Erickson and Whited (2000, JPE)

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November 14, 2016

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I. Introduction

- Corporate investment decision: 2 competing theories

1. Tobin (1969, JMCB)
   - ‘q’ theory
   - Neoclassic: Lucas and Prescott (1971, EMA)
   - Marginal q should solely determine the rate of investment
   - Hayashi (1982, EMA): CRS+perfect competition⇒marginal q=average q
   - Efficient market⇒average q=Tobin’s q (market value/replacement value, observable!)
2. Fazzari, Hubbard and Petersen (1988, Brookings Papers on Economic Activity)
   - FHP hypothesis
   - Information asymmetry story: Close to Pecking Order theory
   - Financially constrained firms: Internal funds↑⇒Investment↑
   - Besides q, additional RHS variables are playing an additional role empirically

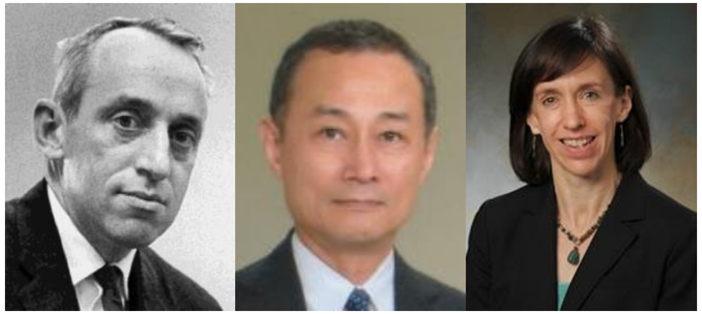
Two Competing Theories

q theory of investment

- Under the ideal conditions, marginal q solely determines the investment decision
  - Perfect competition, efficient market etc.
  - By and large, theoretical prediction

FHP hypothesis

- Under the unideal condition, cash flow plays a role in explaining the investment decision of financially constrained firms
  - Information imperfections in equity and credit markets
  - By and large, empirical observation



Fazzari, Hubbard and Petersen (1988)

Independent variable and summary statistic	Class 1	Class 2	Class 3
		1970–75	
Q_{it}	−0.0010	0.0072	0.0014
	(0.0004)	(0.0017)	(0.0004)
$(CF/K)_{it}$	0.670	0.349	0.254
	(0.044)	(0.075)	(0.022)
$\bar{R}^2$	0.55	0.19	0.13
		1970–79	
Q_{it}	0.0002	0.0060	0.0020
	(0.0004)	(0.0011)	(0.0003)
$(CF/K)_{it}$	0.540	0.313	0.185
	(0.036)	(0.054)	(0.013)
$\bar{R}^2$	0.47	0.20	0.14
		1970–84	
Q_{it}	0.0008	0.0046	0.0020
	(0.0004)	(0.0009)	(0.0003)
$(CF/K)_{it}$	0.461	0.363	0.230
	(0.027)	(0.039)	(0.010)
$\bar{R}^2$	0.46	0.28	0.19

- Table 4: Regress (I/K) on Q and (CF/K)
  - Class 1: Pays less dividend, constrained
  - (CF/K)↑⇒(I/K)↑
  - More constrained, bigger CF coefficients
  - Supports FHP hypothesis and challenges Tobin's q theory

II. A Simple Investment Model

- The problem is

$$\max_{\{I_t, K_{t+1}\}} V_t = E_t\left[\sum_{j=0}^{\infty}\left(\prod_{s=1}^{j} b_{t+s}\right)\left[\Pi\left(K_{t+j}\right) - \psi\left(I_{t+j}, K_{t+j}\right) - I_{t+j}\right]\right] \text{ s.t. } K_{t+1} = (1-d)K_t + I_t$$

- By solving Lagrangian

$$\underbrace{1 + \frac{\partial\psi}{\partial I_t}}_{\substack{\text{marginal cost}\\ \text{of investment}}} = \underbrace{E_t\left[\sum_{j=1}^{\infty}\left(\prod_{s=1}^{j} b_{t+s}\right)(1-d)^{j-1}\left(\frac{\partial\Pi}{\partial K_{t+j}} - \frac{\partial\psi}{\partial K_{t+j}}\right)\right]}_{\text{expected marginal benefit of investment=unobservable marginal q}} = \chi_t$$

