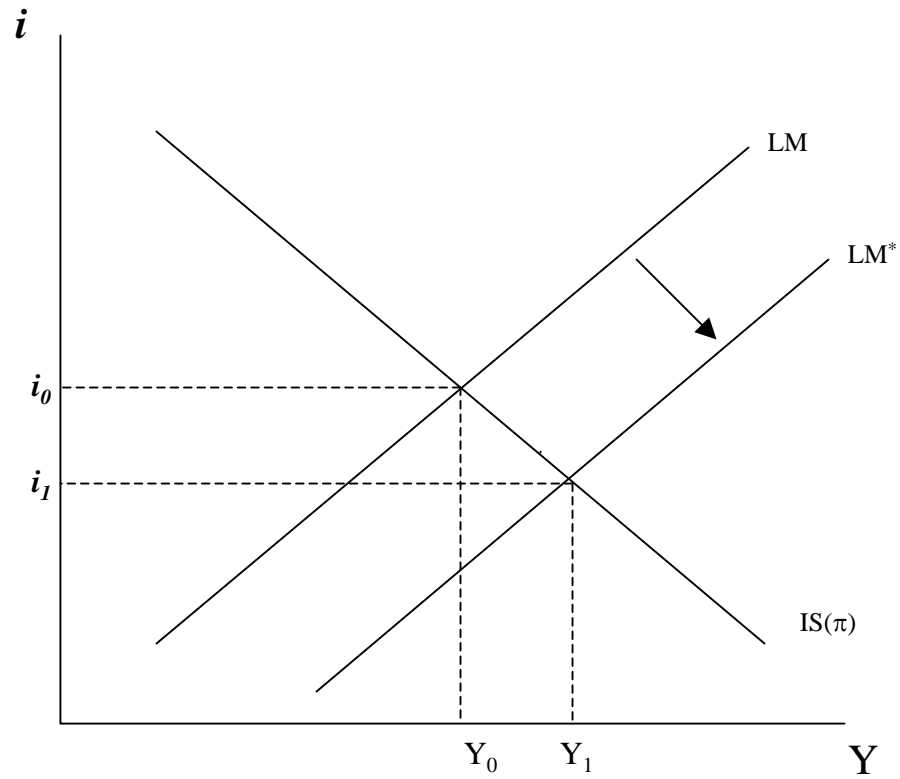


The Liquidity Effect

Liquidity Effect in IS-LM Model



Theoretical Literature:

- Kydland and Prescott (1982), *Econometrica*
- Long and Plosser (1982), *JPE*
- Cooley and Hansen (1989), *AER*
- Fuerst (1992), *JME*
- Christiano and Eichenbaum (1992), *AER*
- Cook (1999), *JME*
- Edge (2000), *BOG Federal Reserve*

Real
Economy

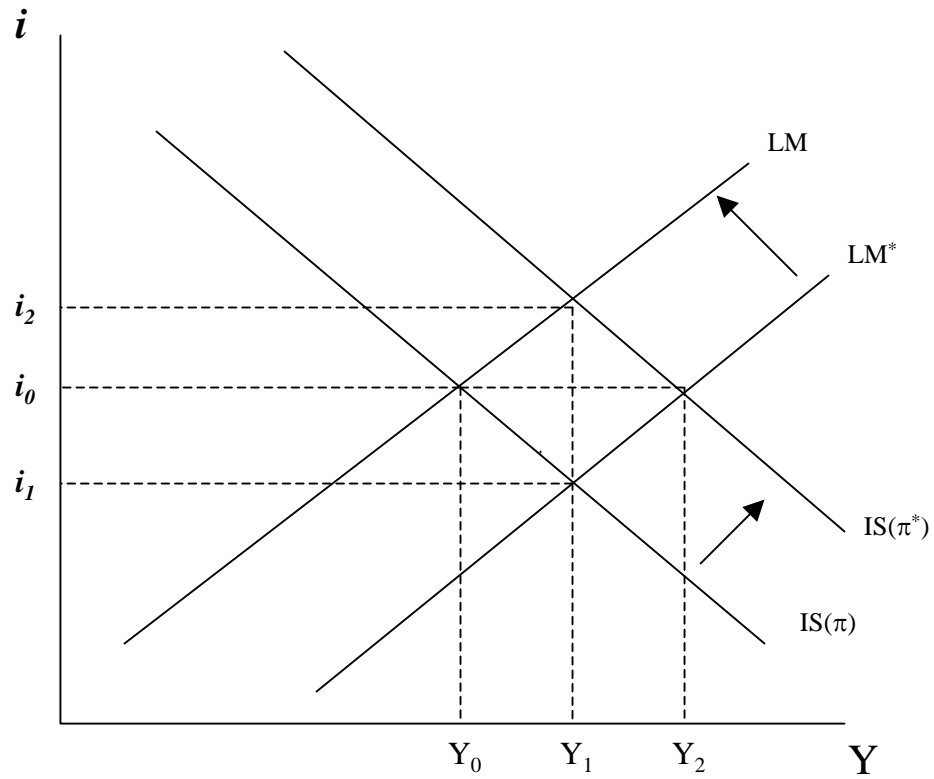
Monetary Economy-
No Liquidity Effect

Monetary Models
that Generate
Liquidity Effects

Empirical Literature:

- Cagan and Gandolfi (1969), *AER*
 - Melvin (1983), *Economic Inquiry*
 - Reichenstein (1987), *Economic Inquiry*
 - Leeper and Gordon (1992), *JME*
 - Gali (1992), *QJE*
 - Lastrapes and Selgin (1995), *JMacro*
 - Strongin (1995), *JME*
 - Christiano and Eichenbaum (1997), *REStat*
 - Pagan and Robertson (1998), *REStat*
- } Finds Liquidity Effects
- } Liquidity Effects Vanish in Late 1970s
- } Find Liquidity Effects in a Structural VAR
- } Find Liquidity Effect using Non-Borrowed Reserves as Policy Instrument
- } Finds that Structural VAR Evidence is Weak

Fisher Effect in IS-LM Model



Long-Run Neutrality and Superneutrality:

- Lucas (1980), *AER*
- Geweke (1986), *Econometrica*
- Mishkin (1992), *JME*
- Crowder and Hoffman (1996), *JMCB*
- Crowder (1998), *Economic Inquiry*
- King and Watson (1997), *FRB Richmond Econ Quarterly*
- Koustas and Serletis (1999), *JME*
- Fisher and Seater (1993), *AER*

Find Evidence in Favor of the LRN and/or LRSN Hypothesis

Find Evidence Against LRN and/or LRSN

Derive Necessary and Sufficient Conditions for LRN and LRSN

Importance of the Orders of Integration of German Variables:

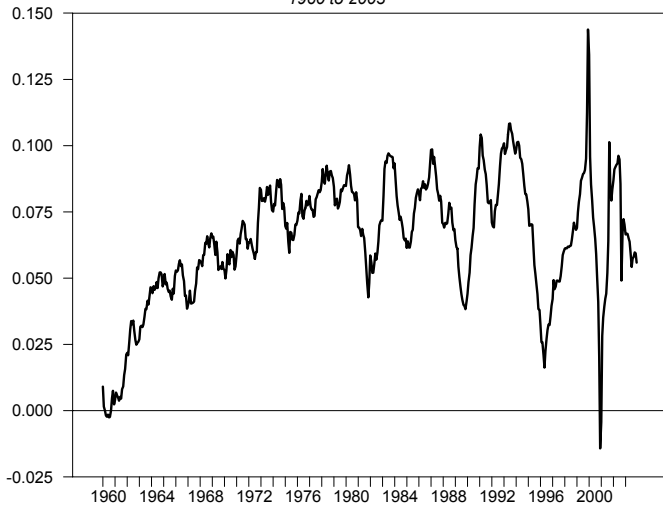
- Fisher and Seater (1993) show that LRN and LRSN can only be tested when variables are integrated.
- Crowder (1998) finds evidence that monetary base growth and inflation are $I(1)$ and $CI(1,1)$ consistent with LRN.
- Crowder and Hoffman (1996) find evidence that inflation and nominal interest rates are $I(1)$ and $CI(1,1)$ consistent with LRSN.
- Granger and Newbold (1977) and Phillips (1986) discuss spurious regression.
- Phillips (1987) shows that inference in non-standard regressions with integrated variables.

Overview of my Results:

- Base growth, inflation and nominal interest rates $I(1)$
- Base growth, inflation and nominal interest rates $CI(1,1)$
- Two long-run equilibria \Rightarrow one common $I(1)$ component
- Two innovations have temporary effects, One innovation has permanent effect
- Cointegration \Rightarrow restrictions on the reduced form VAR
- Using one extra ID restriction (money growth responds with a one-period lag to inflation innovation) generates IRFs consistent with Liquidity Effect
- My empirical model can explain the results using NBR

