EC 831: Applied Methods in Macroeconomics

Aeimit Lakdawala

Michigan State University

Spring 2014

Liu, Waggoner & Zha (2011)

Sources of macroeconomic fluctuations: A regime-switching DSGE approach

Regime Switching DSGE Model

Markov switching variables govern

1. time variation in shock variances
   - governed by regime switching variable s_t^*
2. time variation in the inflation target
   - governed by regime switching variable s_t

Standard New-Keynesian Setup

Monopolistic Competition and Price Indexation:

- Labor Markets
- Intermediate Goods Market

Households:

- Standard utility function
- Habit formation in consumption

Shocks

1) Price Markup

2) Wage Markup

3) Technology

4) Preference shock (Household Discount Factor Shock)

5) Investment specific technology

6) Capital depreciation

7) Government spending

8) Monetary policy

Capital Depreciation Shock

$$
\begin{aligned}
K_t &= (1-\delta_t)K_{t-1} + \left(1 - S\frac{I_t}{I_{t-1}}\right) I_t \\
\ln \delta_t &= (1-\rho_d)\ln \delta + \rho_d \ln \delta_{t-1} + \sigma_d(s_t^*)\varepsilon_{dt}
\end{aligned}
$$

Monetary Policy Rule

$$R_t = \rho_r R_{t-1} + (1 - \rho_r) \left[\phi_\pi (\pi_t - \pi^*(s_t) + \phi_y y_t) \right] + \sigma_r(s_t^*) \varepsilon_{rt}$$

Solution of DSGE Model

How do we solve a DSGE model with regime switching?

Solution of DSGE Model

How do we solve a DSGE model with regime switching?

1) Linearize around steady-state

- Time-varying variances don't matter for agent's decisions

2) Inflation target only shows up in constant term

- Can be accommodated into a linear framework

$\Rightarrow$ Standard solution methods for linearized DSGE models apply

Solution of DSGE Model

Consider two regimes for inflation target:

Write the inflation target as

$$\pi^*(s_t) = [\pi^*(1)\pi^*(2)]\, e_{s_t} \tag{1}$$

where

$$e_{s_t} = \begin{pmatrix} \mathbb{1}_{\{s_t=1\}} \\ \mathbb{1}_{\{s_t=2\}} \end{pmatrix}$$

Then we can write e_{s_t} as an AR(1) process

$$e_{s_t} = Qe_{s_{t-1}} + \nu_t \tag{2}$$

where Q is the transition matrix of s_t

Solution of DSGE Model

We can just substitute (1) into the monetary policy rule

$$R_t = \rho_r R_{t-1} + (1 - \rho_r) \left[\phi_\pi (\pi_t - \pi^*(s_t) + \phi_y y_t)\right] + \sigma_r(s_t^*)\varepsilon_{rt}$$

and add (2) as an extra equation to our model.

Solution of DSGE Model

Solution is of the following form

$$f_t = c(s_t) + Ff_{t-1} + C(s_t^*)\varepsilon_t$$

Estimation: How would you estimate this model?

Data

8 observables

1. **Real per capita GDP**
2. **Real per capita Consumption**
3. **Real per capita Investment**
4. **Real Wages**
5. **Per capita Hours**
6. **GDP Deflator**
7. **Fed Funds Rate**
8. **Investment-specific technology**: "inverse of the relative price of investment"

TABLE 2. Comprehensive measures of model fits.

Model	Marginal Data Density
DSGE-con	5741.24
DSGE-2v	5832.38
DSGE-2c	5739.32
DSGE-2cv	5832.60
DSGE-2c2v	5830.84
DSGE-2v2v	5826.95
DSGE-3v	5813.91

Figure : v: variance, c: inflation target, 2c2v: 2 regime switching variables

Inflation Target

In DSGE-2cv, inflation target is

- 2.18% for one regime
- 1.70% for the other regime.

In DSGE-2c2v, inflation target is

- 2.4% for one regime
- 2.1% for the other regime.