- Derive a regression model by imposing a structure on the cost function ψ

$$\text{marginal cost} = 1 + a_1 + a_2 \nu_{it} + 2a_3\frac{I_{it}}{K_{it}} = \text{marginal } q_{it} \Rightarrow \frac{I_{it}}{K_{it}} = \alpha + \beta \text{marginal } q_{it} + u_{it}$$

III. Data and Estimators

- 1992–1995 (4 cross-sections), 737 manufacturing firms
- The cross-sectional model

$$
\begin{aligned}
y_i = \frac{I_i}{K_i} &= \alpha_0 + \alpha_1 \frac{CF_i}{K_i} + \alpha_2 d_i \frac{CF_i}{K_i} + \alpha_3 d_i + \chi_i \beta + u_i \\
&= \mathbf{z}_i^\top \boldsymbol{\alpha} + \chi_i \beta + u_i \\
\text{where } d_i &= 1\{i = \text{financially constrained}\} \\
x_i = \text{Tobin's } q_i &= \gamma_0 + \underbrace{\chi_i}_{\text{marginal} q_i} + \varepsilon_i, \quad \exists \text{measurement error}
\end{aligned}
$$

- “Partial out” non-noisy variables first

$$
\begin{aligned}
y_i - \mathbf{z}_i^\top \boldsymbol{\mu}_y &= \eta_i \beta + u_i \\
x_i - \mathbf{z}_i^\top \boldsymbol{\mu}_x &= \eta_i + \varepsilon_i \\
\text{where } (\boldsymbol{\mu}_y \quad \boldsymbol{\mu}_x \quad \boldsymbol{\mu}_\chi) &\equiv E\left[\mathbf{z}_i \mathbf{z}_i^\top\right]^{-1} E[\mathbf{z}_i (y_i \quad x_i \quad \chi_i)] \\
\eta_i &\equiv \chi_i - \mathbf{z}_i^\top \boldsymbol{\mu}_\chi
\end{aligned}
$$

III. Data and Estimators (cont'd)

- Then

$$\boldsymbol{\alpha} = \boldsymbol{\mu}_y - \boldsymbol{\mu}_x \beta$$

$$\rho^2 = \text{population } R^2 = \frac{\boldsymbol{\mu}_y^\top \mathrm{Var}[\mathbf{z}_i] \boldsymbol{\mu}_y + E[\eta_i^2]\beta^2}{\boldsymbol{\mu}_y^\top \mathrm{Var}[\mathbf{z}_i] \boldsymbol{\mu}_y + E[\eta_i^2]\beta^2 + E[u_i^2]}$$

- Moment conditions (exact-identification)

$$E\left[\left(y_i - \mathbf{z}_i^\top \boldsymbol{\mu}_y\right)^2\right] = \beta^2 E[\eta_i^2] + E[u_i^2]$$

$$E\left[\left(y_i - \mathbf{z}_i^\top \boldsymbol{\mu}_y\right)\left(x_i - \mathbf{z}_i^\top \boldsymbol{\mu}_x\right)\right] = \beta E[\eta_i^2]$$

$$E\left[\left(x_i - \mathbf{z}_i^\top \boldsymbol{\mu}_x\right)^2\right] = E[\eta_i^2] + E[\varepsilon_i^2]$$

$$E\left[\left(y_i - \mathbf{z}_i^\top \boldsymbol{\mu}_y\right)^2\left(x_i - \mathbf{z}_i^\top \boldsymbol{\mu}_x\right)\right] = \beta^2 E[\eta_i^3]$$

$$E\left[\left(y_i - \mathbf{z}_i^\top \boldsymbol{\mu}_y\right)\left(x_i - \mathbf{z}_i^\top \boldsymbol{\mu}_x\right)^2\right] = \beta E[\eta_i^3]$$

III. Data and Estimators (cont'd)

- Additional moment conditions (over-identification)

$$E\left[\left(y_i - \mathbf{z}_i^{\top}\boldsymbol{\mu}_y\right)^2\left(x_i - \mathbf{z}_i^{\top}\boldsymbol{\mu}_x\right)^2\right] = \beta^2\left(E[\eta_i^4] + E[\eta_i^2]E[\varepsilon_i^2]\right) + E[u_i^2]\left(E[\eta_i^2] + E[\varepsilon_i^2]\right)$$

$$E\left[\left(y_i - \mathbf{z}_i^{\top}\boldsymbol{\mu}_y\right)\left(x_i - \mathbf{z}_i^{\top}\boldsymbol{\mu}_x\right)^3\right] = \beta\left(E[\eta_i^4] + 3E[\eta_i^2]E[\varepsilon_i^2]\right)$$

