國科會社會科學研究中心學術研習營

資本投資與金融中介

王泓仁
中央研究院經濟研究所
hjwang@econ.sinica.edu.tw

國立嘉義大學

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q: Keynes's *The General Theory* (p.151)

The daily revaluations of the Stock Exchange, though they are primarily made to facilitate transfers of old investments between one individual and another, inevitably exert a decisive influence on the rate of current investment. For there is no sense in building up a new enterprise at a cost greater than that at which a similar enterprise can be purchased (HJW note: 若自己建公司比到股票市場上購買相同的公司還花錢, 就應直接購買, 不要投資); whilst there is an inducement to spend on a new project what may seem an extravagant sum, if it can be floated off on the Stock Exchange at an immediate profit (HJW note: 若投資之後可以馬上在股票市場轉手賺錢, 就應投資).

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Tobin's q Model (neo-classical + adjustment cost)

- Tobin and Brainard, 1977.
- Consider the (naive) measure of q:

$$q = \frac{MV}{RC}, \tag{1}$$

  where $MV =$ market value of the firm, $RC =$ replacement cost of the firm.

- MV: market value of the firm; stock + debt; usually valued by the stock market
  - ◇ Theoretically, a firm's market value is the discounted sum of the firm's future cash flows.

- RC: replacement cost of the firm
- If MV $>$ RC $\Longrightarrow$ on average, each dollar of the firm has a market value greater than it's cost $\Longrightarrow$ invest more.
- Has a theoretical equilibrium value equal to 1.
- More generally, investment is an increasing function of q.

Problems of the Interpretation

- $q = MV/RC = 1.2$ means that the "existing" asset has a market value which is 1.2 times of the cost. But when we do investment, we are adding "new" asset, which may or may not have the same market value as the existing asset.
- Need ***marginal*** q:

$$\text{marginal} \quad q = \frac{\Delta MV}{\Delta RC}, \tag{2}$$

which has an equilibrium value equal to 1.

- Why average q is still popular in empirical studies?
  - ◇ Because it is much easier to measure!!!
- Is average q worthless from a theoretical point of view?
  - ◇ Not really: Hayashi (1982) to the rescue!

Factors causing average q to differ from marginal q

- diminishing/increasing returns to scales
  - ◇ the average q will be larger/smaller than the marginal q
- technical progress makes old equipments obsolete
  - ◇ the average q will be smaller than the marginal q
  - ◇ the case of U.S. chemical industry in the 1970s: Observing investment booms during periods when average q ratios are low or even declining.

- Hayashi (1982, Econometrica) shows that under the assumptions of constant-return-to-scale production technology and competitive market, the average q is the same as the marginal q!!
  - ◇ a life-savor for empirical researchers and generates huge citations!

Replacement Cost vs. Book Value of a Firm

- main difference: inflation bias;
- land: no depreciation but could have huge changes in values; other capital: would depreciation but prices may be stable;
- 如何判定該年資產之「年份結構」, 至爲關鍵。
- institutional knowledge is also important:
  - ◇ 美國: 無資產重估 (except 1980 to 1987, in footnotes);
  - ◇ 台灣: 容許有條件的揭露資產因物價上漲而增值的部分 (資產重估增值):

- ⋆ 必要條件: 當年度躉售物價指數較該資產取得年度或前次依 法令規定辦理資產重估價年度上漲達百分之二十五;
- ⋆ 及使滿足必要條件, 也無強制規定「一定」要重估。

◇ Nevertheless, 資產重估增值提供了 additional information to help measuring the replacement cost.

