Putting Economics (Back)

into

Financial Models

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Typical Sources of Excess Return

1. Factor risk exposures/beta (macro)

2. Intermediation (brokering)

3. Liquidity and or risk transfer (insurance)

4. Mispricing (arbitraging inefficiency)

5. Frontrunning/cheating/information/fraud not yet in quant modeling set.

Extra expected return in Fixed Income typically from sales of explicit or implicit options

1. Duration extension yield $\leftrightarrow$ option to rebalance at forwards.

2. Mortgage spread $\leftrightarrow$ prepayment option

3. Credit/Emerging Market spread $\leftrightarrow$ default option

4. Municipal spread $\leftrightarrow$ tax-code/liquidity option

5. TIPS spread $\leftrightarrow$ Inflation/deflation option

6. etc.

Requirements/features of Classic Option Models

- Helps make money and in taking risks
- Stable, analytically tractable and "stress-able"
- Arbitrage Free
- Investor's behavior and preference irrelevant
- Modeler irrelevant
- Price reflects Value
- Prices of securities are irrelevant to the evolution of the world

Standard Approach for option valuation

1. Assume a distribution for the fundamental variables (typically Gaussian),
2. Estimate the parameters using history and common sense as input,
3. Generate probable paths of evolution (through numerical methods if necessary),
4. Fit remaining free parameters in the model to traded security prices to make model arb free,
5. Price other securities with the model.

Economics* never comes in explicitly, but forms a backdrop during the estimation stage. Approach assumes smooth markets without structural breaks.

*Economics: The study of how the forces of supply and demand allocate scarce resources.

Big problem: There is no unique transformation from risk-neutral to physical probabilities in the real world. Real Markets are not even continuous.

Key idea of risk-neutral pricing: if locally a hedge portfolio can be created, then replace the risk premium with zero. Then, write risk neutral probability in terms of risky probability as shift of means, e.g.

$$\tilde{q} = N(N^{-1}(q) + (\tilde{\mu} - \mu)\sqrt{T}) \qquad (1)$$

where N represents the cumulative normal distribution and the risk-neutral probability is $\tilde{q}$ with physical probability q.

In the absence of explicit economic inputs, option models are fancy fitting algorithms.

Actions of non-economically motivated agents can force deviation of even the most liquid markets to limits where the strongest of arbitrage forces is unable to force reversion to fair valuation.

Example: Central Banks behavior - "you invest in T-Bills in US for safety, not to maximize rate of return." Greenspan (2006)

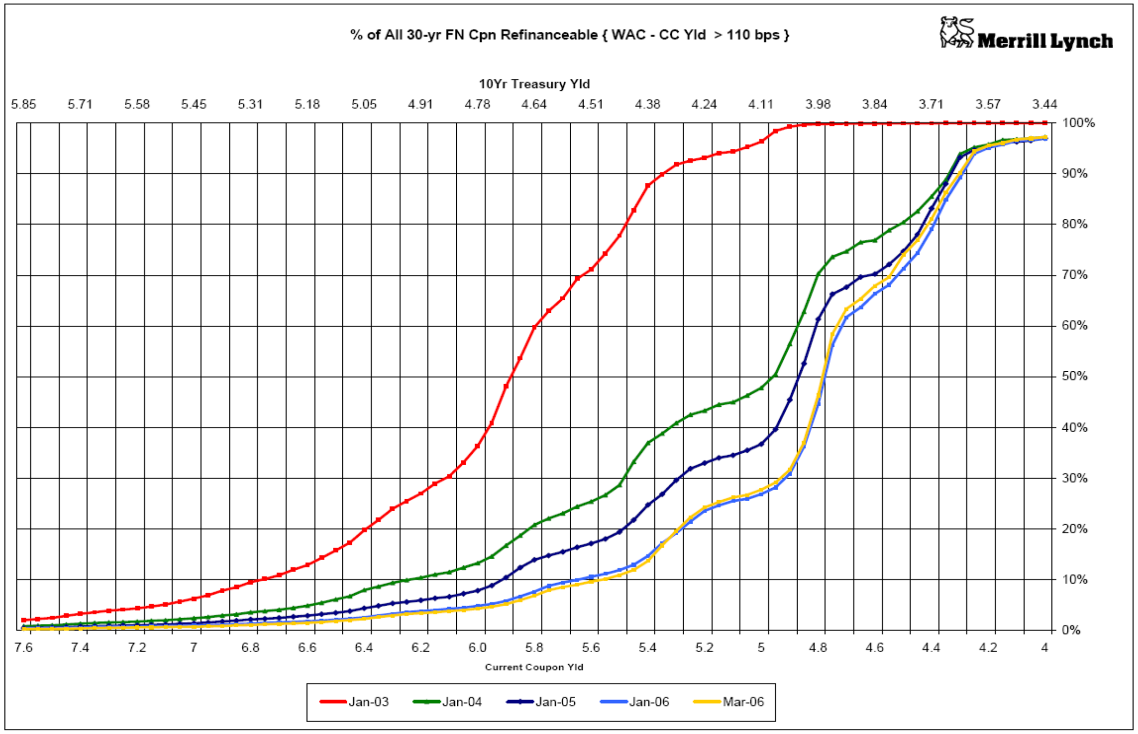
Example: Mortgage Modeling Experts Disagree!

Dealer	OAS(T)	OAS(L)	OAD(R)	OAD(Desk)
Lehman	26	3	4.8	4.6
Goldman	81	34	4.6	4.0
Greenwich	36	17	4.0	4.0
CSFB	52	18	6.1	4.4
Sal	51	16	5.2	4.4
MS	52	29	5.0	4.2
BofA	64	25	4.2	4.5
UBS	44	20	4.9	4.7
Countrywide	107	50	5.1	4.1
JPM	54	23	6.1	4.1
Mer	52	21	5.0	4.1
Bear	65	21	5.3	4.3
Avg	57	23	5.0	4.3
Range	81	47	2.1	0.6
Min	26	3	4.0	4.0
Max	107	50	6.1	4.7

Treasury, LIBOR OASes for current coupon MBS, and research and trading desk OAD on one day (2003).

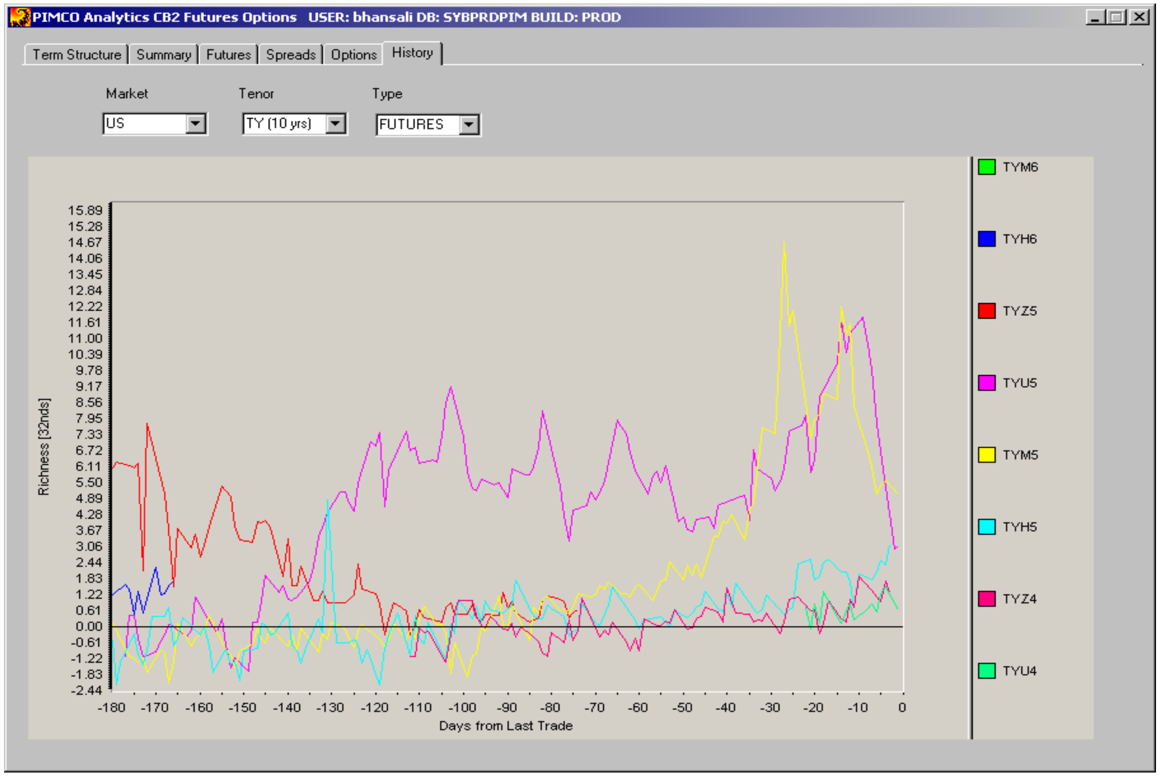
Mortgage prepayment estimates are non-arbitrageable. This is not an academic example. Mortgages are the largest fixed income market and hedging activity can impact every other market, even risk-free benchmarks!