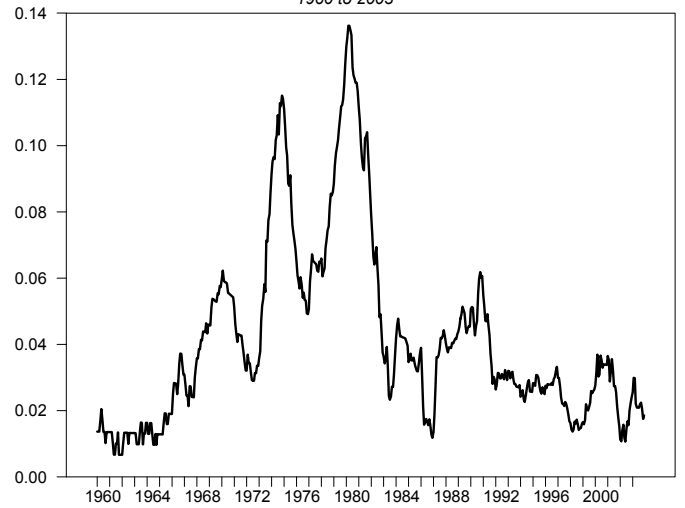
Monetary Base Growth Rate

1960 to 2003



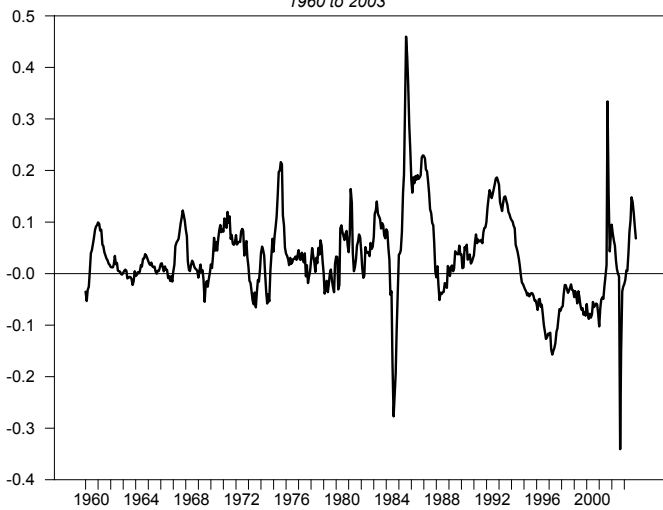
CPI Inflation Rate

1960 to 2003



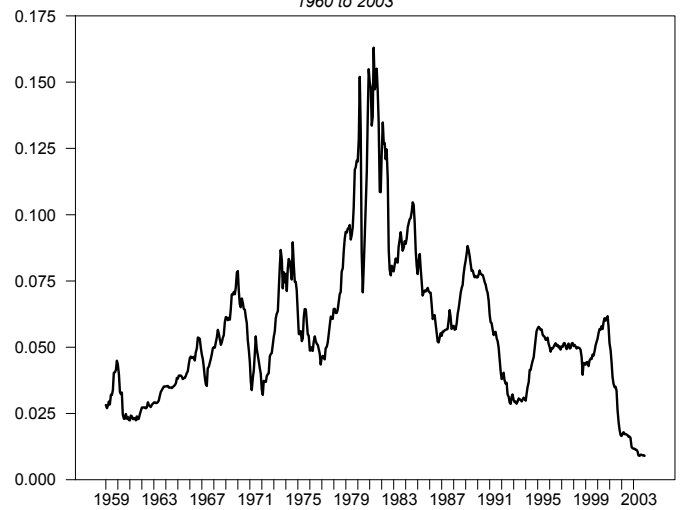
Non-Borrowed Reserves Growth Rate

1960 to 2003



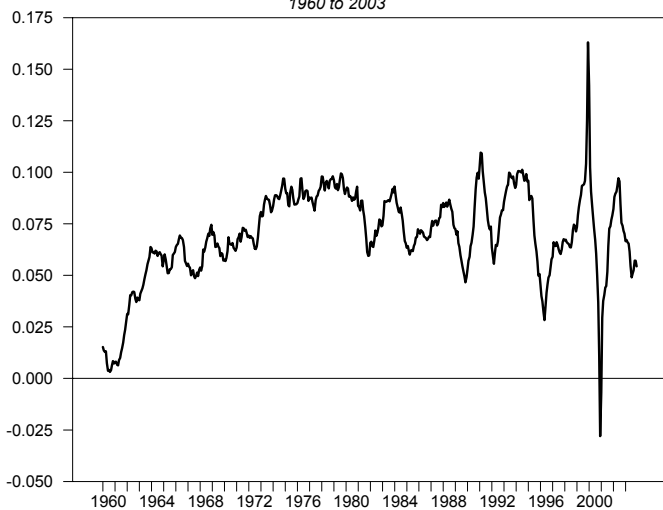
3-Month Treasury Bill Rate

1960 to 2003



Currency Growth Rate

1960 to 2003



5-year Treasury Note Rate

1960 to 2003



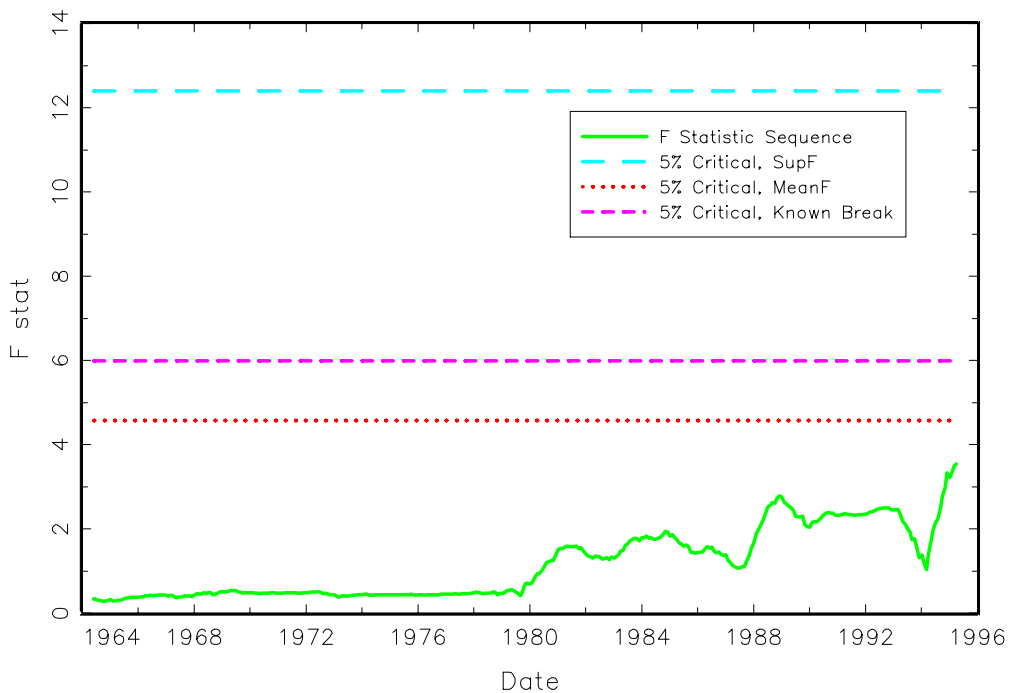
Table 1: Unit Root Test Results

Variable	ADF	DF_{GLS}	DF_{GLSu}	MZ_{α}	MZ_{τ}	CADF	Perron	AR(1)	MA(1)	ARCH(1)	GARCH(1)
Base Growth	-3.61*	-0.79	-3.25*	-1.64	-0.84		-4.07	0.96 (0.07)	0.54 (0.16)	0.28 (0.29)	0.88 (0.14)
NBR Growth	-3.24*	-2.36*	-3.19*	-9.77*	-2.16*		-4.83	0.71 (0.04)	0.16 (0.09)	0.02 (0.01)	0.99 (0.01)
Inflation	-2.36	-1.64	-2.29	-5.89	-1.72		-5.39	0.99 (0.01)	<i>NA</i>	0.12 (0.04)	0.83 (0.05)
T-bill Rate	-2.65	-2.31*	-2.55	-15.64*	-2.74*		-5.79*	1.00 (0.01)	0.40 (0.05)	0.25 (0.05)	0.76 (0.04)
5% CV	-2.86	-1.98	-2.73	-8.10	-1.98		-5.55				

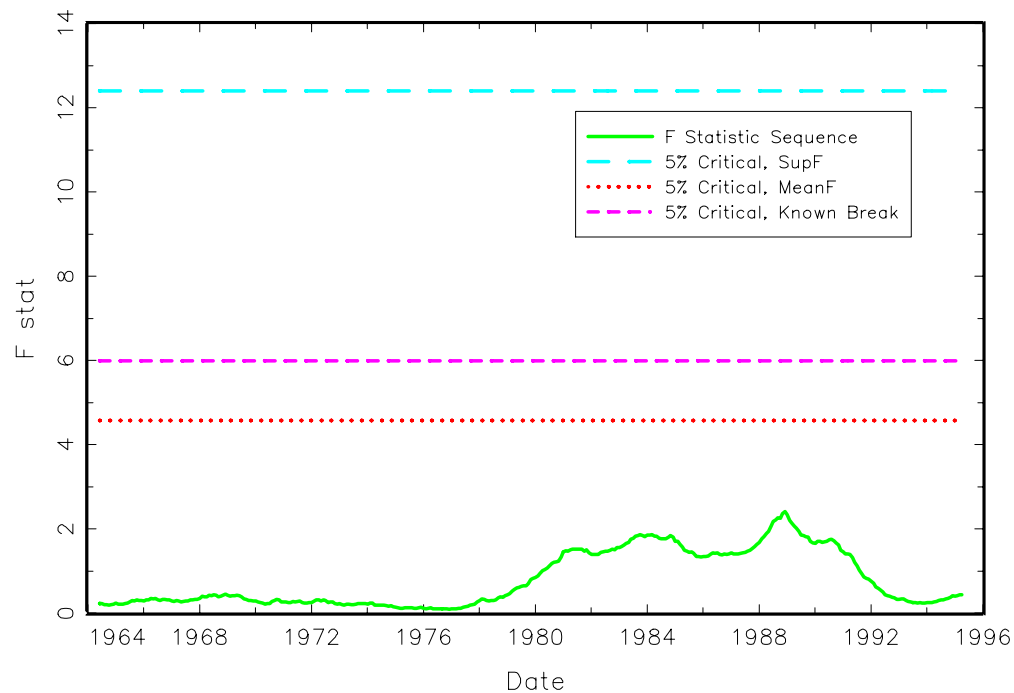
Table 2: Bivariate Cointegration Results - Phillips

Dependent Variable	Base Growth	NBR Growth	Inflation	T-bill Rate
Base Growth			1.38 (0.30)	1.11 (0.15)
NBR Growth			0.56 (0.33)	0.58 (0.27)
Inflation	0.76 (0.18)	1.43 (0.28)		0.83 (0.09)
T-bill Rate	0.92 (0.16)	1.58 (0.34)	1.29 (0.16)	

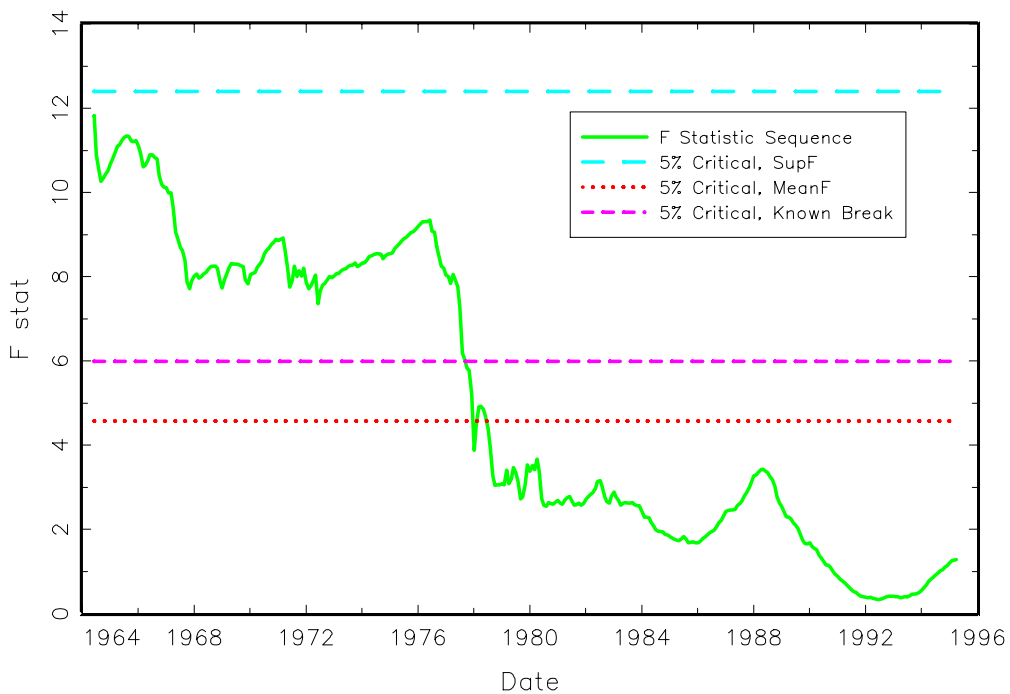
T-bill Rate on Base Growth (constant included)
1960-2003



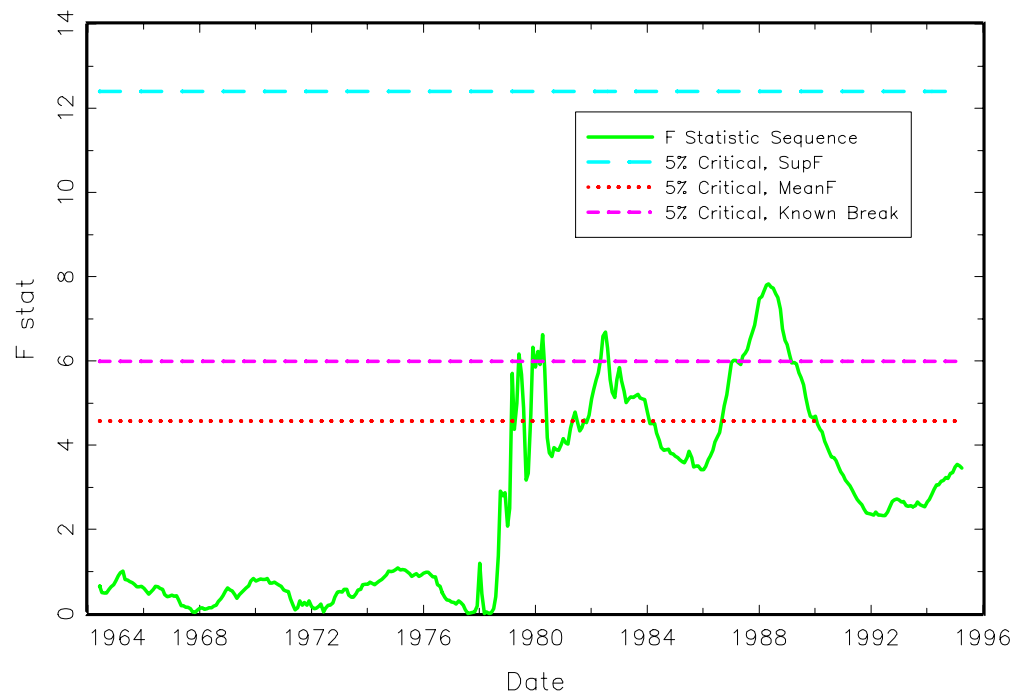
T-bill Rate on Base Growth (no constant)
1960-2003



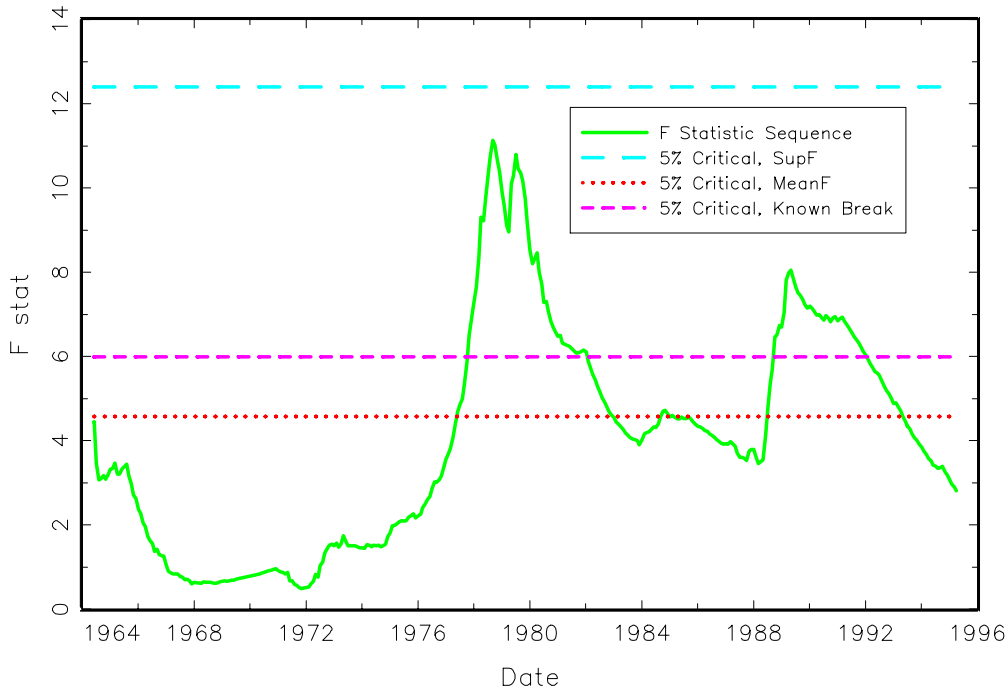
Base Growth on T-bill Rate (constant included)
1960-2003