$\Rightarrow$ Difference not quantitatively important

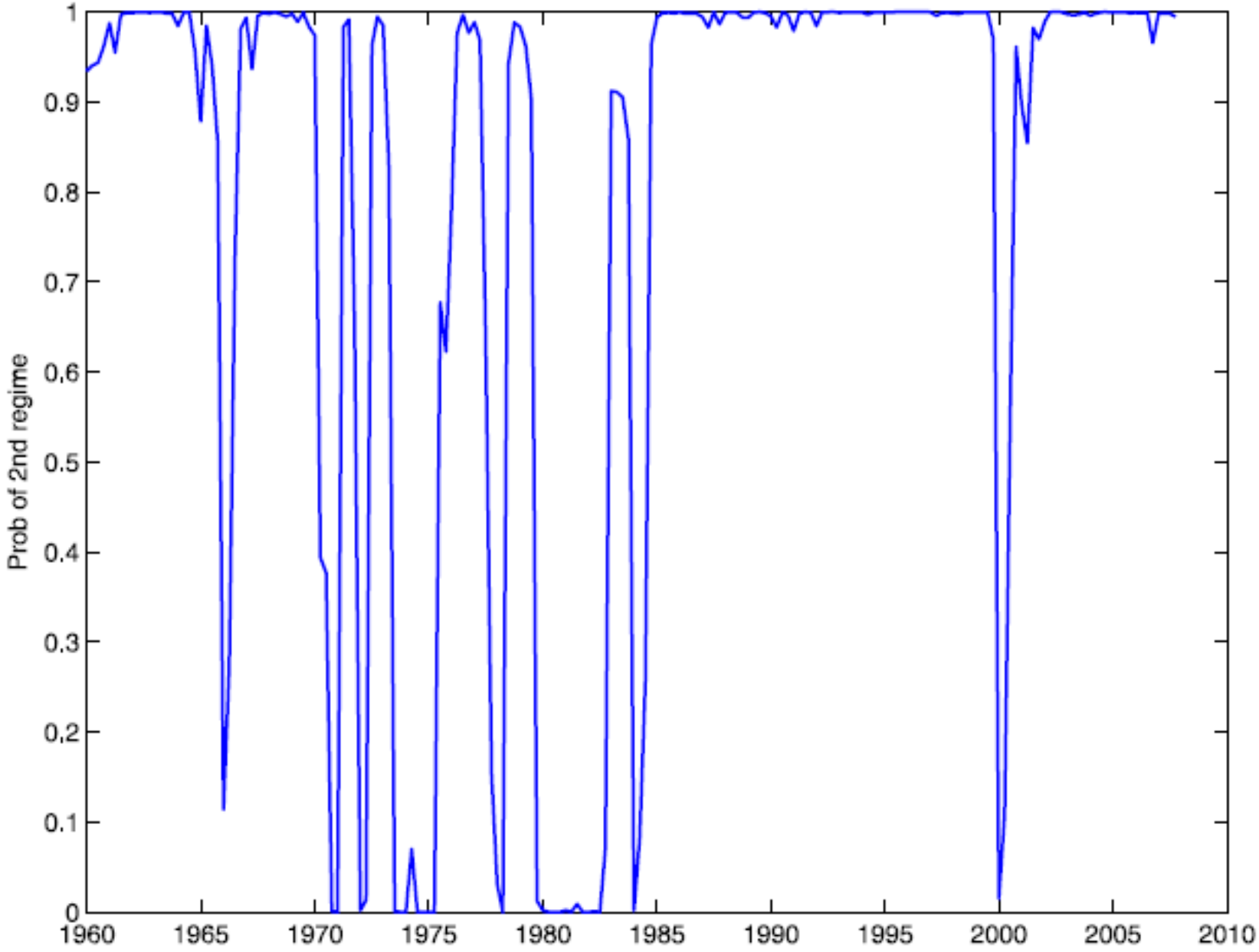

Figure : Posterior probabilities of the less volatile regime (the second regime) for the DSGE-2v model