Measuring the Replacement Costs

- the perpetual inventory method (Lindenberg and Ross, 1981, Journal of Business)
  - ◇ 從古早 (T-j) 開始, 把每一年 (e.x., j=10, 9, 8, ... 0) 的毛投資額, 依「通貨膨脹率」及設算的「折舊率」, 計算它們在 T 年的剩餘市值, 然後把這些數字加起來, 成爲第 T 年的資產重置成本。
  - ◇ 缺點: 需要較長的時間數列。
- the vintage structure method (Lewellen and Badrinath, 1997 Journal of Financial Economics)
  - ◇ 假設 T 年的「毛」資產爲K_T, 則從第 T 年的「毛」投資開始 往回加總, 直到 $I_T + I_{T-1} + I_{T-2} + ... + I_{T-N} = K_T$, 然後再依「通

貨膨脹率」及設算的「折舊率」及, 計算這些 投資在 T 年的剩餘市值, 最後再加總起來。

◇ 優點: 起始年「N」的判定較精確 (第 T 年資產的來源年份結構 (vintage structure) 十分清楚); 對時間樣本短的資料特別有利。

- For Taiwanese data, see 王泓仁 (2000),「估計臺灣地區個體廠商之 Tobin's Q」, 經濟論文,28(2), 149-76. Free programs available!

以年份結構法估計非土地資產重置成本:An Example

已知某公司1995年之 (非土地) 毛資產淨額爲1600(財報中淨資產+ 累積折舊)。

- 可知1995年之資產累積自1992年以來。

Are Different Measures Really Different? (1/2)

SQ: 依帳面值計算 (market to book ratio);LRQ: 依永續存貨法計算; LBQ: 依年份結構法計算。

Are Different Measures Really Different? (2/2)

The q Model (Abel, 1982)

- Assumptions
  - ◇ output price = capital price = 1;
  - ◇ labor cost = $W_t \times L_t$;
  - ◇ capital cost (buying and installing capital) = $I_t + I_t \times \phi\left(\frac{I_t}{K_t}\right)$
    - ⋆ $I_t \times 1 = I_t$ is the cost of buying capital;
    - ⋆ $\phi\left(\frac{I_t}{K_t}\right)$ is the $adjustment\ cost$ of installing one unit of capital, which is convex in the rate of investment: $\phi(I/K) \geq 0$, $\phi(0) = 0$, $\phi_{II}(I/K) > 0$.
  - ◇ no depreciation, so that $\dot{K}_t = I_t - \delta K_t = I_t$.

The Model

$$\max_{I_t, L_t} : V_0 = \int_0^{\infty} e^{-rt} \left\{ (1-\tau) F(K_t, L_t) - W_t L_t - \left[I_t + I_t \phi \left(\frac{I_t}{K_t} \right) \right] \right\} \tag{3}$$

$$s.t. : \dot{K}_t = I_t; \qquad K_0 \quad \text{given} \tag{4}$$

Solution: (current value) Hamiltonian

$$\mathcal{H} = \left\{ (1-\tau)F(K_t, L_t) - W_t L_t - \left[I_t + I_t \phi \left(\frac{I_t}{K_t} \right) \right] \right\} + q_t I_t \tag{5}$$

q_t: current value costate variable. According to the role of a costate in an optimization problem, q_t is the "marginal value" to the firm for an additional capital (or, the shadow price of the additional capital). $\Longrightarrow$ Tobin's marginal q!

The Maximization Principles of the Optimization Problem

$$\text{control} \quad L_t: \quad \frac{\partial \mathcal{H}}{\partial L_t} = 0; \quad \Rightarrow \quad F_L = W_t/(1-\tau), \tag{6}$$

$$\text{control} \quad I_t: \quad \frac{\partial \mathcal{H}}{\partial I_t} = 0;$$

$$\Rightarrow \quad q_t = 1 + \phi(I/K) + (I/K) \cdot \phi'(I/K), \tag{7}$$

$$\text{state} \quad K_t: \quad \dot{K}_t = \frac{\partial \mathcal{H}}{\partial q_t} = I_t; \tag{8}$$

$$\text{costate} \quad q_t: \quad \dot{q}_t = r q_t - \mathcal{H}_k;$$

$$\Rightarrow \quad \dot{q}_t = r q_t - (1-\tau) F_k - (I_t/K_t)^2 \cdot \phi'(I/K), \tag{9}$$

$$\text{T.V.C.:} \qquad \lim_{t \to \infty} e^{-rt} q_t K_q = 0. \tag{10}$$

- From (7): $q_t = 1 + \phi(I/K) + (I/K) \cdot \phi'(I/K)$;
  - $\diamond$ $I = 0 \iff q_t = 1$; (What's the meaning? Is it really necessarily 1?)
  - $\diamond$ The inverse function implies that $I/K = h(q)$: the rate of investment is a function of q. It can be shown that $h'(q) > 0$, $h(1) = 0$.

