

Section 4: Production-based Asset Pricing

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March 29, 2024

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1. Basic structure of the notes

- High-level summary of theoretical frameworks to interpret empirical facts.
- Per asset class, we will discuss:
 1. Key empirical facts in terms of prices (unconditional and conditional risk premia) and asset ownership.
 2. Interpret the facts using the theoretical frameworks.
 3. Facts and theories linking financial markets and the real economy.
 4. Active areas of research and some potentially interesting directions for future research.
- The notes cover the following asset classes:
 1. Equities (weeks 1-5).
 - Predictability and the term structure of risk (week 1)
 - The Cross-section and the Factor Zoo (week 2)
 - Intermediary-based Asset Pricing (week 3)
 - **Production-based asset pricing (week 4)**
 - Asset pricing via demand systems (week 5)
 2. Mutual Funds and Hedge Funds (week 6).
 3. Options and volatility (week 7).
 4. Government bonds (week 8).
 5. Corporate bonds and CDS (week 9).
 6. Currencies and international finance (week 10).
 7. Commodities (week 11).
 8. Real estate (week 12).

2. Equity Prices and the Real Economy: Q-theory and investment returns

2.1. Theoretical framework

- Traditional link between equity prices and investment: Q-theory.
- Q-theory links the *level* of investment to the *level* of the stock market price (Hayashi, 1982).

$$I_t = a(Q_t - 1)$$

where

$$Q = \frac{\text{Market Value of Firm's Assets}}{\text{Replacement Cost of Firm's Assets}}$$

- Instead of linking levels, Cochrane (1991) links changes: stock returns and investment returns. If the model misses low-frequency variation in prices or investment, higher-frequency changes may align better. This paper kicks off the production-based AP literature.
- Cochrane (1996) builds a factor model with the returns on physical investment as asset pricing factors.
- Liu, Whited, and Zhang (2009) provides a recent test of this framework. We will use their setup (ignoring corp. debt, which is part of their model) to set the stage for our discussion.

• **Setup :**

- Optimized operating profits $\Pi(K_{it}, X_{it})$ with constant returns to scale, $\Pi(K_{it}, X_{it}) = K_{it} \partial \Pi(K_{it}, X_{it}) / \partial K_{it}$, where K_{it} is physical capital and X_{it} a vector of aggregate and firm-specific shocks.
- Cobb-Douglas production function, meaning

$$\partial \Pi / \partial K_{it} = \alpha Y_{it} / K_{it},$$

where α is the capital share and Y_{it} is sales.

- Capital accumulation:

$$K_{i,t+1} = I_{it} + (1 - \delta_{it}) K_{it},$$

where δ_{it} is the depreciation of capital.

- If a firm invests, it incurs adjustment costs that are increasing and convex in I_{it} and decreasing in K_{it} :

$$\Phi(I_{it}, K_{it}) = \frac{a}{2} (I_{it} / K_{it})^2 K_{it},$$

where $a > 0$.

- Corporate payouts (dividends) are: ,

$$D_{it} = (1 - \tau_t) [\Pi(K_{it}, X_{it}) - \Phi(I_{it}, K_{it})] - I_{it} + \tau_t \delta_{it} K_{it},$$

where τ_t is the corporate tax rate and $\tau_t \delta_{it} K_{it}$ is the tax shield from capital depreciation.

- Let M_{t+1} denote the SDF of the firms' shareholders. It is **taken as given in the production-based AP literature**. The firm optimizes the (cum-dividend) market value of equity:

$$V_{it} = \max_{I_{i,t}} E_t \left[\sum_{s=0}^{\infty} M_{t+s} D_{t+s} \right].$$

Define the investment return as

$$\begin{aligned} r_{i,t+1}^I &= \frac{\text{Marginal benefit of investment at } t+1}{\text{Marginal cost of investment at } t} \\ &= \frac{(1 - \tau_{t+1}) \left[\alpha \frac{Y_{i,t+1}}{K_{i,t+1}} + \frac{a}{2} \left(\frac{I_{i,t+1}}{K_{i,t+1}} \right)^2 \right] + \tau_{t+1} \delta_{i,t+1} + (1 - \delta_{i,t+1}) \left[1 + (1 - \tau_{t+1}) a \frac{I_{i,t+1}}{K_{i,t+1}} \right]}{1 + (1 - \tau_t) a (I_{it}/K_{it})} \end{aligned}$$

- Liu, Whited, and Zhang (2009) show (for the version of their model without corporate debt) that the investment return equals:

$$r_{i,t+1}^I = r_{i,t+1}^S,$$

where $r_{i,t+1}^S$ is the stock return.

$$r_{i,t+1}^S = \frac{P_{i,t+1} + D_{i,t+1}}{P_{i,t}} = \frac{V_{i,t+1}}{V_{i,t} - D_{i,t}}$$

- Important observation: Investment returns should equal stock returns, **realization-by-realization**.
- In the presence of corporate debt, investment return equals cost of capital = weighted average of the after-tax corporate bond return (b/c of tax shield) and the stock return, where weight on the bond is the market leverage ratio.

$$r_{i,t+1}^I = (1 - w_{i,t}) r_{i,t+1}^S + w_{i,t} (r_{i,t+1}^B - (r_{i,t+1}^B - 1) \tau_{it}),$$

- Marginal Q is defined as the PDV of the future marginal profits from investing in one additional unit of capital.
- Optimality condition for firm investment:
marginal Q = marginal cost of investing:

$$q_{it} = 1 + (1 - \tau_t)a(I_{it}/K_{it})$$

- Under the model's assumptions, we also have

$$q_{it} = \frac{P_{i,t}}{K_{i,t+1}},$$

that is, marginal Q equals average Q (market value to book value of equity).

- Average Q is observable, marginal Q is not. Under the assumption of this model, average Q is a perfect proxy for marginal Q .
- Early work in the investment literature tests whether firm investment rates, I_{it}/K_{it} , line up with average Q , $\frac{P_{i,t}}{K_{i,t+1}}$. (Hayashi, 1982).
- Empirically, this model is rejected. This failure has spurred an entire literature trying to better understand the determinants of firm investment.
- In particular, cash flow and lagged investment matters. See Eberly, Rebelo, and Vincent (2012) for a summary of the literature and generalizations of the standard model.
- **Investment-CAPM**: cross-sectionally varying **expected** returns driven by differences in firm characteristics:

$$E_t[r_{i,t+1}^S] = \frac{E_t \left[(1 - \tau_{t+1}) \left[\alpha \frac{Y_{i,t+1}}{K_{i,t+1}} + \frac{a}{2} \left(\frac{I_{i,t+1}}{K_{i,t+1}} \right)^2 \right] + \tau_{t+1} \delta_{i,t+1} + (1 - \delta_{i,t+1}) \left[1 + (1 - \tau_{t+1}) a \frac{I_{i,t+1}}{K_{i,t+1}} \right] \right]}{1 + (1 - \tau_t) a (I_{it}/K_{it})}$$

- Firms should earn low average stock returns if they have the following characteristics:
 - high **investment** rate today I_{it}/K_{it} ,
 - low sales-to-capital tomorrow $\frac{Y_{i,t+1}}{K_{i,t+1}}$,
 - low investment growth $\frac{I_{i,t+1}}{K_{i,t+1}}$,
 - high rates of depreciation tomorrow $\delta_{i,t+1}$,
 - low market leverage today (in the extension with corp. debt).
 - the components of the numerator contribute to the firm's **profitability**. Low profitability, low return.
- In the **Consumption-CAPM**, covariances of returns with IMRS of consumers are sufficient statistics for expected returns. In the **Investment-CAPM**, firm characteristics are sufficient statistics for expected returns. These are the **demand** and **supply** theories of asset pricing. In **general equilibrium, the two must coincide**.
- May be easier to test the investment CAPM than the consumption CAPM due to measurement issues with consumption and aggregation issues (in incomplete markets). Recall the previous lecture.

2.2. Production-based explanations of the value premium

- **Zhang (2005)** uses a version of this framework to study the value premium
- SDF M is exogenous and has one aggregate source of risk x ;
 $m = \log(M)$

$$m_{t+1} = \log \beta - \gamma_t(x_{t+1} - x_t)$$

where $\gamma_t = \gamma_0 + \gamma_1(x_t - \bar{x})$, and $\gamma_0 > 0$, $\gamma_1 < 0$. Should remind you of Consumption-CAPM with $x_t = c_t$ and γ_t time-varying risk aversion which is higher in recessions (low x_t times). Calibrated to match the Sharpe ratio on equity, the average real risk-free rate, and the volatility of the real risk-free rate.

- Continuum of firms with persistent, idiosyncratic productivity risk z_{it} and aggregate productivity x_t , Cobb-Douglas production, fixed costs of production f , and a downward-sloping demand curve for their goods. Profits:

$$\Pi(k_t, z_{it}; x_t, p_t) = \exp(x_t + z_{it} + p_t)k_t^\alpha - f$$

- Adjustment costs are asymmetric :

$$\Phi(I_{it}, K_{it}) = \frac{a_t}{2}(I_{it}/K_{it})^2 K_{it},$$

where $a_t = \theta^+ \cdot 1_{I_{it} \geq 0} + \theta^- \cdot 1_{I_{it} < 0}$. Disinvestment is more costly than investment: $\theta^- > \theta^+ > 0$. Calibration sets $\theta^-/\theta^+ = 10$.

- Asymmetry captures that average rate of disinvestment is much lower than investment rate; in data: 1.4% vs. 13.5%.

- Form cross-section of firms sorted by B/M ratio in a simulation of the model:

Table III
Properties of Portfolios Sorted on Book-to-Market

This table reports summary statistics for HML and 10 book-to-market portfolios, including mean, m , volatility, σ , and market beta, β . Both the mean and the volatility are annualized. The average HML return (the value premium) is in annualized percent. Panel A reports results from historical data and benchmark model with asymmetry and countercyclical price of risk ($\theta^-/\theta^+ = 10$ and $\gamma_1 = -1000$). Panel B reports results from two comparative static experiments. Model 1 has symmetric adjustment cost and constant price of risk ($\theta^-/\theta^+ = 1$ and $\gamma_1 = 0$), and Model 2 has asymmetry and constant price of risk ($\theta^-/\theta^+ = 10$ and $\gamma_1 = 0$). All the model moments are averaged across 100 artificial samples. All returns are simple returns.