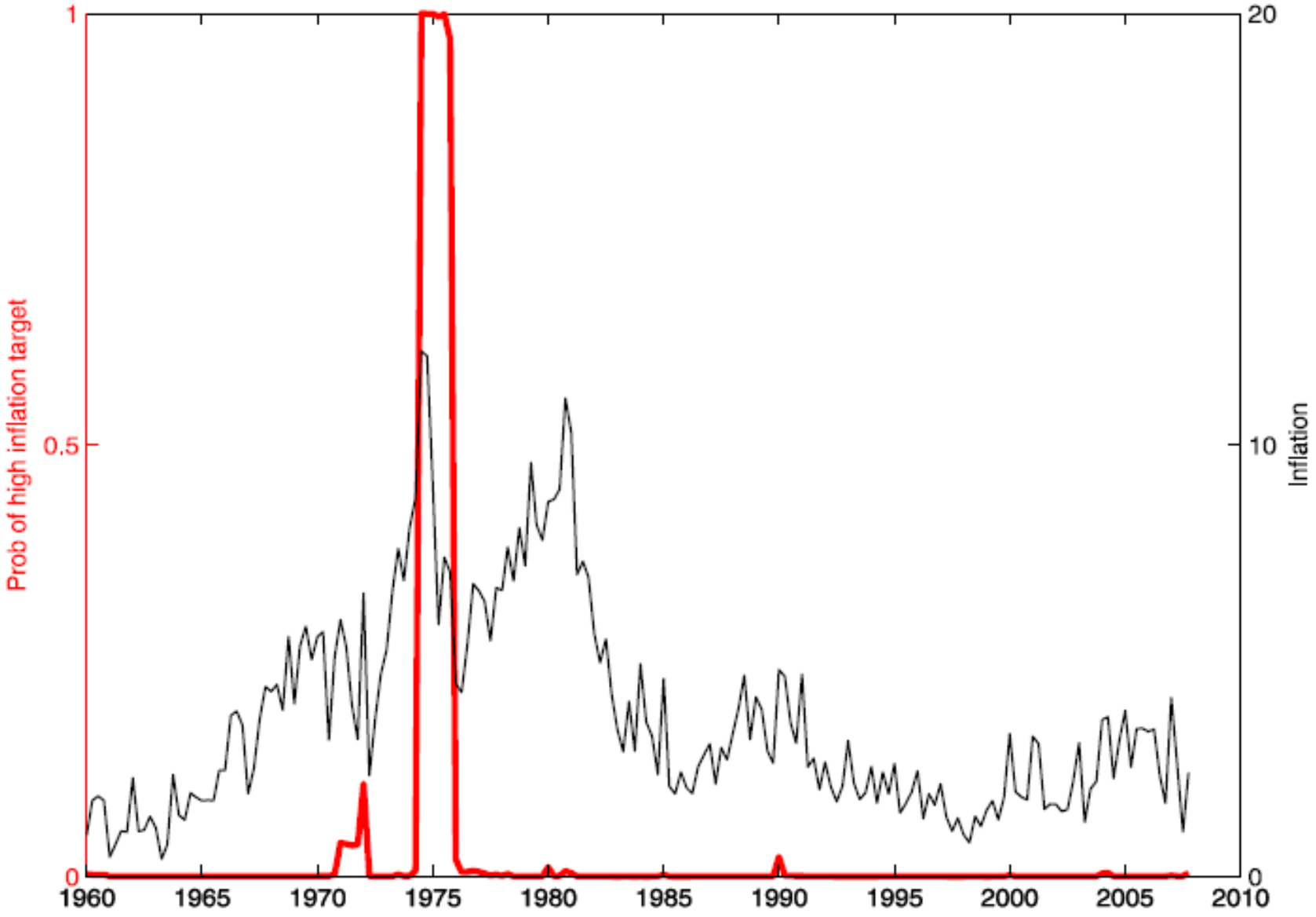

Figure : Posterior probabilities of the high-inflation-target regime for the DSGE-2c