- Apply EMM for

$$\begin{pmatrix} \frac{1}{n}\sum_{i=1}^{n}\left(y_i - z_i^{\top}\hat{\mu}_y\right)^2 - \left(\beta^2 E[\eta_i^2] + E[u_i^2]\right) \\ \vdots \\ \frac{1}{n}\sum_{i=1}^{n}\left(y_i - \mathbf{z}_i^{\top}\boldsymbol{\mu}_y\right)\left(x_i - \mathbf{z}_i^{\top}\boldsymbol{\mu}_x\right)^3 - \beta\left(E[\eta_i^4] + 3E[\eta_i^2]E[\varepsilon_i^2]\right) \end{pmatrix}$$

- Accuracy of measurement

$$\tau^2 = 1 - \frac{\mathrm{Var}[\varepsilon_i]}{\mathrm{Var}[x_i]}$$

IV. Estimates and Tests from U.S. Firm-Level Manufacturing Data

TABLE 2

BOND RATING INTERACTION MODEL: ESTIMATES OF β, THE COEFFICIENT ON MARGINAL q

	OLS	GMM3	GMM4	GMM5
1992	.010	.040	.037	.027
	(.003)	(.010)	(.007)	(.007)
1993	.010	.036	.036	.042
	(.003)	(.007)	(.007)	(.004)
1994	.010	.083	.048	.017
	(.003)	(.078)	(.013)	(.004)
1995	.016	.032	.044	.049
	(.003)	(.008)	(.009)	(.006)
Minimum distance	.012	.038	.038	.032
	(.002)	(.004)	(.004)	(.003)

NOTE.—Standard errors are in parentheses under the parameter estimates.

- Table 1: Neither β nor $E[\eta_i^2]$ equals to 0
  - Implies Non-zero 3rd moments
  - Justifies the use of 3rd moment conditions
- Table 2: Coefficient β for marginal q
  - OLS: Biased toward 0
  - GMM: Corrects the bias
  - Supports Tobin’s q theory: q plays a role
  - Minimum distance: Pooled, 1992–1995
  - GMM3: Just-identification with 3rd moments
  - GMM4: Over-identification with 4th moments
  - GMM5: Over-identification with 5th moments

IV. Estimates and Tests from U.S. Firm-Level Manufacturing Data (cont'd)

TABLE 3
BOND RATING INTERACTION MODEL: ESTIMATES OF α_1 AND $\alpha_1 + \alpha_2$, THE CASH FLOW RESPONSES OF FINANCIALLY UNCONSTRAINED AND CONSTRAINED FIRMS

	OLS	GMM3	GMM4	GMM5
	α_1			
1992	.251	−.071	−.043	.073
	(.072)	(.160)	(.104)	(.098)
1993	.224	−.037	−.038	−.091
	(.057)	(.095)	(.095)	(.072)
1994	.229	−.468	−.134	.161
	(.045)	(.749)	(.133)	(.055)
1995	.183	.097	.038	.012
	(.060)	(.057)	(.063)	(.058)
Minimum distance	.220	.049	−.005	.056
	(.037)	(.045)	(.053)	(.045)
	$\alpha_1 + \alpha_2$			
1992	.125	.031	.039	.073
	(.059)	(.073)	(.062)	(.058)
1993	.084	.018	.018	.004
	(.030)	(.030)	(.030)	(.030)
1994	.083	−.087	−.006	.067
	(.026)	(.205)	(.042)	(.022)
1995	.073	.032	.004	−.008
	(.023)	(.030)	(.042)	(.039)
Minimum distance	.078	.022	.010	.042
	(.017)	(.023)	(.024)	(.018)

NOTE.—Standard errors are in parentheses under the parameter estimates.