	Panel A: Data and Benchmark						Panel B: Comparative Statics					
	Data			Benchmark			Model 1			Model 2		
	m	β	σ	m	β	σ	m	β	σ	m	β	σ
HML	4.68	0.14	0.12	4.87	0.43	0.12	2.19	0.09	0.04	2.54	0.11	0.04
Low	0.11	1.01	0.20	0.09	0.85	0.23	0.08	0.95	0.30	0.08	0.94	0.30
2	0.12	0.98	0.19	0.10	0.92	0.24	0.09	0.97	0.31	0.09	0.97	0.31
3	0.12	0.95	0.19	0.10	0.95	0.25	0.09	0.99	0.31	0.09	0.98	0.31
4	0.11	1.06	0.21	0.11	0.98	0.26	0.09	1.00	0.32	0.10	0.99	0.31
5	0.13	0.98	0.20	0.11	1.01	0.27	0.10	1.00	0.32	0.10	1.00	0.32
6	0.13	1.07	0.22	0.12	1.04	0.28	0.10	1.01	0.32	0.10	1.01	0.32
7	0.14	1.13	0.24	0.12	1.08	0.28	0.10	1.02	0.32	0.10	1.02	0.32
8	0.15	1.14	0.24	0.12	1.12	0.30	0.10	1.03	0.33	0.11	1.04	0.33
9	0.17	1.31	0.29	0.13	1.18	0.31	0.11	1.04	0.33	0.11	1.05	0.33
High	0.17	1.42	0.33	0.15	1.36	0.36	0.11	1.07	0.34	0.12	1.08	0.34

- Since firms are ex-ante identical, and only differ ex-post by their history of productivity shocks $\{z_{is}\}_{s=0}^t$, this is a sort on the history of productivity \approx profitability.

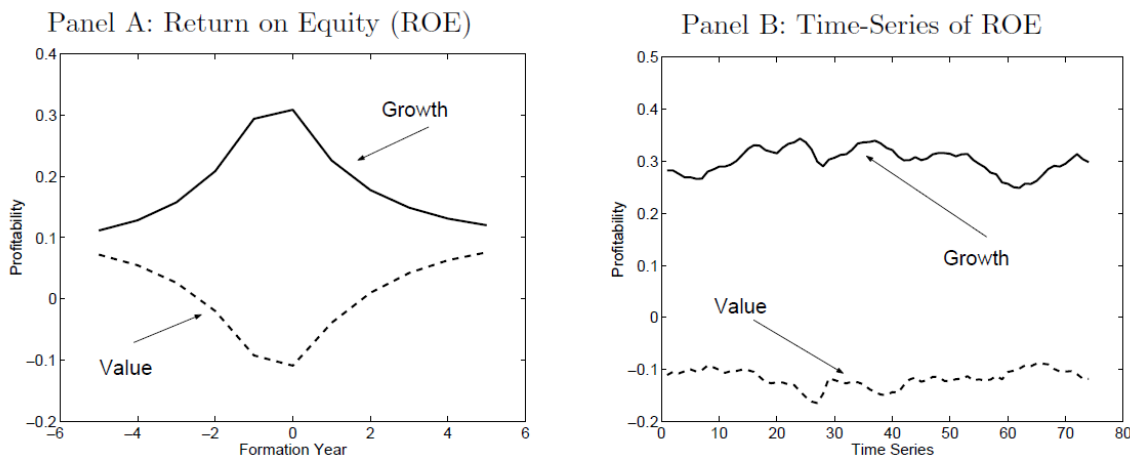


Figure 2. The value factor in profitability (ROE). Following Fama and French (1995), I measure profitability by return on equity, that is $[\Delta k_t + d_t]/k_{t-1}$, where k_t denotes the book value of equity and d_t is the dividend payout. Thus profitability equals the ratio of common equity income for the fiscal year ending in calendar year t and the book value of equity for year $t - 1$. The profitability of a portfolio is defined as the sum of $[\Delta k_{jt} + d_{jt}]$ for all firms j in the portfolio divided by the sum of k_{jt-1} ; thus it is the return on book equity by merging all firms in the portfolio. For each portfolio formation year t , the ratios of $[\Delta k_{t+i} + d_{t+i}]/k_{t+i-1}$ are calculated for year $t + i$, where $i = -5, \dots, 5$. The ratio for year $t + i$ is then averaged across portfolio formation years. Panel A shows the 11-year evolution of profitability for value and growth portfolios. Time 0 on the horizontal axis is the portfolio formation year. Panel B shows the time series of profitability for value and growth portfolios. Value portfolio contains firms in the top 30% of the book-to-market ratios and growth portfolio contains firms in the bottom 30% of the book-to-market ratios. The figure is generated under the benchmark model, and varying θ^-/θ^+ and γ_1 yields similar results.

- Value firms had a history of bad productivity shocks prior to portfolio formation, and have growing productivity after portfolio formation; driven by mean reversion in firm-level productivity z_{it} .
- As discussed in week 2, the value and long-term reversal anomalies are closely connected.

- Since growth firms are more productive than value firms, they tend to invest more, esp. in good times. Growth firms incur more adjustment costs than value firms in good times.
- In bad times, value firms disinvest more. Because of the asymmetric adjustment cost, they incur *much* higher adjustment costs than growth firms in bad times.
- Note that dividends are output minus investment. Output is pro-cyclical because aggregate productivity is pro-cyclical. But investment is also pro-cyclical. That makes dividends less pro-cyclical than output, possibly even counter-cyclical. If the dividend claim is counter-cyclical, the equity risk premium will be very low, possibly even negative.
- This is what makes it so hard to generate an equity risk premium in a production economy, compared to an endowment economy. Firms' production plans absorb some of the aggregate risk. You need to introduce frictions to prevent firms from playing the role of shock absorber. See [Jermann \(1998\)](#) and [Boldrin, Christiano, and Fisher \(2001\)](#).
- In [Zhang \(2005\)](#), the asymmetric adjustment costs do the trick. Value firms are riskier because they are inflexible. In bad times, value firms want to disinvest. But this is very costly, so they avoid it as much as possible. This deprives them from the flexibility to smooth dividends, which now covary more with the business cycle. Hence we get a value premium.
- In this model, the value premium arises because value firms become riskier than growth firms in recessions. There is time-varying exposure to a single aggregate source of risk, i.e., the conditional CAPM holds (but the unconditional CAPM doesn't).

- Papanikolaou (2011) argues that a conditional CAPM, like Zhang (2005), cannot explain the value premium.
- He regresses weekly B/M-sorted portfolio returns on the market factor, allowing the beta to vary each year. The regression residuals show a strong common factor structure, suggesting that there is a second priced factor needed to explain the cross-section of B/M-sorted portfolios.
- Put differently, the high-minus-low B/M portfolio strategy has a positive alpha not only w.r.t the unconditional CAPM but also w.r.t. the conditional CAPM.
- He proposes an asset pricing model with 2 aggregate shocks: standard aggregate TFP shocks + a new **investment-specific technology shock (IST)**. This shock affects the marginal efficiency at which investment can be transformed into new capital goods, ready for production.
- One interpretation of IST shocks: shocks to quality of capital goods. Another interpretation: shocks to the financial intermediary sector (in a very reduced form way!).
- Tradition of thinking of the value of a firm as the sum of the value of assets in place + value of future growth opportunities.
- In the presence of adjustment costs, the value of growth opportunities is strictly positive. This is because Tobin's $Q > 1$: installed capital is more valuable than uninstalled capital. Firms earn rents from installed capital. These rents are the PVFGO.

- Value firms, who by definition have lower Q (market/book), have more assets in place and fewer future growth opportunities. Opposite is true for growth firms.
- Assets in place have a lower exposure to the IST shock than growth opportunities. Therefore, value firms have lower IST-beta than growth firms.
- If the price of IST risk is negative, then this generates a value premium.
- A negative price of IST risk means that positive IST shocks are bad states of the world, states where rep. agent has high marginal utility.
- Intuition: positive IST shocks mean that investment becomes more efficient, which means that investment will rise and consumption will drop. MU of consumption increases = bad state.
- Investors are willing to pay more for securities that pay off when investment opportunities are good - those assets have low returns. Growth stocks are hedges against this innovation risk (positive IST beta).
Note how this is almost opposite intuition as in [Zhang \(2005\)](#).
- Paper uses Epstein-Zin preferences, but needs an EIS < 1 to get the sign on IST-risk price to be negative. The long-run risk literature usually chooses values for the EIS ≥ 1 .
- Value premium generated by the Papanikolaou model is only 1/3 of the value premium in data. Equity risk premium is only 2% per year. Model clearly has quantitative issues of fit.

- Two empirical proxies for IST shock:
 - change in the (relative) price of investment goods.
 - the return spread between investment- and consumption-goods producers (R_{IMC})
- Positive shocks to R_{IMC} lead to increase in investment, a decline in consumption, and a drop in the price of investment goods, both in model and in data.

Table 6: CROSS-SECTIONAL TESTS (I)

Panel A: 10 portfolios sorted on IMC-beta (Consumption Sector only)						
Factor	CAPM	CCAPM	IMC, MKT	IMC, C	p^I, MKT	p^I, C
$A : R_{mkt}$	0.29 [2.34]		0.41 [3.16]		0.14 [0.81]	
$A : \dot{c}$		0.83 [2.17]		1.44 [3.09]		0.32 [0.78]
$Z : R_{imc}$			-0.29 [-1.80]	-0.47 [-2.46]		
$Z : \Delta z^I$					-0.66 [-1.75]	-0.80 [-2.73]
$SSQE(\%)$	0.37	0.78	0.02	0.17	0.06	0.08
J -test	12.3 [0.20]	24.4 [0.00]	5.4 [0.71]	17.8 [0.02]	11.7 [0.17]	14.4 [0.07]
Panel B: 10 portfolios sorted on book-to-market equity (Consumption Sector only)						
Factor	CAPM	CCAPM	IMC, MKT	IMC, C	p^I, MKT	p^I, C
$A : R_{mkt}$	0.40 [3.18]		0.48 [3.40]		-0.11 [-0.45]	
$A : \dot{c}$		1.41 [3.20]		1.46 [3.34]		-0.50 [-1.47]
$Z : R_{imc}$			-0.77 [-1.97]	-0.14 [-0.41]		
$Z : \Delta z^I$					-1.43 [-2.03]	-1.52 [-4.99]
$SSQE(\%)$	0.33	0.27	0.16	0.26	0.12	0.12
J -test	53.3 [0.00]	63.4 [0.00]	34.6 [0.00]	57.4 [0.00]	35.3 [0.00]	18.0 [0.02]

Table 6 shows results of estimating the stochastic discount factor of the model, (40), via generalized method of moments. I report first stage estimates of b_A and b_Z using the identity weighting matrix. I also report the sum of squared pricing errors (SSQE) and the J test of over-identifying restrictions along with p-values in brackets. I report t-statistics in parentheses using Newey-West standard errors, allowing for 1 lag. I use two proxies for the consumption productivity shock A : returns on the market portfolio (MKT) and the growth rate of per capita non-durables plus services consumption (C). I use two proxies for Z : minus the innovation in the relative price of new equipment (Δz^I) using Equation 38, and returns on the portfolio of investment minus consumption producers IMC . I normalize both proxies for Z to have unit standard deviation. The top panel (A), shows estimates of the parameters using a cross-section of 10 portfolios sorted on their univariate beta with respect to the IMC portfolio (β^{IMC}). The bottom panel (B) shows estimates of the parameters using a cross-section of 10 portfolios sorted on their book-to-market ratio. Sample includes annual data from 1963-2008.