Model Based Hedging Can Distort the Underlying Market



The MBS refinancing option. Source: Merrill Lynch

Market imbalance may impact arbitrage relationships even in the deepest markets like T-note futures. Source: PIMCO



Tranche hedge ratios computed using arbitrage arguments don't hold in practice!

Delta-Hedged Tranche Price Changes in May (bp)

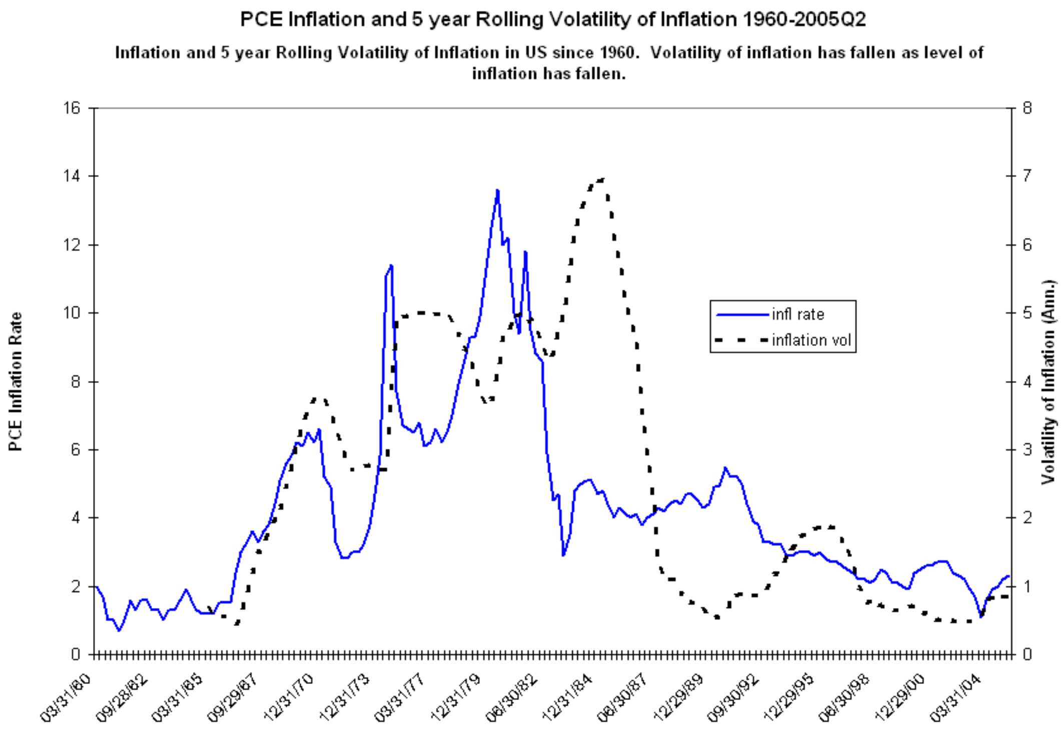
	5Y		10Y	
	US	Euro	US	Euro
0-3% (points upfront chg)	4.0pts	3.9pts	1.5pts	-2.5pts
3-7%	(84)	(49)	133	28
7-10%	(38)	(24)	(85)	(19)
10-15%	(15)	(11)	(37)	(55)
15-30%	(2)	(1)	(14)	(6)

Note: Delta-hedged positions involve selling protection on the tranche versus buying protection a delta-adjusted notional amount of the underlying index.
Source: Morgan Stanley

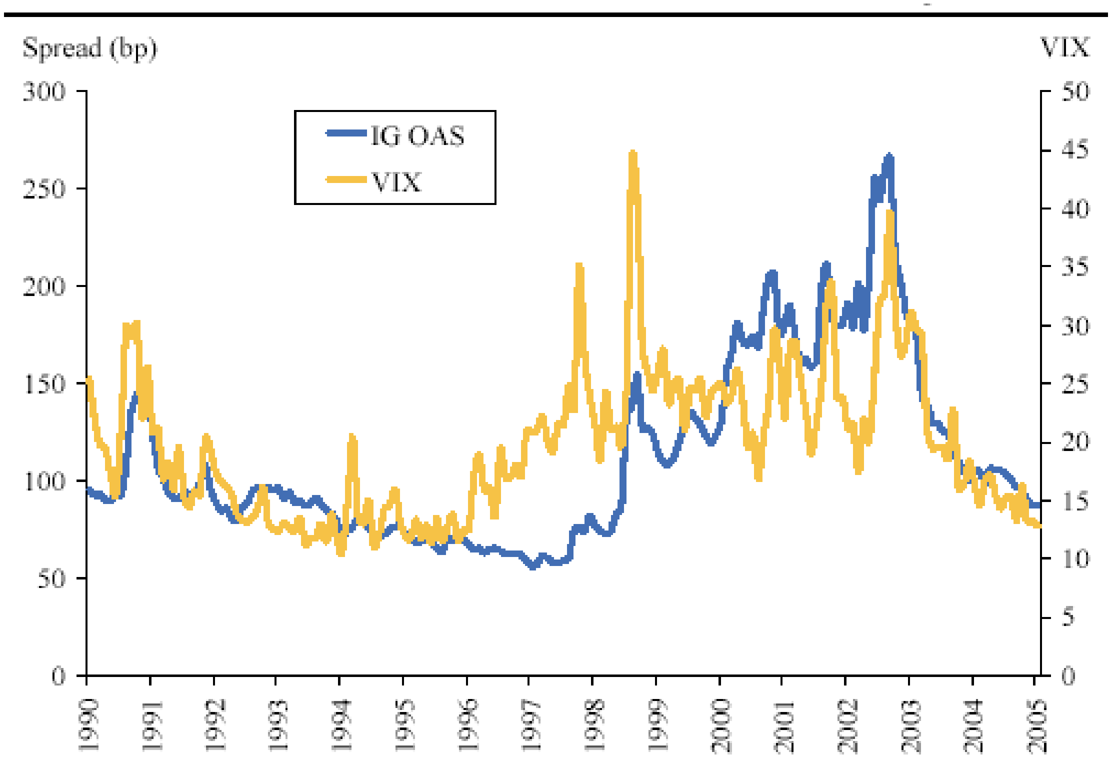
Delta adjusted performance of IG4 tranches. Source: Morgan Stanley

Copula model for correlated credit ignores the economics of defaults.

Falling Economic Volatility is Hard to Capture in Typical Arbitrage Free Models



Model arbitrage can drive convergence of markets.



VIX and Corporate Spreads. Source: Lehman Brothers.

Even the Best Model Hedges Leave Residual Beta

Asset Return Comparisons (Rebalanced to LBAG Duration Monthly, LIBOR Financing)										(	07/91	07/05	)	
Date	LBAG	MBS	TSY	AGCY	CORP	CMBS	TIPS	Muni	EM	HY	ED5	FV	TY	US
MTD	**(0.91)**	(1.17)	(1.00)	(1.01)	(0.63)	(1.16)	(1.12)	(0.17)	(0.06)	1.59	(1.58)	(1.38)	(1.25)	(0.91)
YTD	**1.58**	1.09	1.93	1.46	1.60	1.20	1.01	2.17	3.91	2.50	(0.97)	0.31	1.68	3.25
0.25	**0.71**	0.30	0.59	0.59	1.13	0.49	(0.26)	0.86	3.40	5.06	(0.18)	(0.10)	0.36	1.10
0.5	**0.95**	0.39	1.29	1.03	0.94	0.66	0.98	1.53	3.39	2.61	(0.51)	0.39	1.26	2.15
1	**4.79**	4.66	4.54	4.25	5.27	4.58	5.07	4.81	12.82	10.43	0.96	3.14	4.72	6.61
2	**4.81**	5.21	4.06	4.26	5.20	4.73	5.97	4.31	11.33	11.48	2.14	4.37	5.00	5.42
3	**5.02**	4.10	3.96	4.28	6.14	5.07	6.10	3.74	14.95	14.85	4.58	4.84	4.82	4.60
5	**7.01**	7.27	5.90	7.13	7.08	8.16	7.93	4.93	9.55	6.58	10.62	8.21	7.26	5.53
7	**6.21**	6.23	5.59	6.18	6.11		7.38	4.75	9.60	4.43	8.12	7.27	6.70	5.42
10	**6.75**	6.92	6.25	6.75	6.69						8.07	7.48	7.22	6.32
14	**7.29**	7.24	6.89	7.26	7.46						9.15	8.28	7.85	6.78

