Lecture Notes

Li and Zhang (2010, J. of Financial Economics): Does Q-Theory with Investment Frictions Explain Anomalies in the Cross-Section of Returns?

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News

Theory: demonstrate that the expected return-investment relation should be steeper in firms with high investment frictions

Empirics:

- Some evidence that the investment-to-assets and asset growth anomalies are stronger in financially more constrained firms
- No evidence that investment frictions affect the investment growth, net stock issues, abnormal corporate investment, and net operating assets anomalies
- Investment frictions dominated by limits-to-arbitrage

Outline

Model

Why should investment frictions affect investment-related anomalies?

Two periods, 0 and 1

Firm i's capital: K_{i0} and K_{i1}, $K_{i1} = I_{i0} + (1 - \delta)K_{i0}$

Firm i's return on assets, ROA: Π, constant over two periods

Firm i's operating profits: ΠK_{i0} and ΠK_{i1}

Firm i's investment costs:

$$C(I_{i0}, K_{i0}) = \frac{\lambda_i}{2}\left(\frac{I_{i0}}{K_{i0}}\right)^2 K_{i0}, \quad \lambda_i > 0$$

Model

The first-order condition

Firm i's discount rate: R_i

Firm i's value-maximization problem:

$$\max_{\{I_{i0}\}} \Pi K_{i0} - I_{i0} - \frac{\lambda_i}{2}\left(\frac{I_{i0}}{K_{i0}}\right)^2 K_{i0} + \frac{1}{R_i}\left[\Pi K_{i1} + (1-\delta)K_{i1}\right]$$

Firm i's first-order condition:

$$R_i = \frac{\Pi + 1 - \delta}{1 + \lambda_i(I^*_{i0}/K_{i0})}$$

Model

The investment-discount rate relation and its interaction with investment frictions

Totally differentiating the first-order condition w.r.t. R_i:

$$\frac{d(I_{i0}^*/K_{i0})}{dR_i} = -\frac{[1+\lambda_i(I_{i0}^*/K_{i0})]^2}{\lambda_i(\Pi+1-\delta)} < 0$$

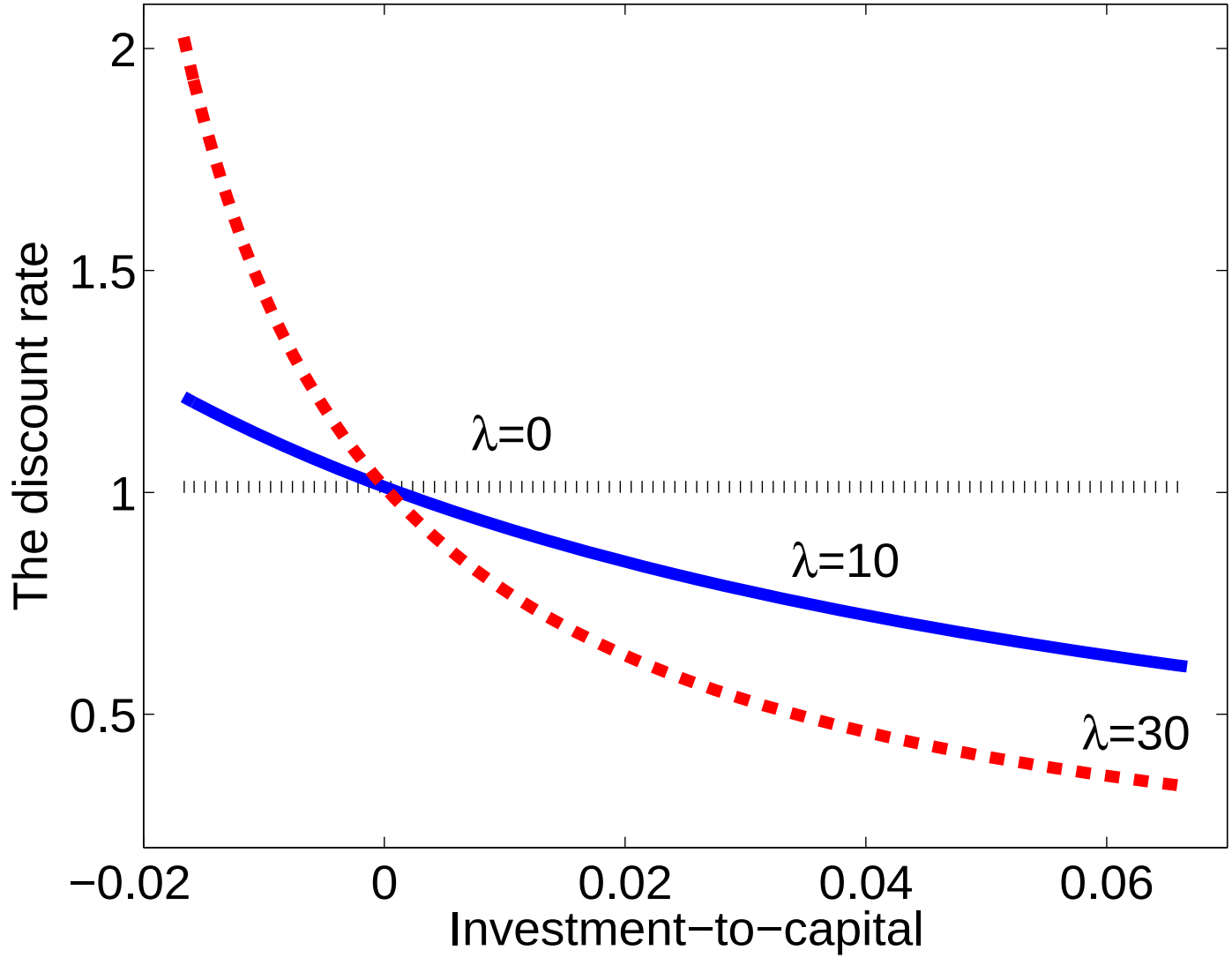
as in Cochrane (1991) and Liu, Whited, and Zhang (2009)