- Estimated price of IST risk is negative. However the point estimates are too large in absolute value relative to the model.
- [Kogan and Papanikolaou \(2014\)](#) flesh out the implications of this model for the value premium in more detail.

2.3. Testing the Equality of stock and investment returns

- Recall prediction $r_{t+1}^I = r_{t+1}^S$
- **Cochrane (1991)** shows that **aggregate** investment returns and stock returns are correlated:

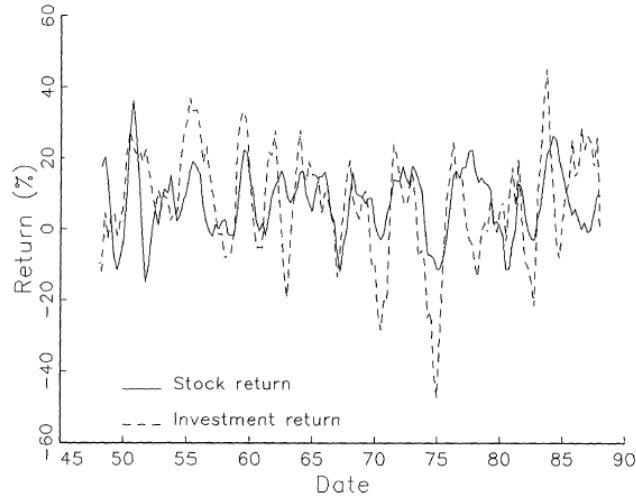


Figure 2. Quarterly observations of annual (from $t - 4$ to t) real returns on the value weighted NYSE portfolio, and annual investment returns.

Table II
Regression of Real Stock Returns on Investment Returns,
Investment Growth, and GNP Growth

This table documents that the correlation between stock returns and investment returns visible in Figure 2 is statistically significant. The data sample is 1947:1–1987:4.

Panel A. Quarterly Returns				
Stock Return ($t - 1 \rightarrow t$) = $\alpha + \beta$ Right Hand Variable ($t - 1 \rightarrow t$) + $\epsilon(t)$				
Right Hand Variable	<i>t</i> -stat.	% <i>p</i> value ^a	Correlation of stock, R.H.V.	Std. error of correlation
Investment returns	3.163	0.186	0.241	0.069
Investment growth	3.103	0.226	0.237	0.068
GNP growth	3.914	0.013	0.294	0.074
Panel B. Overlapping Annual Returns, with Corrected Standard Errors ^b				
Stock Return ($t - 4 \rightarrow t$) = $\alpha + \beta$ Right Hand Variable ($t - 4 \rightarrow t$) + $\epsilon(t)$				
Right Hand Variable	<i>t</i> -stat.	% <i>p</i> value ^a	Correlation of stock, R.H.V.	Std. error of correlation
Investment returns	2.820	0.541	0.385	0.113
Investment growth	3.060	0.259	0.360	0.103
GNP growth	3.921	0.012	0.404	0.097

- Liu, Whited, and Zhang (2009) focus on **firm-level** stock and investment returns. Rather than testing whether the two are equal point-by-point, they test whether average returns (first moment) and return volatilities (second moment) are the same.
- Look at cross-section of 30 tests assets: 10 SUE, 10 BM, and 10 CI (= investment growth). Sample: Jan 1963-Dec 2005.
- Start by focussing only on expected returns. The CAPM, FF3, and C-CAPM fail to price these portfolios (panels b, c, d). The q-theory model does better pricing these portfolios (panel a).

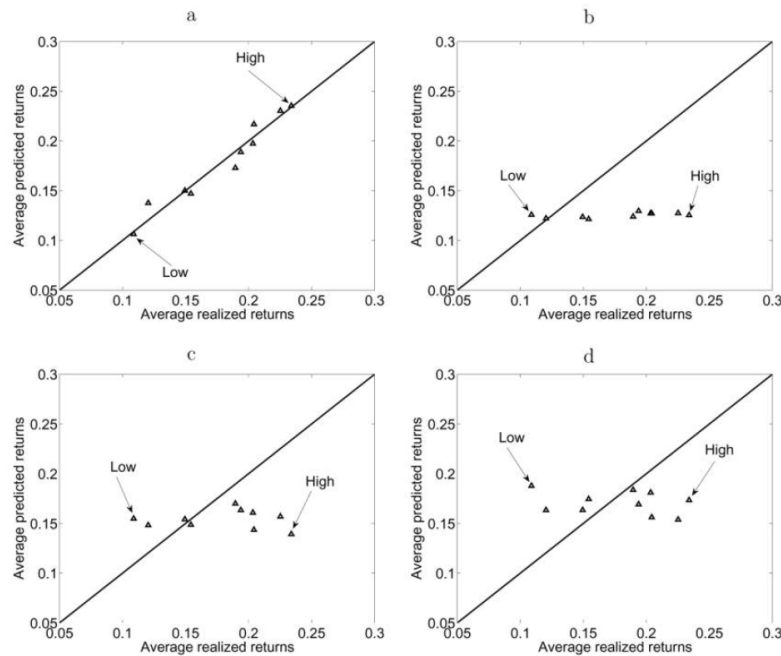


FIG. 1.—Average predicted stock returns versus average realized stock returns, 10 standardized unexpected earnings (SUE) portfolios, matching only expected stock returns. Figures 1a, 1b, 1c, and 1d report the results from the q -theory model, the CAPM, the Fama-French model, and the standard consumption-CAPM, respectively. High denotes the high SUE decile and low denotes the low SUE decile.

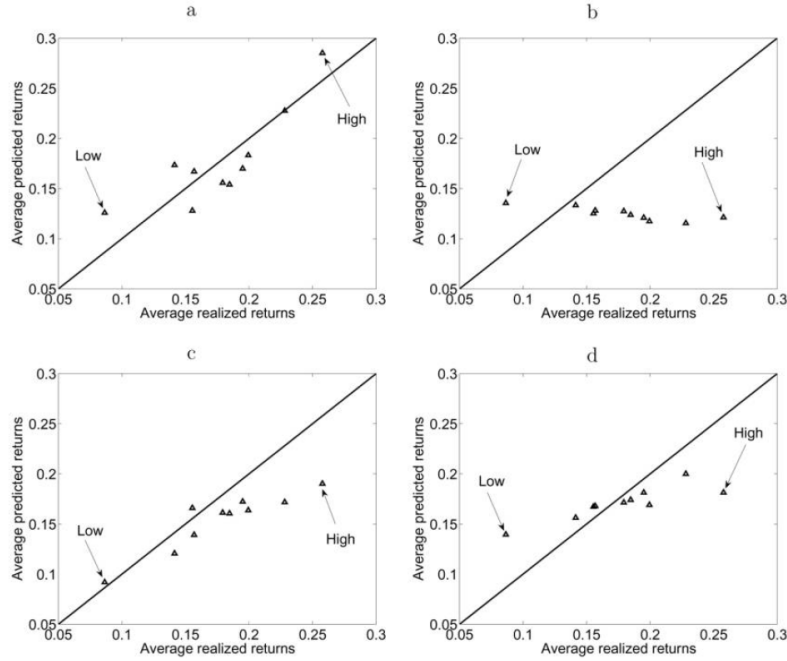


FIG. 2.—Average predicted stock returns versus average realized stock returns, 10 book-to-market (B/M) portfolios, matching only expected stock returns. Figures 2a, 2b, 2c, and 2d report the results from the q -theory model, the CAPM, the Fama-French model, and the standard consumption-CAPM, respectively. High denotes the high B/M decile and low denotes the low B/M decile.

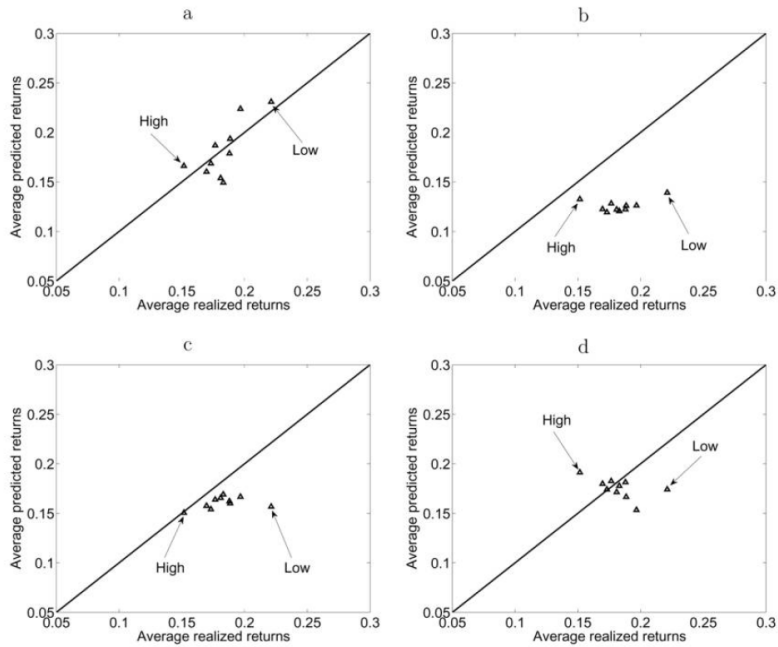


FIG. 3.—Average predicted stock returns versus average realized stock returns, 10 corporate investment (CI) portfolios, matching only expected stock returns. Figures 3a, 3b, 3c, and 3d report the results from the q -theory model, the CAPM, the Fama-French model, and the standard consumption-CAPM, respectively. High denotes the high CI decile and low denotes the low CI decile.

- However, when the model is asked to both match expected returns and the volatilities of returns, the fit deteriorates substantially.