- From (9):

$$(1-\tau)F_k(\cdot) + \left[\left(\frac{I}{K}\right)^2 \phi'\left(\frac{I}{K}\right)\right] = \left(r - \left(\frac{\dot{q}}{q}\right)\right) q, \quad (11)$$

  - ◇ LHS: benefit of the last unit of capital: after-tax income + (you-guess-what);
  - ◇ RHS: user cost of the last unit of capital: "real" interest rate times price.

- Using (7) and (9) to solve for q_t, we get,

$$q_t = \int_t^\infty e^{-r(s-t)} \left[(1-\tau) F_k + \left(\frac{I}{K}\right)^2 \phi' \left(\frac{I}{K}\right) \right] ds. \quad (12)$$

  - ◇ The value of the last unit of capital (q_t, the $marginal$ q) equals the discouned sum of its marginal benefit;
  - ◇ q_t summarizes all the information about the future that is relevant to the firm's investment decision; $\Longrightarrow$ q_t is a sufficient statistic of investment!!
  - ◇ Hayashi (1982) shows that if the production function is CRTS

and the market is competitive, than the above q_t becomes

$$q_t = \frac{V_t}{K_t \times 1}, \tag{13}$$

which is the average q!

Comments

- The adjustment cost is necessary for the story.
- Differences between the model's q and Tobin's q:
  - **Tobin's q:** (1) rooted in the valuation of the stock market;
    (2) q is an incentive to invest;
    (3) Always has an equilibrium value equal to 1.
  - **Model's q:** (1) do not require the stock market;
    (2) q is the shadow price of capital. It is not an "incentive" for investment; rather it is determined jointly along with optimal investment.
    (3) Does not necessarily has an equilibrium value equal to 1.

The Empirical Evaluation of the q Theory (Is q really a sufficient statistic?)

The empirical performance of the q model is miserable. The coefficient of the (average) q is often small and insignificant, and model residuals are often correlated with outputs and other variables. Possible reasons:

- ◇ The difference between the marginal q and the empirical average q is important.
- ◇ Difficult to account for the long and variable lags of firms' response to deviation of q from par.

- ◇ Managers do not respond to $noises$ of the stock market fluctuations. (A neo-classical view, which is not quite consistent with Tobin's original view.)

- ◇ Firms face financing constraints. $\Longrightarrow$ Financial variables should be included, otherwise, omitted variable problem.

Why a Firm's Financial Status/Variables Had Been Neglected?

- The Modigliani–Miller theorem:
  - ◇ Modigliani and Miller (1958), The Cost of Capital, Corporate Finance, and Theory of Investment, AER, 48, 261-297.
  - ◇ If the information is symmetry and the capital market is perfect, the costs of the firm's internal finance (retained earnings, equity, etc.) and external finance (debt, etc.) are the same. $\Longrightarrow$ The internal and external funds are perfect substitutes.
  - ◇ A firm's capital structure is irrelevant to its value. Finance is

only a veil.

- Following this literature, investment decisions depend only on "real" variables, but not "financial" variables such as internal liquidity, debt leverage, or dividend policy.

Why Financial Variables are Now Common in Investment Models?

- The breakdown of the perfect market assumption $\Longrightarrow$ the internal and external funds no longer perfect substitutes $\Longrightarrow$ financial variables should matter to the investment.
  - ◇ Why breakdown?
  - ◇ What to do with the investment model when internal and external funds are imperfect substitute? (Short answer: adding financial variables into the model is one way to go).

