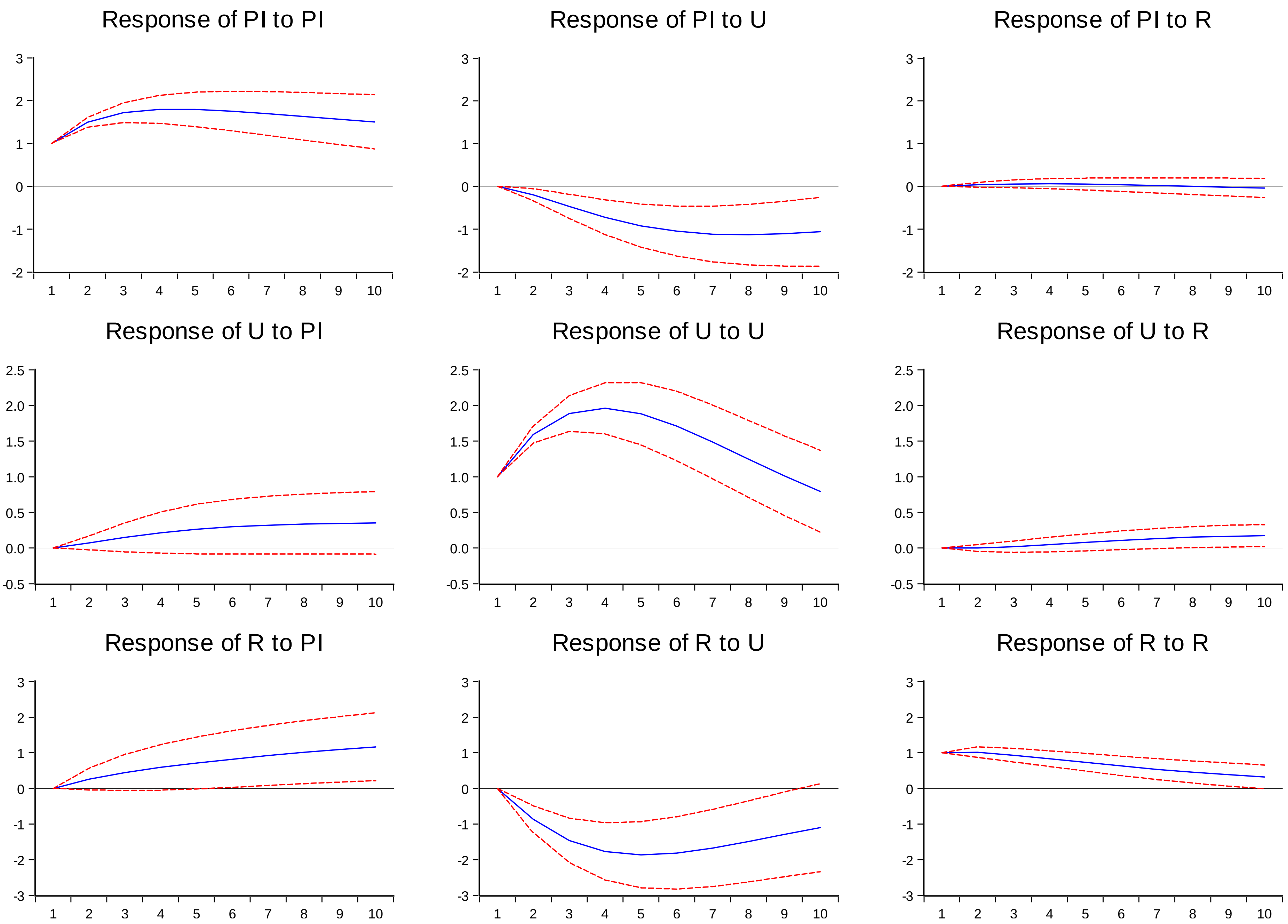

percent
20
16
12
8
4
0
PI
U
R
1960
1970
1980
1990
2000
2010

Vector Autoregression Estimates, (Eviews): 1955Q3 2011Q4 [t-value in brackets]

	PI	U	R
PI(-1)	1.493709	0.069717	0.257393
	[25.8660]	[1.42398]	[1.67973]
PI(-2)	-0.509598	-0.067106	-0.140108
	[-8.71516]	[-1.35366]	[-0.90300]
U(-1)	-0.197355	1.590920	-0.865766
	[-2.78772]	[26.5063]	[-4.60872]
U(-2)	0.170520	-0.633061	0.845529
	[2.45850]	[-10.7656]	[4.59412]
R(-1)	0.036667	-0.001178	1.013047
	[1.30057]	[-0.04930]	[13.5415]
R(-2)	-0.035442	0.017206	-0.103890
	[-1.27631]	[0.73085]	[-1.40992]
Const	0.212963	0.160966	0.211128
	[2.30893]	[2.05845]	[0.86264]

Impulse response functions (Eviews)

