Topics in Dynamic Asset Pricing

Course Presentation.

Pietro Veronesi

University of Chicago
Booth School of Business
CEPR, NBER

Course Objectives

- This course has two objectives:

  1. Introduce students to the frontier of research in asset pricing: we will cover a number of models and methodologies have been recently developed in the literature to address intriguing empirical regularities.
  2. Teach students how to write coherent research papers: over the eleven weeks I will assign three research ideas that students have to developed into research papers (I provide tips). the TA and I will "referee" such papers providing then feedback on how papers should be written.

- We start by reviewing some (but not all) intriguing empirical regularities.

A Simple Benchmark Model (Lucas Tree Model)

- Aggregate dividends D_t are i.i.d.

$$\frac{dD_t}{D_t} = \mu_d dt + \sigma_d dB_t$$

- $P_t =$ price of stock that is a claim on these dividends. $r_t =$ risk free rate of return.
- A representative agent has infinite life, power utility over consumption, chooses C_t and asset allocation θ_t to

$$\max_{C_t,\theta_t} E_0 \left[\int_0^\infty e^{-\phi t} \frac{C_t^{1-\gamma}}{1-\gamma} dt \right]$$

- Equilibrium: $C_t = D_t$ and $\theta_t = 1 \Longrightarrow$ SDF $= \lambda_t = e^{-\phi t} C_t^{-\gamma}$

$$P_t = E_t \left[\int_t^\infty \frac{\lambda_\tau}{\lambda_t} D_\tau d\tau \right] = \frac{D_t}{R - \mu_d}$$

- where $R =$ discount rate for risky stock

Implications of Benchmark Model

- A large number of empirical regularities clash with this standard paradigm.

1. **Equity premium puzzle:** Stocks have averaged returns of about 7% over treasuries.

   - This number is high compared to the volatility of consumption, of about 1-2%.
   - The canonical model implies

$$\text{Expected Excess Return} \; = \; \gamma \text{Variance of Consumption Growth}$$

   - Even assuming that γ is large, say $\gamma = 10$, we have

$$\text{Expected Excess Return} \; = \; 10 \times (.02)^2 = 0.4\%$$

   - We are an order of magnitude off.

Implications of Benchmark Model

2. **Volatility Puzzle 1:** Return volatility (about 16 %) is too high compared to the volatility of dividends (about 7%).

   - The same classic canonical model has

$$\frac{P_t}{D_t} = \text{Constant}$$

   - This implies

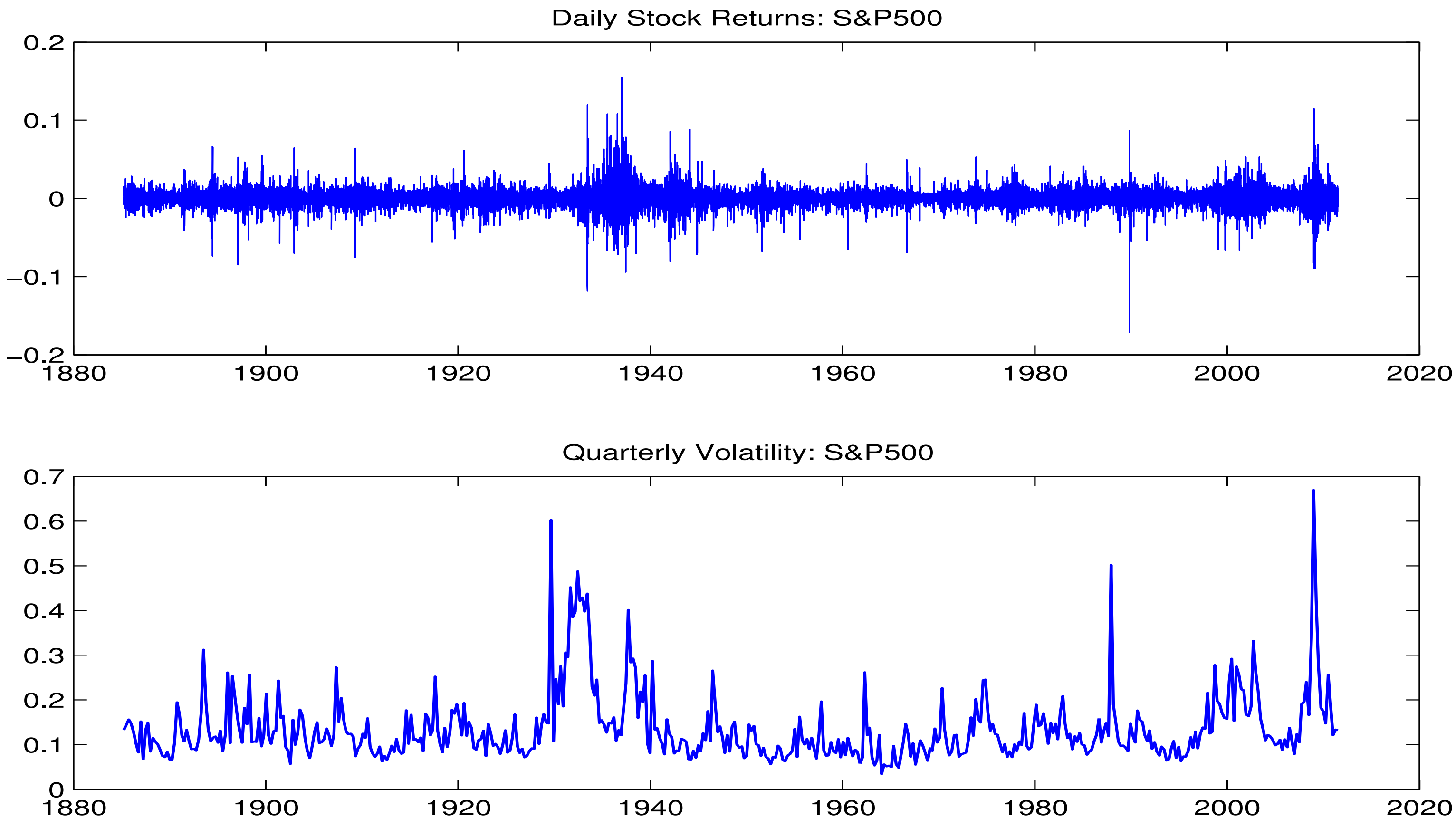
$$\text{Volatility of } \frac{dP_t}{P_t} = \text{Volatility of } \frac{dD_t}{D_t}$$

   - Something else must be time varying to make the volatility higher.
   - Indeed, the canonical model would imply a constant P/D ratio, which we know it is not.

Implications of Benchmark Model

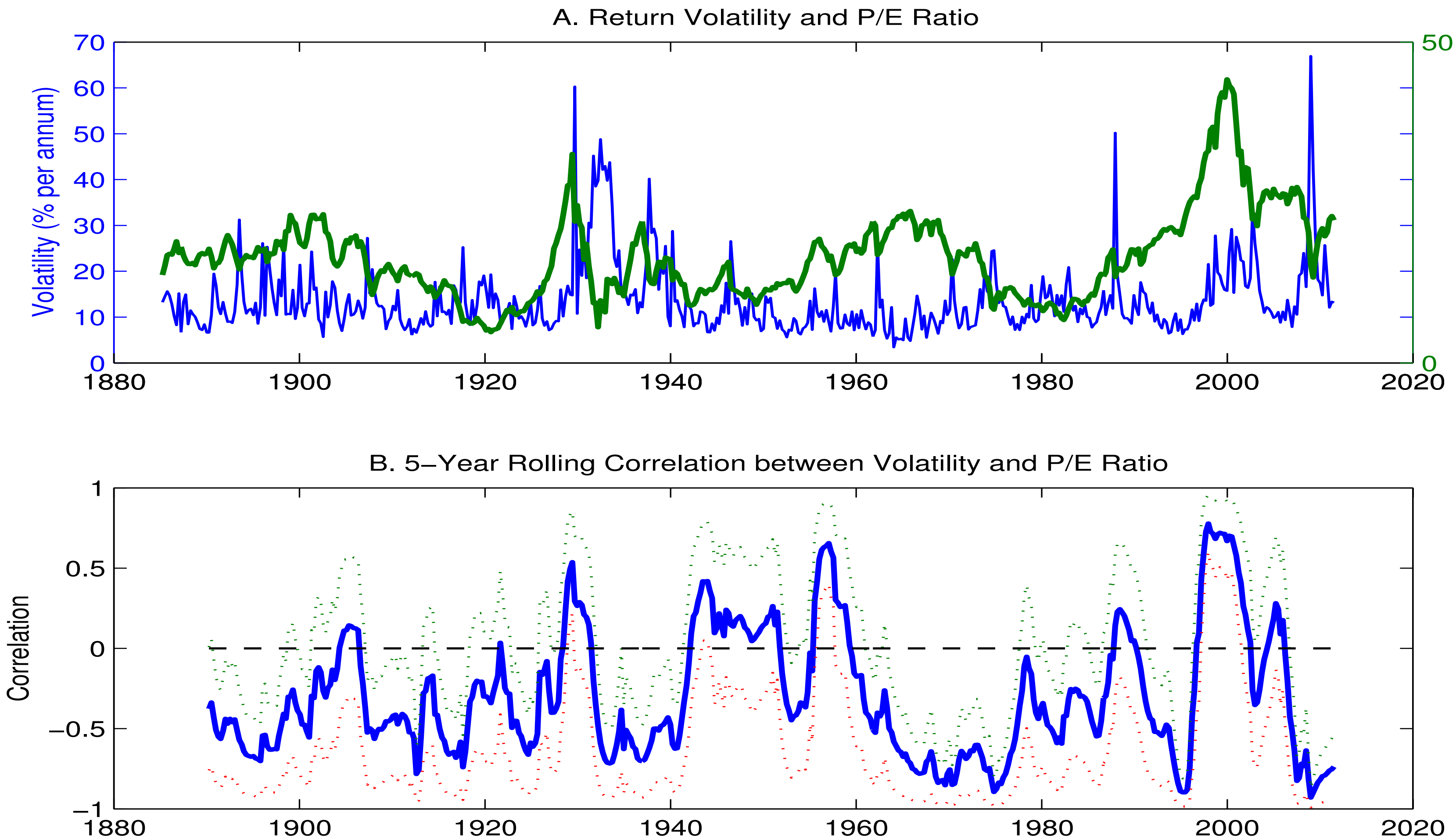
3. **Volatility Puzzle 2:** Return volatility is not only high, but it is time varying.