Information Ratio Comparison (Annualized Excess Return over LBAG/Annualized Standard Deviation of Excess Return, monthly data)														
Date	LBAG	MBS	TSY	AGCY	CORP	CMBS	TIPS	Muni	EM	HY	ED5	FV	TY	US
0.5	**0.00**	(1.82)	1.37	0.62	(0.01)	(1.28)	0.05	0.72	1.55	0.46	(2.37)	(1.01)	0.61	5.60
1	**0.00**	(0.21)	(0.52)	(1.29)	0.72	(0.29)	0.19	0.01	3.03	1.06	(1.98)	(1.32)	(0.08)	2.87
2	**0.00**	0.44	(1.56)	(1.31)	0.66	(0.10)	0.60	(0.27)	2.18	1.43	(1.04)	(0.26)	0.21	0.77
3	**0.00**	(0.30)	(1.55)	(1.36)	1.32	0.05	0.52	(0.62)	2.02	1.64	(0.16)	(0.09)	(0.15)	(0.50)
5	**0.00**	0.10	(1.35)	0.14	0.05	1.04	0.44	(1.01)	0.34	(0.05)	1.07	0.56	0.17	(1.30)
7	**0.00**	0.01	(0.65)	(0.03)	(0.07)		0.50	(0.68)	0.22	(0.20)	0.53	0.50	0.31	(0.59)
10	**0.00**	0.09	(0.62)	0.00	(0.05)						0.42	0.39	0.34	(0.36)
14	**0.00**	(0.03)	(0.55)	(0.06)	0.17						0.57	0.54	0.42	(0.43)

Excess Return Correlation vs. LBAG														
Date	LBAG	MBS	TSY	AGCY	CORP	CMBS	TIPS	Muni	EM	HY	ED5	FV	TY	US
0.5	1.00	0.45	0.18	0.43	(0.35)	0.93	(0.55)	(0.94)	0.03	(0.44)	0.94	0.51	0.54	0.43
1	1.00	0.10	0.07	0.34	(0.22)	0.74	(0.47)	(0.95)	0.08	(0.43)	0.74	0.58	0.52	(0.10)
2	1.00	0.32	(0.30)	0.48	(0.28)	0.73	(0.41)	(0.92)	0.24	(0.45)	0.77	0.75	0.73	(0.48)
3	1.00	0.39	(0.32)	0.28	(0.27)	0.59	(0.18)	(0.93)	(0.02)	(0.46)	0.38	0.56	0.62	(0.21)
5	1.00	0.42	(0.13)	0.36	(0.33)	0.49	(0.24)	(0.87)	(0.20)	(0.38)	0.51	0.55	0.58	(0.17)
7	1.00	0.38	(0.14)	0.27	(0.26)		(0.32)	(0.82)	(0.13)	(0.38)	0.47	0.51	0.52	(0.18)
10	1.00	0.32	(0.11)	0.24	(0.22)						0.44	0.52	0.55	(0.09)
14	1.00	0.20	(0.07)	0.14	(0.12)						0.53	0.57	0.59	(0.13)

Asset Excess Return and Correlation to Bond Aggregate. (PIMCO)

Can we try to put in economics right from the beginning?

Let us build an economically motivated, arbitrage free model of the term structure to quantify the value (of pure options) in the yield curve and see if we can explain, not just fit the dynamics of the yield curve.

Economically Motivated Term Structure Model

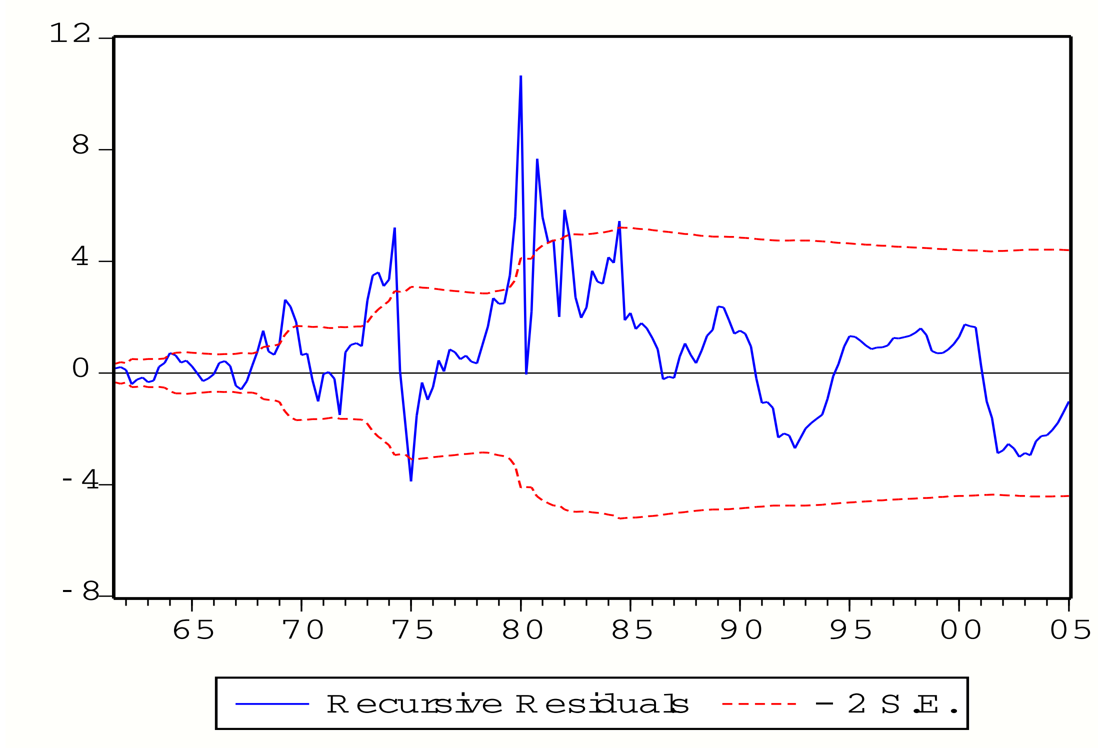
$$i_t = (r^* - \theta_1 \pi^*) + \theta_1(\pi_t) + \theta_2(u^* - u_t) + \pi_t. \quad (2)$$

r^* = Real funds rate

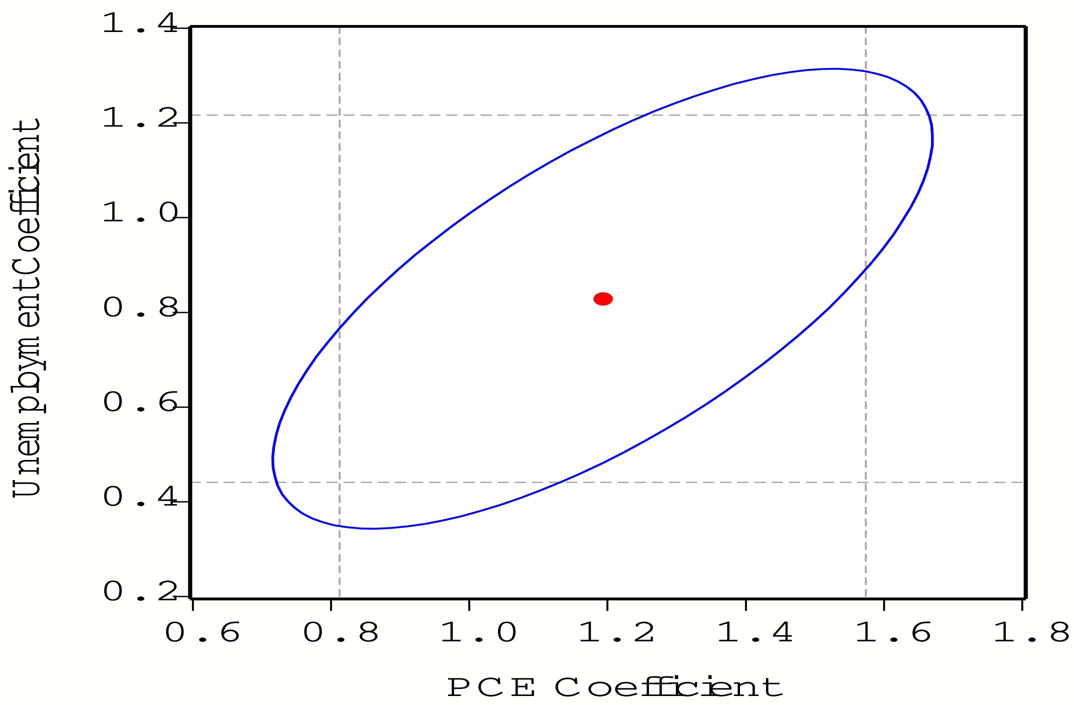
π^* = Target inflation rate - PCE deflator