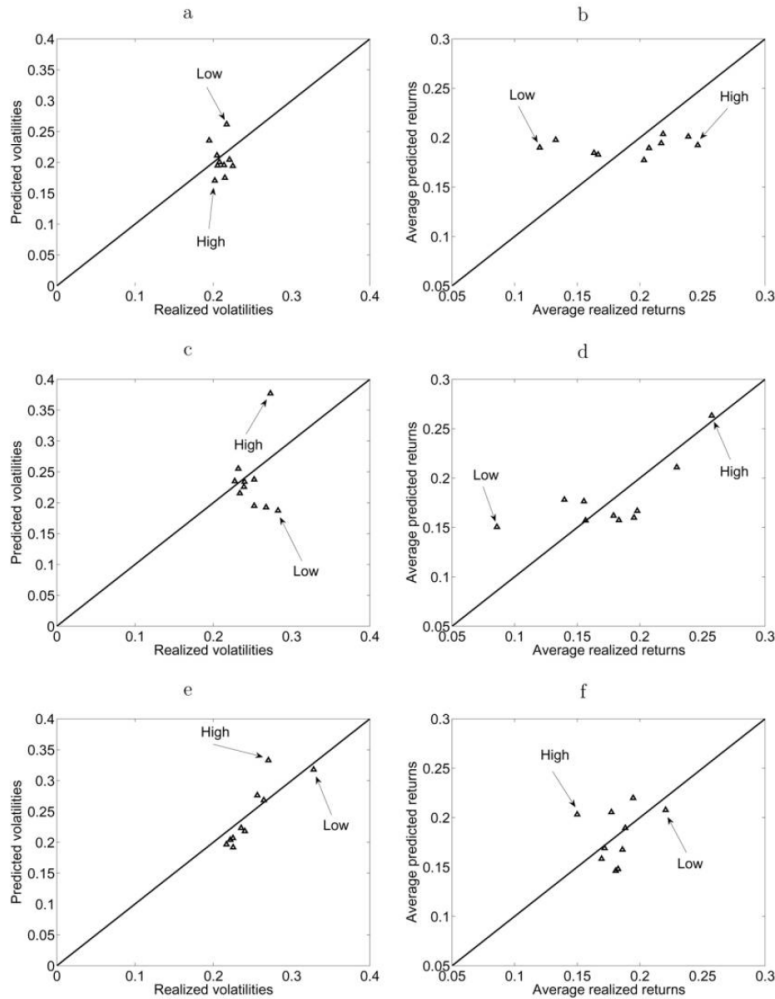


FIG. 4.—Predicted stock return volatilities versus realized stock return volatilities, average predicted stock returns versus average realized stock returns, the q -theory model, matching expected returns and variances simultaneously. Figures 4a, 4c, and 4e report the volatility plots for the 10 SUE portfolios, the 10 B/M portfolios, and the 10 CI portfolios, respectively. Figures 4b, 4d, and 4f report the expected return plots for the 10 SUE portfolios, the 10 B/M portfolios, and the 10 CI portfolios, respectively.

- In sum, the q-theory model does a poor job of matching expected returns and variances simultaneously in the SUE and CI portfolios but a somewhat better job in the B/M portfolios.
- Estimation picks large adjustment cost parameter a and capital share parameter α to match volatilities, but that worsens the fit for the expected returns.
- **The correlation puzzle:** Recall that investment returns and stock returns should be the same in realization, across firms and time.
- So far, we just matched average returns and volatilities, not the correlations.

TABLE 5
CORRELATIONS

	A. 10 SUE PORTFOLIOS				B. 10 B/M PORTFOLIOS				C. 10 CI PORTFOLIOS			
	Low	5	High	All	Low	5	High	All	Low	5	High	All
$\rho(r_{it+1}^S, r_{it+1}^{Iw})$	-.3	-.2	-.3	-.1**	-.2	-.2	-.1	-.1**	.2	-.3**	-.3*	-.1
$\rho(r_{it}^S, r_{it+1}^{Iw})$.2	.0	.1	.2***	.1	.2	.3***	.2***	.4***	.2	.3*	.2***
$\rho(r_{it+1}^S, I_{it+1}/I_{it})$	-.3	-.2	-.2	-.1	-.1	-.1	-.1	-.2***	-.3*	-.3**	-.1	-.0
$\rho(r_{it}^S, I_{it+1}/I_{it})$.2	.0	-.0	.1**	.1	.2	.3*	.1***	.2	.1	.3	.2***

NOTE.—We report time-series correlations of stock returns (contemporaneous, r_{it+1}^S , and one-period-lagged, r_{it}^S) with levered investment returns, r_{it+1}^{Iw} , and with investment growth, I_{it+1}/I_{it} . In each panel we report results for only three (low, 5, and high) out of 10 portfolios to save space. $\rho(\cdot, \cdot)$ denotes the correlation between the two series in the parentheses. In the last column of each panel (all) we report the correlations and their significance by pooling all the observations for a given set of 10 testing portfolios. The levered investment returns are constructed using the parameters in panel A of table 2.

* Significant at the 10 percent level.

** Significant at the 5 percent level.

*** Significant at the 1 percent level.

- Unfortunately, the correlations are often negative, which contradicts the model's prediction of a perfectly positive correlation. Lagging stock returns to capture the slow adjustment of firm investment to discount rate changes helps somewhat.

2.4. The new Q-factor model

- We saw that the Fama-French 3-factor model fails to account for an increasing number of asset pricing anomalies.
- Hou, Xue, and Zhang (2015) propose a 4-factor implementation of the investment CAPM that explains many of the anomalies that prove challenging for the FF3 model.

$$E[r^i] - r^f = \beta_{MKT}^i E[r_{MKT}] + \beta_{SMB}^i E[r_{SMB}] + \beta_{I/A}^i E[r_{I/A}] + \beta_{ROE}^i E[r_{ROE}]$$

where $r_{I/A}$ is the return on a portfolio of low minus high investment stocks (average return of 0.45% per month), and r_{ROE} is the return on a portfolio of high minus low profitability stocks (average return 0.58% per month).

- Explore 80 anomalies, forming value-weighted decile returns (using NYSE breakpoints). Only 35 anomaly returns are significant to begin with.
- For these 35, the q-factor model has average alpha of 0.20% per month, in contrast to 0.55% per month for FF3 and 0.33% for the 4-factor Carhart model. Q-model also much better at explaining earnings momentum anomaly than even the Carhart model (which has a price momentum factor).

Some Intuition

- Recall the simple q-theory model:

$$E_t[r_{i,t+1}^S] = \frac{E_t[\Pi_{i,t+1}]}{1 + a(I_{i,t}/A_{i,t})}$$

where Π here denotes the marginal profitability of investment; profits are $\Pi_{i,t}A_{i,t}$.

- Investment (I/A) predicts returns negatively because, given expected cash flows, a high cost of capital implies low net present values of new capital (q) and low investment, and low costs of capital imply high net present values of new capital (q) and high investment.

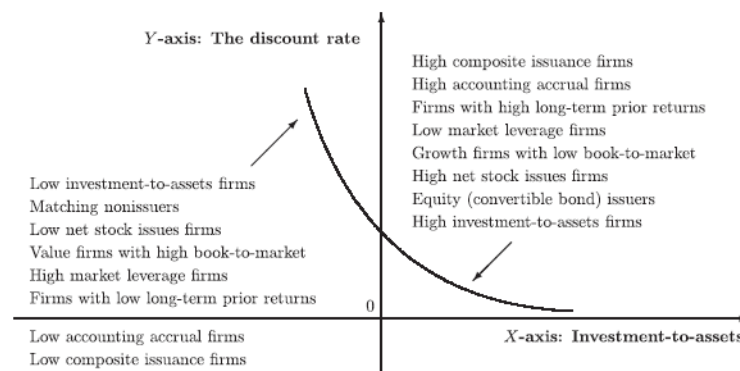


Figure 1
The investment channel

- Can account for asset growth anomaly
- Can account for value anomaly ($I/A \propto q = Q = M/B$)
- high M/B can result from string of positive prior returns

- Profitability (*ROE*) predicts returns positively because high expected ROE relative to low investment must imply high discount rates. The high discount rates are necessary to offset the high expected ROE to induce low net present values of new capital and low investment. If the discount rates were not high enough, firms would instead observe high net present values of new capital and invest more. Conversely, low expected ROE relative to high investment must imply low discount rates. If the discount rates were not low enough to counteract the low expected ROE, firms would instead observe low net present values of new capital and invest less.

- Momentum winners have higher exp. profitability
- Less distressed firms have higher exp. profitability
- Sorting on earnings surprises is sorting on profitability

- Q-factor returns and alphas

Table 1
Empirical properties of the q-factors

Panel A: Descriptive statistics								Panel B: Correlation matrix (p-values)						
	Mean	α	β_{MKT}	β_{SMB}	β_{HML}	β_{UMD}	R^2	$r_{1/A}$	r_{ROE}	MKT	SMB	HML	UMD	
r_{ME}	0.31 (2.12)	0.23 (1.62)	0.17 (4.33)				0.06	r_{ME}	-0.11 (0.02)	-0.31 (0.00)	0.25 (0.00)	0.95 (0.00)	-0.07 (0.13)	0.01 (0.90)
		0.04 (1.09)	0.02 (1.59)	0.99 (57.37)	0.17 (7.05)		0.93	$r_{1/A}$		0.06 (0.20)	-0.36 (0.00)	-0.22 (0.00)	0.69 (0.00)	0.05 (0.31)
		0.01 (0.15)	0.02 (2.40)	0.99 (61.51)	0.19 (7.34)	0.03 (2.16)	0.94	r_{ROE}			-0.19 (0.00)	-0.38 (0.00)	-0.09 (0.06)	0.50 (0.00)
$r_{1/A}$	0.45 (4.95)	0.52 (5.93)	-0.15 (-5.58)				0.13	MKT				0.28 (0.00)	-0.32 (0.00)	-0.15 (0.00)
		0.33 (4.85)	-0.06 (-3.66)	-0.02 (-0.81)	0.39 (11.98)		0.50	SMB					-0.23 (0.00)	-0.01 (0.79)
		0.28 (3.85)	-0.05 (-3.24)	-0.02 (-0.87)	0.41 (11.94)	0.05 (1.97)	0.52	HML						-0.15 (0.00)
r_{ROE}	0.58 (4.81)	0.63 (5.62)	-0.11 (-2.38)				0.04							
		0.77 (6.94)	-0.09 (-2.08)	-0.33 (-5.75)	-0.20 (-2.38)		0.20							
		0.50 (4.75)	-0.03 (-0.98)	-0.33 (-4.38)	-0.10 (-1.48)	0.28 (6.27)	0.40							

- Conclusion: The Q-model fairs well in explaining a large cross-section of average returns. But, paper does not impose volatility restrictions nor explores the correlation puzzle.

- [Goncalves, Xue, and Zhang \(2020\)](#) draw attention to two empirical challenges: aggregation and capital heterogeneity.
- Standard procedure is to [aggregate](#) accounting variables of all firms in a portfolio, then compute investment returns on the portfolio, and compare them to stock returns on the portfolio.
 - Implicitly assumes all firms have same investment rate
 - Ignores heterogeneity in firm-level variables that could be useful for identification of structural parameters (marginal adjustment cost and marginal productivity of capital)
 - ⇒ Better to first construct firm-level investment returns, then aggregate to portfolio level
- [Capital heterogeneity](#) across firms is important: not all firms have just Property, Plant, and Equipment. More on this below. [GXZ \(2020\)](#) focus on working capital for which there are no adjustment costs.
 - PPE is only 38% on average of PPE+working capital
- Resulting modifications result in much better fit, more stable structural parameters across test portfolios. Model can now explain value and momentum simultaneously (for similar structural parameters), which [Liu, Whited, and Zhang \(2009\)](#) could not.
- Positive correlation between stock returns and investment returns of around 10% at the firm- and 20% at the portfolio-level.