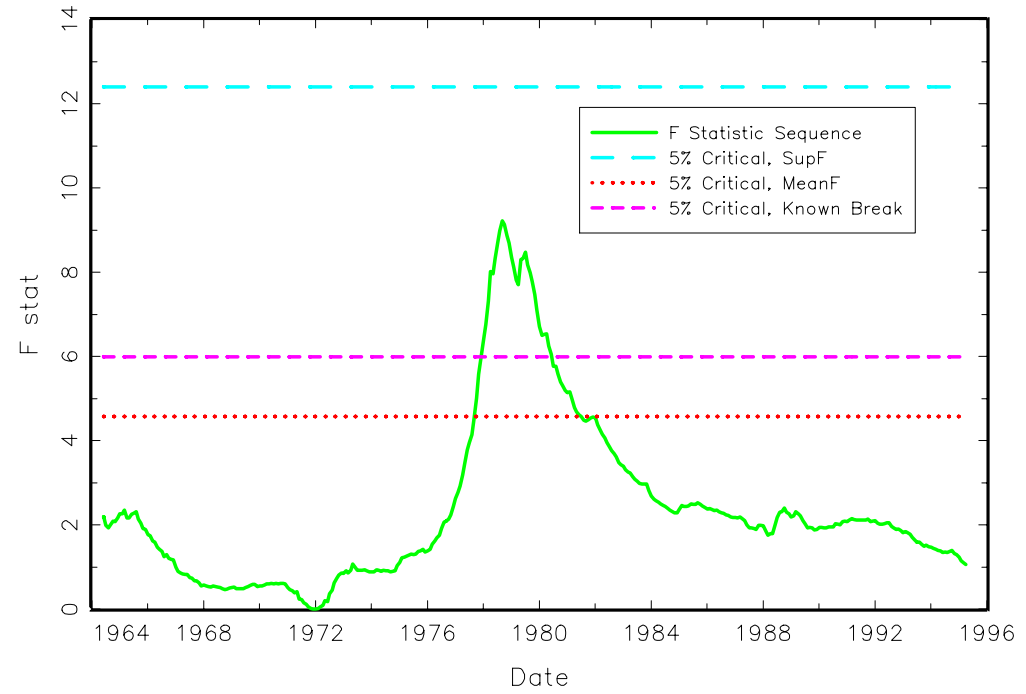
Base Growth on T-bill Rate (no constant)
1960-2003



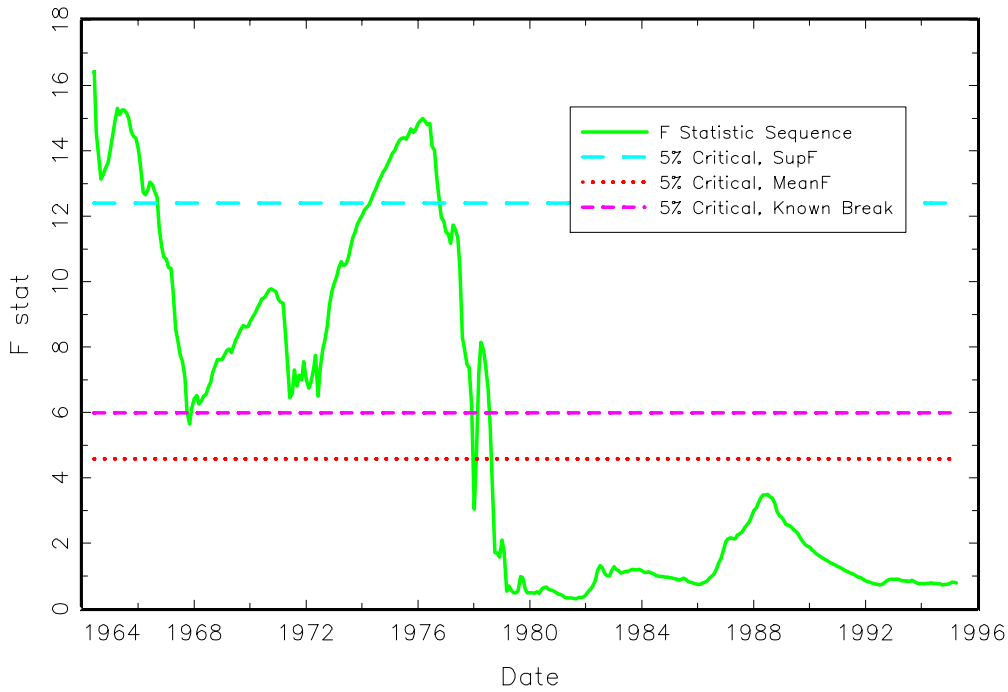
T-bill Rate on Inflation (constant included)
1960-2003



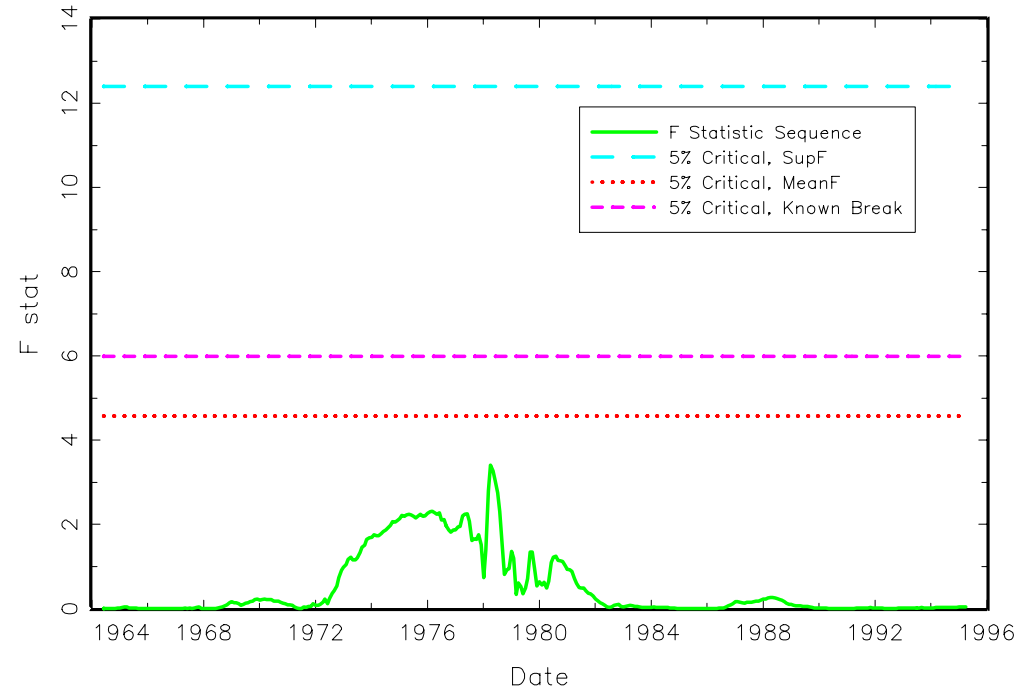
T-bill Rate on Inflation (no constant)
1960-2003



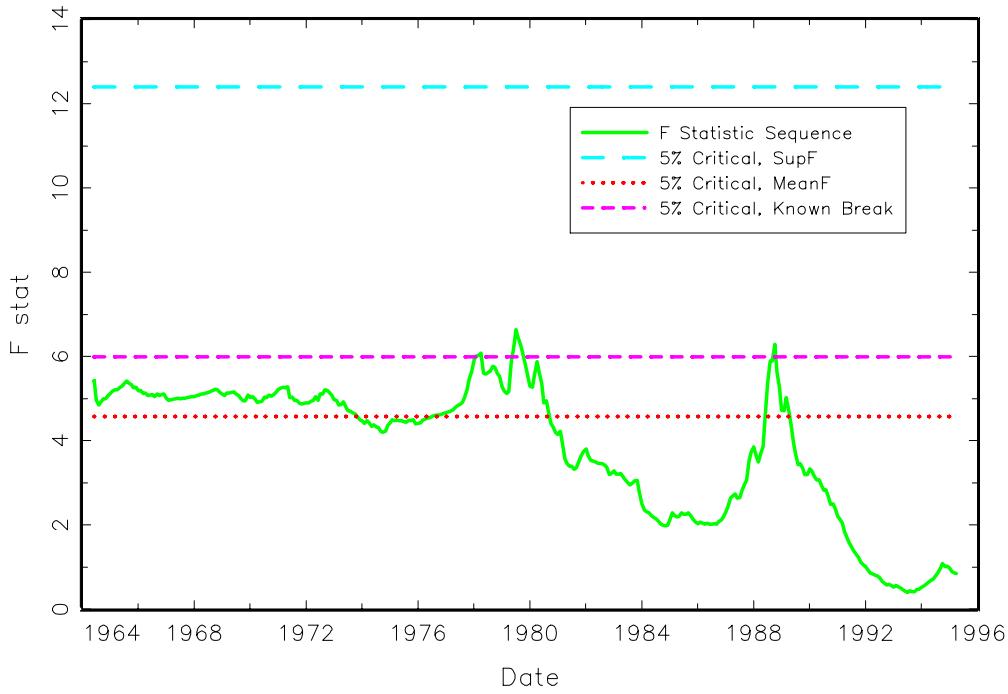
Inflation on T-bill Rate (constant included)
1960-2003



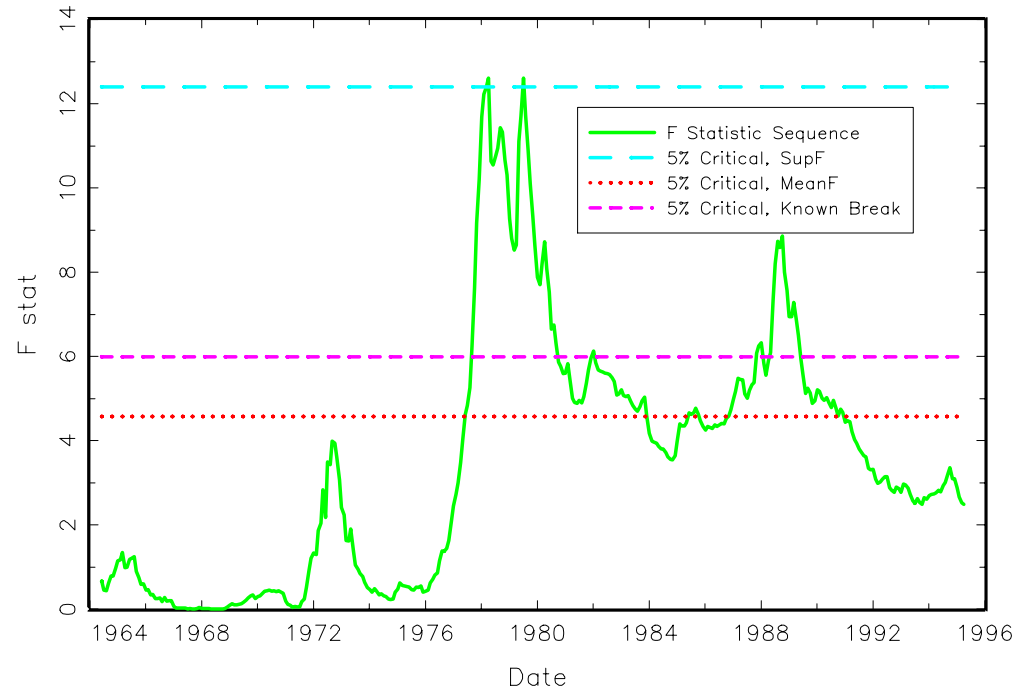
Inflation on T-bill Rate (no constant)
1960-2003



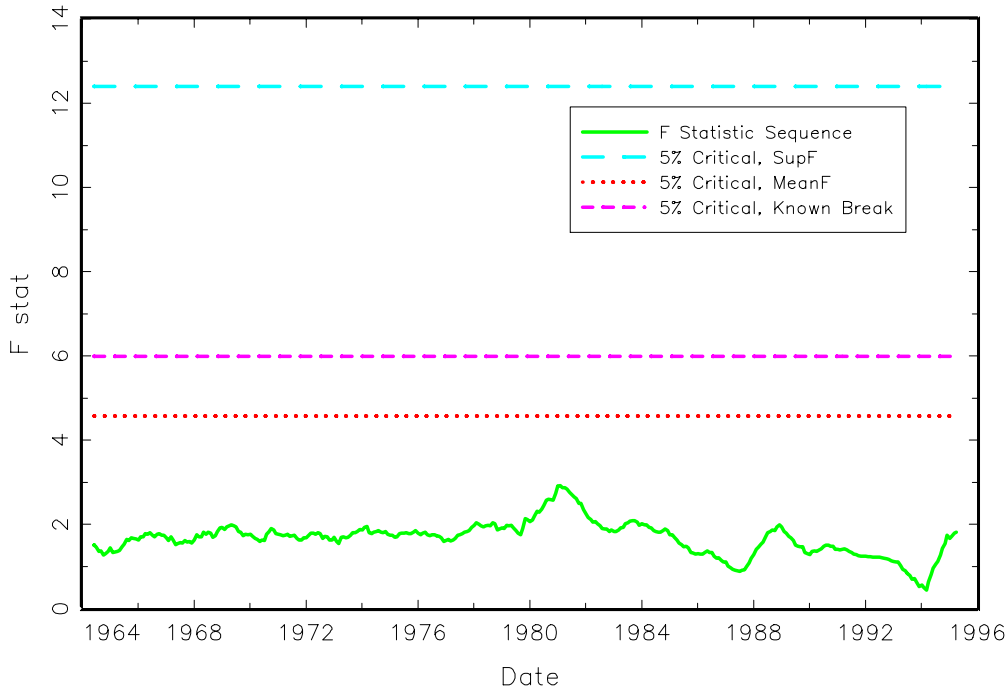
Base Growth on Inflation (constant included)
1960–2003



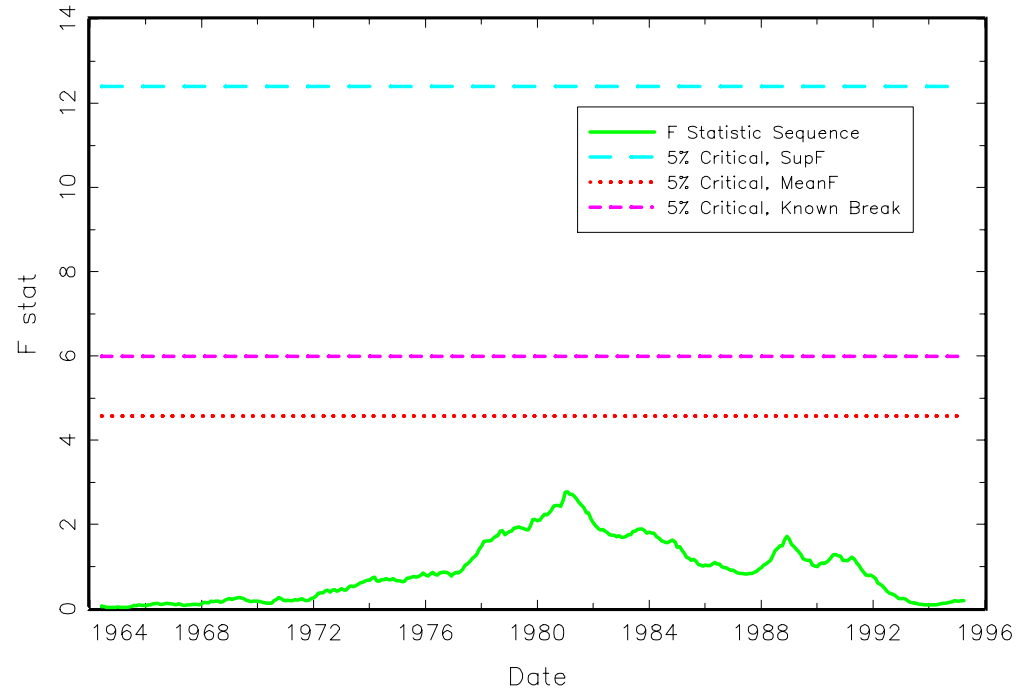
Base Growth on Inflation (no constant)
1960–2003