u^* = Target unemployment rate - proxy for output gap

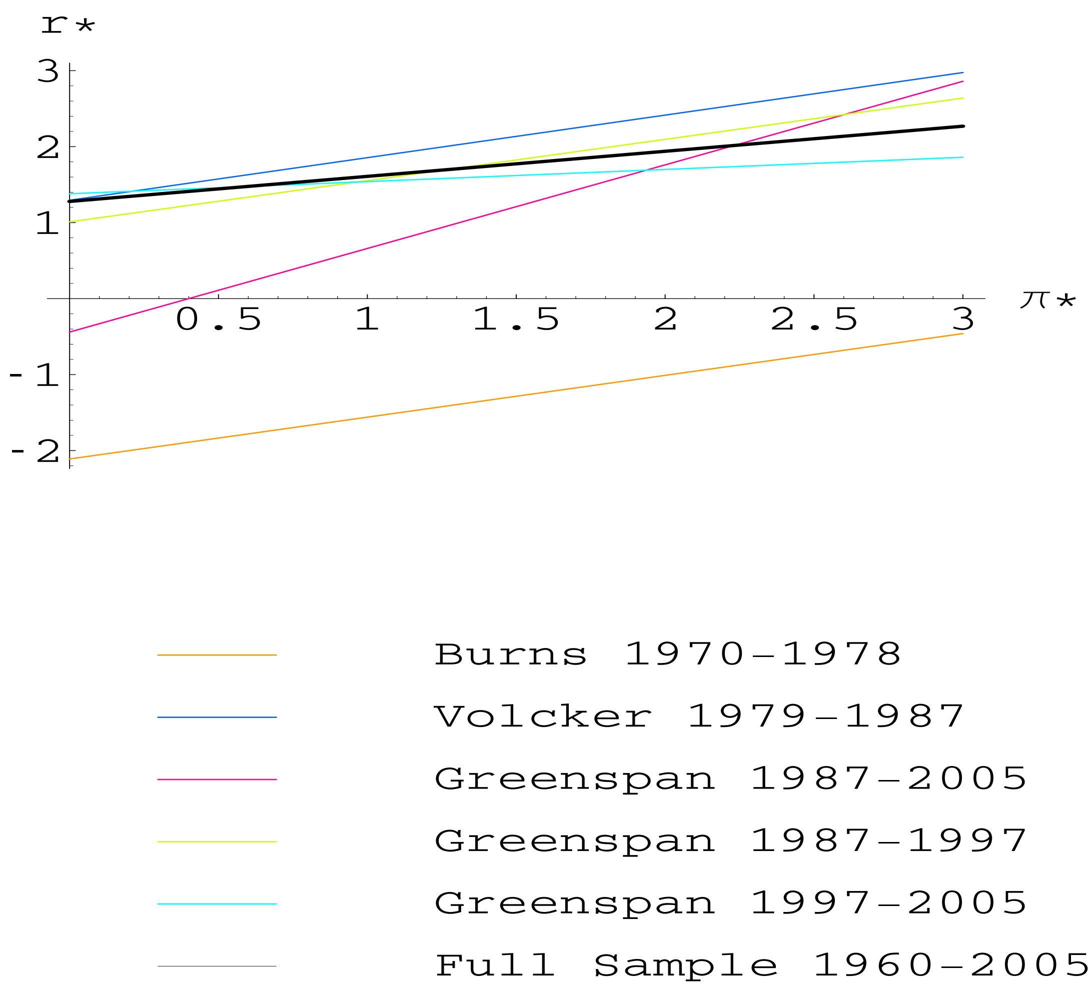
The Taylor Rule is the building block for the yield curve. Short rate set by the Fed and transmitted across the yield curve by no-arb condition. Yields are expectations of an exponential in short rates.



Econometric tests show possibility of structural breaks in Taylor Rule in the mid 70s to mid-80s.



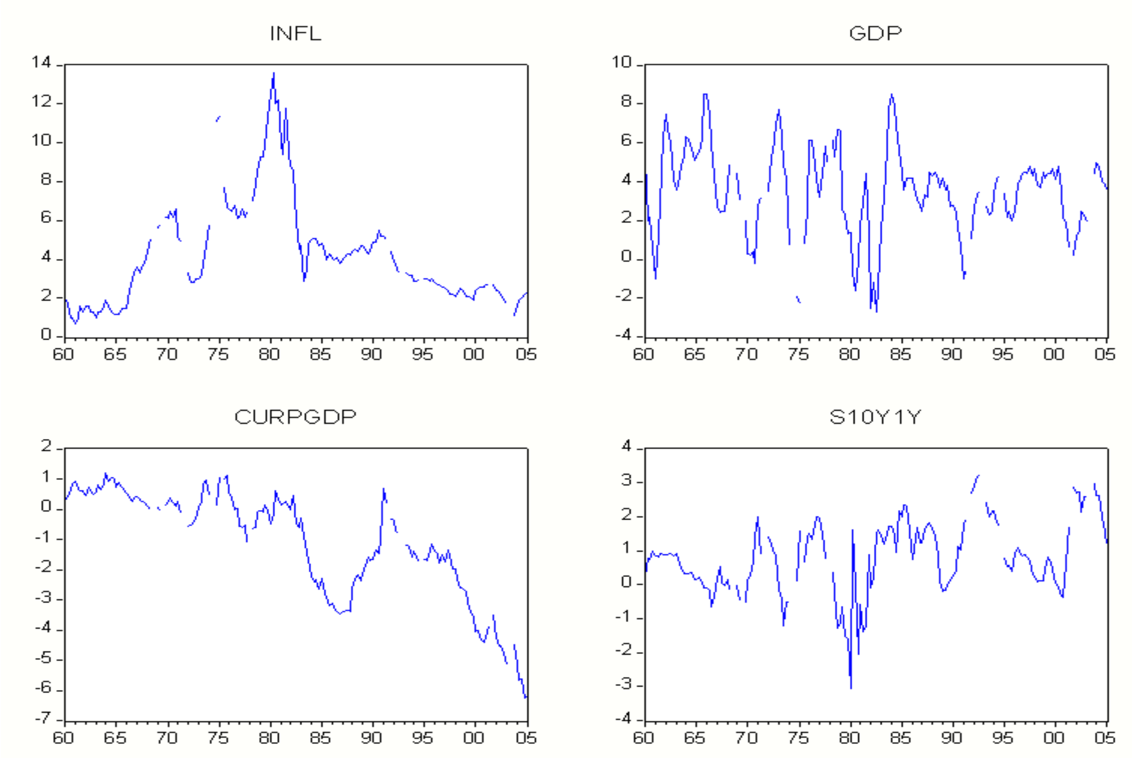
Coefficient tradeoffs in Greenspan years estimated for 1984-2005 period at 95% confidence level. There is a lot of uncertainty in economic tradeoffs.


r*
π*
3
2
1
-1
-2
0.5
1
1.5
2
2.5
3
Burns 1970–1978
Volcker 1979–1987
Greenspan 1987–2005
Greenspan 1987–1997
Greenspan 1997–2005
Full Sample 1960–2005

Period	c	θ_1	θ_2	R^2
Burns 70Q3-78Q1	-2.118(1.835)	0.555(0.326)	2.737(0.483)	0.54
Volcker 79Q3-87Q2	1.295(1.120)	0.561(0.178)	0.623(0.280)	0.72
Greenspan 87Q3-05Q1	-0.435(0.295)	1.107(0.110)	1.995(0.128)	0.859
Greenspan 87Q3-98Q3	1.109(0.188)	0.540(0.059)	1.940(0.069)	0.96
Greenspan 98Q4-05Q1	1.379(0.546)	0.161(0.339)	2.494(0.093)	0.96
60Q1-05Q1	1.279(0.372)	0.330(0.090)	0.562(0.136)	0.58

Estimation of the relationship between target real rate and inflation rate for different Fed regimes using equation 2. Here the constant c is given by the relationship $c = r^* - \theta_1 \pi^*$.