- [Delikouras and Dittmar \(2021\)](#) return to the correlation puzzle.
- If stock returns and investment returns are equal, then projecting the SDF onto the span of stock returns or onto the span of investment returns should deliver the same coefficients ($d^I = d^S$).

$$M_{t+1} = c + d'_I \left(R_{t+1}^I - \bar{R}^I \right) + \xi_{t+1}^I$$

$$M_{t+1} = c + d'_S \left(R_{t+1}^S - \bar{R}^S \right) + \xi_{t+1}^S$$

- If firms adjust investment until the SDF that satisfies the Euler equation for the equity claim also satisfies the Euler equation for investment, then:

$$E \left[\left(c + d'_S \left(R_{t+1}^S - \bar{R}^S \right) \right) R_{t+1}^I \right] = 1$$

- Vice-versa, SDF that satisfies the Euler equation for investment should price stocks:

$$E \left[\left(c + d'_I \left(R_{t+1}^I - \bar{R}^I \right) \right) R_{t+1}^S \right] = 1$$

- Form SDF projection on 9 stock portfolios double-sorted on I/A and ROE which are the key portfolios that follow from the investment CAPM and are central in the [HXZ \(2015\)](#) paper.
- GMM estimation strongly rejects both sets of moments.
- Find that investment returns covary positively with this SDF: investments pay off in bad states of the world (when SDF is high) \Rightarrow hard to generate a positive investment risk premium
- Powerful rejection of equivalence of stock return-based SDF and investment return-based SDF.

- [GXZ \(2020\)](#) think that [Delikouras and Dittmar \(2021\)](#) are mostly picking up specification and measurement error in investment returns.

2.5. *Other forms of capital*

- Most of the production-based asset pricing literature thinks about physical capital investment (PP&E).
- One exception we saw was [GXZ \(2020\)](#) who added a second source of capital: working capital, which was not subject to adjustment costs.
- However, firms have other sources of capital that are increasingly important in the “new economy:” human capital (skilled labor), organizational/brand capital, customer capital, data.

2.5.1. Labor/Human capital

- A branch of the literature thinks of firms’ investment in workers, relaxing the standard assumption that firms hire and fire workers in frictionless spot markets for labor.
- Hiring and firing workers indeed is costly. There are labor adjustment costs. This makes hiring decisions forward-looking, just like physical capital investments.
- Therefore, there are rents to the firm from having hired a worker. Value of an “installed” worker inside the firm exceeds the value of a worker outside the firm; Tobin’s $Q > 1$.
- [Bazdrech, Belo, Lin \(2014\)](#) show that firms with higher hiring rates have lower average returns in the data.

- Value-weighted returns of decile portfolios shorted on hiring rate. First panel: returns, t-stats, SR
Second panel: CAPM-alpha, t-stat, beta, t-stat, R^2 ;
Third panel: FF3-alphas, t-stat, three betas, R^2

VALUE-WEIGHTED					
All Firms					
Low	2	5	9	High	L-H
7.03	5.96	4.15	4.90	1.42	5.61
2.47	2.26	1.76	1.52	.38	2.26
.39	.34	.26	.24	.06	.34
m.a.e. = 1.38					
2.25	1.40	-.07	-.66	-4.78	7.03
1.69	1.13	-.07	-.48	-2.73	2.90
1.01	.96	.89	1.18	1.31	-.30
31.99	32.67	37.82	41.01	31.98	-4.96
.78	.79	.82	.82	.77	.08
m.a.e. = 1.06					
.85	.14	.19	.71	-2.41	3.26
.68	.11	.20	.58	-1.66	1.61
1.05	1.04	.95	1.06	1.15	-.10
.04	-.10	-.23	.22	.26	-.22
.22	.26	.05	-.32	-.51	.73
.79	.81	.84	.86	.84	.32

- Build a model with **stochastic labor and capital adjustment costs**. Firms with good idiosyncratic productivity shocks want to expand: hire and invest. An aggregate shock that lowers adjustment costs will benefit these firms.
- This shock has a negative price of risk for the same reason that the IST shock in Papanikolaou (2011) has a negative risk price.
- The value of these expanding firms increases upon the shock that lowers adjustment costs. These firms are a hedge against the shock. They should have lower average returns.

- [Belo, Lin, Li, and Zhao \(2017\)](#) show that the negative relationship between hiring rate and future stock returns is much steeper in industries that rely more on high-skill workers. Spread return is 8.6% in high-skill industries and 0.9% in low-skill industries. Consistent with model where replacing high-skilled workers is more costly.
- Other well-known papers in this labor branch of the production-based AP literature: [Kuehn, Petrosky-Nadeau, and Zhang \(2018\)](#), [Favilukis and Lin \(2015\)](#) . Common idea in these papers is that wages are rigid and this is useful for making stocks volatile and risky. Wages act like operating leverage.

2.5.2. Organizational capital

- Organizational capital refers to a production factor that is neither physical capital nor unskilled labor. It reflects the human capital of its skilled workers and managers, the relationships with its customers and suppliers, business processes, and internal organization.
- Organizational capital is partially embodied in the skilled workers of the firm, because their know-how is lost if they leave the firm. See [Lustig, Syverson, and Van Nieuwerburgh \(2011\)](#) for an optimal contracting theory of organizational capital with predictions for the relationship between the managerial compensation distribution and the firm size distribution.
- [Eisfeldt and Papanikolaou \(2013\)](#) finds that firms with more organizational capital are riskier; their shareholders earn higher average returns in compensation for this risk exposure.

- The accounting item Sales, General, and Administrative Expenses (SG&A), which includes items like consulting expenses, setting up distribution channels, etc. measures the flow to organizational capital (but maybe a noisy proxy).
- Firms in the top quintile of the organizational capital/SG&A distribution have average stock returns that are 4.8% higher per year than firms in the bottom quintile. The CAPM alpha is 5.6%.
- In their model, firms with a large amount of organizational capital are fundamentally riskier because they are more exposed to aggregate shocks that improve the technological frontier.
- Positive shocks to the technology frontier are bad news for shareholders because they improve the outside option of the firm's workers, for whom it is now more valuable to leave.
- Equity holders must give up a larger share of the profits from organizational capital to keep these "key (wo)men."
- In firms with a lot of organizational capital, the share of profits from organizational capital that goes to workers is already higher, hence the larger sensitivity.
- If times of positive shocks to frontier technology are also times of high marginal utility (for example because the reallocation it causes absorbs resources otherwise available for consumption), then the model generates a positive risk premium differential between high- and low organizational capital-firms. Innovative firms have a negative beta to frontier technology shocks, and these shocks carry a negative price of risk.

2.5.3. Customer capital

- [Gourio and Rudanko \(2014\)](#) think of firms' investments in customer acquisition.
- Build a search model where firms must search for customers and spending on *marketing* improves probability of finding and selling to a customer. Once they have found a customer, they form a long-term relationship: stock of customer capital is a valuable asset to the firm.
- Value of firm exceeds value of physical capital; Tobin's Q is above 1, profit rates are above cost of capital, markups are positive.
- Cost of customer acquisition acts like adjustment cost: dampens firms' response to shocks, as well as creating a sluggish (delayed) response to shocks. Thus this provides a micro-foundation for adjustment costs.
- Helps explain why investment responds little to contemporaneous Q but also—and even more so—to lagged investment.
- Use the same SG&A item to measure investment in customer capital, just like Eisfeldt and Papanikolaou. Story is quite different though! Installed customers vs. installed managers.
- Similar paper on brand capital and the cross-section by [Belo, Lin, and Vitorino \(2014\)](#).

2.5.4. Combining various sources of capital

- The value of a firm can be thought of as the sum of the value of all of its sources of capital.
- Firms have physical capital, unskilled labor, skilled labor, and brand/organizational capital:

$$P_t = Q_t^K K_t + Q_t^L L_t + Q_t^S S_t + Q_t^B B_t$$

where the various Q s reflect the market value of a unit of installed capital. With adjustment costs in each of these factors, these Q s are all greater than 1.

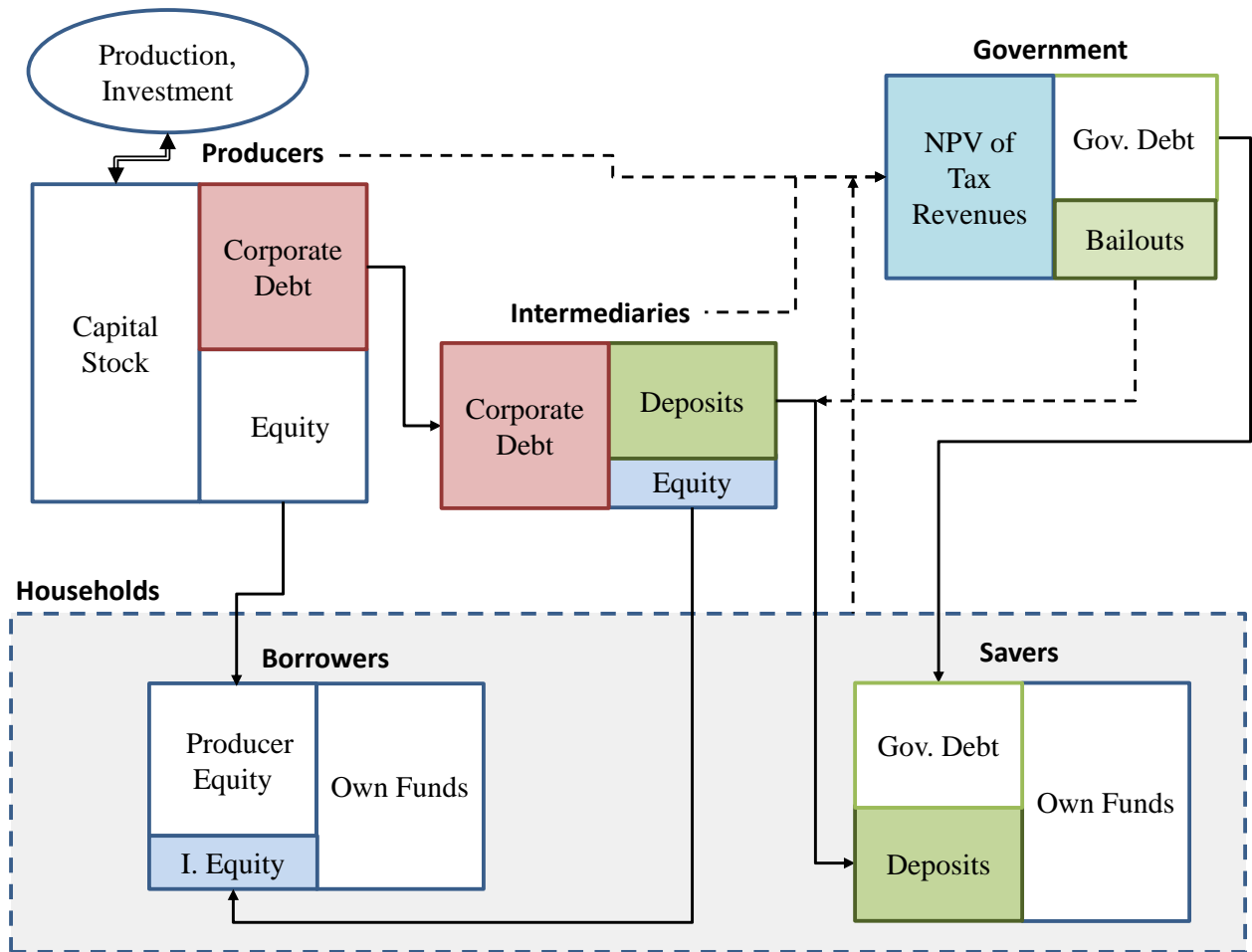
- [Belo, Gala, Salomao, and Vitorino \(2021\)](#) estimate adjustment cost parameters for these different capital stocks to obtain a decomposition of firm value.