Asymmetric Information in Capital Market

Myers and Majluf (1984), Journal of Financial Economics

- **Key Idea:** Managers have private information (i.e, know more about the firm and the investment project) but outside investors (i.e, bankers, financiers) do not. Consequence: Internal funds and external funds are no longer substitutes! The following is why:

  ◇ **Lemon Problem Causes Issuing New Shares Costly:** A firm is valued to the market average. For a good firm, the new shareholders implicitly requires a premium to purchase the shares. 10個人10股擁有一個20元公司。向第11個人募1股2元, 成爲11個人擁有的22元公司。但這第11個人只願以1股1.8元的

代價加入。原10個股東同意否?

◇ **Agency Cost causes Issuing New Debt Costly:** Because of limited liability, firm managers may act in the interests of shareholders but not the creditors. (Interests of the two parties may not always be the same). Therefore, creditors may impose increasing marginal cost on new debt.

- **Consequence:** "Pecking order" of finance: internal funds (cash flow, retained earnings) $\longrightarrow$ debt (bank credit) $\longrightarrow$ bonds $\longrightarrow$ new equity. Different forms of finance are not perfect substitutes!

Implications when Internal and External Funds are not Perfect Substitutes

- A firm follows pecking orders in selecting financing instruments.
  - ◇ if investment can be financed entirely by internal funds or the firm has no problem borrowing $\Longrightarrow$ firm behaves like neo-classical $\Longrightarrow$ financial variables do not $appear$ to matter to its investment behavior
  - ◇ if internal funds are not enough and it has difficulty obtaining external funds $\Longrightarrow$ investment co-moves with internal funds $\Longrightarrow$ display sensitivity of investment to internal funds
    - ⋆ This is one way that financial variables enter the investment

model when capital market is imperfect.

Are Financing Constraints Really Exist?

- Key: Constrained firms and unconstrained firms behave differently.
- Euler equation approach
  - ◇ micro theory; do not need q; difficult
- Reduced form approach $(popular)$
  - ◇ ad hoc; requires q; easy and flexible
- Common to both: Require separating samples into a constrained group and an unconstrained group $a\ priori$, and test for the different behaviors between the groups.

- ◇ firms size: large vs. small,
- ◇ dividend payout policy: high payout vs. low payout,
- ◇ leverage ratio: low ratio vs. high ratio,
- ◇ group membership: group vs. non-group

The Euler Equation Approach (Whited 1992 JF)

Strategy

- The FOC w.r.t. K_{it}: (complicated)
- The FOC w.r.t. B_{it}:
  $1 + \lambda_{it} - \left(\frac{1}{1+R}\right)(1 + i_t)\, E_t\,(1 + \lambda_{i,t+1}) = \gamma_{it}$.
- The multiplier γ_{it} is the increase in the present value of the firm if the debt constraint were to be relaxed by one unit.
- Essentially, the hypothesis is: $\gamma_{it} = 0$ for unconstrained firms, and $\gamma_{it} \neq 0$ for constrained firms.
- Combining the two FOC together, and estimate the Euler equation on constrained and unconstrained groups of firms.

The Reduced Form Approach

- A reduced form regression:

$$\left(\frac{I}{K}\right)_t = \alpha + \beta \cdot q_t + \gamma \cdot \text{Cash Flow}_t + \delta \mathbf{Z}_t + \epsilon_t, \qquad (14)$$

- **Hypothesis:** $\gamma = 0$ for unconstrained firms, and $\gamma > 0$ for constrained firms.
- sample separation criterions:
  - ◇ firms size: large vs. small,
  - ◇ dividend payout policy: high payout vs. low payout,

- ◇ leverage ratio: low ratio vs. high ratio,
- ◇ group membership: group vs. non-group

Problems of this Popular Strategy

- the reduced form is too $ad\ hoc$: It is not clear how financing constraints, liquidity variables, and investment spending should interact with each other (Chirinko 1997).
- ambiguity in interpreting the cash flow coefficient.
- the sample classification is also $ad\ hoc$
- Cannot quantify the effects of constraints.

An Alternative Strategy (Wang, 2003 JBES)

Financing constraints should have one-sided effects on a neo-classical, frictionless level of the investment.

Financing constraints should have one-sided effects on a neo-classical, frictionless level of the investment.