Macro Data: PCE inflation, GDP, Current Account Deficits and Shape of the Yield Curve



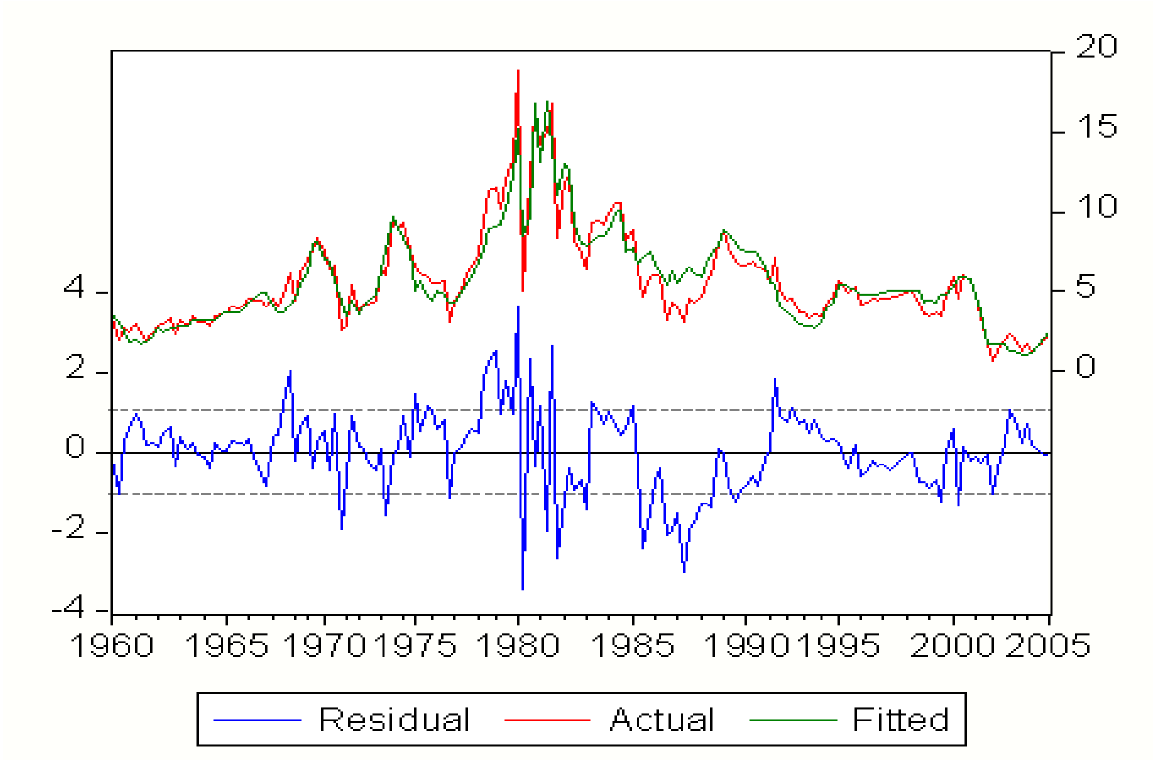
A simple, exactly solvable arb-free model:

$$\begin{aligned} dx &= -\mu_x(x-\theta_x)\,dt + \sigma_x\,dw_x \\ dy &= -\mu_y\,y\,dt + \sigma_y\,dw_y \\ dz &= k(x+y-z)\,dt \end{aligned}$$

z: instantaneous short rate; x related to inflation, y an economic activity factor; θ_x long term infl target. Last equation similar to a Taylor rule.

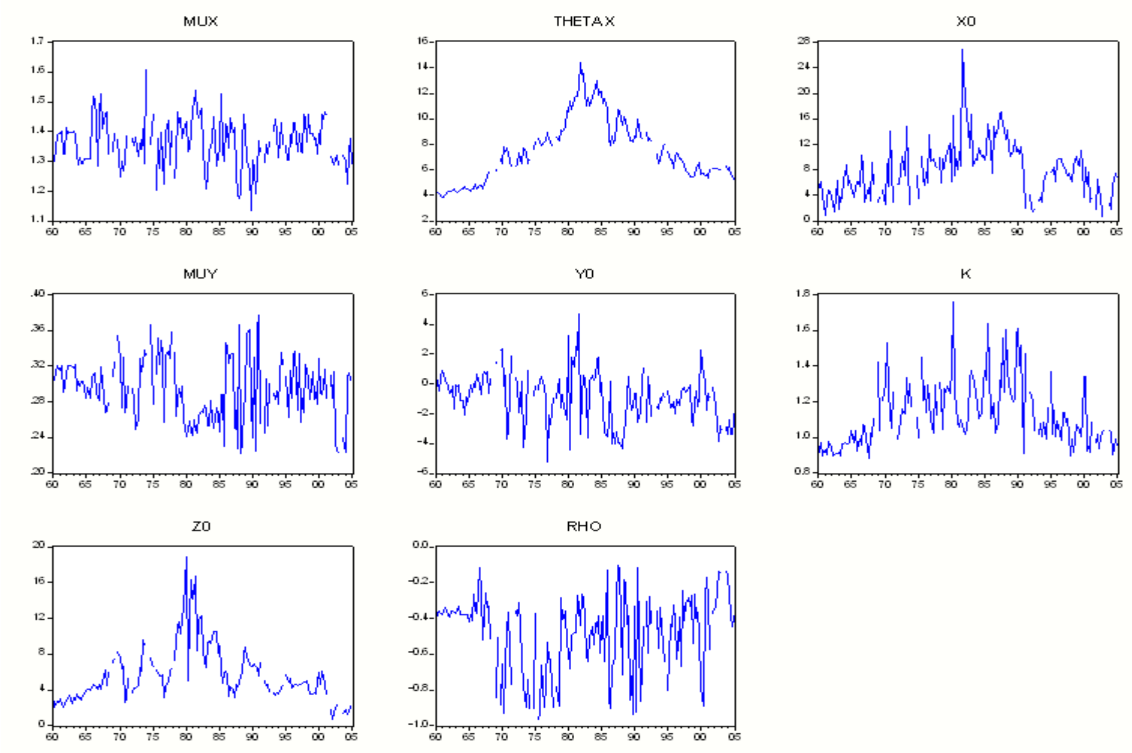
$$P(t,T) = E_t[e^{-\int_t^T z(\alpha)d\alpha}] = e^{-Y(T-t)} \qquad (3)$$

By construction, model tracks the Fed.



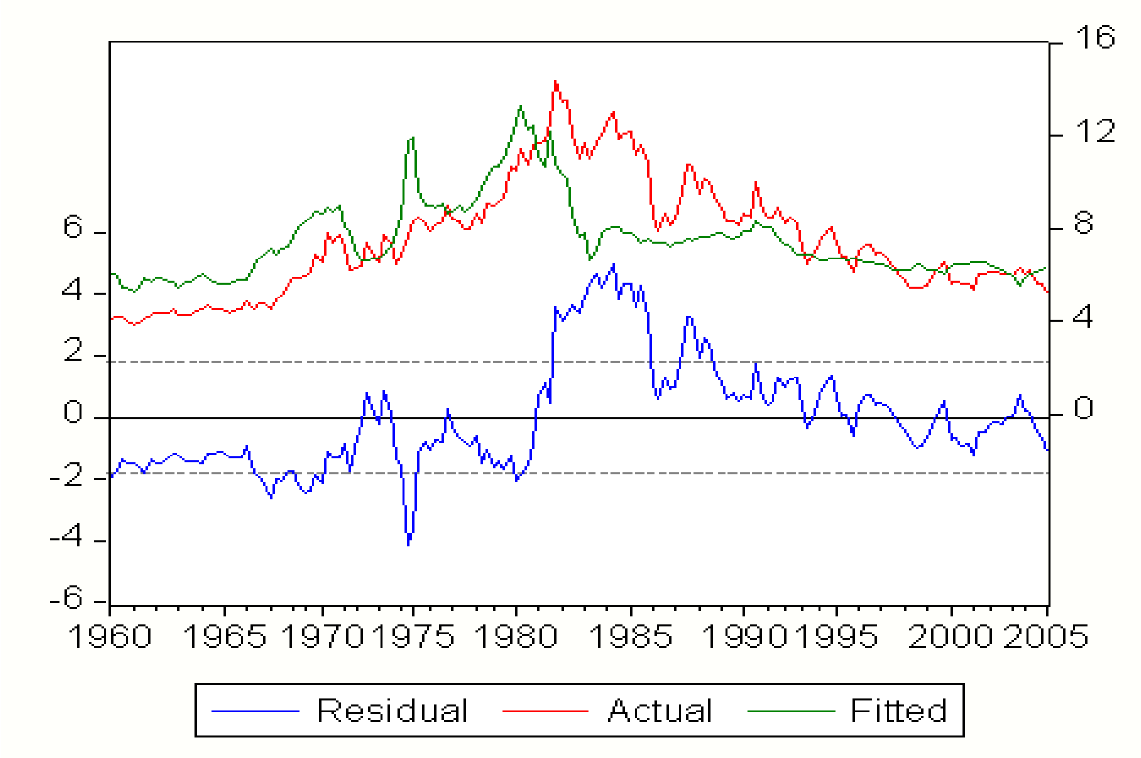
Fed Funds Rate and instantaneous short rate z