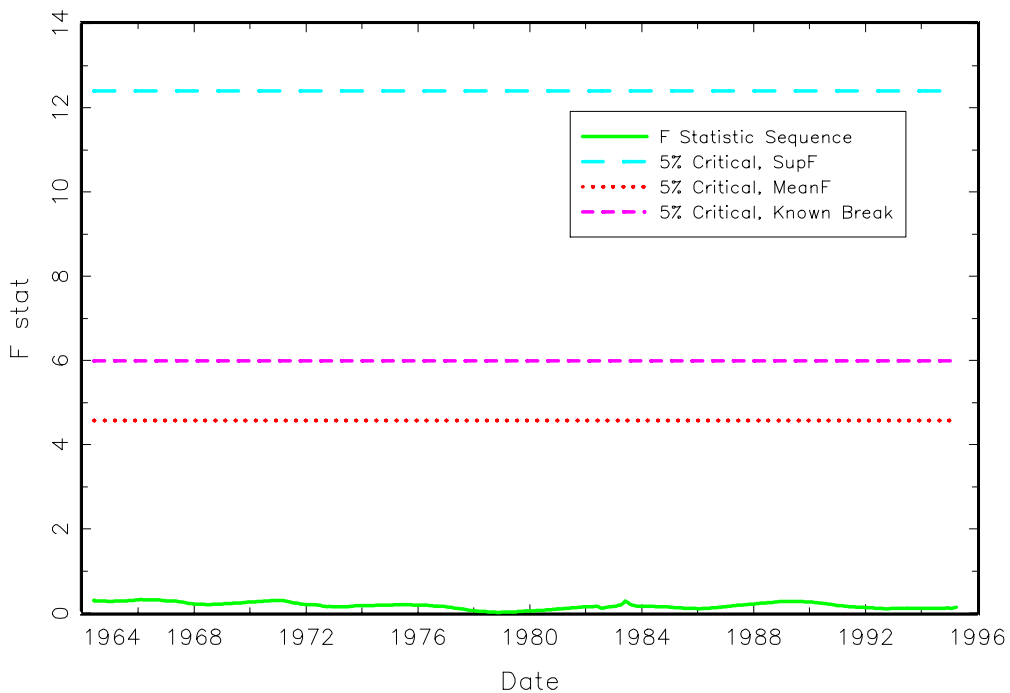
Inflation on Base Growth (constant included)
1960–2003



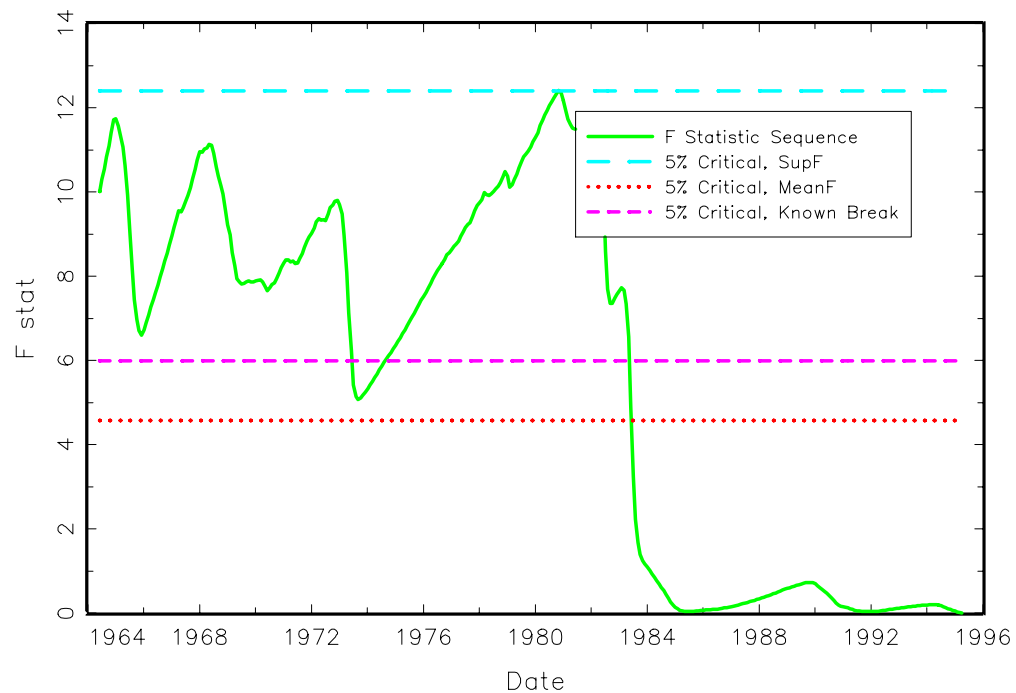
Inflation on Base Growth (no constant)
1960–2003



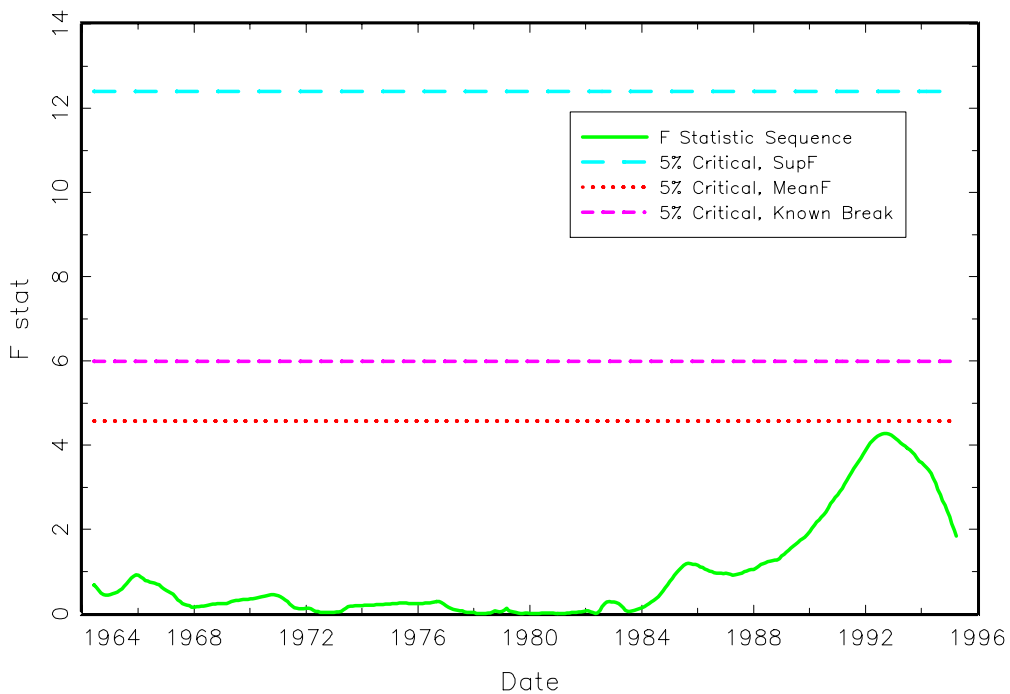
T-bill Rate on NBR Reserves Growth (constant included)
1960–2003



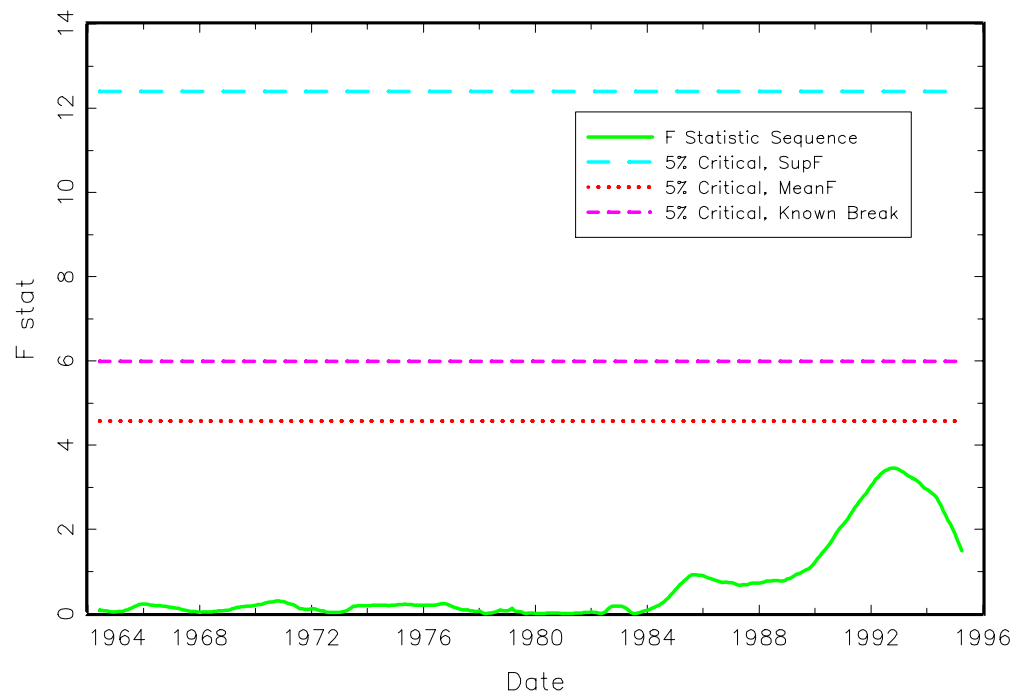
T-bill Rate on NBR Reserves Growth (no constant)
1960–2003



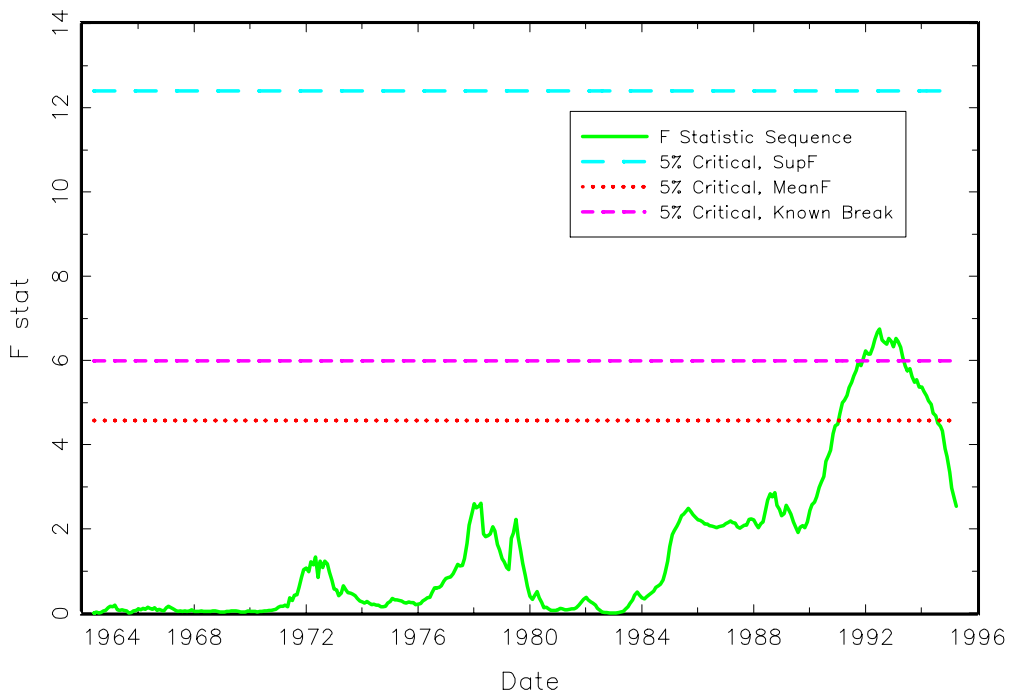
NBR Reserves Growth on T-bill Rate (constant included)
1960–2003