- Historically, (annualized) market return volatility fluctuated wildly, ranging between 60 - 70 % in the 30s (and 2008-2009) to less that 5% in the middle of the 1960s.



Implications of Benchmark Model

4. **Volatility Puzzle 3:** Volatility and price/earning ratios are sometimes positively correlated.



Implications of Benchmark Model

5. **Risk Free Rate Puzzle:** The usual canonical model implies that the interest rate is given by

$$r = \phi + \gamma\mu_c - \frac{1}{2}\gamma(\gamma+1)\sigma_c^2$$

- If $\gamma = 10$ for instance, using $\mu_c = 2\%$, $\sigma_c = 1\%$ and $\phi = 2\%$ we find $r = 21\%$
- The problem is γ that is too high: If we set $\gamma = 2$ we obtain $r = 6\%$.
- Note the tension between equity premium puzzle (need γ high) and risk free rate puzzle (need γ low).

Implications of Benchmark Model

6. **Predictability:** Stock returns are predictable by, say, the dividend price ratio, earnings price ratio, etc.

   - Predictability regression

$$\text{Cumulated Returns } (t \rightarrow t+\tau) = \alpha + \beta x_t + \epsilon_{t,t+\tau}$$

where x_t is a predictor observable at time t.

Table 1: Return Predictability – CRSP Sample: 1927 - 2010

Predictor	Horizon (Quarters)	α	β	$t(\alpha)$	$t(\beta)$	R^2
Log Div Yield	1	0.10	0.02	1.72	1.53	1.1%
Log Earn Yield (1 y)	1	0.09	0.03	2.32	1.99	1.1%
Log Earn Yield (10 y)	1	0.13	0.04	2.80	2.55	2.2%
Term Spread	1	0.01	0.46	0.74	1.05	0.3%
Return Variance	1	0.02	-0.15	2.47	-0.24	0.0%
Credit Spread	1	0.01	0.62	0.40	0.37	0.2%
Book / Market	1	-0.02	0.06	-1.27	2.03	2.4%
Log Payout yield	1	0.15	0.06	2.44	2.28	1.7%
Log Div Yield	4	0.42	0.11	2.56	2.29	5.2%
Log Earn Yield (1 y)	4	0.35	0.11	3.08	2.59	3.9%
Log Earn Yield (10 y)	4	0.52	0.17	3.57	3.09	9.2%
Term Spread	4	0.02	2.12	0.65	1.94	1.6%
Return Variance	4	0.05	0.04	2.51	0.03	0.0%
Credit Spread	4	0.03	1.78	0.87	0.54	0.4%
Book / Market	4	-0.09	0.23	-1.46	2.93	8.0%
Log Payout yield	4	0.73	0.32	3.89	3.47	10.2%
Log Div Yield	12	1.12	0.29	4.37	3.75	14.2%
Log Earn Yield (1 y)	12	1.00	0.32	3.20	2.71	11.6%
Log Earn Yield (10 y)	12	1.31	0.42	3.25	2.78	22.1%
Term Spread	12	0.02	8.53	0.18	2.16	9.3%
Return Variance	12	0.15	-0.37	2.43	-0.09	0.0%
Credit Spread	12	0.11	4.13	1.00	0.73	0.7%
Book / Market	12	-0.17	0.53	-1.01	2.33	15.7%
Log Payout yield	12	1.76	0.75	3.21	2.77	22.6%

Note: t-statistics computed using Newey West standard errors

Table 2: Return Predictability – "cay" Sample: 1952 - 2010

Predictor	Horizon (Quarters)	α	β	$t(\alpha)$	$t(\beta)$	R^2
Log Div Yield	1	0.10	0.02	2.02	1.75	1.5%
Log Earn Yield (10 y)	1	0.07	0.02	1.64	1.34	0.9%
cay	1	0.01	0.87	2.42	3.88	4.3%
Term Spread	1	0.00	0.66	0.34	1.61	1.3%
Book / Market	1	0.00	0.02	0.16	0.86	0.4%
Investment/Capital	1	0.15	-3.88	2.98	-2.69	3.0%
Log Payout yield	1	0.09	0.04	1.57	1.36	0.9%
Log Div Yield	4	0.43	0.11	2.33	1.99	6.6%
Log Earn Yield (10 y)	4	0.30	0.09	2.05	1.65	4.2%
cay	4	0.05	3.61	2.92	3.97	16.6%
Term Spread	4	0.02	2.29	0.58	2.21	3.6%
Book / Market	4	0.00	0.10	-0.03	1.15	2.1%
Investment/Capital	4	0.47	-11.78	2.57	-2.19	6.1%
Log Payout yield	4	0.47	0.19	2.41	2.10	5.5%
Log Div Yield	12	1.06	0.26	3.30	2.94	16.1%
Log Earn Yield (10 y)	12	0.73	0.20	2.32	1.91	9.9%
cay	12	0.14	8.59	4.12	6.70	38.1%
Term Spread	12	0.07	4.99	1.30	3.28	6.6%
Book / Market	12	0.07	0.15	0.57	0.78	1.9%
Investment/Capital	12	1.28	-31.38	4.29	-3.80	16.7%
Log Payout yield	12	1.12	0.44	3.63	3.15	12.0%

Note: t-statistics computed using Newey West standard errors

Implications of Benchmark Model

- This result raises a number of issues, such as:

(a) Why are stock return predictable?

(b) Why the regression coefficients (and significance) depend on the time interval used?

(c) What are the implication for an investor who is allocating his wealth between stocks and bonds to maximize his life time utility?

(d) Why stock return volatility **does not** predict future excess returns? After all, the canonical model has

$$\text{Expected Excess Return} = \gamma \text{Variance of Stock Return}$$

- Using more sophisticated models for volatility, some studies find a significantly positive relation, but some others find a significant negative relation. There is still a considerable debate.

Implications of Benchmark Model

7. **Cross-sectional Predictability Puzzle**: Some type of stocks yield an average return that is not consistent with the canonical model.

- The canonical model implies that expected excess returns of asset i is given by:

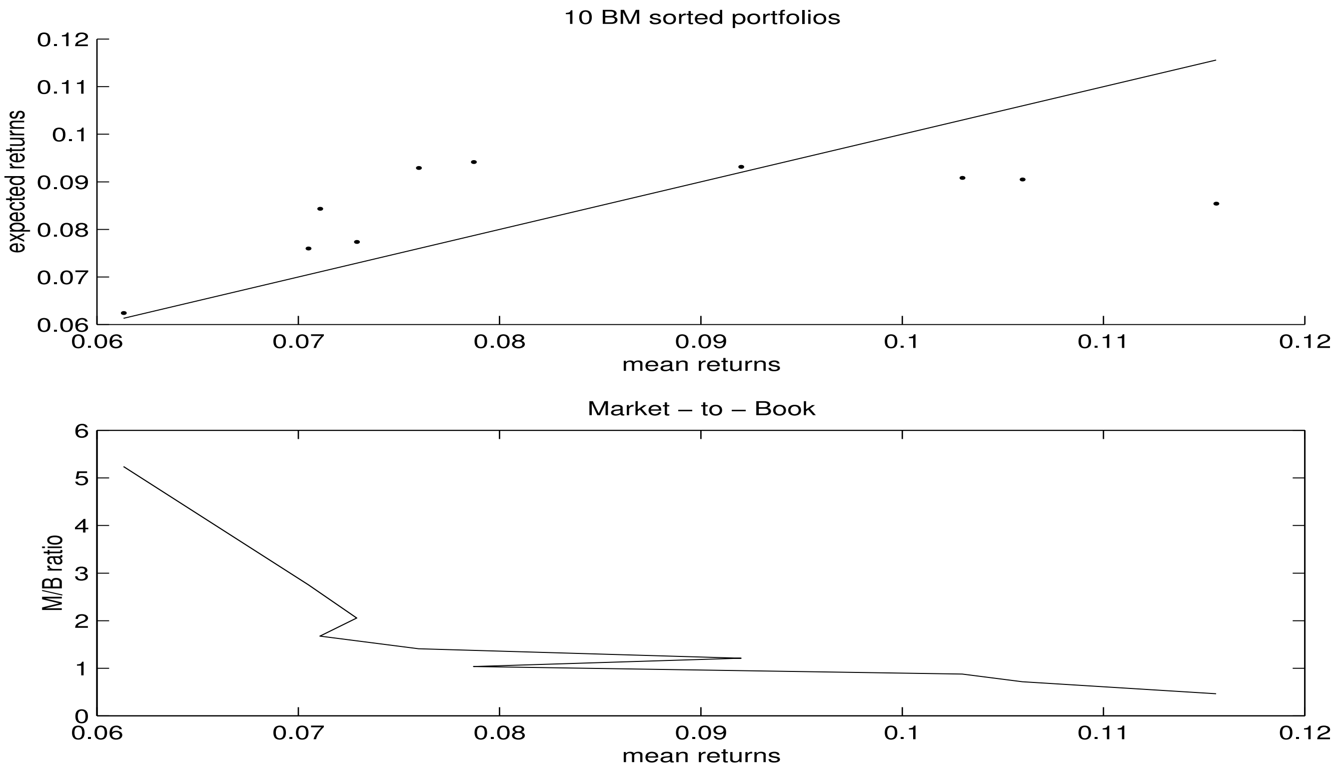
$$\begin{aligned} E\left[\text{Excess Return}_t^i\right] &= \gamma \text{Cov}\left(\text{Return}^i, \text{Consumption Growth}\right) \\ &= \beta^i E\left[\text{Excess Return of Mkt Portfolio}\right] \end{aligned}$$