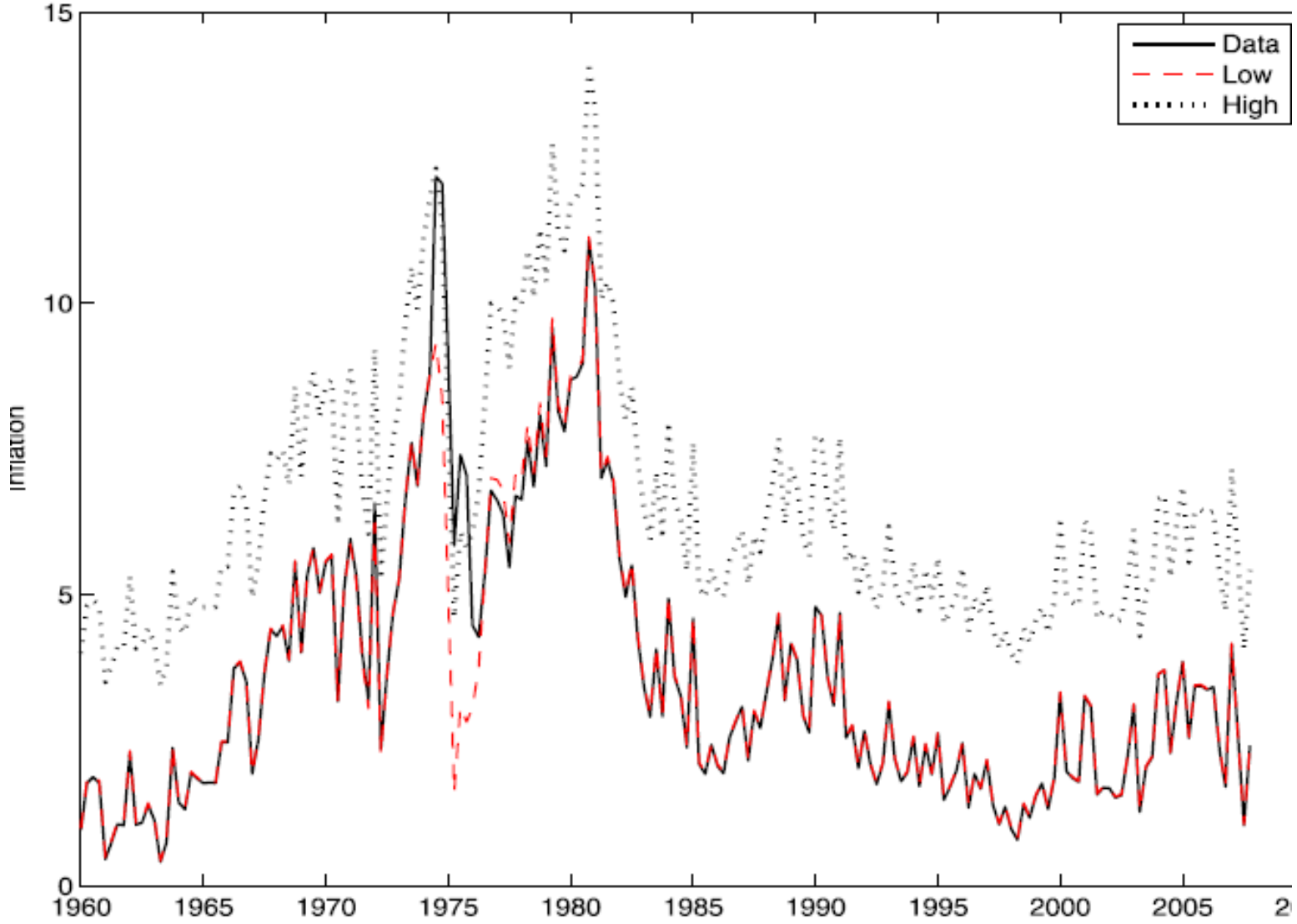

Figure : Counterfactual paths of inflation simulated from the DSGE-2c model when the inflation target was fixed atthe low-target regime (the dashed line) and at the high-target regime (the dotted line) throughout the sample.