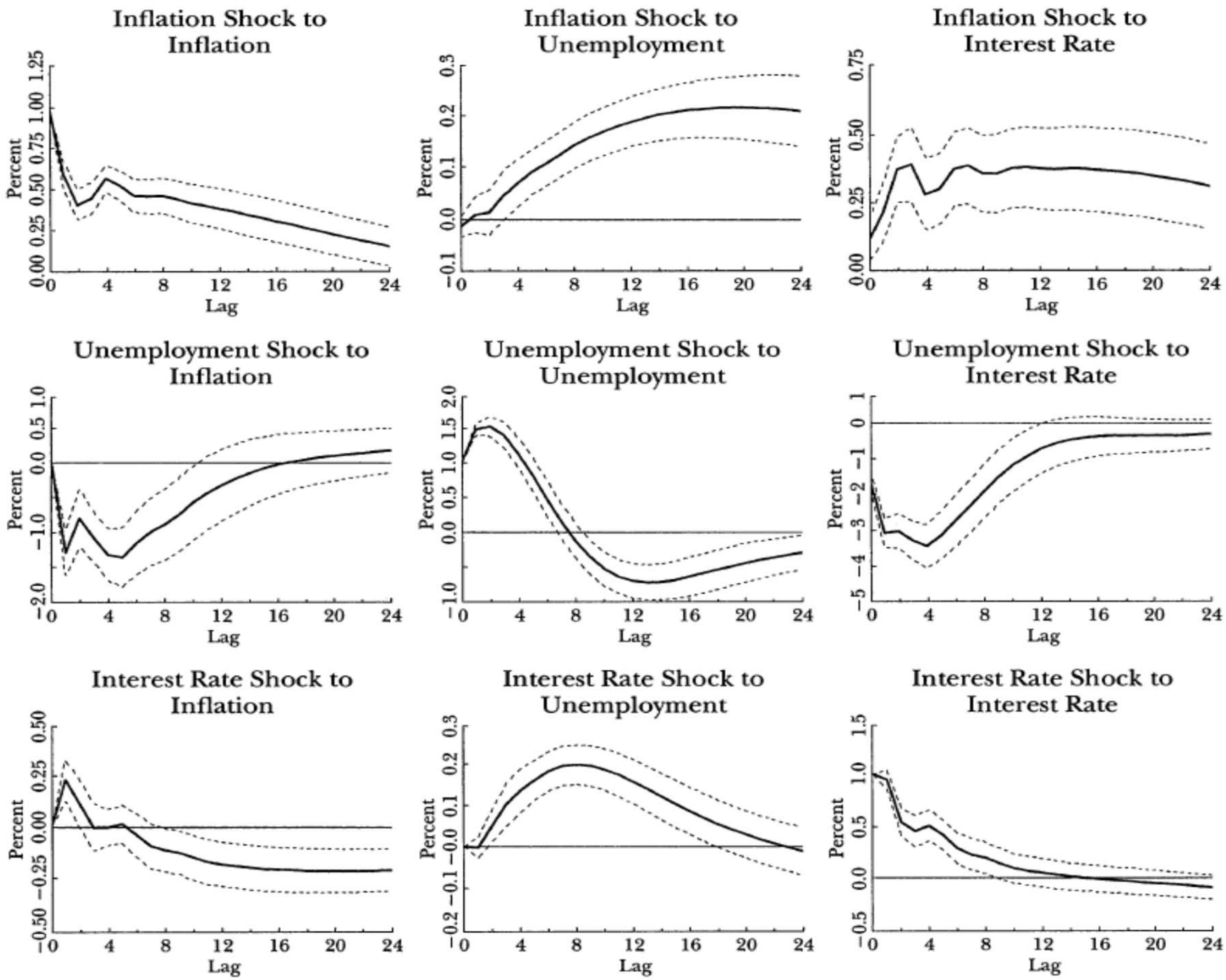
Response to Nonfactorized One Unit Innovations ± 2 S.E.



Granger Causality Tests; Sample: 1955Q1 - 2011Q4

Null Hypothesis:	Prob.
U does not Granger Cause PI	0.0002
PI does not Granger Cause U	0.0175
R does not Granger Cause PI	0.0093
PI does not Granger Cause R	0.0939
R does not Granger Cause U	0.0061
U does not Granger Cause R	0.0010

Impulse Responses in the Inflation-Unemployment-Interest Rate Recursive VAR



Source: Stock and Watson (2001)

Granger Causality

A. *Granger-Causality Tests*

	Dependent Variable in Regression		
Regressor	π	u	R
π	0.00	0.31	0.00
u	0.02	0.00	0.00
R	0.27	0.01	0.00

p - values are shown in the table

Source: Stock and Watson (2001)

Key Monetary Facts Revealed

- Strong dynamic correlation of each series
  - Diagonal elements of impulse response funtion
- Unemployment impacts inflation negatively
- Inflation impacts unemployment positively
  - Because unemployment and output gap move inversely (and relatively contemporaneously), the signs in second and third points above should reverse if you use the output gap.
- Unemployment impacts interest rate negatively
- Inflation impacts interest rate positively
- Interest rate impacts unemployment positively

Thinking About What Might Explain the Facts

$\pi_t = \pi_{t-1} + .3y_t + v_t$ (slow price adjustment)

$y_t = .9y_{t-1} - .2(i_t - \pi_t) + e_t$ (inter-temporal substitution)

$i_t = 1.5\pi_t + .5y_t + w_t$ (monetary policy rule)

$u_t = -.4y_t$ (Okun's Law)

where

u_t is the unemployment rate (deviation from mean)
y_t is real output as a percentage deviation from trend
i_t is the nominal interest rate (deviation from mean)
π_t is the inflation rate (target rate assumed to be zero)
e_t ,v_t w_t are serially uncorrelated zero mean shocks

Question: Would implied three equation VAR result in IRF and Granger-causality as in the data?