- where

$$\beta^i = \frac{\text{Cov}\left(\text{Return}^i, \text{Return Mkt Portfolio}\right)}{\text{Var}\left(\text{Return Mkt Portfolio}\right)}$$

- Portfolios of stocks that are sorted by Book-to-Market Ratio or by Size and Book to Market do not satisfy this relation.
- For instance, using Book-to-Market sorted portfolios, we obtain the following

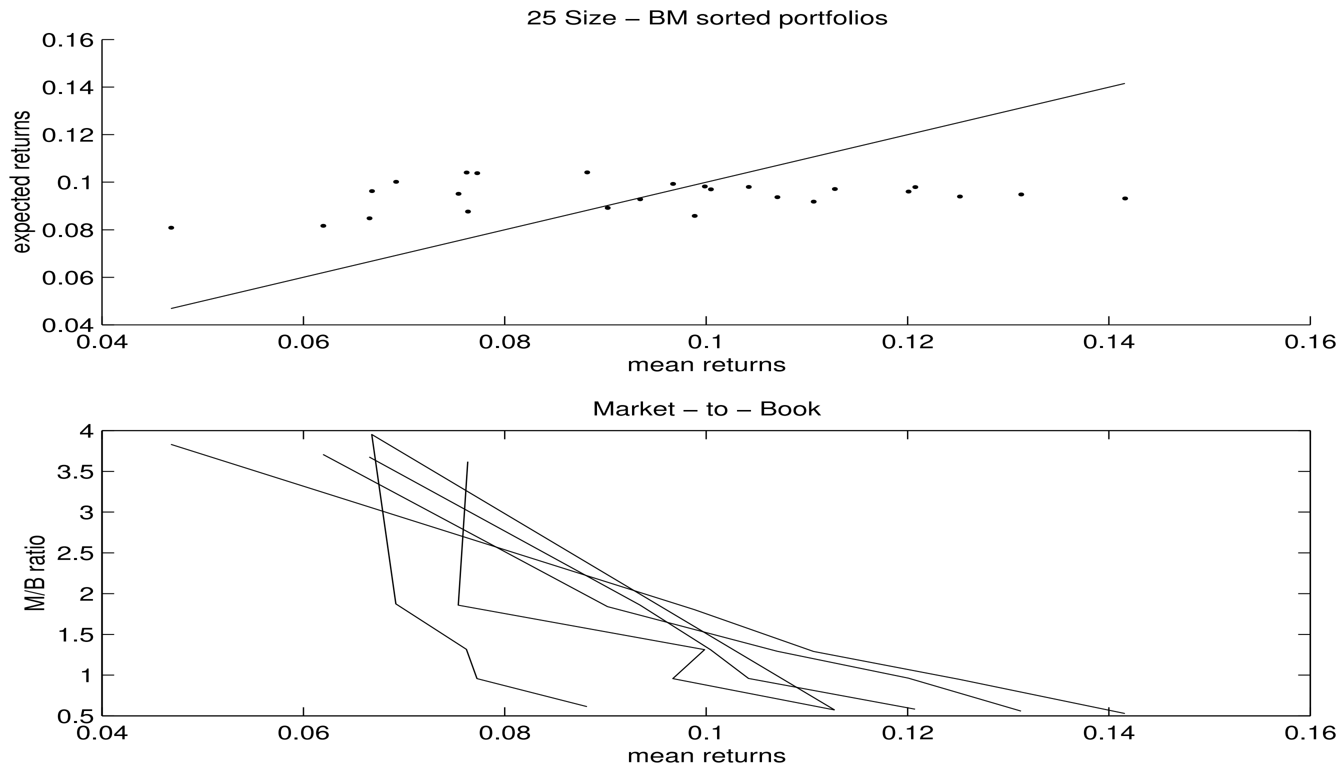
Implications of Benchmark Model



- The top panel shows the the average return on B/M sorted portfolio on the x-axis, and the one implied by the CAPM ($=$ beta $\times$ Average Return of Market Portfolio) on the y-axis
- They should line up, but they don't

Implications of Benchmark Model

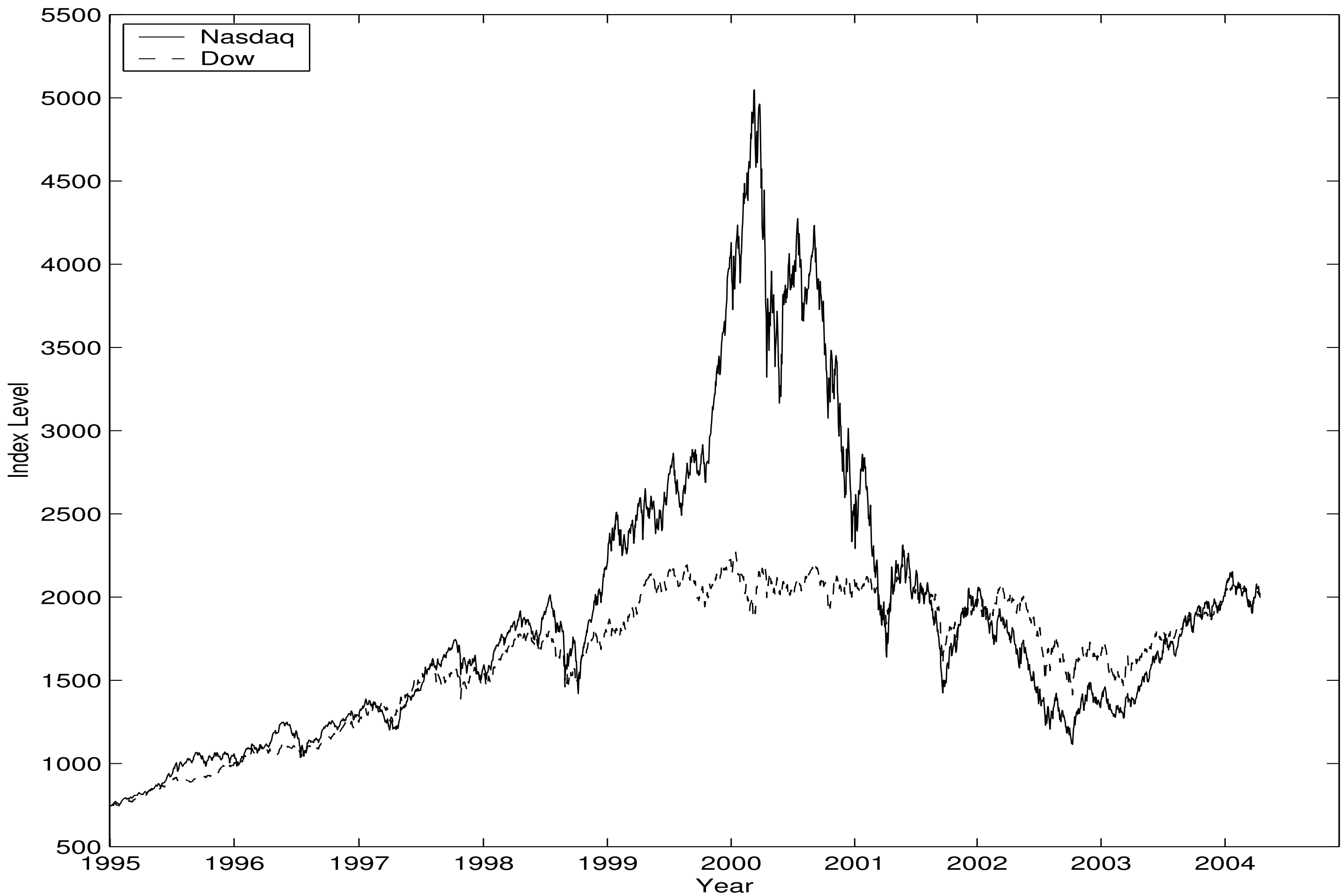
- It is even worse if one uses Size and Book-to-Market portfolios (the so-called FF 25 portfolios)



- Adding to this, momentum portfolios (sorted by past winners and losers) show similar and perhaps more striking pattern.