TABLE 5. Forecast error variance decomposition: Regime I.[a]

Horizon	MP	PM	WM	GS	Ntech	Pref	Btech	Dep
				Output				
4Q	5.1443	4.1486	21.7621	12.8076	21.7050	1.4694	0.2106	32.7525
8Q	2.6618	4.1472	36.6626	6.3157	23.4311	0.5821	0.3289	25.8707
16Q	1.2227	2.9278	49.3857	3.4905	25.7249	0.2658	0.3942	16.5885
20Q	0.9756	2.5166	52.4044	2.9881	26.1211	0.2121	0.4119	14.3702
				Investment				
4Q	8.2082	5.7979	14.4682	0.7438	4.7909	0.5182	1.5667	63.9061
8Q	4.6292	6.2905	22.8817	1.1375	7.1533	0.7034	2.2140	54.9904
16Q	3.2021	5.9545	30.5410	1.2310	10.2411	0.6839	3.6330	44.5134
20Q	3.0318	5.7789	32.0371	1.1764	11.1034	0.6478	4.2787	41.9460
				Hours				
4Q	6.2409	4.6560	33.5268	18.7046	3.9659	2.0046	0.0815	30.8198
8Q	3.4031	4.8188	58.8519	10.9127	1.8040	0.9368	0.1388	19.1339
16Q	1.7212	3.0812	76.6957	6.8522	0.9926	0.4698	0.1114	10.0761
20Q	1.3929	2.5430	79.8568	6.0511	0.8162	0.3841	0.0938	8.8619
				Real Wage				
4Q	6.2726	14.9794	24.5772	0.2213	34.1127	1.1717	0.2982	18.3668
8Q	5.6839	19.8200	12.8581	0.1161	31.7275	0.5643	0.2978	28.9321
16Q	3.3235	20.6873	6.9996	0.1603	36.8344	0.3290	0.3967	31.2691
20Q	2.8272	19.7771	5.9603	0.1726	39.2705	0.2857	0.4580	31.2486
				Inflation				
4Q	17.1586	11.2160	34.3253	1.1835	0.1755	1.1923	0.5994	34.1493
8Q	17.1334	9.3782	36.9222	1.1124	0.1509	1.0689	0.7772	33.4568
16Q	14.3407	7.9953	40.9412	0.9402	0.1589	0.9094	0.7557	33.9585
20Q	12.8011	7.2902	42.2714	0.8484	0.2053	0.8251	0.6802	35.0783

the monetary policy shock (MP),
the price-markup shock (PM),
the wage-markup shock (WM),
the government spending shock (GS),
the neutral technology shock (Ntech),
the preference shock (Pref),
the biased technology shock (Btech),
the depreciation shock (Dep).

"capital depreciation shocks, neutral technology shocks, and wage markup shocks account for 70% - 80% of the fluctuations in output, investment, hours, and inflation under each regime for the forecast horizons beyond eight quarters."