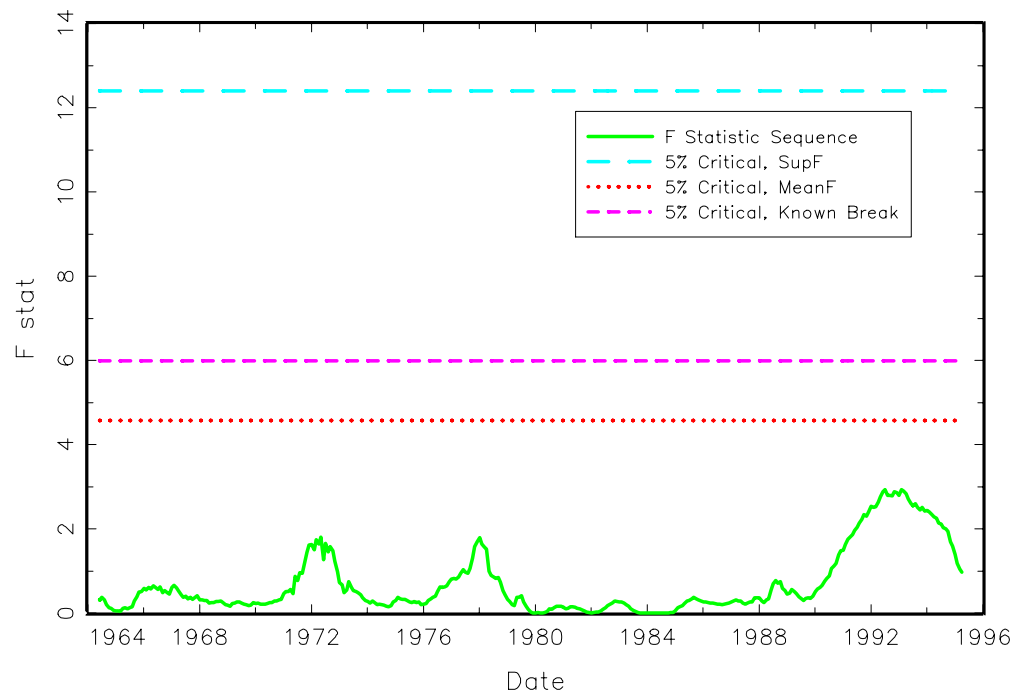
NBR Reserves Growth on T-bill Rate (no constant)
1960–2003



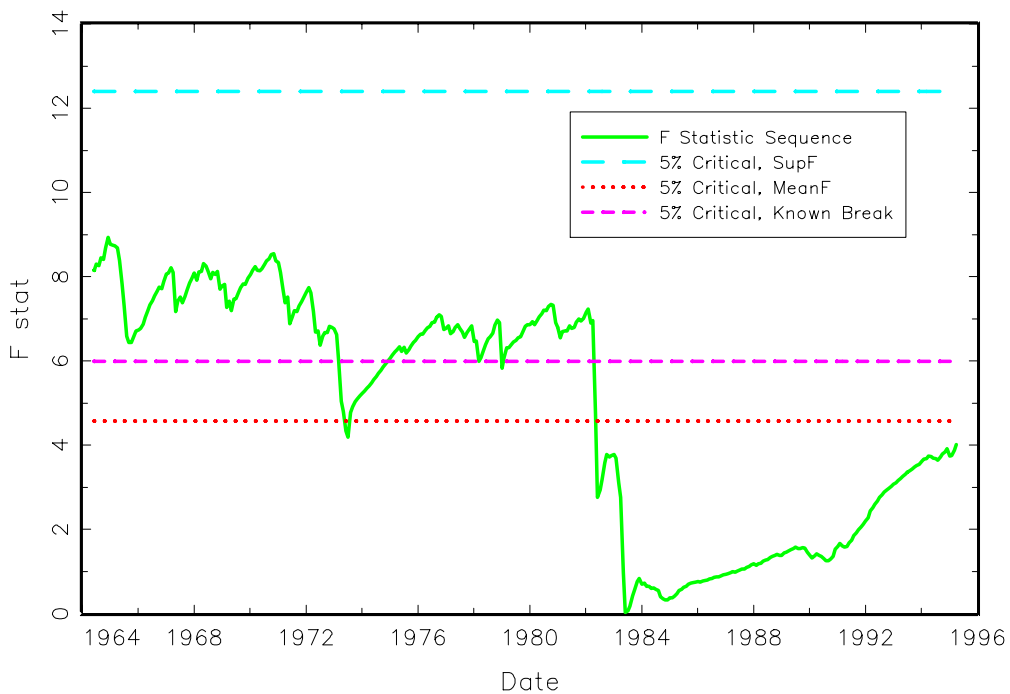
NB Reserves Growth on Inflation (constant included)
1960–2003



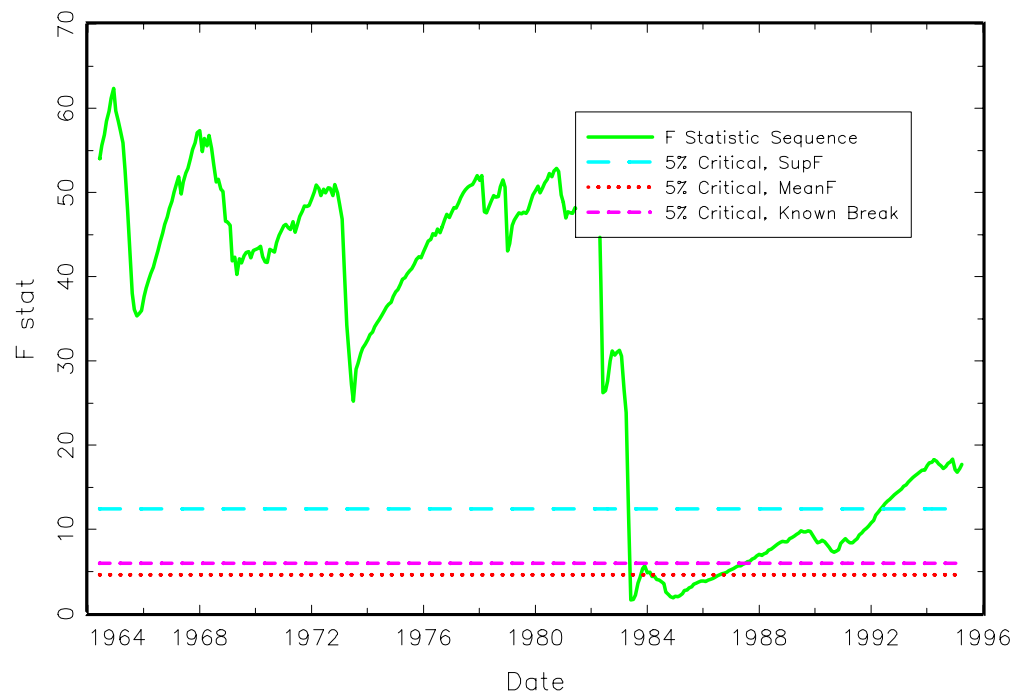
NB Reserves Growth on Inflation (no constant)
1960–2003



Inflation on NB Reserves Growth (constant included)
1960–2003



Inflation on NB Reserves Growth (no constant)
1960–2003



Identifying the Structural Model from the Reduced Form Estimates

Define the stationary vector time series $Z_t = [\Delta m_t, \Delta i_t]'$,

$$Z_t = A(L)\varepsilon_t, \quad E[\varepsilon_t \varepsilon_t'] = I \quad (1)$$

where L is the lag operator, $A(\lambda) = \sum_{j=0}^{\infty} A_j \lambda^j$ and $\varepsilon_t = [\varepsilon_t^m, \varepsilon_t^i]$. The Wold representation theorem implies a reduced form MAR for Z_t :

$$Z_t = C(L)u_t, \quad E[u_t u_t'] = \Omega \quad (2)$$

The relationship between the reduced form and structural parameters is given by $u_t = A_0 \varepsilon_t$, $A_j = C_j A_0$.

Identification of the structural model from the reduced form is achieved through suitable restrictions on the A_0 matrix.

Since the reduced form covariance matrix, Ω , has three distinct elements, three restrictions are already imposed on the six parameters in A_0 by noting that the above assumptions imply $A_0 A_0' = \Omega$. This extra identifying restriction often takes the form of zero restriction on the upper off-diagonal elements of A_0 , then A_0 will have the form,

$$A_0 = \begin{bmatrix} a_{11} & 0 \\ a_{21} & a_{22} \end{bmatrix}. \quad (3)$$

Unfortunately, this type of restriction implies a specific contemporaneous relationship among the endogenous variables that is often incompatible with economic theory.

An alternative identification strategy is to impose long-run restrictions:

$$A(1) = \sum_{j=0}^{\infty} A_j = \begin{bmatrix} A_{11}(1) & 0 \\ A_{21}(1) & A_{22}(1) \end{bmatrix} \quad (4)$$

From the relationship between the structural and reduced form VAR models, i.e. $A(1) = C(1)A_0$, the identification restriction in (4) can be imposed by suitable specification of A_0 .

Consider an equivalent representation of the system given in (2) by defining $X_t = [m_t, i_t]'$. X_t is a cointegrated system where $\beta = [1, -1]'$.

Engle and Granger (1987) demonstrate that the cointegrated system X_t has an error-correction model (ECM) representation as,

$$\Delta X_t = \alpha\beta' X_{t-1} + \sum_{j=1}^{k-1} \Gamma_j \Delta X_{t-j} + \nu_t \quad E[\nu_t \nu_t'] = \Sigma \quad (5)$$

where α is the 2×1 matrix of equilibrium adjustment or error-correction coefficients.

From Granger's Representation Theorem the moving average representation of (5) exists and can be written as,

$$\Delta X_t = D(L)\nu_t \quad (6)$$

where the matrix polynomial $D(\lambda)$ can be decomposed as $D(\lambda) = D(1) + (1 - \lambda)D^*(\lambda)$, with $D^*(\lambda) = (D(\lambda) - D(1))(1 - \lambda)^{-1}$.

Johansen (1991) shows that when X_t is integrated of order one or less then the matrix $\xi = (\alpha'_\perp \Gamma(1) \beta_\perp)^{-1}$, where $\Gamma(1) = I - \sum_{j=1}^{k-1} \Gamma_j$, exists and is nonsingular. The total impact matrix from (6) has the form $D(1) = \beta_\perp \xi \alpha'_\perp$ where β_\perp and α_\perp are 2×1 orthogonal complements to β and α such that $\beta' \beta_\perp = 0$ and $\alpha' \alpha_\perp = 0$. Using these relations allows (6) to be written in common trends representation (CTR) form as,

$$X_t = D(1)(1 - L)^{-1} \nu_t + D^*(L) \nu_t \quad (7)$$

where $(1 - L)^{-1} \nu_t = \sum_{s=0}^t \nu_s = \tau_t$ are the common (random walk) trend components in X_t . The total impact matrix $D(1)$ will have reduced rank of one allowing the interpretation of (7) as a common trends representation.

Given the earlier assumption regarding X_t , the orthogonal complement to β can be given by $\beta_\perp = [1, 1]'$. Thus the CTR can be explicitly written as,

$$X_t = \begin{bmatrix} m_t \\ i_t \end{bmatrix} = \begin{bmatrix} \xi \alpha_{1\perp} & \xi \alpha_{2\perp} \\ \xi \alpha_{1\perp} & \xi \alpha_{2\perp} \end{bmatrix} \begin{bmatrix} \tau_{1,t} \\ \tau_{2,t} \end{bmatrix} + \begin{bmatrix} C_{11}^*(L) & C_{12}^*(L) \\ C_{21}^*(L) & C_{22}^*(L) \end{bmatrix} \begin{bmatrix} \nu_{1,t} \\ \nu_{2,t} \end{bmatrix}. \quad (8)$$

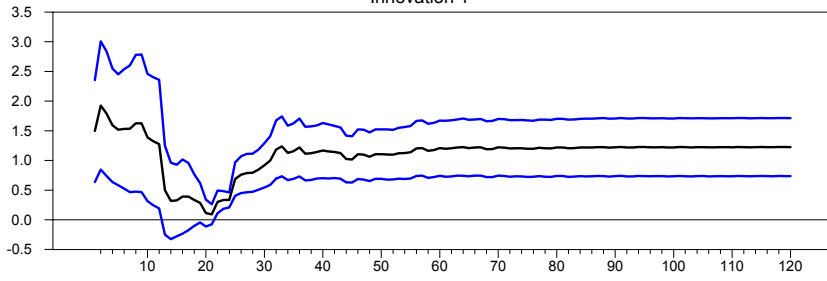
From the CTR in (8) it can be seen that the common trend is proportional to $\alpha'_\perp \nu_t$. Given that the structural model in (1) implies that the transitory innovations are orthogonal to the permanent innovations, it must be the case that the transitory innovations are proportional to $\alpha' \Sigma^{-1} \nu_t$. In order to recover the structural innovations (and other structural parameters) a suitable choice for A_0^{-1} is given by,

$$A_0^{-1} = \begin{bmatrix} (\alpha'_\perp \Sigma \alpha_\perp)^{-1/2} \alpha_{1\perp} & (\alpha'_\perp \Sigma \alpha_\perp)^{-1/2} \alpha_{2\perp} \\ (\alpha' \Sigma^{-1} \alpha)^{-1/2} \alpha_1 \Sigma^{-1} & (\alpha' \Sigma^{-1} \alpha)^{-1/2} \alpha_2 \Sigma^{-1} \end{bmatrix} \quad (9)$$

as this ensures that the permanent and transitory innovations are uncorrelated and delivers a lower triangular $A(1)$ matrix.