Implications of Benchmark Model

8. **Tech "Bubble":** Typical to talk about technology bubbles (e.g. late 1990s)



Implications of Benchmark Model

- Was it a bubble?
- Why do stock prices tend to go up and then down around technological revolutions?
- Examples:
  - the early 1980s (biotechnology, PC)
  - the early 1960s (electronics)
  - the 1920s (electricity, automobiles)
  - the early 1900s (radio)

Implications of Benchmark Model

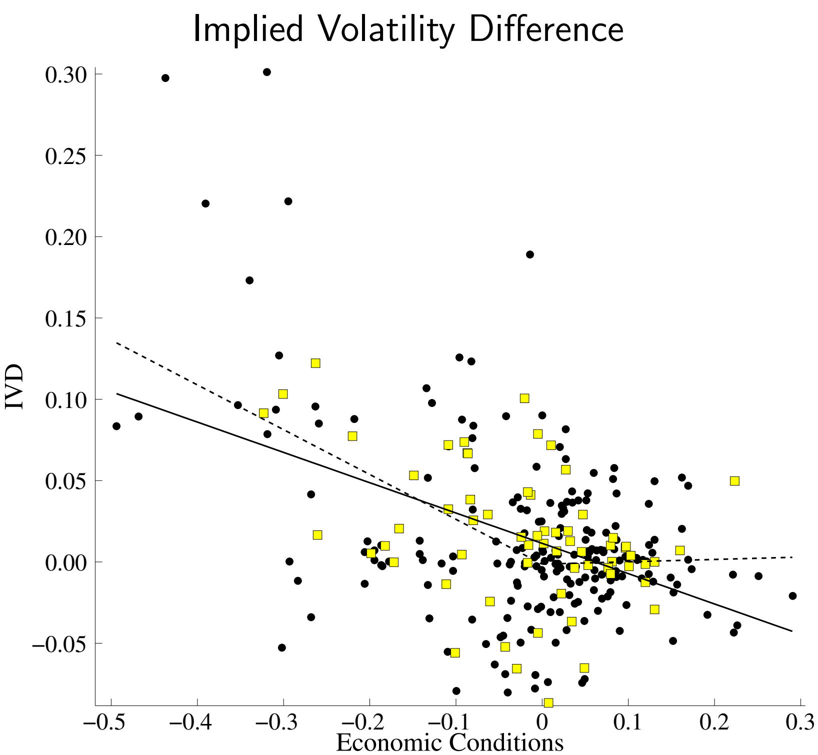
9. **Presidential Cycle**. Why are average excess returns higher during democratic presidencies?

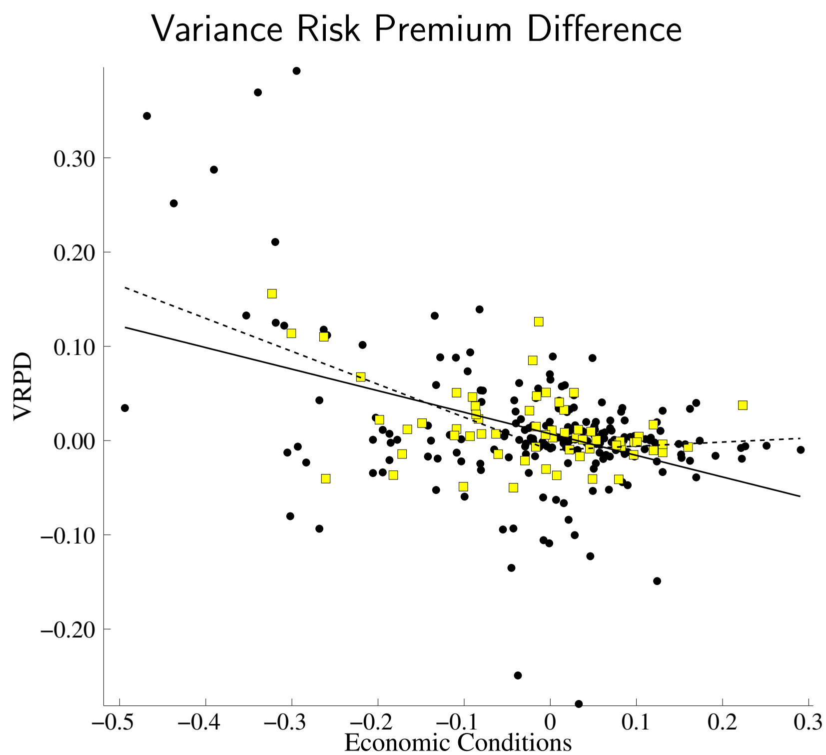
	Sample: 1927 - 2009		
	Rep	Dem	t-diff
Average Excess Returns (%/year)	0.79	10.37	2.30
Average Real Div Growth (%/year)	4.17	5.93	1.29
Average P/D Ratio	32.00	28.95	1.4 (logs)
Average Volatility (%/year)	15.48	14.39	1.67
Median Excess Return (%/year)	7.75	16.11	-
Median Nominal Dividend Growth (%/year)	7.00	7.92	-
Median P/D Ratio	26.83	23.62	-
Median Volatility (%/year)	12.08	11.66	-

See also: Santa Clara and Valkanov "Political Cycles and the Stock Market" Journal of Finance, 2003

Implications of Benchmark Model

10. **Political events and Risk Premia**. Why put options are especially expensive around elections or global summits?





Benchmark Portfolio Allocation Model

- Consider now the model above for stock returns with same preferences, but now we do not impose market clearing ($\theta = 1$).
- In this case, the utility maximization problem of an investor with investment horizon T is

$$J\left(W_0, 0\right) = \max_{\{(C_t),(\boldsymbol{\theta}_t)\}} E_0\left[\int_0^T e^{-\phi t}\frac{C_t^{1-\gamma}}{1-\gamma}dt\right]$$

- subject to the budget constraint

$$dW_t = \left\{W_t\left(\theta_t(\mu - r) + r\right) - C_t\right\}dt + W_t\theta_t\sigma d\mathbf{B}_t$$

- The solution to this program yields an investment in stocks equal to

$$\text{Fraction of Wealth Invested in Stocks} = \theta_t = \frac{\text{Excess Return on the Stock Market}}{\gamma\text{Variance of Stock Returns}}$$

Implications of Benchmark Portfolio Allocation Model

1. **Portfolio Allocation Puzzle 1:** The typical stockholders holds too little in stocks compared to what a canonical model would require.
   - Using unconditional averages, Excess Stock Return = 7% and Volatility of Returns = .16 %, we obtain

     Table: Portfolio Allocation

	Risk Aversion				
	2	4	6	8	10
Investment	136%	68%	45%	34 %	27 %

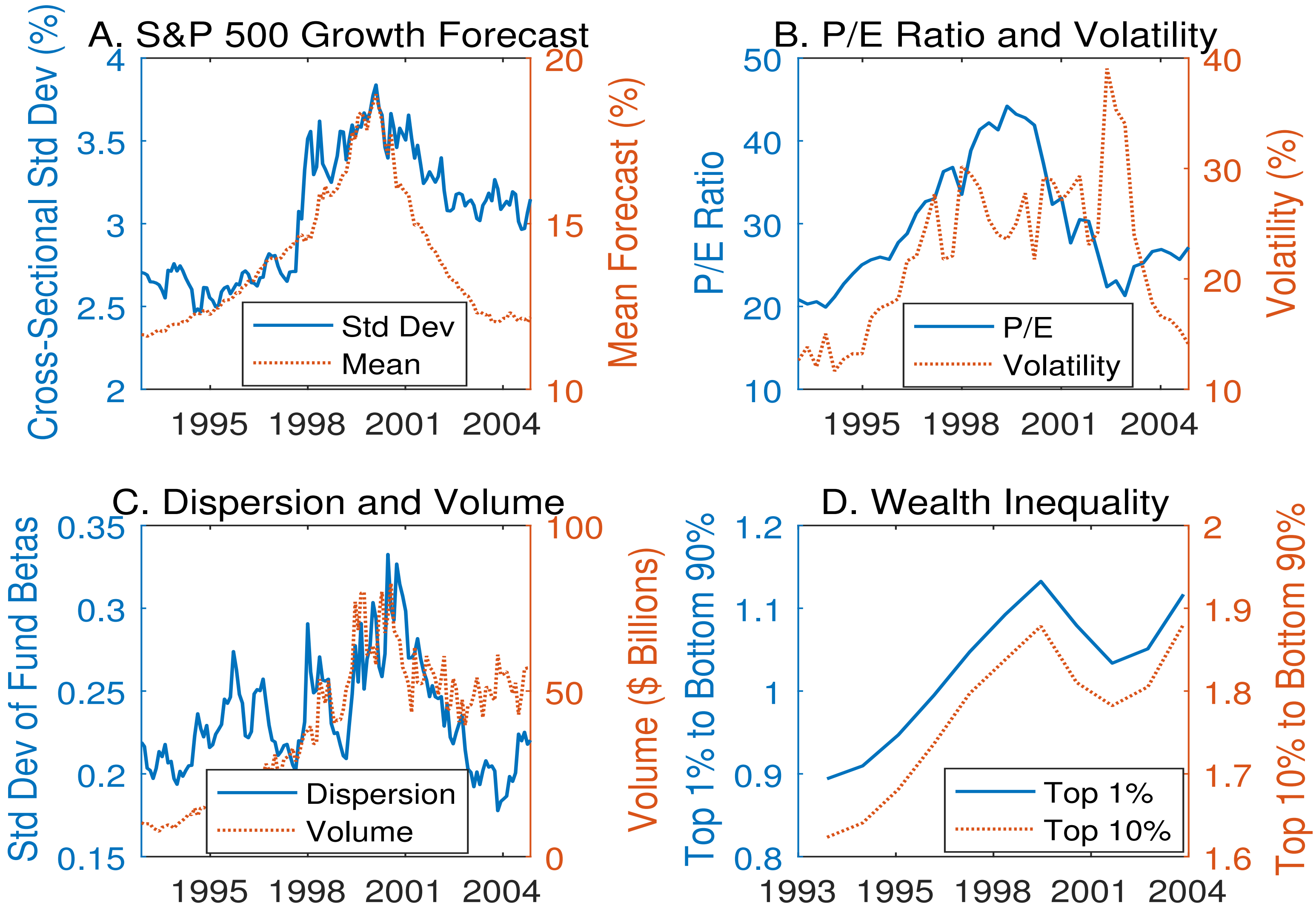
   - In contrast, depending on estimates, typical household holds betwee 6 % to 20 % in equity. Conditional on participating to the stock market, these number increase to about 40% of financial assets.