2.5.5. Data as an asset

- Data and data-processing capacity has become a key asset for firms in the modern economy
- Particularly clear for large tech firms, which make up an increasing fraction of the overall stock market capitalization.
- Could similarly think about aggregate changes in technology that lower the cost of acquiring or processing data, such as **Artificial Intelligence** tools. Such shocks would stimulate investment (in IT and data scientists) and lower consumption, and have a negative price of risk.
- Big-data firms would do well when the cost of acquiring or processing data falls (negative beta) and earn higher expected returns.
- Actual realizations of shocks that improve data productivity/technology would result in high realized returns for big data firms
- For more on how to think of data in a production-based framework, see [Farboodi and Veldkamp \(2020\)](#), [Farboodi and Veldkamp \(2021\)](#), [Chung and Veldkamp \(2021\)](#), [Abis and Veldkamp \(2021\)](#).
- [Eisfeldt, Schubert, Zhang, and Taska \(2024\)](#) shows that firms with workers who are more exposed to disruption from generative AI earn higher returns in the window around the release of ChatGPT. Effects larger for firms with more data assets. Suggests labor-technology substitution channel.

2.6. Intermediary-based asset pricing with production

- Elenev, Landvoigt, and Van Nieuwerburgh (2021) solve a full-fledged general equilibrium model that embeds an intermediary sector into a macro-economic model with firms and households. Allows to think about *real implications* of intermediation frictions.
- Setup
 - One monolithic leveraged financial sector called “banks”
 - Banks are owned by risk averse shareholders
 - Banks face Basel-style **regulatory capital constraints limiting their debt** to a certain fraction of the market value of their assets = minimum equity capital requirement
 - Banks enjoy government bailout guarantees: deposit insurance, too-big-to-fail guarantees. This motivates the constraint.
 - Banks can raise new equity from their owners but that is costly
 - Leverage and bank equity capital are endogenous objects
 - All shocks arise in the non-financial corporate sector: firms are hit by aggregate TFP shocks and by idiosyncratic shocks. The cross-sectional variance of these shocks is an aggregate state variable (*uncertainty* shock).
 - Firms face adjustment costs, borrow from banks, maximize firm value by choosing investment and leverage.



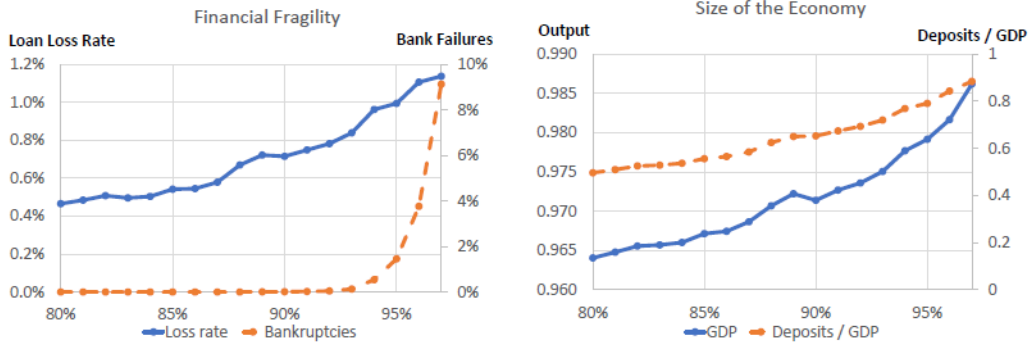
- Fully calibrated model that generates
 - observed amount of corporate default risk
 - observed credit spread (see credit spread puzzle discussion later in course)
 - observed avg. corporate sector leverage (35%)
 - observed avg. financial sector leverage (95%)
 - realistic macro-economic dynamics
 - rare, severe financial crises with substantial bank bankruptcies and government bailouts

- Financial sector leverage falls in downturns, esp. in financial crises

- In *financial crises*, banks suffer large credit losses and are forced to shrink, delever, and raise equity to satisfy their regulatory constraint. Going forward, banks earn high credit spreads and enjoy cheap costs of debt (deposit rates are ultra low), so they would like to lend. But they are held back by their borrowing constraint and by the cost of raising outside equity. Firms investment shrinks due to lack of bank loans at first and high credit spreads afterwards.
- In *regular recessions* (not accompanied by a financial crisis), banks are equally constrained but the reason for the constraint binding is fundamentally different. Productivity and labor income are temporarily low, and investment opportunities are weak. This reduces corporate loan demand. Savers reduce their demand for safe assets to smooth consumption, and supply of govt debt goes up due to low tax revenue and increased govt spending. Deposit rates are fairly high, making intermediation unprofitable. Low profitability depletes equity capital, and to avoid raising costly external equity banks exhaust their debt capacity.

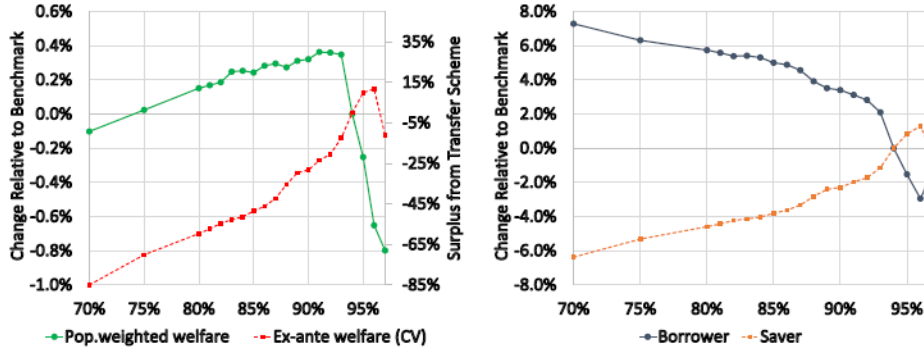
- Model is used to think about macro-prudential policy. [Admati and Hellwig \(2015\)](#) advocate 25% equity capital requirements for banks, a dramatic increase from the current 6%. BIS and Minneapolis Fed reports endorse this proposal. Our paper shows this may not be a good idea.
 - There is a fundamental trade-off between *financial sector stability*, which increases with higher equity capital requirements, and the *size of the economy*, which decreases with higher capital requirements
 - Welfare is maximized around current capital requirements. Depending on how agents are weighted, slightly higher or slightly lower requirements are optimal. These policies redistribute wealth.
 - Counter-cyclical capital requirements make savers better off, and allow for a Pareto improvement (after transfers).

Figure 5: Effect of tighter capital requirement on size and fragility of the economy



The left panel plots the loss rate on the loans held by banks and the failure rate of banks as a function of the macro-prudential policy parameter ξ . The right panel plots output and the ratio of deposits to output as a function of the macro-prudential policy parameter ξ . Each dot represents a different economy where all parameters are the same as in the benchmark, except for ξ . The benchmark economy has $\xi = .94$.

Figure 6: Welfare Across Macro-Prudential Policy Experiments



The left panel plots the ex-post population-weighted aggregate welfare function \mathcal{W}^{pop} in green and the ex-ante consumption equivalent variation welfare function \mathcal{W}^{ceV} in red as a function of the macro-prudential policy parameter ξ . The right panel plots the value function of Borrower (black) and Saver (orange) as a function of the macro-prudential policy parameter ξ . Each dot represents a different economy where all parameters are the same as in the benchmark, except for ξ . The benchmark economy has $\xi = .94$.

2.7. *Some concluding thoughts*

- **Economic interpretation:** The investment CAPM models test whether firms are at their first-order condition given asset prices.
- That is, it tells us whether investment responds to asset prices.
- Although interesting, and important to understand the real implications of asset prices, it is not an explanation of asset prices.
- Because the SDF is not specified, this line of work is silent about why average return spreads across characteristics-sorted portfolios are not matched with spreads in covariances empirically. Need equilibrium models that also endogenize SDF.
- Many asset pricing anomalies show up in other asset classes: carry, momentum, and value are also present in currencies, Treasuries, and commodities. Investment-based asset pricing cannot “explain” those facts easily.
- Alternative links between equity prices and the real economy (see [Bond, Edmans, and Goldstein, 2012](#)):
 1. Managers may learn from stock prices.
 2. Asset prices can be used in contracting.

3. Macro-economic Announcement Effects

- A large literature studies the response of stock prices to macro-economic news.
- Classic paper on this topic is [Cutler, Poterba, and Summers \(1988\)](#).
- More recently, [Savor and Wilson \(2013\)](#) look at three types of announcements: inflation, unemployment, and the FOMC monetary policy decision announcement.
- From 1958-2009, announcement days earn on average 11.4bp, compared to 1.1bp on non-announcement days.

TABLE 1
Summary Statistics for Daily Stock Market Excess Returns

Table 1 presents the distribution of stock market excess returns on announcement days and nonannouncement days. Announcement days are those trading days when CPI/PPI (CPI before 1971 and PPI afterward) numbers, employment numbers, and FOMC interest rate decisions are scheduled for release. The sample covers the period 1958–2009. Market excess returns are computed as the difference between the CRSP value-weighted market return and the risk-free rate. The daily risk-free rate is derived from the 1-month risk-free rate provided by CRSP. *t*-statistics are given in square brackets. All numbers are expressed in basis points, and the numbers in bold are of special interest.