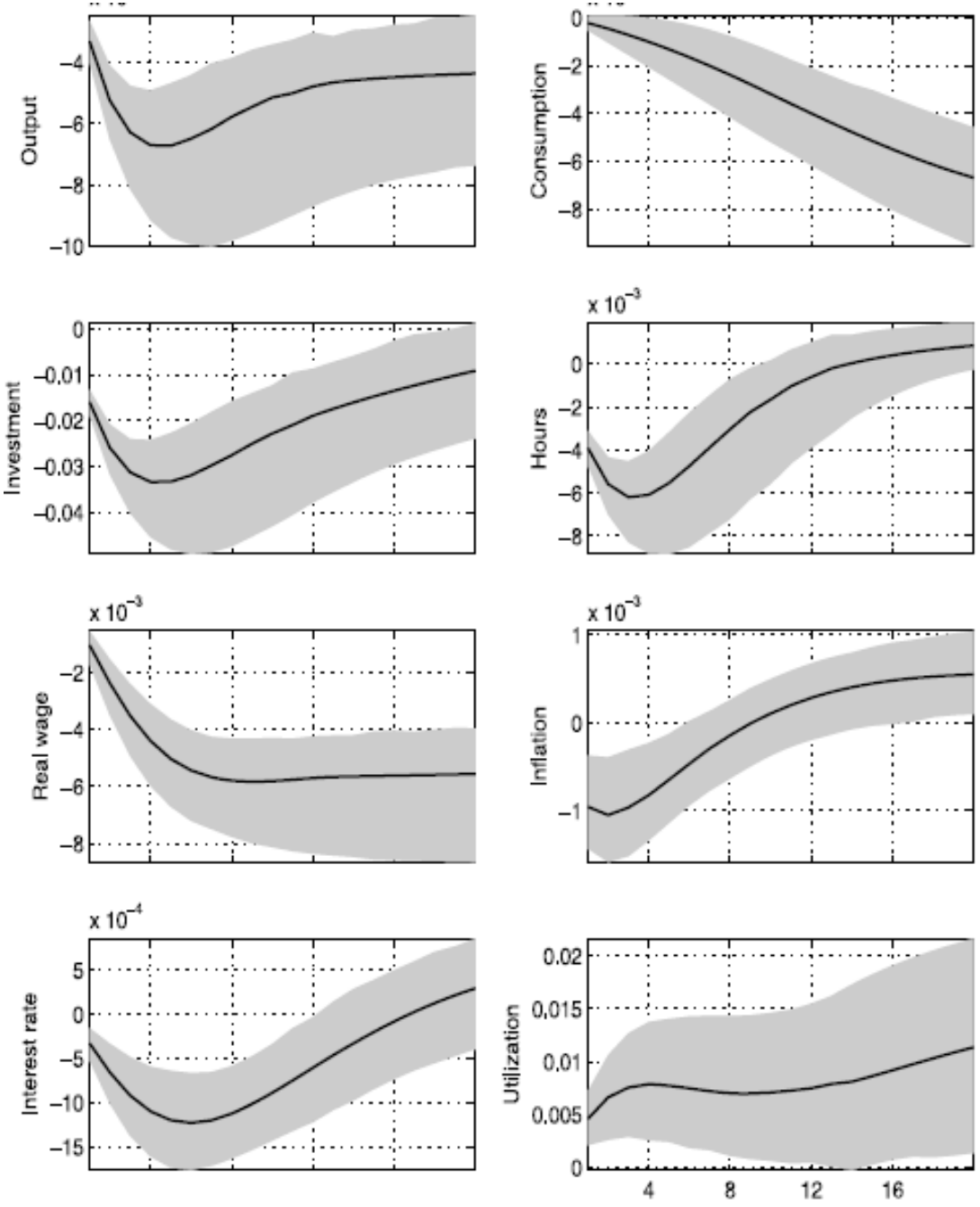

Figure : Impulse response to depreciation shock

What is a shock to capital depreciation?

"shock to the depreciation rate represents destruction of capital and therefore resembles a shock to the quality of capital"

What is a shock to capital depreciation?

"shock to the depreciation rate represents destruction of capital and therefore resembles a shock to the quality of capital"

"In each period, as a fraction of goods becomes obsolete randomly, the capital used to produce those obsolete goods becomes worthless. In aggregate, the law of motion for capital would feature a depreciation shock"