Implications of Benchmark Portfolio Allocation Model

2. **Portfolio Allocation Puzzle 2:** The canonical model with constant investment opportunity set implies that the portfolio allocation should not depend on the age of investor.
   - This is in contrast with the behavior of investors: Investors increase their holdings in equity for the first 1/2 of their life cycle, and decrease it afterwards.
3. **Portfolio Allocation Puzzle 3:** Many investors do not participate in the stock market, while the canonical model would imply always some participation to the market (at worse, short the market).
4. **Portfolio Allocation Puzzle 4:** Many investors invest in own company stocks, especially in their retirement plan. Diversification arguments clearly points at "shorting" the stock, if anything.

Benchmark Model: No Trading and Wealth Inequality

- Representative agents models don't have implications about trading or cross-sectional differences in wealth inequality, which are important features of the data.



Benchmark Model: No Trading and Wealth Inequality

- What forces determine trading and wealth inequality dynamics?
  - Asymmetric information
  - Differences of beliefs
  - Heterogeneity in preferences
- Can we reconcile standard representative agent models with such trading dynamics?
  - Aggregation becomes difficult. But progress in recent times.

Nominal Long Term Bonds in Benchmark Model

- I now introduce an exogenous inflation process, and obtain nominal long term bond prices.
- The log dividend (consumption) $c = log(C)$ and log CPI $q_t = \log Q_t$ grow according to the joint stochastic model

$$\begin{aligned} dc_t &= gdt + \sigma_c dW_{c,t} \\ dq_t &= i_t dt + \sigma_q dW_{q,t} \\ di_t &= (\alpha - \beta i_t)\, dt + \sigma_i dW_{i,t} \end{aligned}$$

  - $i_t =$ is the expected inflation rate $i_t = E_t[dq_t]/dt$.
- The First Order Condition is (recall $\lambda_t = e^{-\phi t} C_t^{-\gamma}$)

$$Z(i_t, t; T) = E\left[\frac{\lambda_T}{\lambda_t}\frac{Q_t}{Q_T}\right]$$

- yielding

$$Z(i_t, t; T) = e^{A_0(\tau) - A_\beta(\tau) i_t}$$

- where $A_\beta(\tau)$ and $A_0(\tau)$ are two function of time to maturity $\tau = T - t$

Implications of Benchmark Model

1. The instantaneous nominal rate r_t is given by the constant real rate + inflation risk premium + expected inflation

$$r_t = \lim_{T-t\to 0} y(t;T) = -\lim_{\tau\to 0} \frac{A_0(\tau) - A_1(\tau)\, i_t}{\tau} = c + i_t$$

   - where

$$c = \left(\rho + \gamma g - \frac{1}{2}\gamma^2\sigma_c^2\right) - \gamma\sigma_c\sigma_q\rho_{qc} - \frac{1}{2}\sigma_q^2$$

2. The whole yield curve depends on the current expected inflation $i_t = E[dq_t]/dt$.

$$y(t;T) = -\frac{\log(Z(i_t,t;T))}{\tau} = -\frac{A_0(\tau)}{\tau} + \frac{A_\beta(\tau)}{\tau} i_t$$

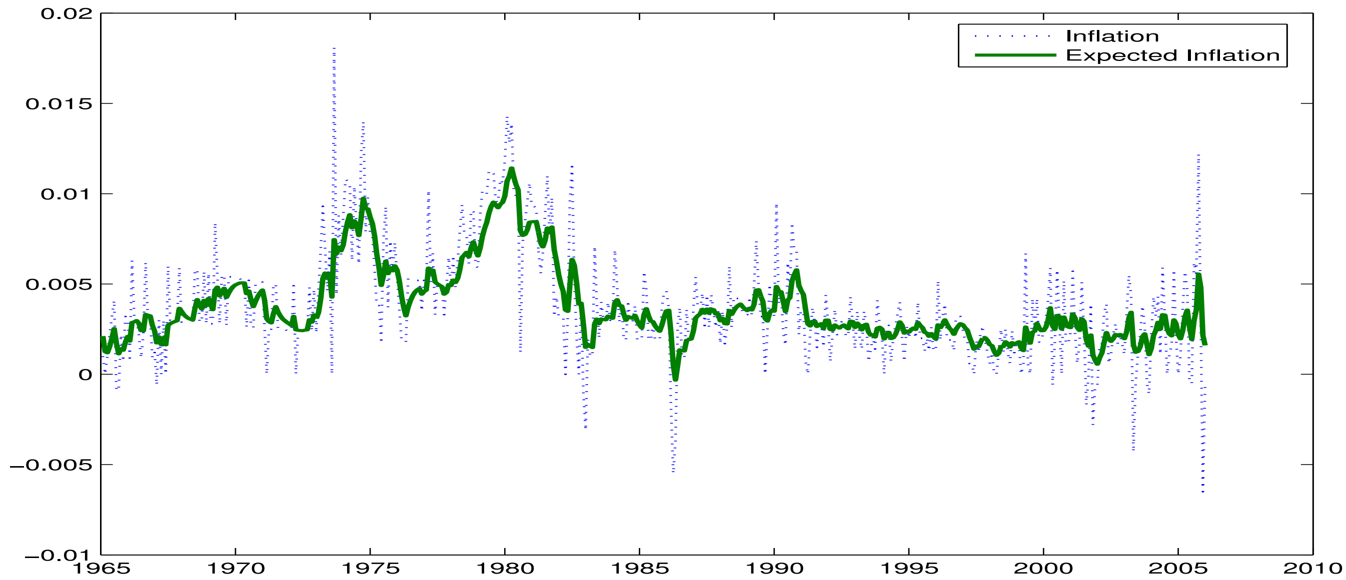
   - In particular, all of the yields are perfectly correlated.

3. The Term Spread (Slope) is

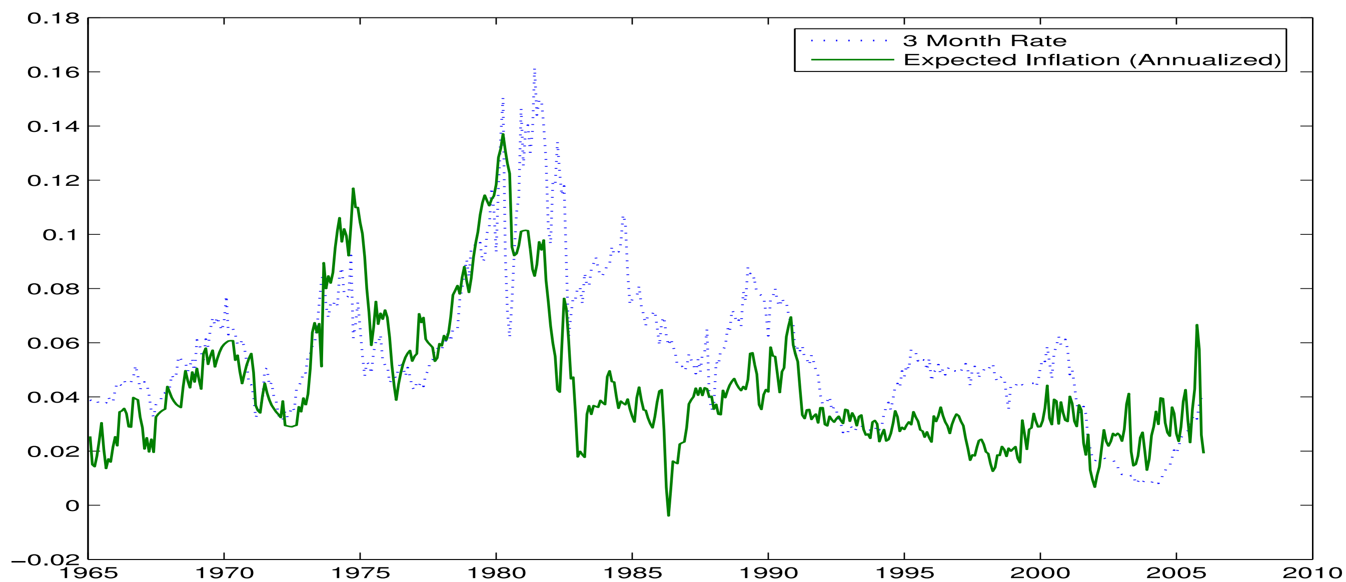
$$y_\infty - r_t = \left(\frac{\alpha}{\beta} - i_t\right) - \frac{1}{\beta}\left(\gamma\sigma_i\sigma_c\rho_{ic} + \sigma_i\sigma_q\rho_{iq}\right) - \frac{\sigma_i^2}{2\beta^2}$$

   - Note that since $\rho_{ic} < 0$ (typically), $\gamma\sigma_i\sigma_c\rho_{ic}/\beta < 0$. Higher risk or risk aversion, the higher the long end of the yield curve.