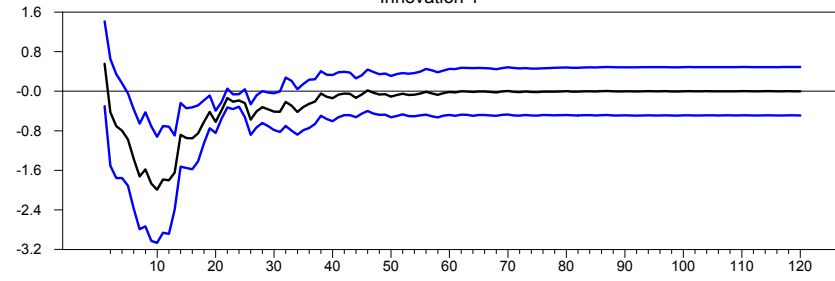
Response of Monetary Base Growth Rate

Innovation 1



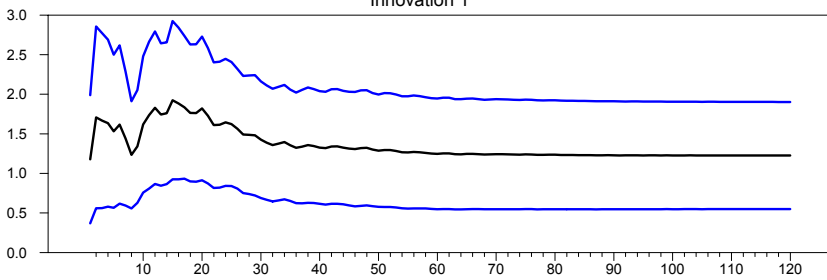
Response of Non-Borrowed Reserves Growth Rate

Innovation 1



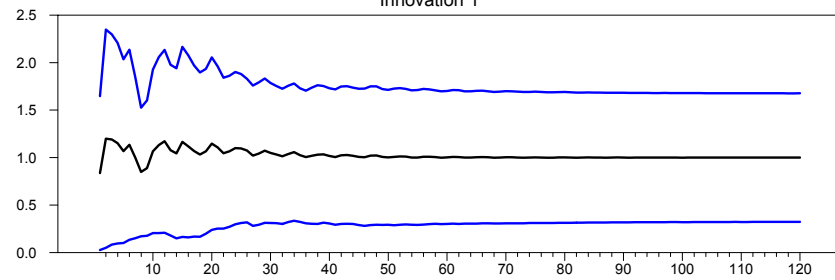
Response of Nominal Interest Rate

Innovation 1



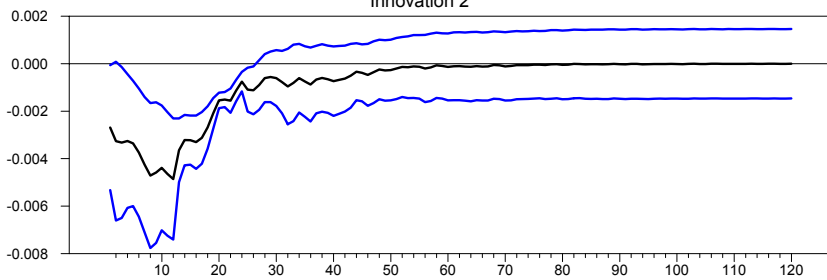
Response of Nominal Interest Rate

Innovation 1



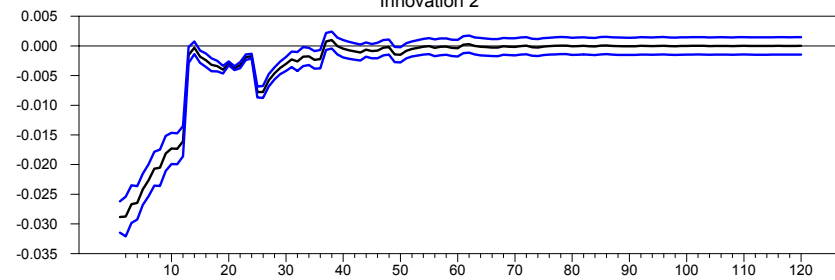
Response of Monetary Base Growth Rate

Innovation 2



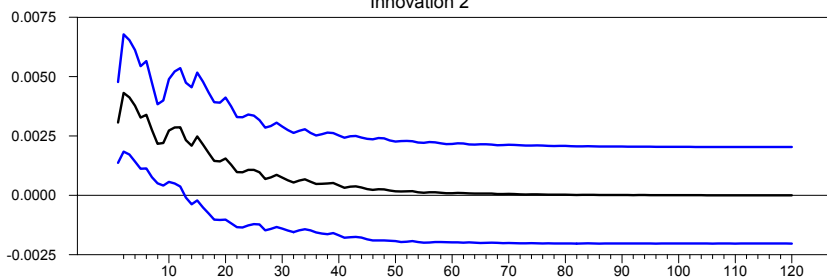
Response of Non-Borrowed Reserves Growth Rate

Innovation 2



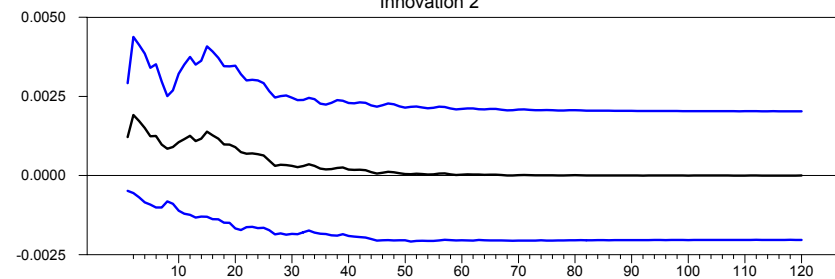
Response of Nominal Interest Rate

Innovation 2



Response of Nominal Interest Rate

Innovation 2



Monetary Base Growth Cointegration Results - Johansen (no constant)

Eigenvalues	Trace Test	10% CV	Marginal Sig	H ₀ :No. CIVs
0.038	28.84	21.78.	0.012	0
0.017	9.12	10.47	0.162	1
0.001	0.12	2.98	0.778	2

$$X_t \hat{\beta} = \begin{bmatrix} \Delta m & \pi & i \end{bmatrix} \begin{bmatrix} 1.00 & 0.00 \\ 0.00 & 1.00 \\ -1.13 & -0.76 \\ (0.10) & (0.09) \end{bmatrix}$$

$$\hat{\alpha} = \begin{bmatrix} \text{CIV 1} & \text{CIV 2} \\ -0.017 & 0.003 \\ (0.008) & (0.012) \\ 0.013 & -0.017 \\ (0.004) & (0.007) \\ 0.018 & 0.015 \\ (0.007) & (0.011) \end{bmatrix}$$

Monetary Base Growth Cointegration Results - Johansen (with constant)

Eigenvalues	Trace Test	10% CV	Marginal Sig	H ₀ :No. CIVs
0.049	41.63	32.27	0.009	0
0.017	16.16	17.98	0.167	1
0.014	7.14	7.56	0.119	2

$$X_t \hat{\beta} = \begin{bmatrix} \Delta m & \pi & i & 1 \end{bmatrix} \begin{bmatrix} 1.00 & 0.00 \\ 0.00 & 1.00 \\ -0.55 & -0.86 \\ (0.17) & (0.25) \\ -0.04 & 0.01 \\ (0.01) & (0.02) \end{bmatrix}$$

$$\hat{\alpha} = \begin{bmatrix} \text{CIV 1} & \text{CIV 2} \\ \hline -0.043 & 0.014 \\ (0.012) & (0.012) \\ 0.016 & -0.017 \\ (0.007) & (0.007) \\ 0.020 & 0.016 \\ (0.011) & (0.012) \end{bmatrix}$$

Non-Borrowed Reserves Growth Cointegration Results - Johansen (no constant)

Eigenvalues	Trace Test	10% CV	Marginal Sig	H ₀ :No. CIVs
0.031	25.02	21.78	0.040	0
0.016	8.70	10.47	0.187	1
0.001	0.68	2.98	0.470	2

$$X_t \hat{\beta} = \begin{bmatrix} \Delta nbr & \pi & i \end{bmatrix} \begin{bmatrix} 1.00 & 0.00 \\ 0.00 & 1.00 \\ -0.69 & -0.77 \\ (0.24) & (0.09) \end{bmatrix}$$

$$\hat{\alpha} = \begin{bmatrix} \text{CIV 1} & \text{CIV 2} \\ -0.082 & 0.047 \\ (0.023) & (0.081) \\ 0.003 & -0.012 \\ (0.002) & (0.007) \\ 0.005 & 0.018 \\ (0.003) & (0.011) \end{bmatrix}$$

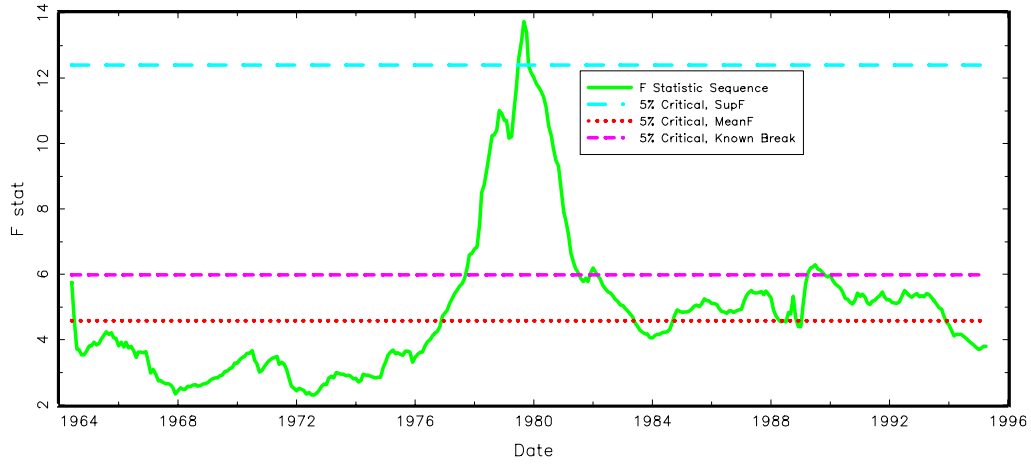
Non-Borrowed Reserves Growth Cointegration Results - Johansen (with constant)

Eigenvalues	Trace Test	10% CV	Marginal Sig	H ₀ :No. CIVs
0.037	31.25	32.27	0.125	0
0.016	12.09	17.98	0.440	1
0.007	3.64	7.56	0.468	2

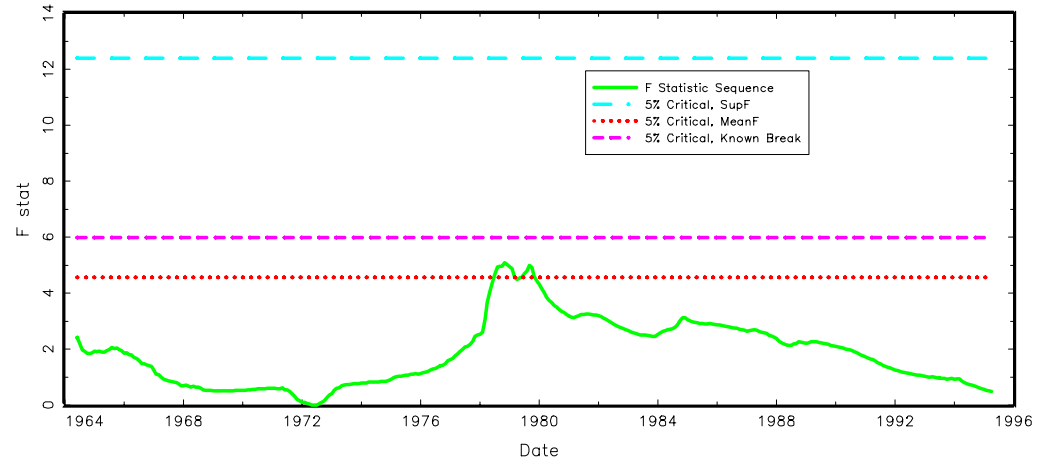
$$X_t \hat{\beta} = \begin{bmatrix} \Delta nbr & \pi & i & 1 \end{bmatrix} \begin{bmatrix} 1.00 & 0.00 \\ 0.00 & 1.00 \\ -2.01 & -1.02 \\ (0.85) & (0.31) \\ 0.09 & 0.02 \\ (0.05) & (0.02) \end{bmatrix}$$

$$\hat{\alpha} = \begin{bmatrix} \text{CIV 1} & \text{CIV 2} \\ -0.070 & 0.058 \\ (0.020) & (0.080) \\ 0.004 & -0.011 \\ (0.002) & (0.006) \\ 0.005 & 0.020 \\ (0.003) & (0.011) \end{bmatrix}$$

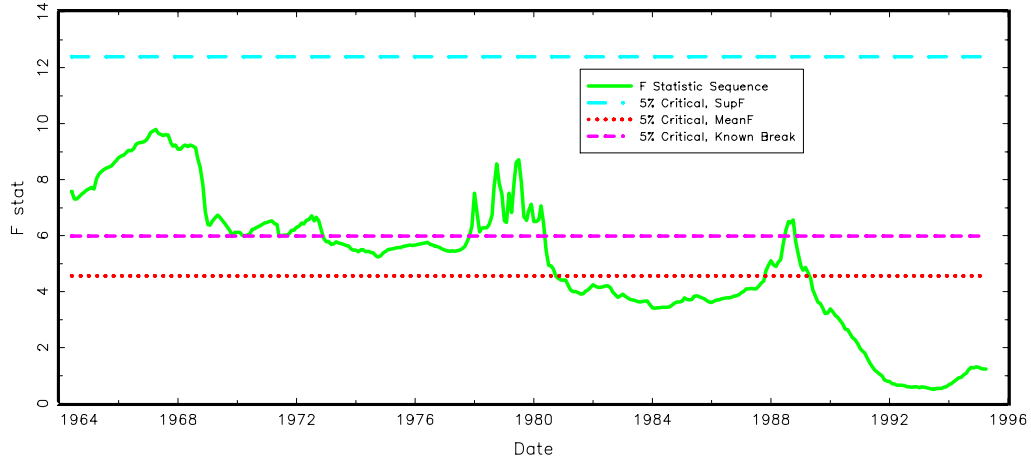
T-bill Rate on Base Growth and Inflation (constant included)
1960-2003