	Panel A. All Obs.			Panel B. Excl. Outliers (< 1 percentile or > 99 percentile)		
	Ann.	Nonann.	Diff.	Ann.	Nonann.	Diff.
Mean	11.4 [4.41]	1.1 [1.29]	10.3 [3.77]	11.7 [5.39]	1.3 [1.88]	10.4 [4.55]
1st percentile	-258.2	-257.7	-1.2	-208.4	-203.2	-5.1
25th percentile	-34.7	-40.8	6.1	-33.3	-39.3	6.0
Median	13.5	4.3	9.2	13.5	4.3	9.2
75th percentile	59.0	45.2	13.7	57.8	44.3	13.5
99th percentile	292.6	242.4	50.3	233.4	191.3	42.1
Std. dev.	98.6	94.6		81.8	75.4	
Skewness	-0.6	-0.6		0.0	-0.2	
Kurtosis	8.5	19.7		1.1	0.8	
N	1,450	11,641		1,420	11,407	

- How do we interpret this fact economically?

- [Lucca and Moench \(2015\)](#) take this research one step further, with potentially several broader insights.
- They focus on FOMC announcement days that are scheduled in advance, which is the case since 1994.
- The stunning fact is that the returns accrue [before](#) the actual announcement.

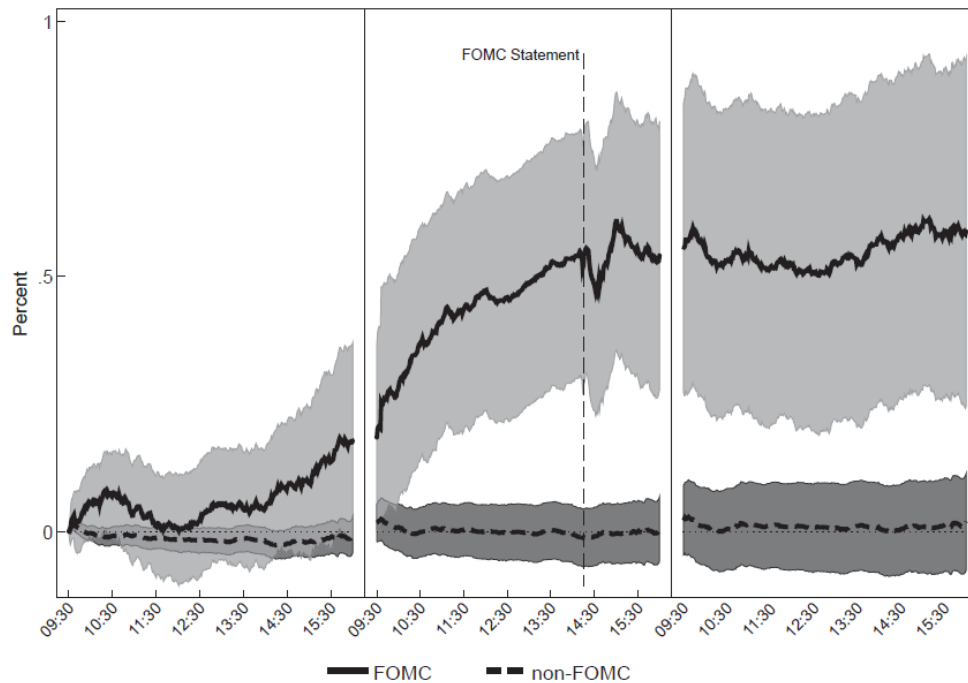


Figure 1. Cumulative returns on the S&P500 index. This figure shows the average cumulative return on the S&P500 index on three-day windows. The solid black line is the average cumulative return on the SPX from 9:30 am ET on days prior to scheduled FOMC announcements to 4:00 pm ET on days after scheduled FOMC announcements. The dashed black line shows average cumulative returns on the SPX on all other three-day windows that do not include FOMC announcements. The gray shaded areas are pointwise 95% confidence bands around the average returns. The sample period is from September 1994 through March 2011. The dashed vertical line is set at 2:15 pm ET, when FOMC announcements are typically released in this sample period.

- The entire effect is before the announcement. Actual announcement returns respond to surprises, but they average to zero.

- Risk based? Volatility and volume decline prior to the announcement. Investors appear to be in “wait-and-see” mode.

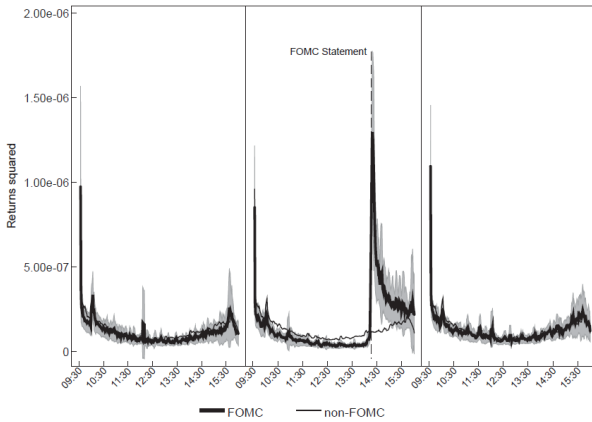


Figure 3. Intraday realized volatility of S&P500 index returns. This figure shows intraday realized volatility over three-day windows. The thick line is the average five-minute rolling sum of squared tick-by-tick returns on the S&P500 from 9:30 am ET on days prior to scheduled FOMC announcements to 4:00 pm ET on days after scheduled FOMC announcements. The sample period is from September 1994 through March 2011. The thin line is the result of the same calculation on all other three-day windows that do not contain FOMC announcements. Shaded areas represent pointwise 95% confidence bands around FOMC means.

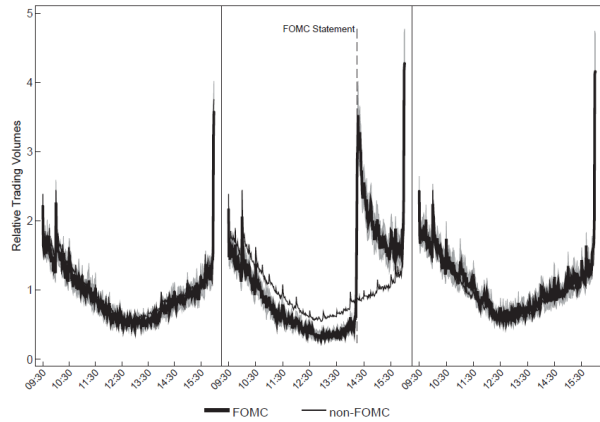


Figure 4. Intraday trading volumes for the E-mini S&P500 future. This figure shows intraday trading volume of E-mini S&P500 futures over three-day windows. The thick line is the average five-minute (scaled) rolling average number of contracts traded from 9:30 am ET on the days before scheduled FOMC announcements until 4:00 pm ET on days after scheduled FOMC announcements. For each minute, the rescaling is relative to the 21-day prior average trading volume. The thin line is the result of the same calculation on all other three-day windows that do not contain FOMC announcements. Shaded areas represent pointwise 95% confidence bands around FOMC means.

- The same is true in international returns in response to FED announcements.

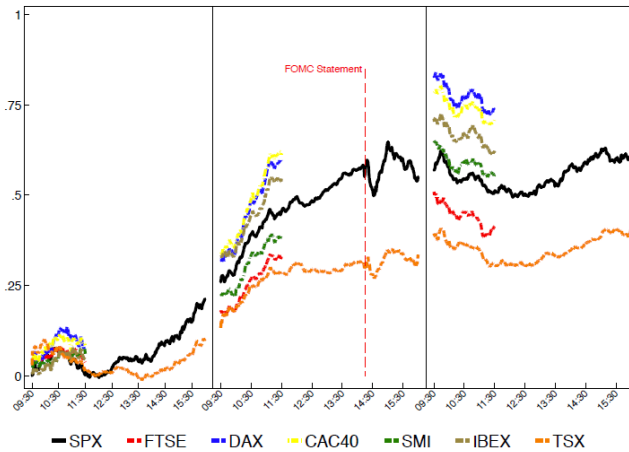


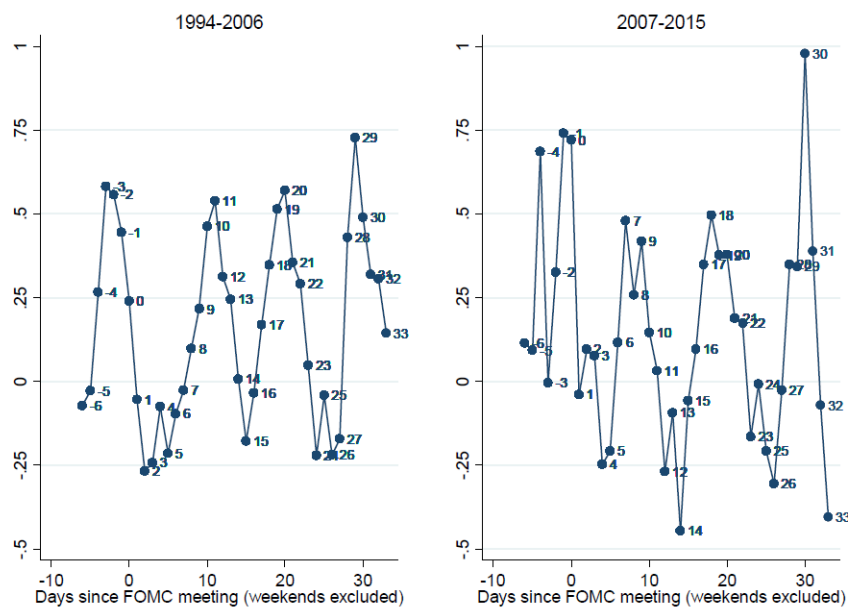
Figure B.3. Cumulative Returns on International Stock Market Indexes Around FOMC Announcements. This chart plots the average cumulative one-minute return on the SPX and other major international equity market indexes over the three day window around scheduled FOMC announcements. The solid black line shows the average cumulative return on the SPX from 9:30 a.m. EST on the days before scheduled FOMC announcements until 4:00 p.m. on days after scheduled FOMC announcements. The colored dashed lines show the cumulative returns on the German DAX, the U.K.’s FTSE100, the French CAC40, the Spanish IBEX, the Swiss SMI, and the Canadian TSX over the same three day window. All stock indexes are only shown during hours of trading on the respective exchanges. The sample period is from January 1996 through March 2011. The dashed vertical red line is set at 2:15 p.m. EST, the time when FOMC announcements were typically released during that period.

- Possible interpretations:

- Information leakage? [Cieslak, Morse, and Vissing-Jorgensen \(2019\)](#) show that equity premium is earned in the weeks of Fed Board monetary policy meetings (bi-weekly) + unofficial Fed communication with private sector.