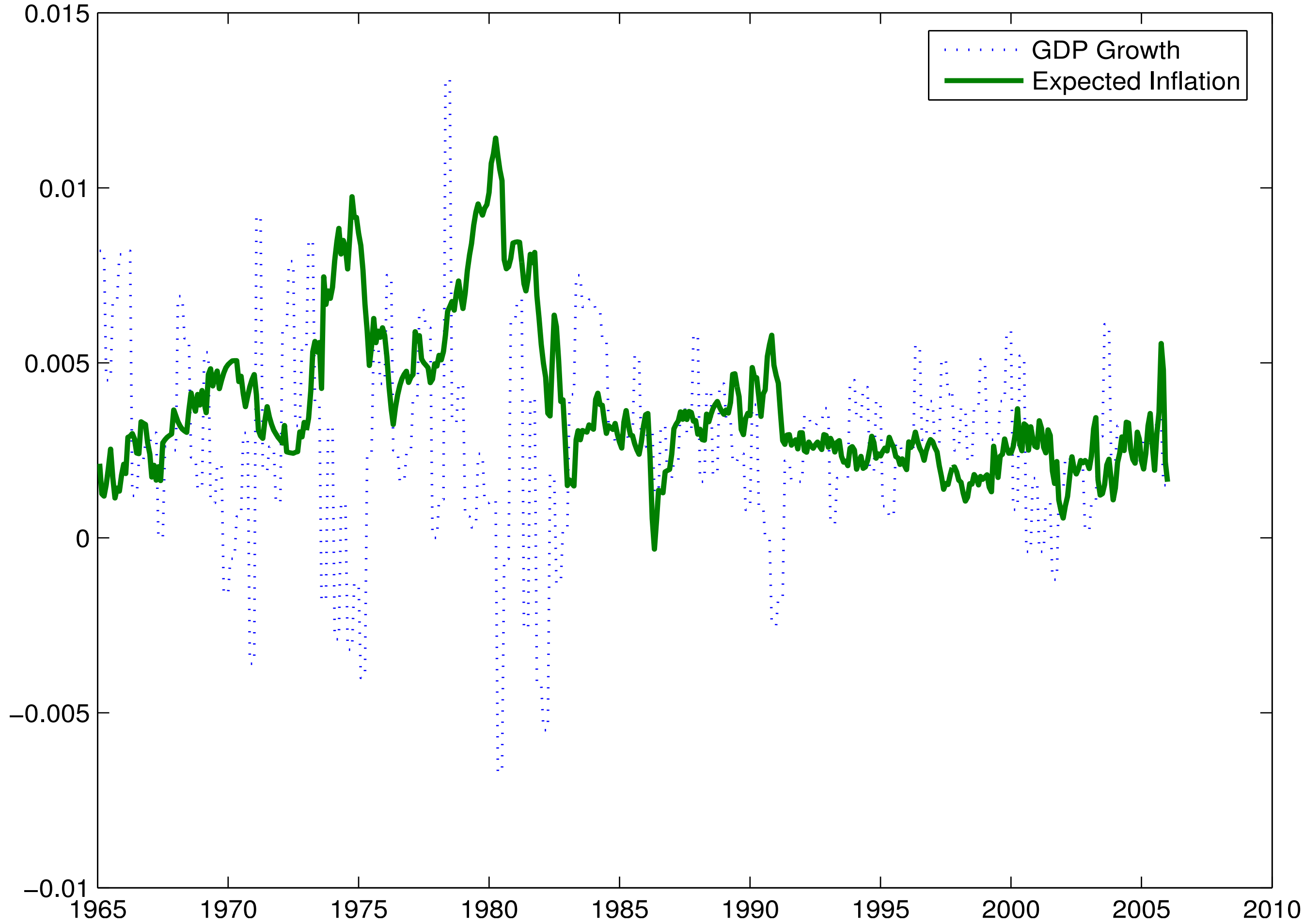
Inflation and Expected Inflation



Inflation and 3-month TBill rate



Expected Inflation and GDP growth



Implications of Benchmark Model

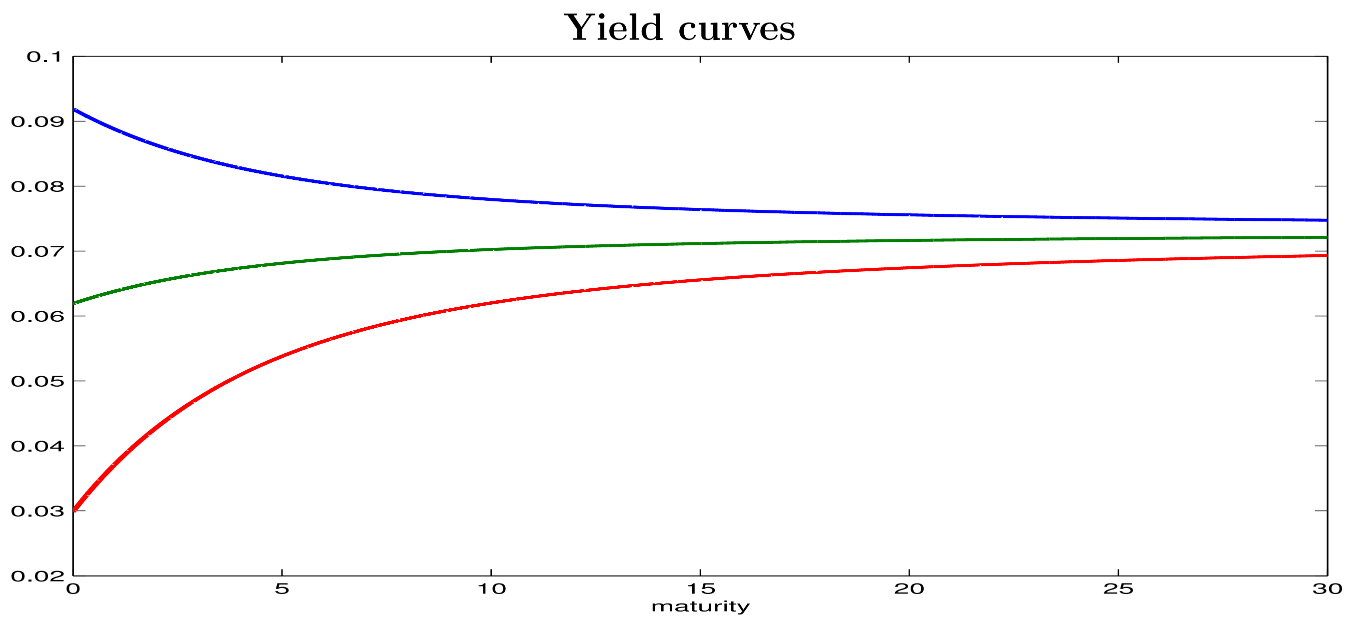
4. The model requires a large risk aversion to produce reasonable yield curves and a reasonable market price of risk λ

   - Using data on inflation and GDP growth ($= C$), we obtain the following parameters for the processes

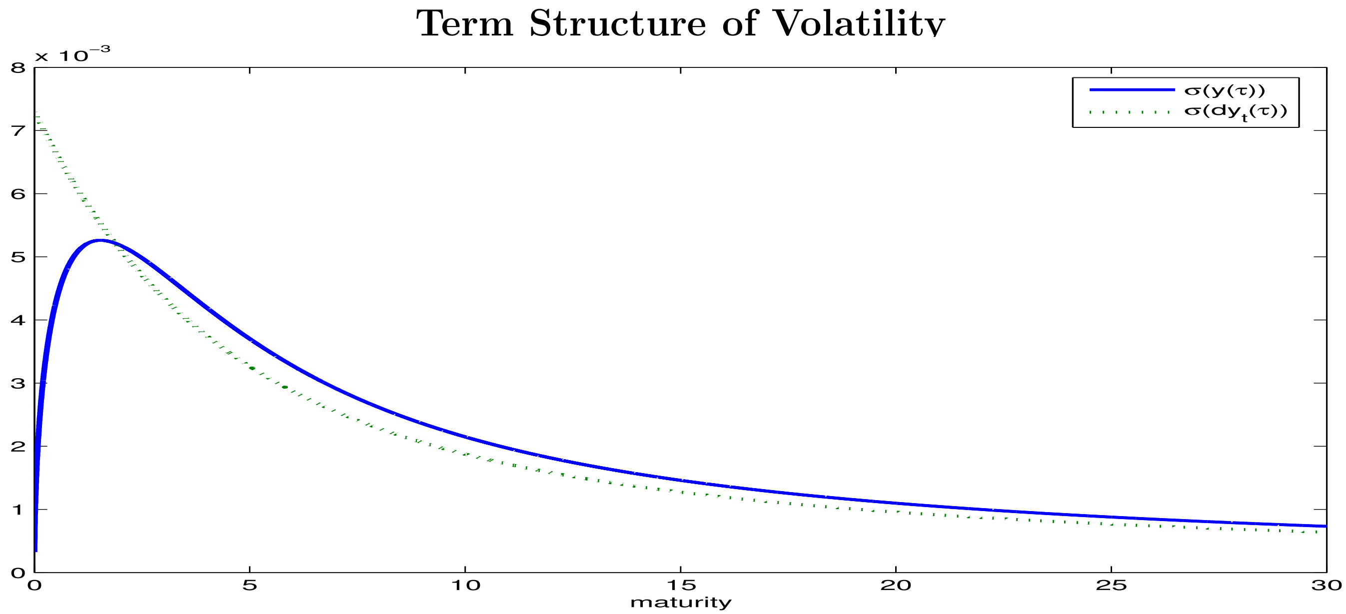
α	β	g	σ_y	σ_q	σ_i	ρ_{yq}	ρ_{yi}	ρ_{iq}
.0160	0.3805	0.02*	0.02*	0.0106	0.0073	-.1409	-.2894	0.8360

* The estimates of GDP growth were $g = .0321$ and $\sigma_y = 0.0098$, which made it hard to generate sensible yield functions. The parameters assumed are closer to consumption growth

- Using utility parameters $\rho = .1$ and $\gamma = 104$ we get a real rate $c = .02$. $\xi = -0.5931$
- Risk free rate puzzle kicks in:
  - For "reasonable" γ, the interest rate is too high.
  - Lowering γ to $\gamma \approx 0.5$ generates also reasonable yield curves, but they are not upward sloping in average. Moreover, the market price of risk is too low.