Other model factors are extracted from market using no-arb solution



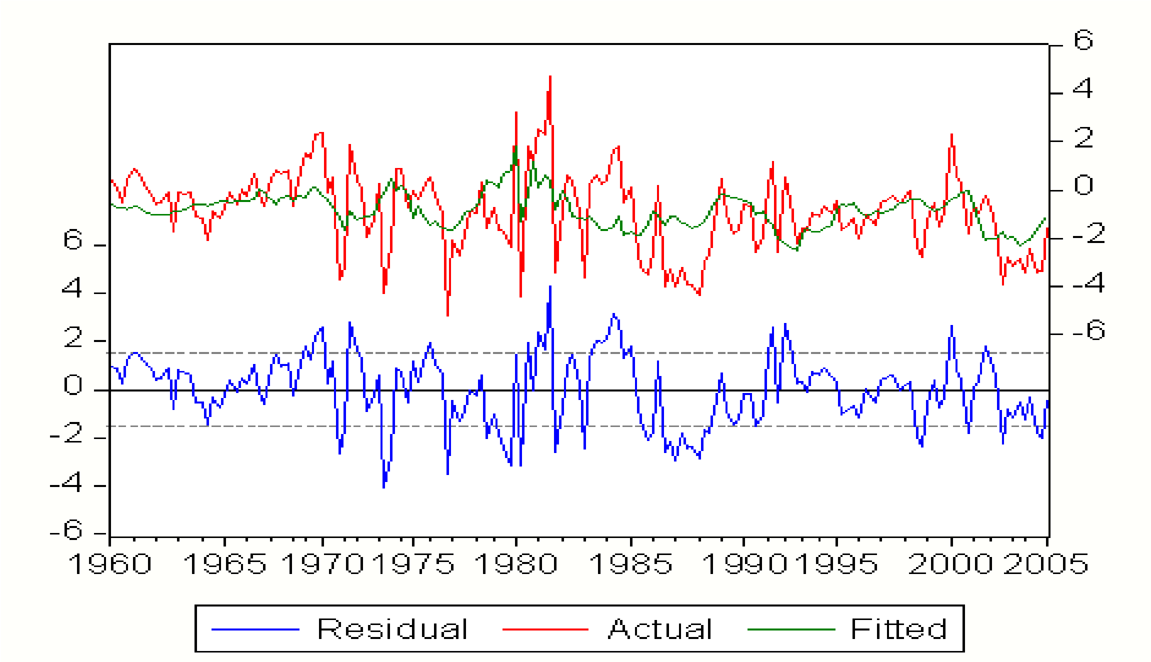
Model Fits using only 1y, 3y, 5y, 10y treasuries as input.

θ_x = LT Inflation Expectations Trending Down



$\theta_x = 4.868 + 0.619 * \text{INFL}$

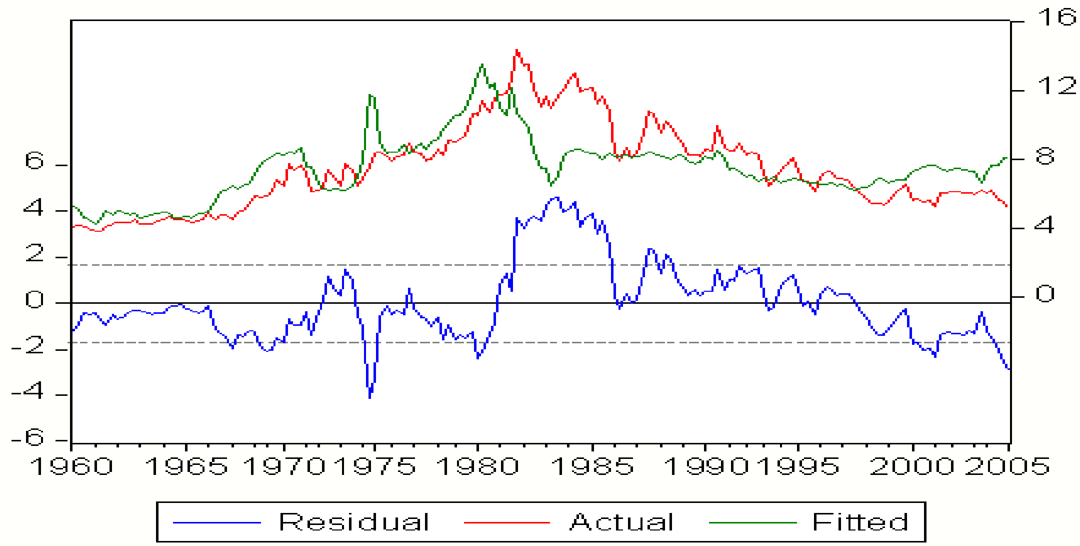
Curve shape is related to risk premium



$y_0 = -0.14 - 0.0422 * \text{GDP} - 0.00579 * \text{INFL} - 0.667 * (10Y - 1Y).$

Only $10Y - 1Y$ is statistically significant.

Impact of non-economic agents - Recycling of current account deficit has reduced market implied long term inflation expectations.



Inflation expectations regressed against actual inflation rates and current account deficit: $\theta_x = 4.13 + 0.687 * \text{INFL} - 0.387 * \text{CURPGDP}$, infl t-stat = 13, CAD t-stat= 5, so both variables are significant. Regression $r^2 = 0.54$.

Asymmetric Fed Policy - model the "deflation put" in the Taylor Rule to partially explain the "conundrum" *

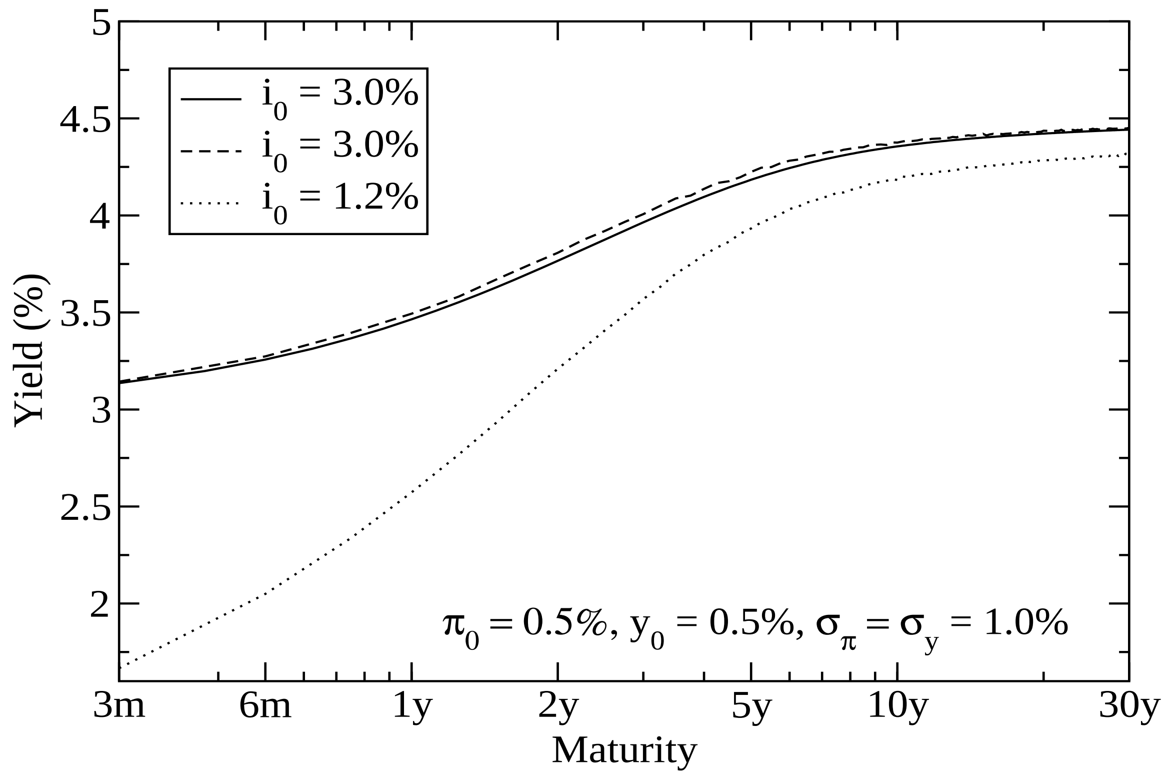
$$i(t) = (r^* + \alpha N[\pi_{\text{min}}, \sigma_{\pi_{\text{avg}}}, \pi(t)] + \theta_1(\pi(t) - \pi^*) + \theta_2(u^* - u(t)) + \pi(t). \quad (4)$$