The investment-discount rate relation varies with investment costs:

$$d\left|\frac{d(I_{i0}^*/K_{i0})}{dR_i}\right|/d\lambda_i = -\frac{[1+\lambda_i(I_{i0}^*/K_{i0})]^2}{\lambda_i^2(\Pi+1-\delta)} < 0$$

Model

Plot $R_i = (\Pi + 1 - \delta)/(1 + \lambda_i(I^*_{i0}/K_{i0}))$ with $\Pi = .15/12$ per month and $\delta = 0$



Model

How investment frictions affect the expected return-investment relation? Intuition

$$R_i = \frac{\Pi + 1 - \delta}{1 + \lambda_i (I^*_{i0}/K_{i0})}$$

When investment is frictionless, $\lambda_i = 0$, investment is infinitely elastic to the discount rate, or R_i is flat in I^*_{i0}/K_{i0}

With frictions, $\lambda_i > 0$, investment now predicts future returns

The greater is λ_i, the less elastic investment is, a given change in I^*_{i0}/K_{i0} corresponds to a higher magnitude change in R_i

Model

The investment frictions hypothesis

The negative expected return-investment relation is steeper in firms with high investment costs than in firms with low investment costs

Tests

Design

Fama-MacBeth cross-sectional regressions of monthly percent returns on a given investment-related anomaly variable in subsamples with high, medium, and low investment frictions

Null Hypothesis: The magnitude of the slope is higher in the high-frictions subsample than in the low-frictions subsample

Alternative: Mispricing can persist when arbitrage costs outweigh arbitrage benefits, Shleifer and Vishny (1997). Horse races between investment frictions and limits-to-arbitrage proxies

Tests

Identify investment frictions with firm-level proxies of financing constraints

Asset size: Total assets, annual sorts, the small-assets tercile = more constrained, the big-assets tercile = less constrained

Payout ratio: (Dividends for preferred stocks + Dividends for common stocks + Share repurchases)/Operating income before depreciation, annual sorts, the low-payout tercile = more constrained, the big-payout tercile = less constrained

- For firms with negative earnings (zero dividends = more constrained, positive dividends = less constrained)

Bond ratings: Unrated = more constrained, rated = less constrained

Tests

Proxies for limits-to-arbitrage

Idiosyncratic volatility: Residual volatility from daily market regressions over 250 days ending on June 30 of year t, annual sorts, the low-Ivol tercile = low arbitrage costs, the high-Ivol tercile = high arbitrage costs