Yield curves
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0
5
10
15
20
25
30
maturity

Maturity


Term Structure of Volatility
x 10^-3
8
7
6
5
4
3
2
1
0
σ(y(τ))
σ(dy_t(τ))
0
5
10
15
20
25
30
maturity

Implications of Benchmark Model

5. The volatility of bond yields changes ($\sigma(dy)$) is constant over time but depends on maturity:

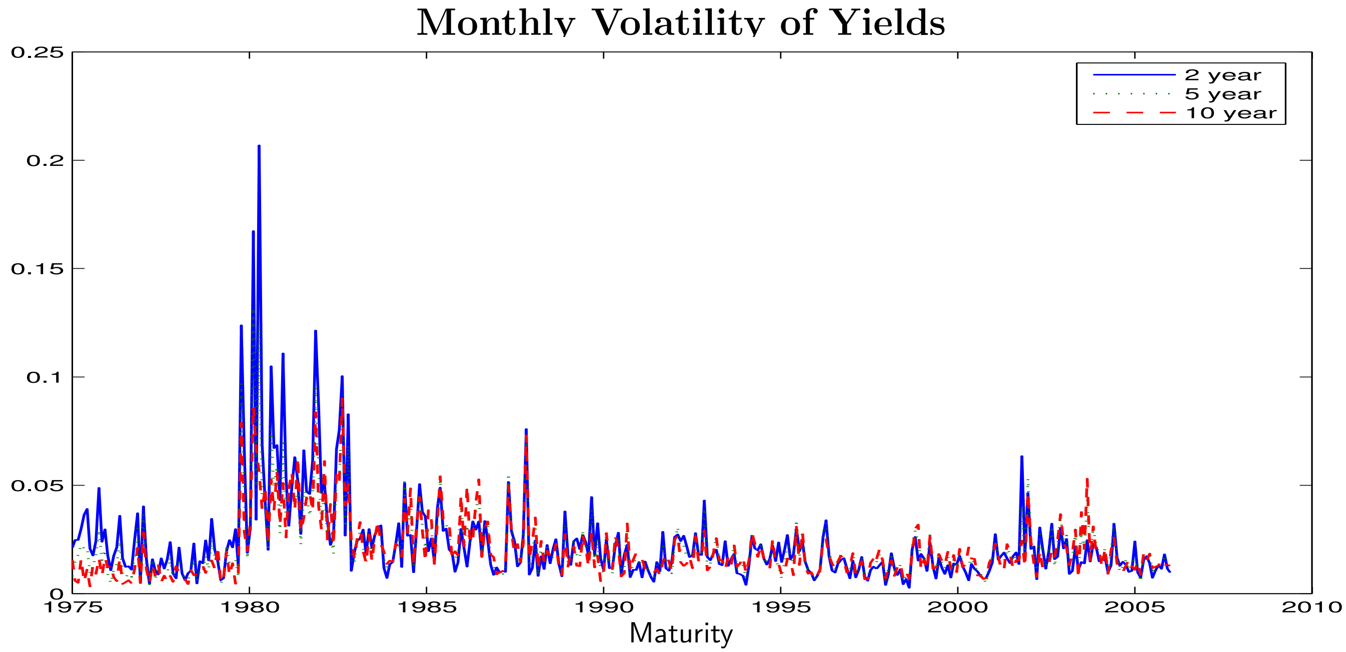
$$\sigma_y(t;T) = \frac{1-e^{-\beta\tau}}{\beta\tau}\sigma_i$$

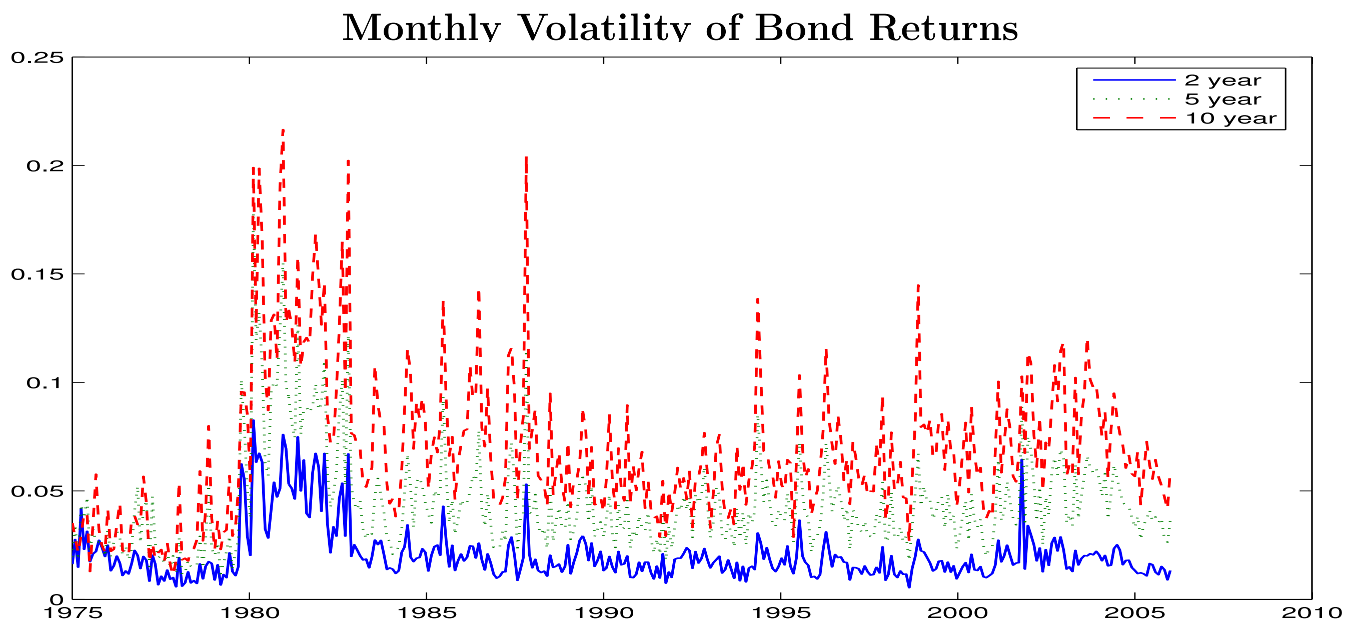
6. The bond risk premium is also constant, and given by

$$E\left[\frac{dZ}{Z}\right]/dt - r_t = \sigma_Z \xi$$

where

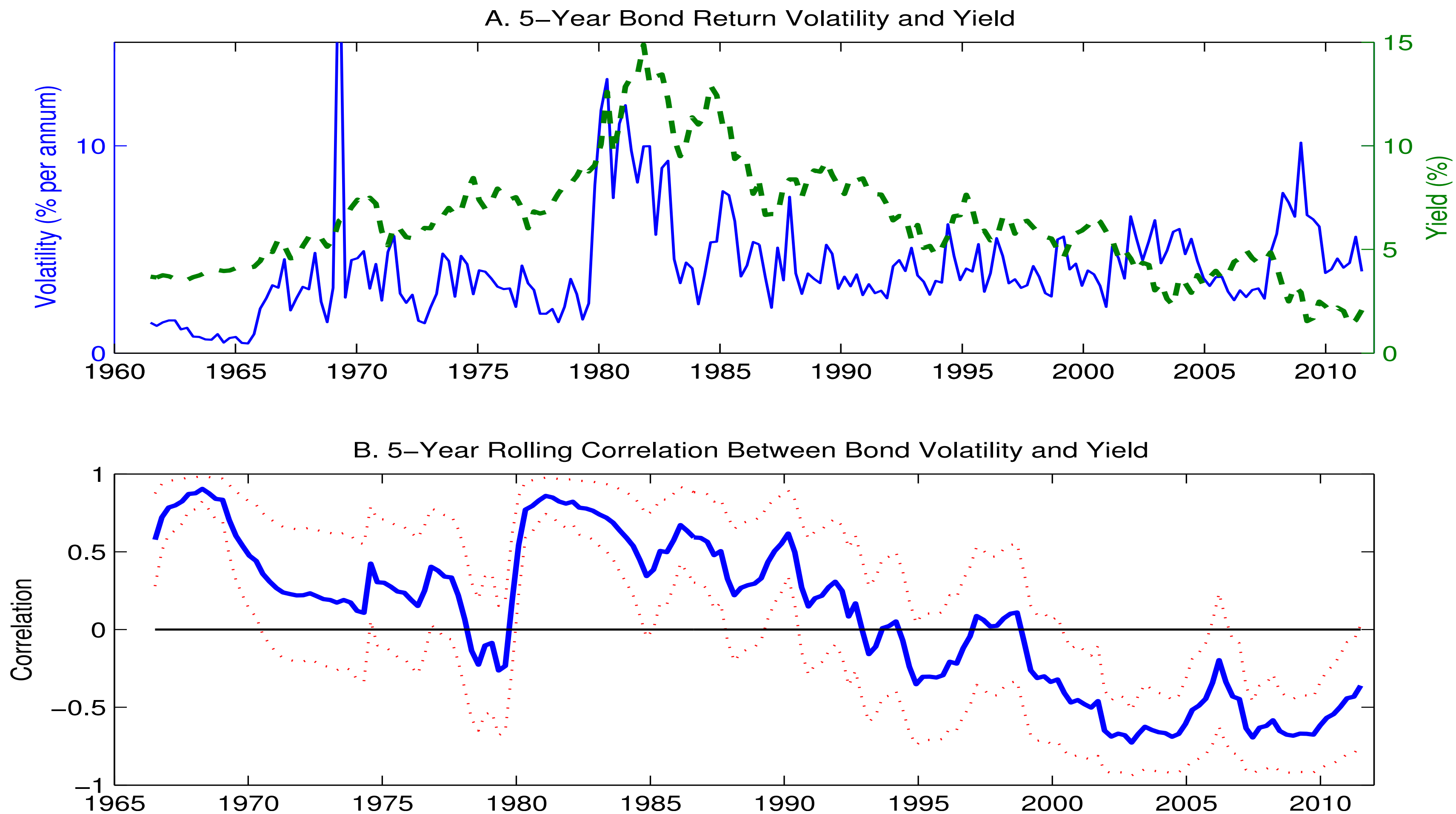
- $\sigma_Z =$ vol of$dZ/Z = -A_\beta(\tau)\sigma_i$
- $\xi = \gamma\sigma_c\rho_{ic} + \sigma_q\rho_{iq}$ is **Market Price of (inflation) Risk**
  - No time varying risk premium and no predictability