Figure 2. Stock returns over the FOMC cycle, by time period

Panel A. Sub-periods of 1994 to 2015. Average 5-day excess return, t to $t+4$ (percent)



- Learning & disagreement? [Cocoma \(2020\)](#): investors optimally stop learning from costly signals when they anticipate an upcoming public information release. When they stop learning, disagreement drops. This leads to a reduction in risk and an increase in prices. Disagreement and risk shoot up after announcement.
- Alternative models of preferences? [Ai, Bansal, and Rosoiu \(2018\)](#) propose preferences that capture uncertainty aversion to price the risk present in the pre-announcement period. Expected utility does not generate a risk premium

for a scheduled pure news event. Explanation requires very high risk in pre-announcement period, and drop in risk right after announcement. Opposite of Cocoma .

* Pre-announcement drift in prices is explained by gradual information revelation prior to the announcement due to information leakage as in Cieslak, Morse, and Vissing-Jorgensen (2019)

- Any explanation should be cross-checked with other asset classes, and **in particular with the bond market.**
- There is no drift in bond markets, which one would think should be more sensitive to FOMC announcements than equities.

Table VIII
Fixed Income Instruments

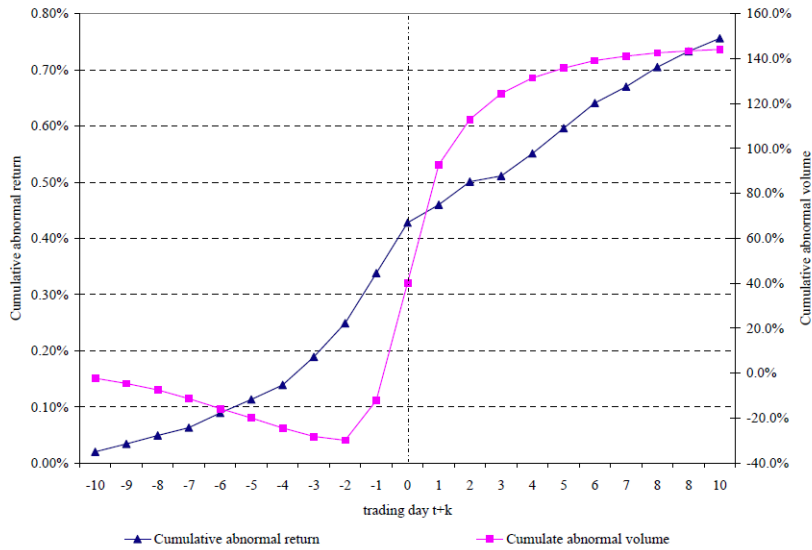
The sample in the top panel is September 1, 1994 to March 30, 2011 and the dependent variables are percent yield changes from 2 pm on date $t - 1$ to 2 pm on date t . “pre-FOMC dummy” is a variable that takes the value of one if the next 24-hour trading interval comprises a scheduled FOMC announcement, and zero otherwise. Samples in the bottom panel differ depending on data availability as reported in the bottom row and start no earlier than January 2, 1980 and end on March 30, 2011. The dependent variables in this sample are close-to-close yield changes in percent prior to 1994, and yield changes in percent from 2 pm on the day before a scheduled FOMC announcement to 2 pm on the announcement day after 1994. “FF” are rates implied by the front (next month) in the first two-thirds (last third) of each month. “ED-4” is the fourth euro implied rate. Variables denoted “TREAS” refer to yields on the 3 months, 2 years, 5 years, and 10 years benchmark Treasury issues. ***Significant at 1%, **significant at 5%, *significant at 10%. Robust standard errors are shown in brackets.

	FF	ED-4	TREAS-3M	TREAS-2Y	TREAS-5Y	TREAS-10Y
Post-1994 Sample						
pre-FOMC dummy	0.001 [0.001]	0.007 [0.006]	0.001 [0.004]	0.006 [0.004]	0.001 [0.004]	-0.002 [0.004]
Const.	-0.002 [0.0004]***	-0.001 [0.001]	-0.001 [0.001]	-0.002 [0.001]	-0.001 [0.001]	-0.001 [0.001]
Obs.	4,322	4,325	4,210	4,325	4,325	4,325
No. of FOMC	131	132	132	132	132	132
Post-1980 Sample						
pre-FOMC dummy	0.002 [0.001]	0.008 [0.006]	-0.010 [0.007]	-0.004 [0.005]	-0.006 [0.005]	-0.009 [0.005]*
Const.	-0.002 [0.0004]***	-0.001 [0.001]	-0.001 [0.001]	-0.001 [0.001]	-0.001 [0.001]	-0.001 [0.001]
Obs.	5,765	6,454	7,867	7,986	7,986	7,986
No. of FOMC	170	193	245	245	245	245
Sample period	1988:12–2011:03	1986:04–2011:03	1980:01–2011:03	1980:01–2011:03	1980:01–2011:03	1980:01–2011:03

- Broader interpretation in relation to other announcements:
 - Lamont and Frazzini (2007) on earnings announcements.

Figure 3: CAR and volume around earnings announcements, 1973–2004

This figure shows event-time daily cumulative abnormal return and cumulative turnover in trading day $t+k$ for firms announcing earnings at date t . Abnormal return is defined as daily return minus an equally weighted portfolio of non-announcing firms. Scaled volume is defined as share volume in month t divided by average volume in the previous 250 trading days. Abnormal volume is defined as scaled volume minus the equal weight average of scaled volume for all firms on that day. This figure includes firms in the period 1973–2004 with market capitalization (as of the previous month) above the median market capitalization of CRSP firms. Volume and return are in percent.



- Their interpretation: Due to small investors buying when announcements catch their attention.

- Next interesting fact about the FOMC days: The CAPM works.
- [Savor and Wilson \(2014\)](#) for 10 industry portfolios, 10 beta-sorted portfolios, and 25 size-BM portfolios:

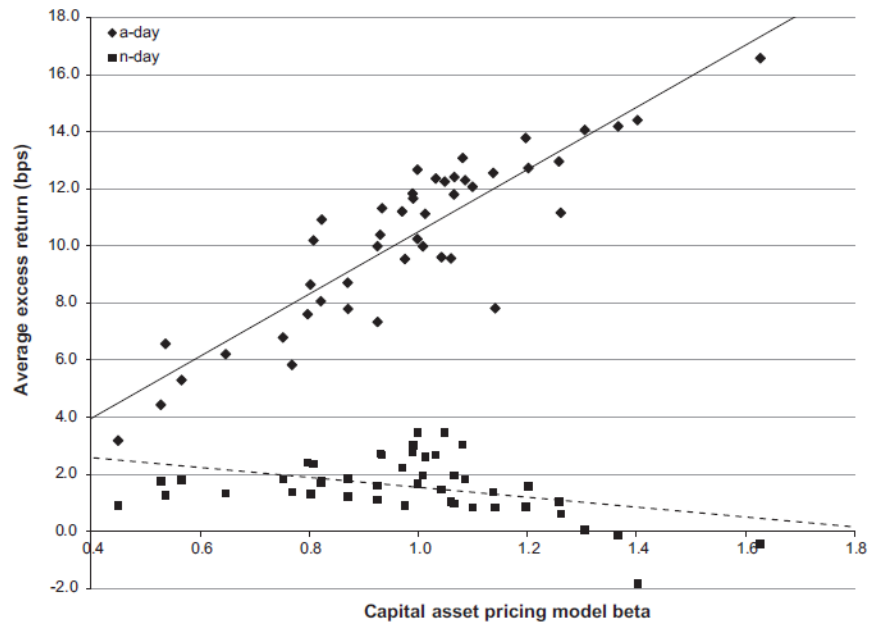
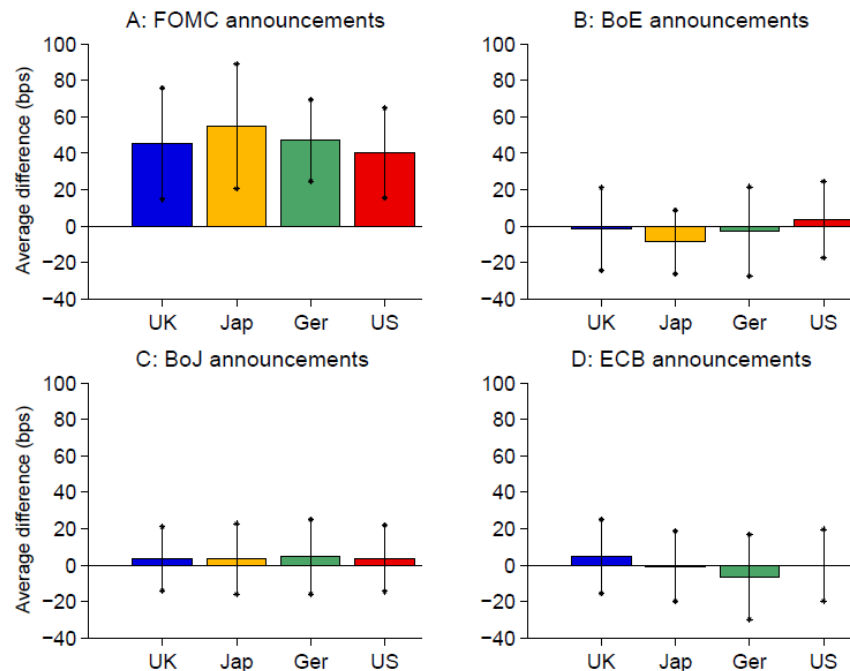


Fig. 2. Average excess returns for ten beta-sorted, 25 Fama and French, and ten industry portfolios. This figure plots average daily excess returns in basis points (bps) against market betas for ten beta-sorted portfolios, 25 Fama and French size- and book-to-market-sorted portfolios, and ten industry portfolios separately for announcement days or a-days (days on which inflation, employment, or Federal Open Market Committee interest rate decisions are scheduled to be announced) and non-announcement days or n-days (all other days). The implied ordinary least squares estimates of the securities market line for each type of day are also plotted. The sample covers the 1964–2011 period. For each test portfolio, the same estimate of its full-sample beta is used for both types of day.

- Also, note that the announcement premium seems particular to the FED and not to other central banks (Brusa, Savor, and Wilson, 2020).

1998-2013

One central bank (Fed) to rule them all



- Cieslak, Morse, and Vissing-Jorgensen (2021) use natural language processing to analyze the text of FOMC minutes. They find that Fed officials believe that the stock market affects aggregate consumption through a consumption-wealth effect. After a large inter-meeting stock market drop, they are more likely to lower the Fed Funds rate. However, the Fed does not appear to over-react to the stock market. Rather the stock market is a useful predictor of future economic activity. The extent to which the Fed believes that the stock market predicts the macro-economy is similar to the predictions of professional private sector forecasters.