Dollar trading volume: Share volume times daily closing price over the past 12 months, annual sorts, the low-volume tercile = high arbitrage costs, the high-volume tercile = low arbitrage costs

Tests

Investment-related anomaly variables

Investment-to-assets, I/A: (Change in PPE + Change in inventories)/Lagged total assets, Chen and Zhang (2009)

Asset growth, $\triangle A/A$: Change in total assets/Lagged total assets, Cooper, Gulen, and Schill (2008)

Investment growth, $\triangle I/I$: Change in CAPX/Lagged CAPX, Xing (2008)

Tests

Investment-related anomaly variables

Net stock issues, *NSI*: log growth rate of the split-adjusted shares outstanding, Fama and French (2008)

Abnormal corporate investment, *ACI*:
$3CE_t/(CE_{t-1} + CE_{t-2} + CE_{t-3}) - 1$ with CE = CAPX/Sales, Titman, Wei, and Xie (2004)

Net operating assets, *NOA*: (Operating assets − Operating liabilities)/Lagged total assets, Hirshleifer, Hou, Teoh, and Zhang (2004)

Tests

Cross-correlations

	Asset size	Payout ratio	Bond rating	Ivol	Volume
Asset size	1				
Payout ratio	0.45	1			
Bond rating	−0.37	−0.21	1		
Ivol	−0.64	−0.55	0.29	1	
Volume	0.73	0.27	−0.35	−0.39	1

Tests

Testing the investment frictions hypothesis

	I/A	$\triangle A/A$	$\triangle I/I$	NSI	ACI	NOA
Full Sample	−0.69	−0.74	−0.08	−1.87	−0.05	−0.51
	(−4.9)	(−8.3)	(−5.5)	(−7.0)	(−1.6)	(−5.1)
Small asset size	−0.85	−0.83	−0.09	−1.27	−0.04	−0.47
Big asset size	−0.33	−0.47	−0.05	−1.50	0.02	−0.45
Small-minus-big	[−2.1]	[−2.4]	[−0.9]	[0.6]	[−1.0]	[−0.1]
Low payout ratio	−0.93	−0.81	−0.10	−1.39	−0.08	−0.50
High payout ratio	−0.39	−0.66	−0.06	−2.20	−0.03	−0.56
Low-minus-high	[−2.5]	[−1.2]	[−1.4]	[1.9]	[−1.2]	[0.5]
With bond rating	−0.47	−0.50	−0.05	−1.82	−0.09	−0.51
Without bond rating	−0.86	−0.90	−0.10	−1.86	−0.03	−0.50
Without-minus-with	[−2.5]	[−3.8]	[−2.4]	[−0.1]	[1.6]	[0.2]

Tests

Testing the investment frictions hypothesis, controlling for size, B/M, and momentum

	I/A	$\triangle A/A$	$\triangle I/I$	NSI	ACI	NOA
Full Sample	−0.49	−0.52	−0.07	−1.28	−0.02	−0.56
	(−3.8)	(−6.4)	(−5.2)	(−5.7)	(−1.0)	(−6.8)
Small asset size	−0.68	−0.57	−0.07	−0.88	−0.07	−0.67
Big asset size	−0.20	−0.38	−0.04	−1.38	0.02	−0.43
Small-minus-big	[−2.1]	[−1.3]	[−0.6]	[1.4]	[−1.7]	[−1.7]
Low payout ratio	−0.62	−0.51	−0.06	−0.89	−0.05	−0.51
High payout ratio	−0.27	−0.45	−0.06	−1.73	−0.01	−0.63
Low-minus-high	[−1.8]	[−0.5]	[−0.2]	[2.4]	[−1.0]	[1.1]
With bond rating	−0.23	−0.29	−0.05	−1.28	−0.05	−0.44
Without bond rating	−0.65	−0.65	−0.08	−1.28	−0.01	−0.59
Without-minus-with	[−2.8]	[−3.6]	[−1.3]	[−0.0]	[1.1]	[−1.8]

Tests

Do limits-to-arbitrage affect anomalies?