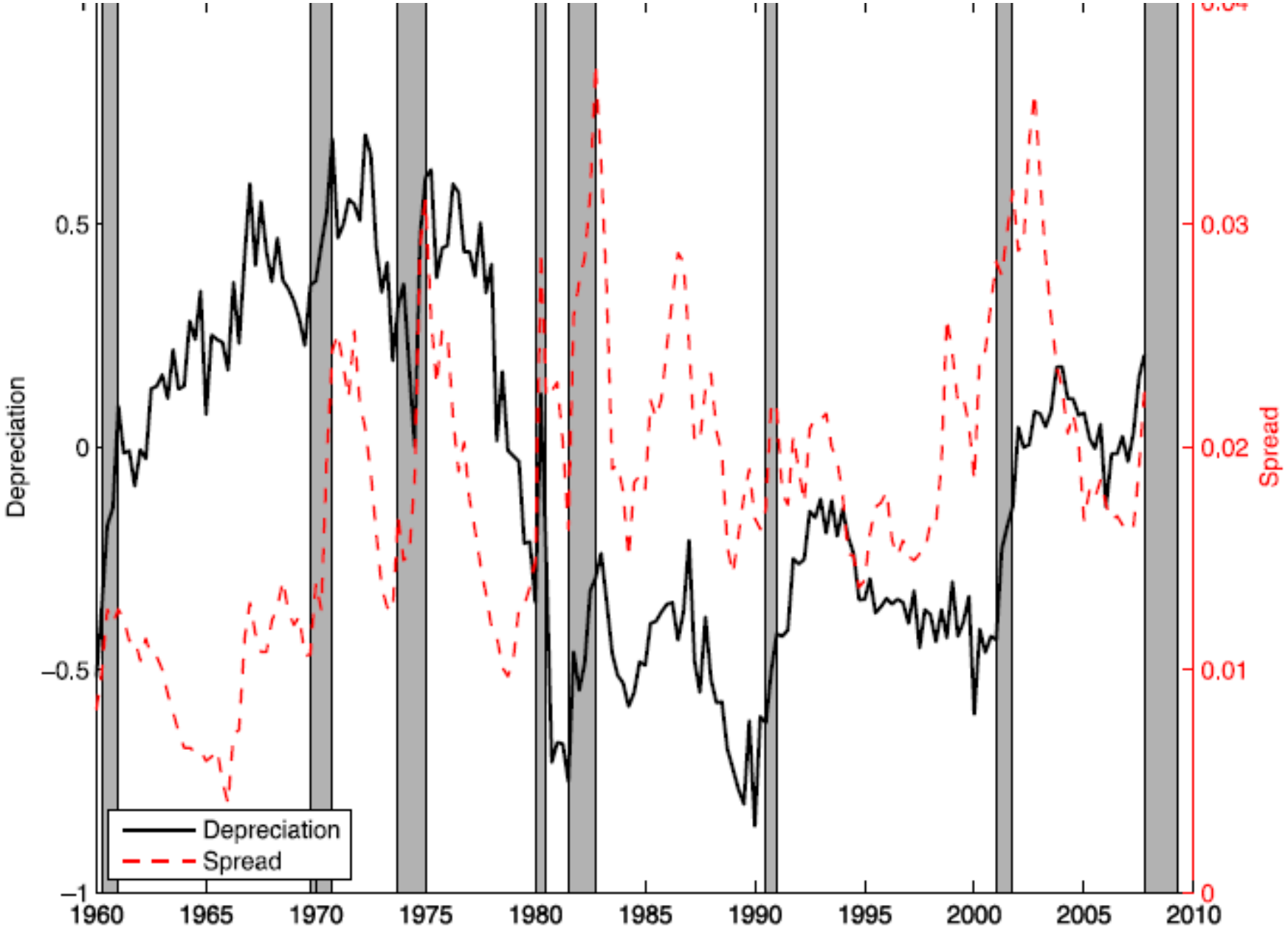

Figure : Historical paths of depreciation shocks and the spread between the Baa corporate and the 10-year treasury yields.

"Our estimation indicates that heteroskedasticity in shock disturbances is crucial for the model's empirical fit and that changes in shock variances tend to take place simultaneously rather than independently."

- But we assume that these shocks are uncorrelated, so what is going on here?

"The depreciation shock, along with the standard TFP shock and the wage-markup shock, is an important driving source of business-cycle fluctuations in the U.S. economy."