Fit	θ_1	θ_2	α	r^2
Standard	0.795 (1.78)	2.55 (9.64)	0	0.80
$\pi_{\text{min}} = 2\%$	0.795	2.55	-0.597 (2.19)	0.84
$\pi_{\text{min}} = 1\%$	0.795	2.55	-0.964 (1.49)	0.82
$\pi_{\text{min}} = 20\%$	0.795	2.55	-0.49 (3.03)	0.87

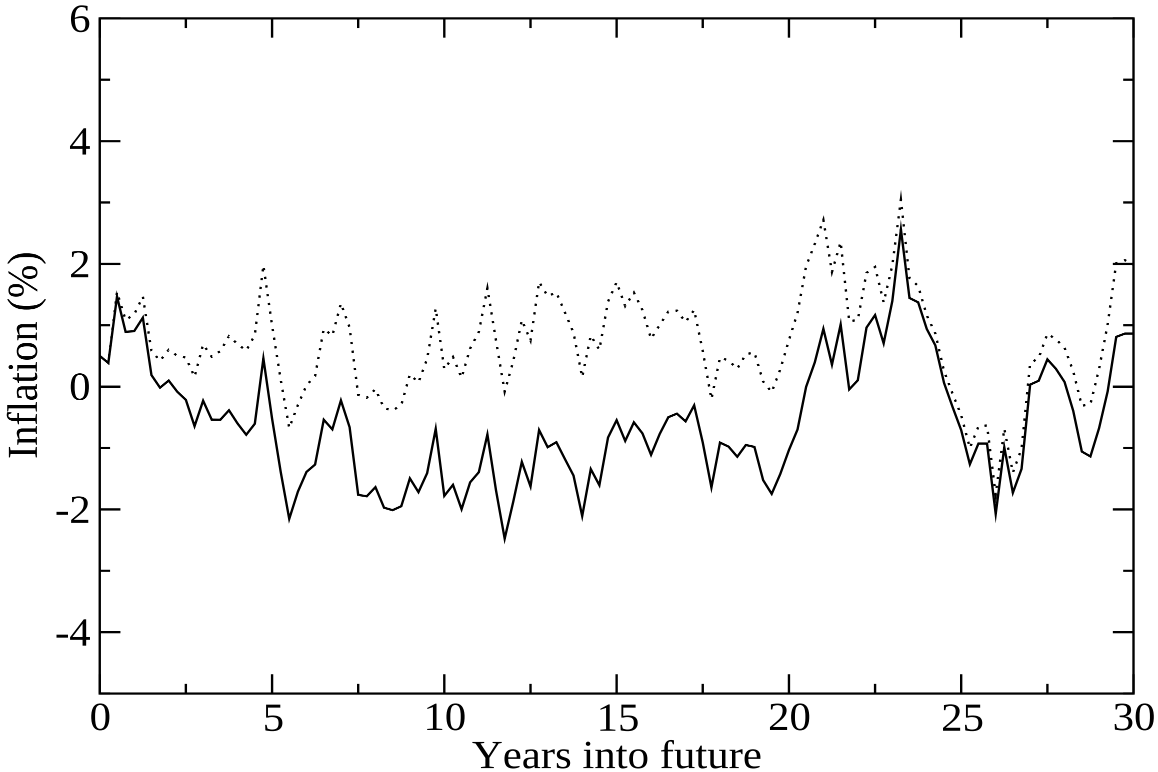
*Bhansali and Wise (2005)

The Taylor rule based model can be evolved to obtain the full yield curve for different types of economies and monetary policies (US, Japan). Japanese yield curve might be preparing for a rapid return of risk premium.*

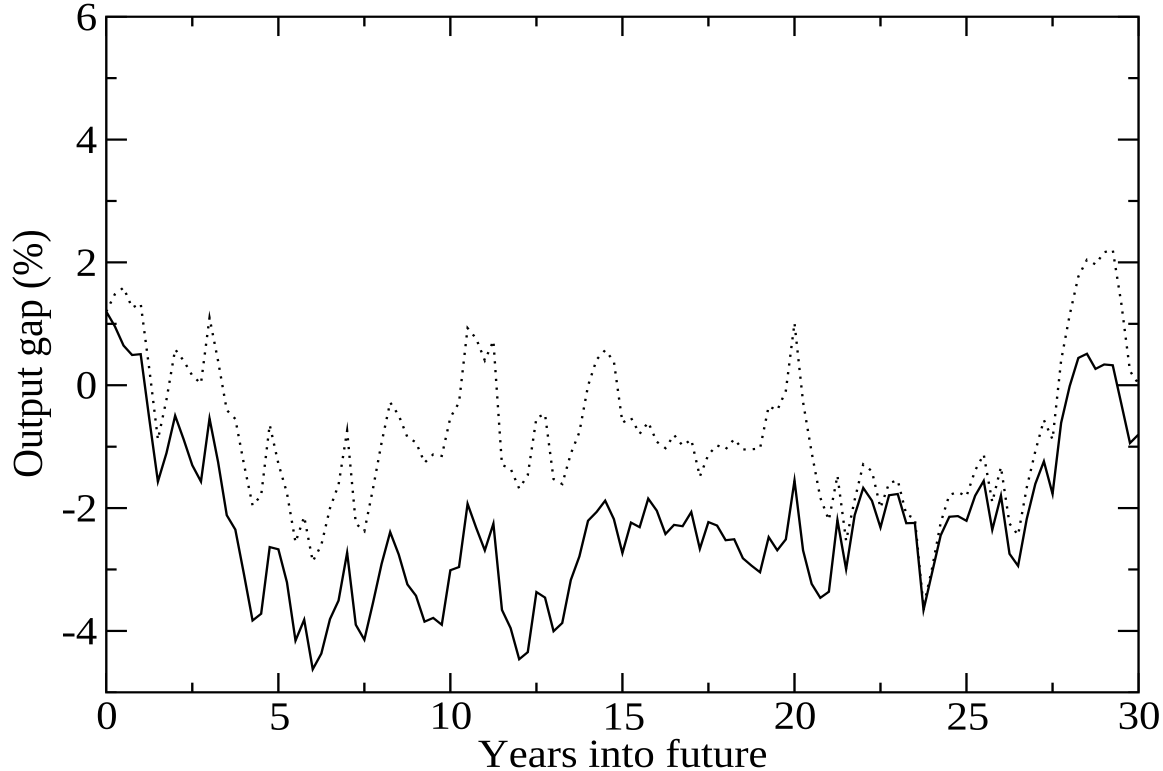
*Dorsten, Bhansali, Wise (2006)