	I/A	$\triangle A/A$	$\triangle I/I$	*NSI*	*ACI*	*NOA*
Low Ivol	−0.10	−0.16	−0.02	−1.49	−0.01	−0.29
High Ivol	−1.01	−0.99	−0.10	−1.54	−0.05	−0.61
High-minus-low Ivol	[−4.2]	[−5.7]	[−2.7]	[−0.1]	[−0.8]	[−2.4]
Low Dvol	−1.18	−0.94	−0.09	−1.82	−0.12	−0.80
High Dvol	−0.45	−0.50	−0.09	−1.54	−0.02	−0.47
Low-minus-high Dvol	[−2.8]	[−2.2]	[−0.0]	[−0.6]	[−1.8]	[−2.2]

Tests

Do limits-to-arbitrage affect anomalies? controlling for size, B/M, and momentum

	I/A	$\triangle A/A$	$\triangle I/I$	*NSI*	*ACI*	*NOA*
Low Ivol	0.01	−0.11	−0.03	−1.15	0.00	−0.33
High Ivol	−0.83	−0.70	−0.08	−0.98	−0.04	−0.71
High-minus-low Ivol	[−4.1]	[−4.4]	[−1.5]	[0.5]	[−0.9]	[−2.9]
Low Dvol	−0.90	−0.73	−0.07	−1.50	−0.07	−0.71
High Dvol	−0.25	−0.36	−0.07	−1.38	−0.02	−0.50
Low-minus-high Dvol	[−2.8]	[−2.3]	[−0.0]	[−0.3]	[−1.1]	[−1.4]

Tests

Horse races with two-by-two splits: the effect of financing constraints after controlling for idiosyncratic volatility

	I/A	$\triangle A/A$	$\triangle I/I$	NSI	ACI	NOA
Low Ivol,	0.06	0.04	−0.06	−0.58	−0.04	0.10
small-minus-big asset	[0.3]	[0.3]	[−1.7]	[−1.3]	[−0.9]	[0.9]
High Ivol,	−0.14	−0.16	0.01	−0.07	−0.01	0.05
small-minus-big asset	[−0.6]	[−1.1]	[0.4]	[−0.2]	[−0.3]	[0.4]
Low Ivol,	−0.40	−0.18	−0.05	−0.31	−0.12	−0.06
low-minus-high payout	[−2.1]	[−1.4]	[−1.6]	[−0.8]	[−2.6]	[−0.6]
High Ivol,	−0.16	−0.15	−0.01	0.47	0.00	−0.02
low-minus-high payout	[−0.7]	[−1.0]	[−0.3]	[1.0]	[0.1]	[−0.1]
Low Ivol,	−0.19	−0.15	−0.04	−0.29	−0.02	0.16
without-minus-with rating	[−1.1]	[−1.1]	[−1.5]	[−0.8]	[−0.4]	[1.7]
High Ivol,	−0.21	−0.33	−0.03	−0.04	0.08	−0.06
without-minus-with rating	[−1.0]	[−2.5]	[−1.1]	[−0.1]	[1.5]	[−0.5]

Tests

Horse races with two-by-two splits: the effect of financing constraints after controlling for dollar trading volume

	I/A	$\triangle A/A$	$\triangle I/I$	NSI	ACI	NOA
Low Dvol,	−0.96	−0.34	−0.06	−0.21	−0.10	−0.18
small-minus-big asset	[−3.1]	[−1.6]	[−1.3]	[−0.4]	[−1.6]	[−0.9]
High Dvol,	0.10	−0.10	−0.01	0.31	−0.10	0.17
small-minus-big asset	[0.3]	[−0.4]	[−0.2]	[0.4]	[−1.3]	[0.9]
Low Dvol,	−0.41	−0.21	−0.04	1.16	−0.03	0.06
low-minus-high payout	[−1.6]	[−1.2]	[−1.4]	[2.0]	[−0.6]	[0.4]
High Dvol,	−0.33	−0.13	−0.02	0.35	−0.05	0.09
low-minus-high payout	[−1.4]	[−0.9]	[−0.6]	[0.7]	[−0.8]	[0.6]
Low Dvol,	−0.57	−0.71	−0.03	−0.62	0.04	−0.18
without-minus-with rating	[−2.0]	[−3.7]	[−0.8]	[−1.1]	[0.8]	[−1.1]
High Dvol,	−0.37	−0.25	−0.06	−0.25	0.08	−0.04
without-minus-with rating	[−1.7]	[−1.6]	[−1.7]	[−0.6]	[1.5]	[−0.3]