Monthly Volatility of Yields
2 year
5 year
10 year
0.25
0.2
0.15
0.1
0.05
0
1975
1980
1985
1990
1995
2000
2005
2010
Maturity


Monthly Volatility of Bond Returns
2 year
5 year
10 year
0.25
0.2
0.15
0.1
0.05
0
1975
1980
1985
1990
1995
2000
2005
2010

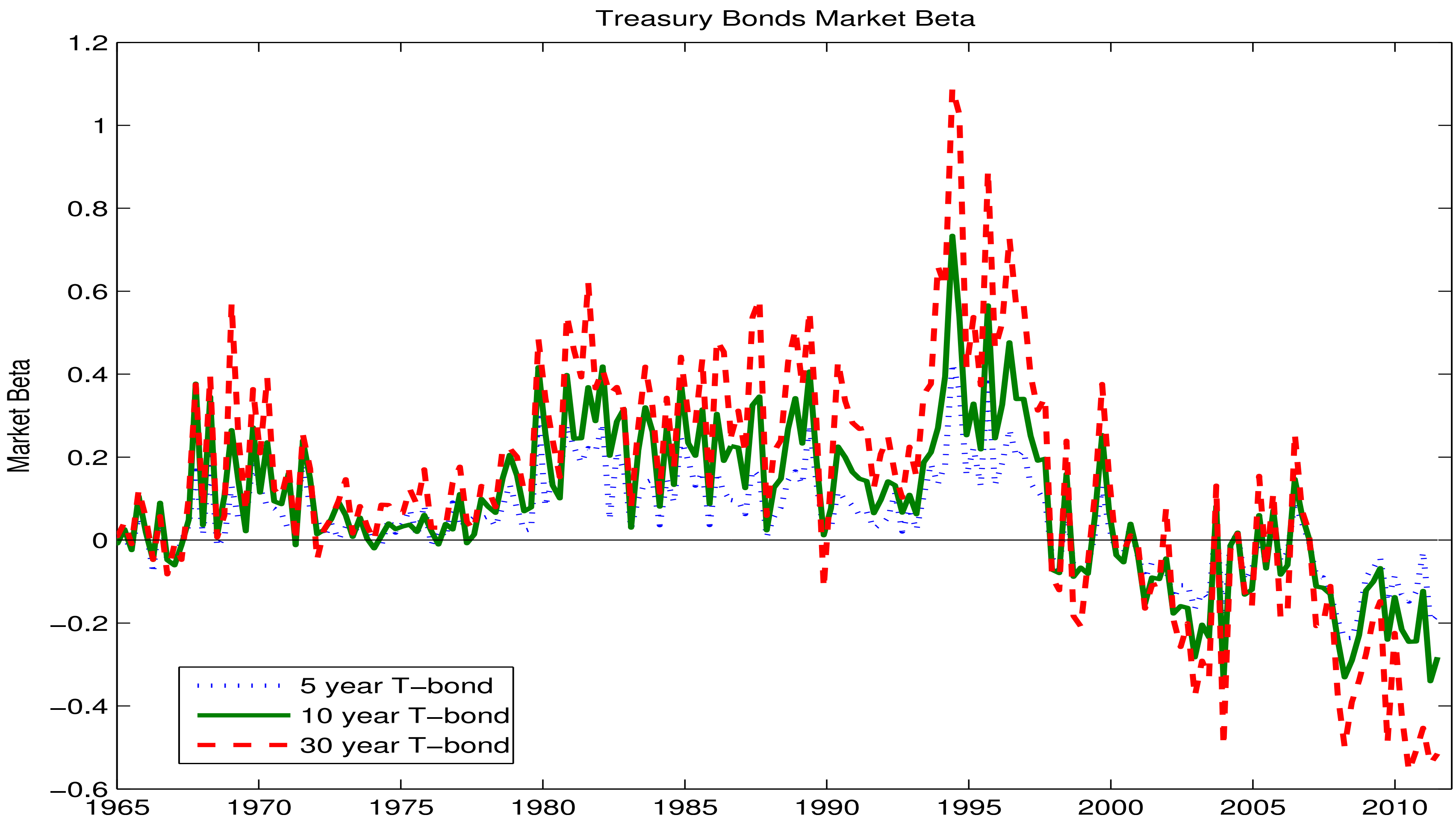
Bond Return Volatility and Yields

- Bond return volatility and yields are positively or negatively correlated



The Treasury Bond Market Betas

- Bond return become negative beta assets in the last two decades



Bond Predictability. Fama Bliss (1987)

- Fama and Bliss classic paper show that bond return are predictable by the forward spread.

$$\text{holding period excess log return} = \alpha + \beta \left(f_t^{(n)} - y(t,1) \right) + \epsilon_t$$

- where n = horizon (in years)

Fama Bliss Regressions: 1960 - 2010

n	α	β	t(α)	t(β)	R^2
2	0.0018	0.7850	0.6020	2.8129	10.94%
3	-0.0002	1.2246	-0.0446	3.5671	17.50 %
4	-0.0031	1.5325	-0.4309	3.4255	17.19 %
5	0.0014	1.0862	0.1316	1.8760	6.97%

- However, evidence from Euro, UK, Japan is much less clearcut. What's different there?

Bond Predictability. Cochrane and Piazzesi (2003)

- Cochrane and Piazzesi (2003) show that there is a single combination of forwards that explain bond excess returns.
  - What is an economic model that generates that effect?
  - Intriguinly, Cochrane Piazzesi factor works also outside US, while Fama Bliss regressions do not. What is the factor capturing?

This Course Covers (subject to change, though)

- Foundations: Complete markets, state price densities, consumption/portfolio allocation, the martingale method.
- (Some) portfolio allocation models with
  - Time varying investment opportunities
  - Incomplete information (learning)
- Habit formation and time varying risk preferences
  - Time-series and cross-sectional predictability
- Heterogeneous preferences, beliefs, and trading
  - Heterogenous risk aversion
  - Heterogeneous habits
  - Heterogeneous beliefs
- Incomplete information, learning and stock and bond returns
  - Valuation with uncertainty in long term growth.
- Politics and asset prices
  - Political news and returns
- Market incompleteness and constraints

Requirements

- Big Homework Assignments (30%):
  - I will assign three research ideas / projects during the terms.
  - Your assignments will be to develop such research ideas into coherent papers. This will involve (a) solving a model; (b) obtain predictions; (c) compare predictions with the data.
  - The paper must have the form of a paper, with an introduction, body of the paper, data analysis, conclusion, appendix.
  - The TA and I will be the referees: Give you feedback to improve writing.
  - You can work in groups, but with a limit of 3 per group.
- Weekly Mini Homework Assignments (10%):
  - Every class, I will write on the board some assignments related to missing steps in the notes.
  - You must turn in a sheet with the missing steps. This is individual work (no group).
- In-class Exam (30%)
  - There will be a "midterm" on Tuesday February 18. Essentially 1 1/2 hour on the material covered in class.
- Term Paper (25%)
  - A paper on the topics covered in class, due by the beginning on Spring quarter.
- Class participation (5%).

Crazy Schedule

	Tuesdays	Fridays	Comment
Week 1	Jan 7. 3:30-6:30 pm	Jan 10. 8:30-11:30 am	
Week 2	Jan 14. No class		
Week 3	Jan 21. 3:30-6:30 pm		
Week 4	Jan 28. 3:30-6:30 pm	Jan 31. 8:30-11:30 am	
Week 5	Feb 3. No class		Paper #1
Week 6	Feb 11. 3:30-6:30 pm		
Week 7	Feb 18. 3:30-6:30 pm (midterm)	Feb 21. 8:30-11:30 am	
Week 8	Feb 25. No class		Paper #2
Week 9	March 3. 3:30-6:30 pm		
Week 10	March 10. No class		Paper #3
Week 11	March 17 - 3:30-6:30 pm	March 20 - 8:30-11:30 am	(Exam week)