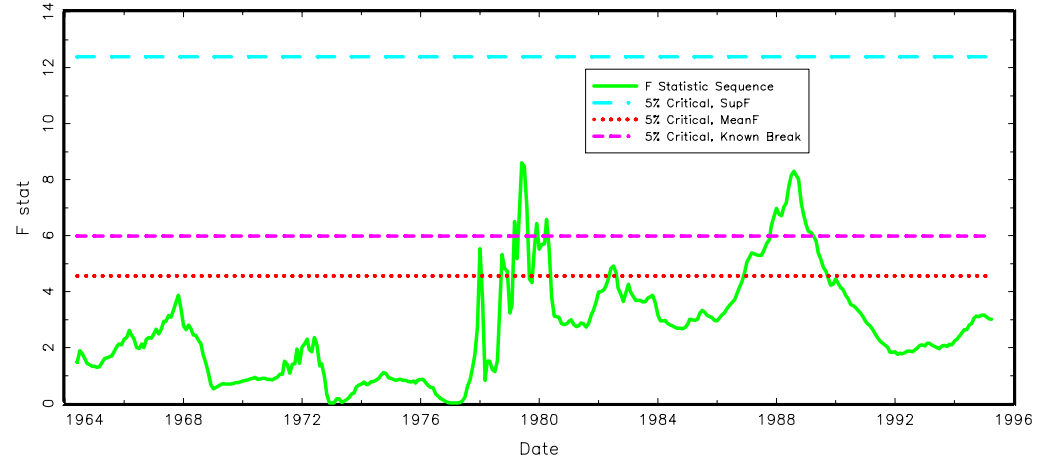
T-bill Rate on Base Growth and Inflation (no constant)
1960-2003



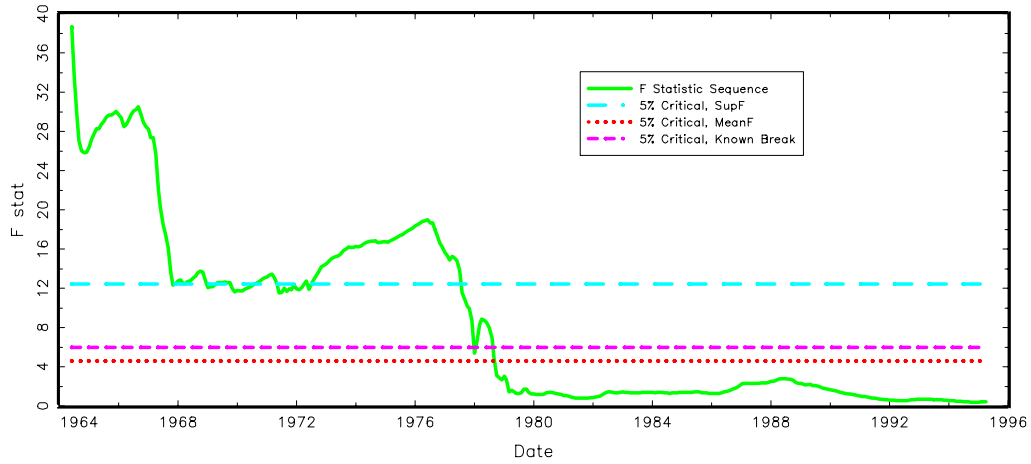
Base Growth on T-bill Rate and Inflation (constant included)
1960-2003



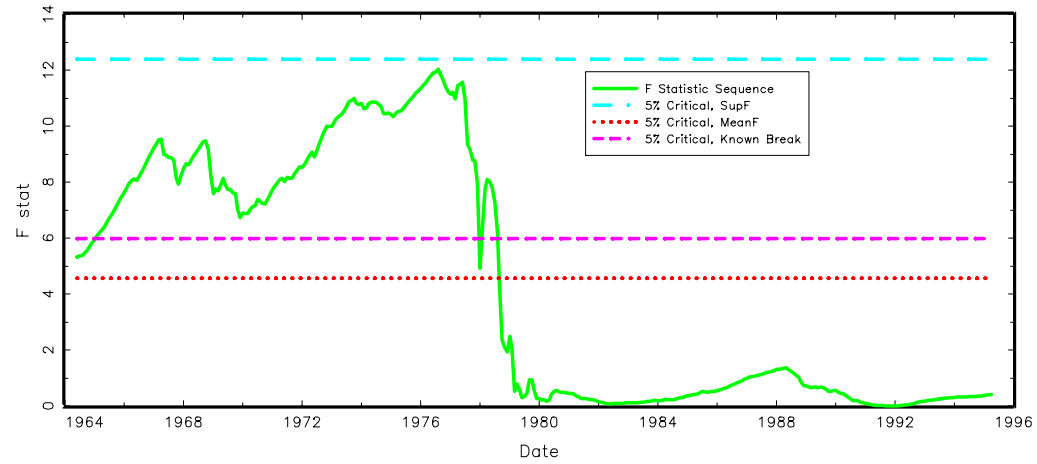
Base Growth on T-bill Rate and Inflation (no constant)
1960-2003



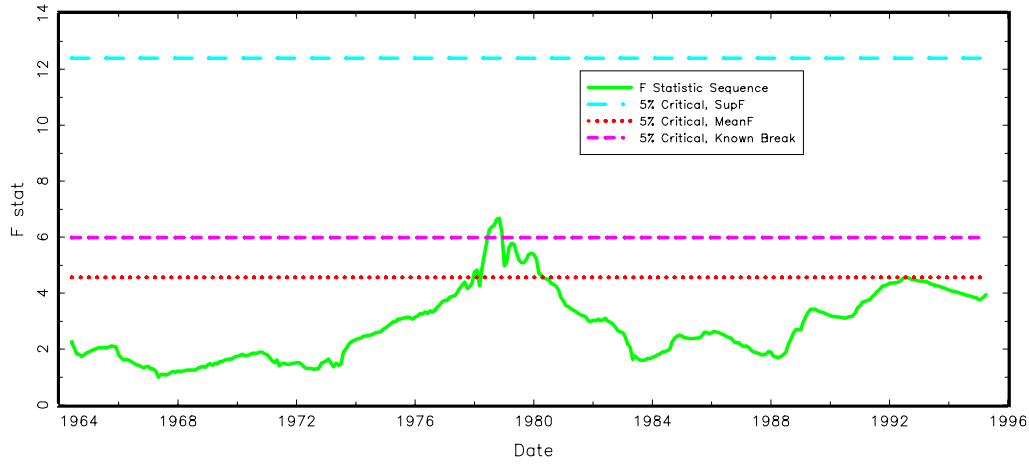
Inflation on T-bill Rate and Base Growth (constant included)
1960-2003



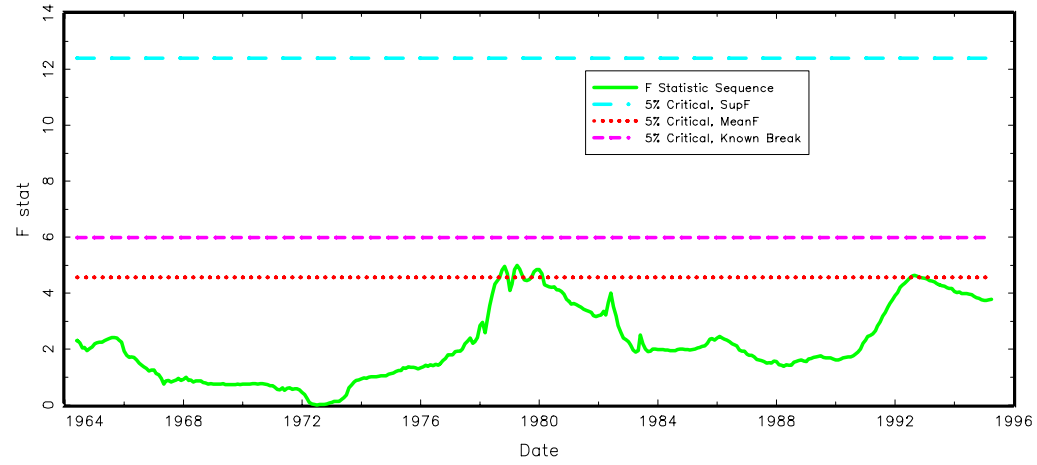
Inflation on T-bill Rate and Base Growth (no constant)
1960-2003



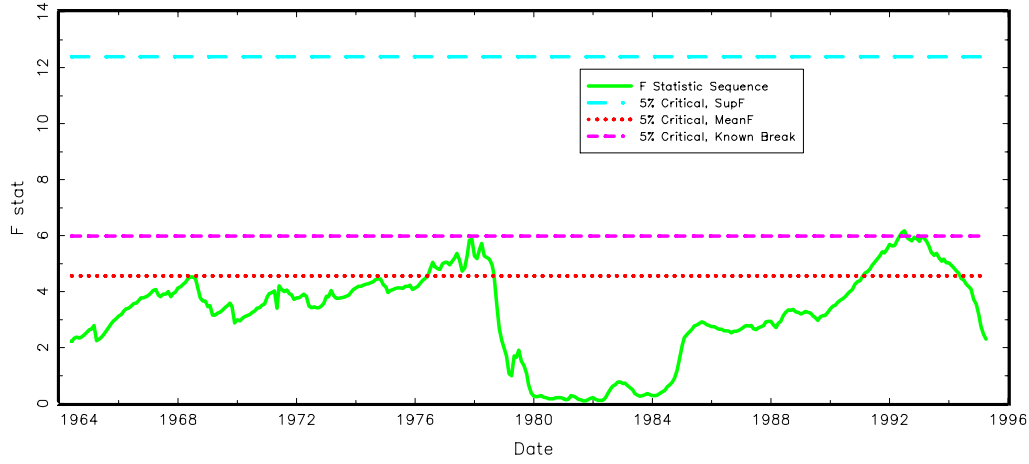
T-bill Rate on NB Reserves Growth and Inflation (constant included)
1960-2003



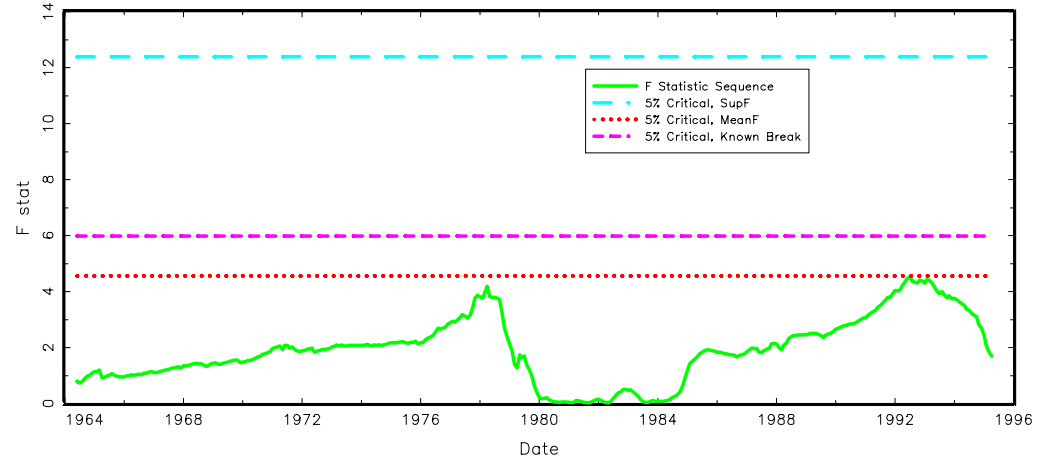
T-bill Rate on NB Reserves Growth and Inflation (no constant)
1960-2003



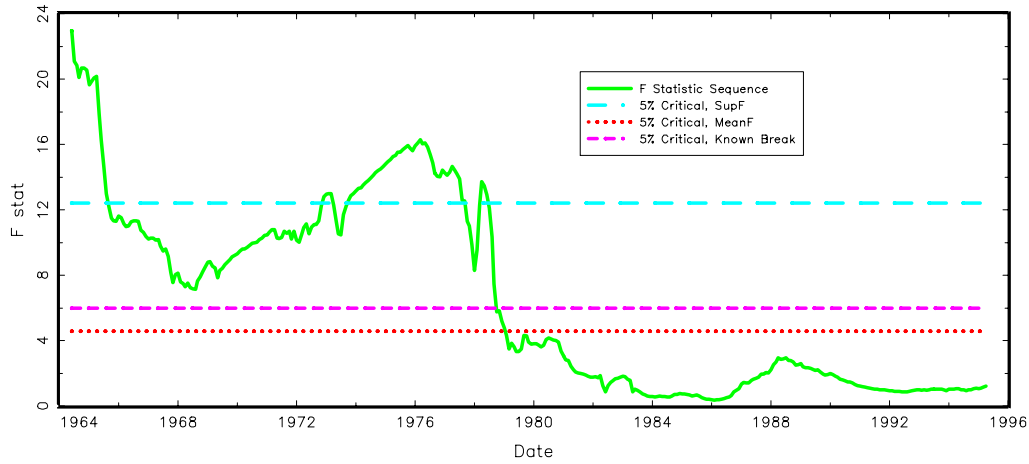
NB Reserves Growth on T-bill Rate and Inflation (constant included)
1960-2003



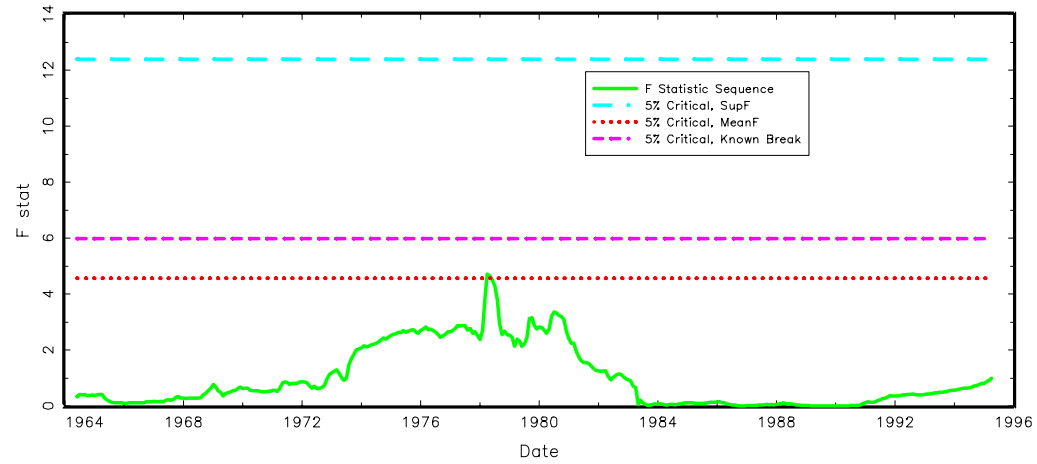
NB Reserves Growth on T-bill Rate and Inflation (no constant)
1960-2003