Tests

Horse races with two-by-two splits: the effect of idiosyncratic volatility after controlling for financing constraints

	I/A	$\triangle A/A$	$\triangle I/I$	NSI	ACI	NOA
Small asset,	−0.63	−0.57	−0.01	0.83	0.03	−0.25
high-minus-low Ivol	[−2.9]	[−3.8]	[−0.6]	[1.8]	[0.7]	[−1.9]
Big asset,	−0.43	−0.37	−0.09	0.32	0.01	−0.20
high-minus-low Ivol	[−1.8]	[−2.4]	[−2.2]	[0.7]	[0.1]	[−1.6]
Low payout,	−0.38	−0.43	−0.02	0.54	0.09	−0.18
high-minus-low Ivol	[−1.9]	[−3.1]	[−0.8]	[1.3]	[1.9]	[−1.5]
High payout,	−0.61	−0.46	−0.06	−0.24	−0.03	−0.22
high-minus-low Ivol	[−2.4]	[−2.7]	[−1.8]	[−0.5]	[−0.5]	[−1.6]
With rating,	−0.57	−0.43	−0.06	0.16	−0.06	−0.09
high-minus-low Ivol	[−2.4]	[−2.7]	[−1.6]	[0.4]	[−1.0]	[−0.7]
Without rating,	−0.59	−0.61	−0.05	0.40	0.03	−0.32
high-minus-low Ivol	[−2.8]	[−4.2]	[−1.6]	[1.0]	[0.7]	[−2.7]

Tests

Horse races with two-by-two splits: the effect of dollar trading volume after controlling for financing constraints

	I/A	$\triangle A/A$	$\triangle I/I$	NSI	ACI	NOA
Small asset,	−0.80	−0.37	−0.04	−0.51	0.00	−0.28
low-minus-high Dvol	[−2.3]	[−1.6]	[−0.8]	[−0.7]	[0.1]	[−1.4]
Big asset,	0.26	−0.13	0.01	0.01	0.01	0.07
low-minus-high Dvol	[1.0]	[−0.6]	[0.1]	[0.0]	[0.1]	[0.4]
Low payout,	−0.57	−0.38	−0.01	−0.15	−0.03	−0.26
low-minus-high Dvol	[−2.4]	[−2.2]	[−0.4]	[−0.3]	[−0.6]	[−1.7]
High payout,	−0.49	−0.30	0.01	−0.96	−0.05	−0.23
low-minus-high Dvol	[−2.1]	[−1.6]	[0.2]	[−1.9]	[−1.0]	[−1.5]
With rating,	−0.30	0.03	−0.03	0.11	−0.07	−0.08
low-minus-high Dvol	[−1.0]	[0.2]	[−0.7]	[0.2]	[−1.2]	[−0.4]
Without rating,	−0.50	−0.44	0.00	−0.26	−0.10	−0.22
low-minus-high Dvol	[−2.0]	[−2.5]	[0.2]	[−0.5]	[−1.9]	[−1.5]

Conclusion

Summary and interpretation

The expected return-investment relation should be steeper in firms with high investment frictions as predicted by q-theory

Some evidence that investment frictions affect the investment-to-assets and asset growth anomalies, but not the investment growth, net stock issues, abnormal corporate investment, and net operating assets anomalies

Investment frictions dominated by limits-to-arbitrage in direct horse races: Mispricing seems to better explain the anomalies in question

Conclusion

Update

Lam and Wei (2011) conduct cross-sectional regressions of returns on asset growth on subsamples split by a given measure of limits-to-arbitrage or investment frictions

Main findings:

- Proxies for limits-to-arbitrage and proxies for investment frictions are often highly correlated;
- the evidence based on equal-weighted returns shows significant support for both hypotheses, while the evidence from value-weighted returns is weaker;
- in direct comparisons, each hypothesis is supported by a fair and similar amount of evidence.