- Table 3: Coefficient αs for cash flow
  - OLS: Seemingly positive and significant
  - GMM: Insignificant with mixed signs
  - Rejects FHP hypothesis: Cash flow does not play a role in explaining investments

IV. Estimates and Tests from U.S. Firm-Level Manufacturing Data (cont'd)

TABLE 4
BOND RATING INTERACTION MODEL: ESTIMATES OF ρ^2, THE POPULATION R^2 OF THE INVESTMENT EQUATION

	OLS	GMM3	GMM4	GMM5
1992	.271	.414	.401	.436
	(.035)	(.115)	(.118)	(.105)
1993	.251	.386	.382	.467
	(.045)	(.097)	(.089)	(.069)
1994	.269	.576	.450	.349
	(.047)	(.279)	(.074)	(.060)
1995	.234	.312	.341	.386
	(.043)	(.061)	(.072)	(.057)
Minimum distance	.258	.350	.385	.398
	(.028)	(.049)	(.049)	(.040)

NOTE.—We define the OLS estimate of ρ^2 to be the OLS R^2. Standard errors are in parentheses under the parameter estimates.

- Table 4: R^2 of the model for investment
  - OLS: About 26%
  - GMM: About 39%
  - q theory performs better in explaining investments than previously thought

IV. Estimates and Tests from U.S. Firm-Level Manufacturing Data (cont'd)

TABLE 5

BOND RATING INTERACTION MODEL: ESTIMATES OF τ^2, THE POPULATION R^2 OF THE MEASUREMENT EQUATION

	GMM3	GMM4	GMM5
1992	.448	.438	.496
	(.058)	(.060)	(.060)
1993	.446	.445	.474
	(.058)	(.053)	(.052)
1994	.372	.469	.720
	(.065)	(.043)	(.084)
1995	.580	.523	.513
	(.055)	(.067)	(.066)
Minimum distance	.501	.470	.505
	(.043)	(.040)	(.043)

NOTE.—Standard errors are in parentheses under the parameter estimates.

- Table 5: R^2 of the model for Tobin's q
  - 0 implies perfect meaningless and 1 implies perfect measurement
  - About 47%
  - The marginal q can only partially be explained by Tobin's q
- Table 6: J test
  - Moment conditions are insignificantly different from 0
  - Justify the use of over-identification
- Table 7: Parameter constancy test
  - Parameters across cross-sectional models are not significantly different from each other (except the case of GMM5)

V. Spurious Differences in Cash Flow Sensitivity

TABLE 9
ESTIMATES OF μ_{x1}, μ_{y1}, AND VAR (z_{i1})

	1992	1993	1994	1995
$\hat{\mu}_{y1}$:				
Constrained	.159	.109	.107	.111
Unconstrained	.366	.322	.327	.263
$\hat{\mu}_{x1}$:				
Constrained	3.217	2.521	2.349	2.457
Unconstrained	10.990	9.938	9.604	5.155
$\hat{\mu}_{y1}/\hat{\mu}_{x1}$:				
Constrained	.043	.043	.046	.045
Unconstrained	.033	.032	.034	.051
$\widehat{\mathrm{Var}}(z_{i1})$:				
Constrained	.067	.082	.110	.135
Unconstrained	.035	.031	.035	.030

- Table 8: Robustness check with different dummies for financial constraint
  - Use firm size & bond rating+firm size
  - Results are robust enough
- Table 9: The role of Var$[z_{i1}]$

$$\boldsymbol{\alpha} = \boldsymbol{\mu}_y - \boldsymbol{\mu}_x \beta$$

  - Typically the coefficient for (CF/K) α_1 is bigger for constrained firms, but Table 3 shows an opposite result
  - Denominators for both $\boldsymbol{\mu}_y$ and $\boldsymbol{\mu}_x$ contain the 2nd moment of $\mathbf{z}_i$, i.e. $E[\mathbf{z}_i\mathbf{z}_i^T]$
  - Smaller $E[\mathbf{z}_i\mathbf{z}_i^T]$ (unconstrained), bigger $\boldsymbol{\alpha}$
  - This causes the problem in Table 3: bigger α_1 for unconstrained firms

VI. Conclusion

- Tobin's q proxies marginal q
- The measurement error in Tobin's q makes OLS inconsistent
  - Increases α and decreases both β and R^2 spuriously
- GMM estimates the relation consistently
  - Significant β with high R^2 and insignificant α
- Strengthens Tobin's q theory and weaken FHP hypothesis
  - Chirinko (1993, JEL): Marginal q includes the information regarding liquidity constraint as well

Q&A Session

Thanks for Listening