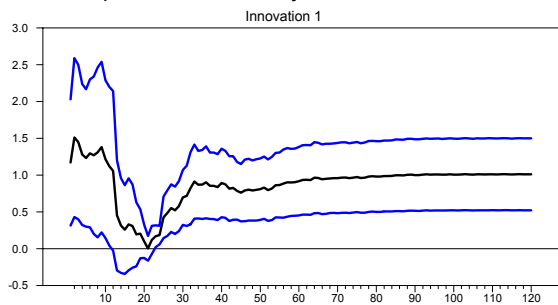
Inflation on T-bill Rate and NB Reserves Growth (constant included)
1960-2003



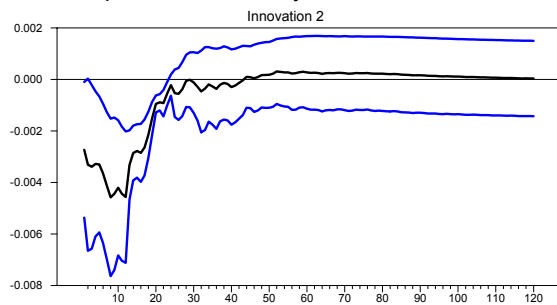
Inflation on T-bill Rate and NB Reserves Growth (no constant)
1960-2003



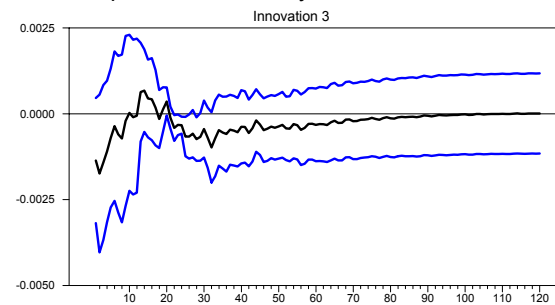
Response of Monetary Base Growth Rate



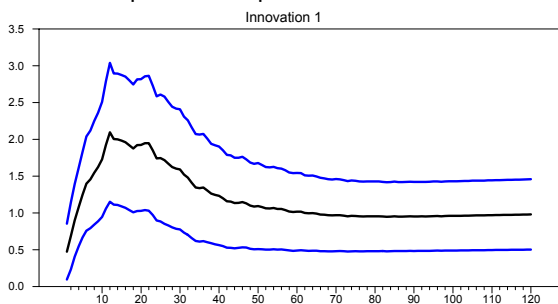
Response of Monetary Base Growth Rate



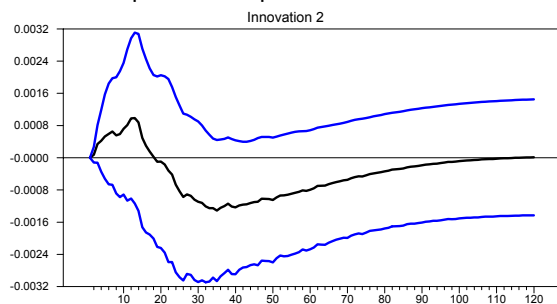
Response of Monetary Base Growth Rate



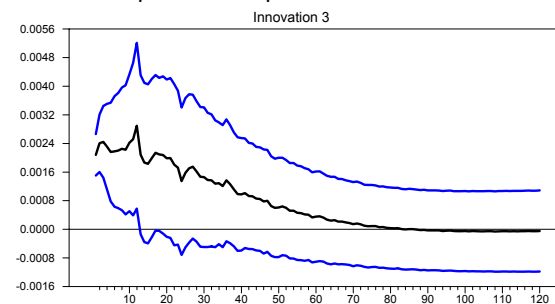
Response of Expected Inflation Rate



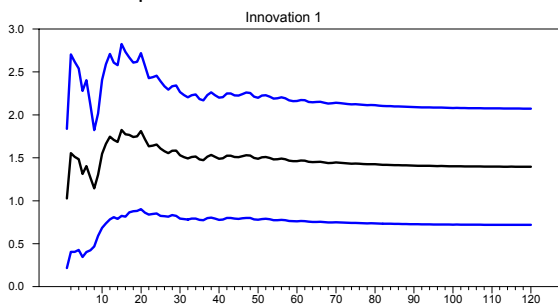
Response of Expected Inflation Rate



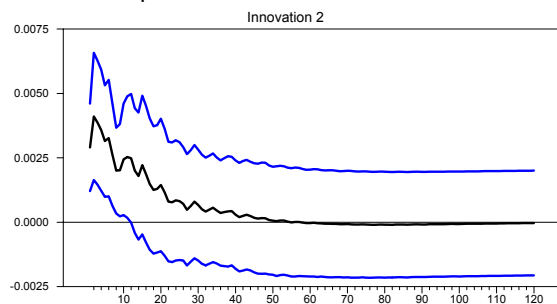
Response of Expected Inflation Rate



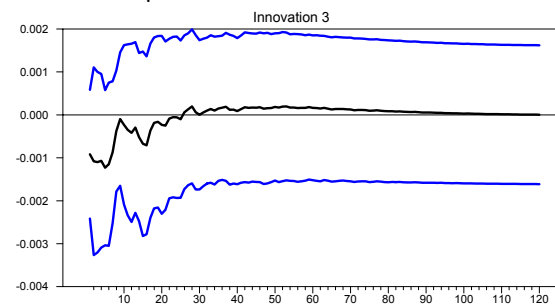
Response of Nominal Interest Rate



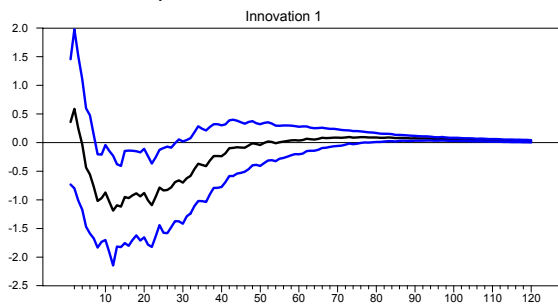
Response of Nominal Interest Rate



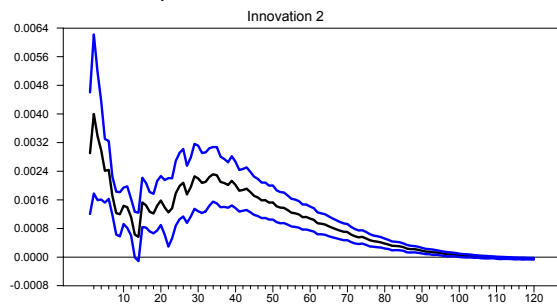
Response of Nominal Interest Rate



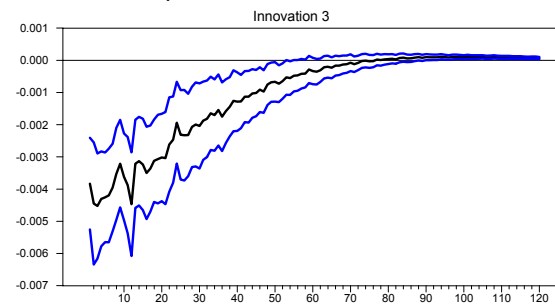
Response of Real Interest Rate



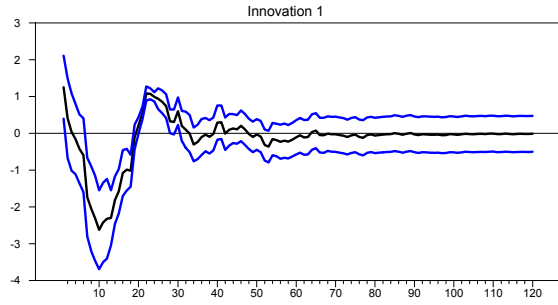
Response of Real Interest Rate



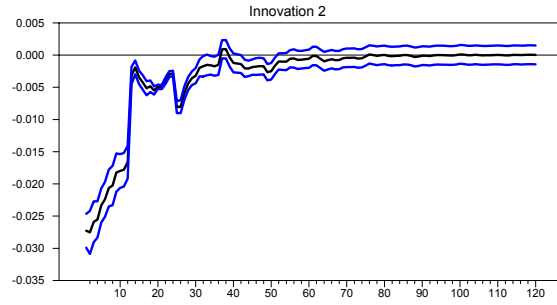
Response of Real Interest Rate



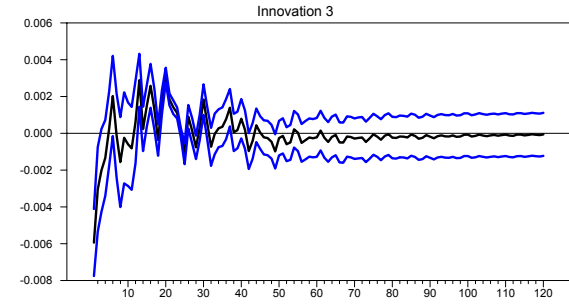
Response of Non-Borrowed Reserves Growth Rate



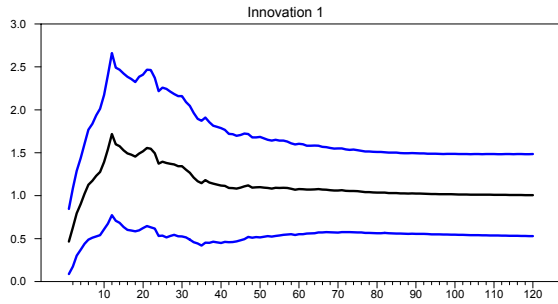
Response of Non-Borrowed Reserves Growth Rate



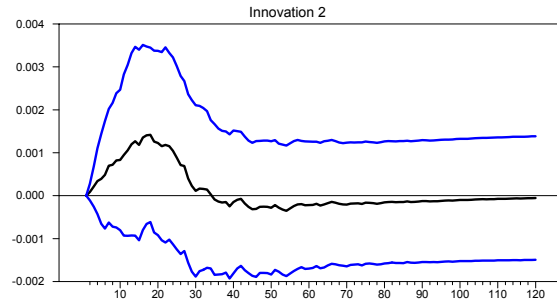
Response of Non-Borrowed Reserves Growth Rate



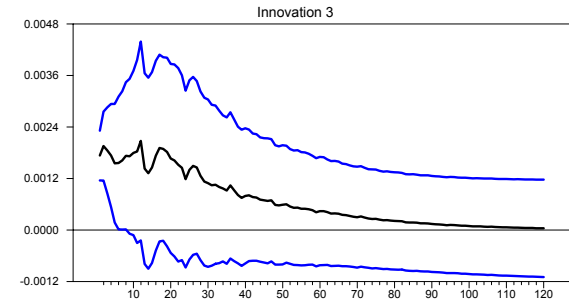
Response of Expected Inflation Rate



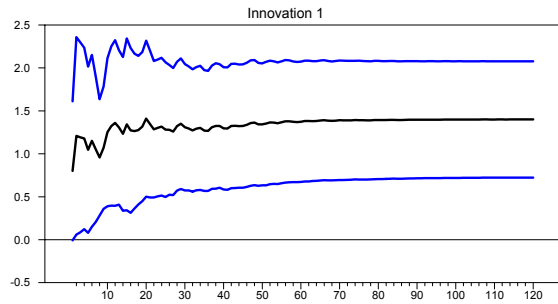
Response of Expected Inflation Rate



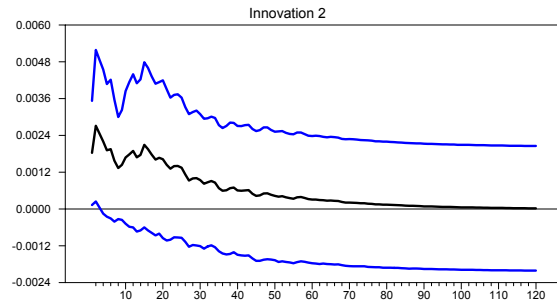
Response of Expected Inflation Rate



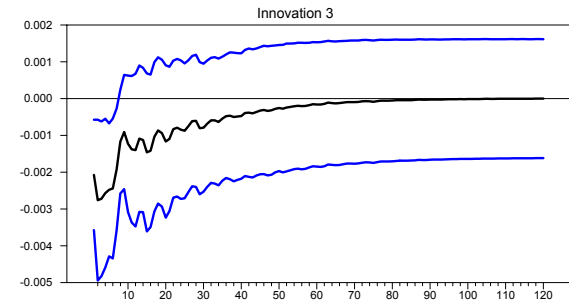
Response of Nominal Interest Rate



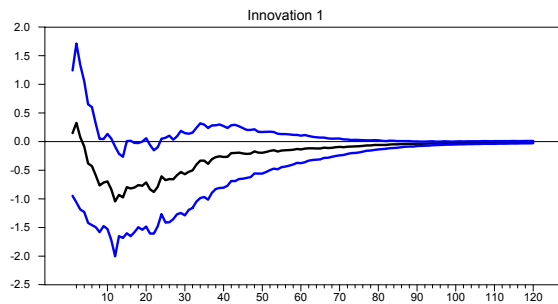
Response of Nominal Interest Rate



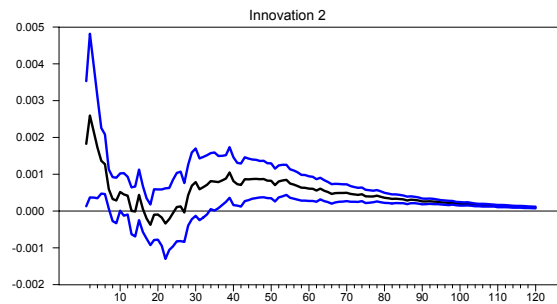
Response of Nominal Interest Rate



Response of Real Interest Rate



Response of Real Interest Rate



Response of Real Interest Rate