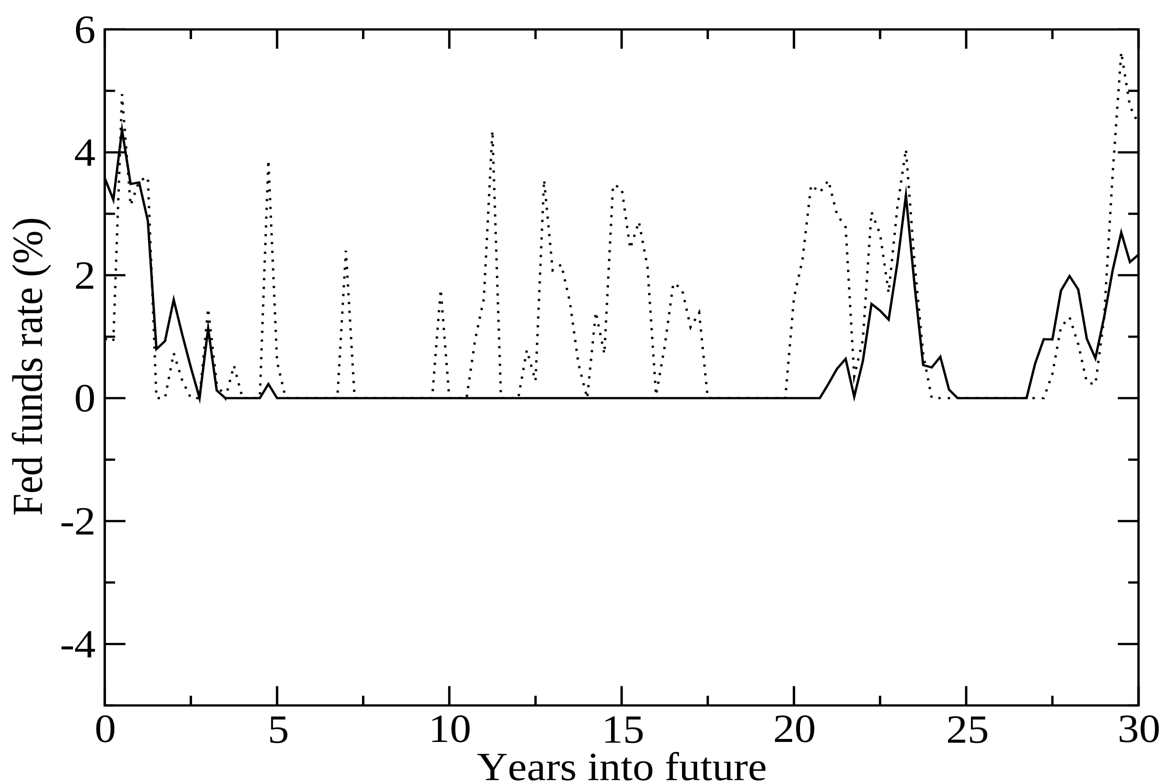
The dashed line is the simulation result for the standard Taylor rule, and the dotted line is the simulation result for the modified Taylor rule with $\pi_{\text{min}} = 1\%$. $\mu_\pi = 1.1\%$, $\mu_y = 0.48\%$, and $\alpha = -3\%, \mu_r = 0$.



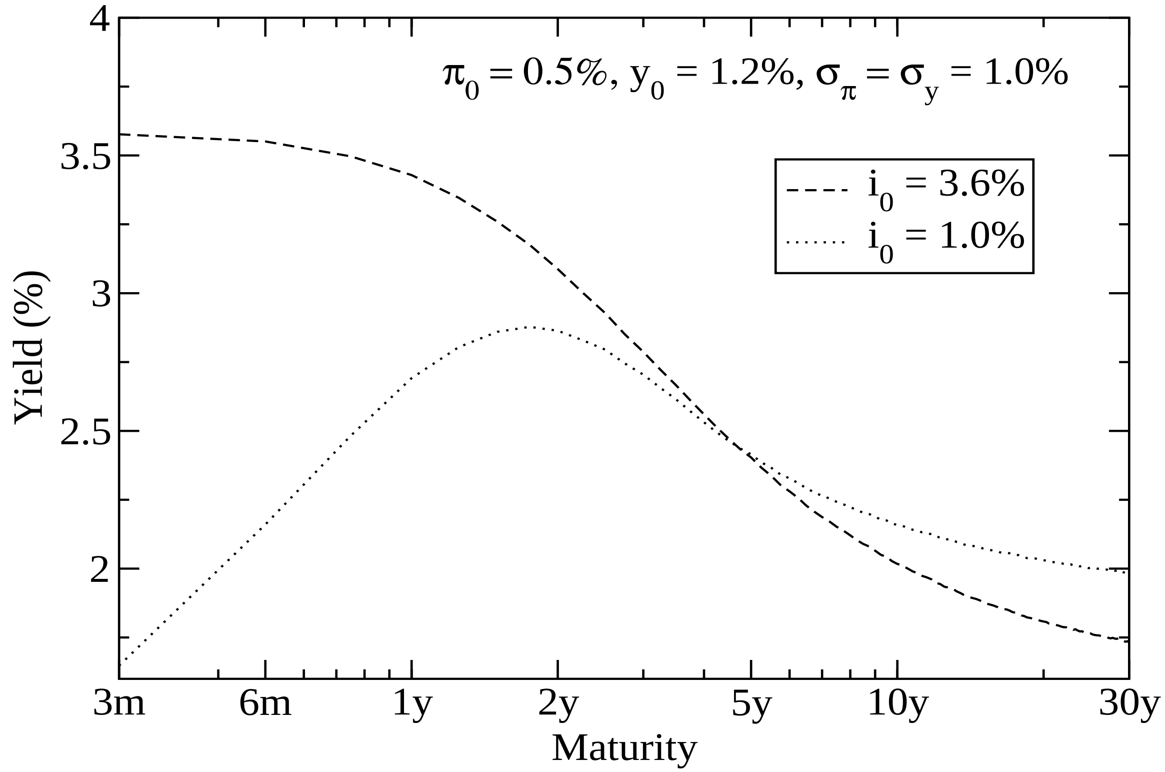
Standard (solid) and deflation put (dotted) Taylor rule evolution in two sample paths of a highly leveraged economy. $\pi_0 = 0.5\%$,$y_0 = 1.2\%$. $\sigma_\pi = \sigma_y = 1.0\%$. $\mu_\pi = 1.1\%$, $\mu_y = 0.48\%$, $\alpha_2 = 0.57$, $\beta_2 = 0.8$, $\tilde{\alpha}_1 = 0.2\%^{-1}$, and $\tilde{\beta}_1 = 0.1\%^{-1}$. The modified rule parameters are $\alpha = -3\%$, $d = 2$, and $\pi_{\text{min}} = 1\%$.



Output Gap for standard (solid) and deflation put (dotted) Taylor rules.

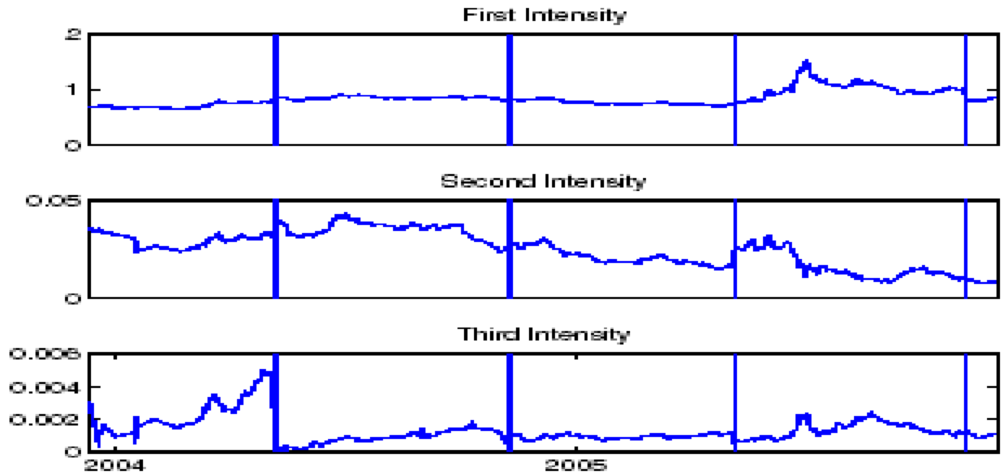


Interest Rate Evolution for standard (solid) and deflation put (dashed) Taylor rules for a highly levered economy.



Yield curves for the highly leveraged economy with initial inflation 0.5% and initial output gap 1.2%. The dashed lines give yield curves for standard Taylor rule evolution, and the dotted lines give yield curves for modified evolution.

CDX and tranches can be used to extract economic content on defaults.*



The liquid CDX indices on average show 64%, 27% and 8% from idiosyncratic, industry specific and economy wide risk. The waiting times are 1.16, 41 and 763 years and correspond to 1, 10 or 70 percent of firms defaulting with 50 percent receovery.

*Longstaff and Rajan, 2006; Duffie and Garleanu, 2001.

“We make models to abstract reality. But there is a meta-model beyond the model that assures us that the model will eventually fail. **Models fail because they fail to incorporate the inter-relationships that exist in the real-world.”**

Myron Scholes, NY, Fall 2005.

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