Therefore, constrained investment can be estimated as a one-sided deviation from the neo-classical level.

- The effect of financing constraint is identified by imposing a one-sided distributional assumption on the constraint.

- The effect is a function of the firm's cash flow and asset size.

Advantages

- Directly measure the effect of constraint, therefore do not have to separate samples $a\ priori$.
- Require relatively weak structural assumptions on the financial and real variables.
  - ◇ the financing constraint has a one-sided distribution effect
  - ◇ the effect of financing constraint can be explained by observables variables
- Can obtain quantitative measures of the effects of financing constraints, which can be used to make cross-sectional as well as cross-time comparisons.

The Model see pic

$$I_i = I_i^* e^{-u_i}, \quad u_i \geq 0,$$

(so that $\log(I_i) = \log(I_i^*) - u_i$)

$$u_i = u\left(Z_i, w_i\right) = Z_i'\delta + w_i;$$

$$w_i \sim TN(0, \sigma_w^2) \quad at - Z_i'\delta,$$

so $u_i \sim TN(Z_i'\delta, \sigma_w^2) \quad at \;\; 0.$

Use a Q model to measure I^*. With some manipulation,

$$\log\left(\frac{\boldsymbol{I_i}}{\boldsymbol{K_i}}\right) = \boldsymbol{\alpha} + \boldsymbol{\beta}\log \boldsymbol{Q_i} + \boldsymbol{v_i} - \boldsymbol{u_i}.$$

Back

Econometrics: A Stochastic Frontier Model

$$y_{i\,t} = \alpha + \tilde{X}_{i\,t}\beta + e_{i\,t}, \tag{25}$$

$$e_{i\,t} = v_{i\,t} + f_i + \tau_t - u_{i\,t}, \tag{26}$$

$$v_{i\,t} \sim \text{i.i.d. } N(0, \sigma_v^2), \tag{27}$$

$$u_{i\,t} \sim \text{non–negative truncation of i.i.d. } N(\mu_{i\,t}, \sigma_{i\,t}^2); \tag{28}$$

$$\mu_{i\,t} = c0 + Z_{i\,t}\delta, \tag{29}$$

$$\sigma_{i\,t}^2 = \exp(c1 + Z_{i\,t}\gamma). \tag{30}$$

The log-likelihood function

$$\begin{aligned}\log[f(y_{i\,t})] &= -\frac{1}{2}\log(\sigma_v^2+\sigma_{i\,t}^2)+\log\left[\phi\left(\frac{y_{i\,t}-X_{i\,t}\beta+\mu_{i\,t}}{\sqrt{\sigma_v^2+\sigma_{i\,t}^2}}\right)\right]\\ &\quad -\log\left[\Phi\left(\frac{\mu_{i\,t}}{\sigma_{i\,t}}\right)\right]+\log\left[\Phi\left(\frac{\check{\mu}_{i\,t}}{\check{\sigma}_{i\,t}}\right)\right],\end{aligned}$$

where

$$\begin{aligned}
\check{\mu}_{i\,t} &= \frac{\sigma_v^2 \mu_{i\,t} - \sigma_{i\,t}^2 (y_{i\,t} - X_{i\,t}\beta)}{\sigma_v^2 + \sigma_{i\,t}^2}, \\
\check{\sigma}_{i\,t}^2 &= \frac{\sigma_v^2 \sigma_{i\,t}^2}{\sigma_v^2 + \sigma_{i\,t}^2},
\end{aligned}$$

Investment Efficiency Index (IEI) IEI pic

IEI measures the degree to which a firm's rate of investment is close to the frictionless level.

$$IEI_{it} = \frac{X_{it}\beta - u_{it}}{X_{it}\beta}.$$

If the dependent variable is in the logarithm,

$$\mathrm{IEI}_{i\,t} = \frac{\exp(X_{i\,t}\beta - u_{i\,t})}{\exp(X_{i\,t}\beta)} = \exp(-u_{i\,t}).$$

The conditional expectation of the IEI is (Jondrow *et al.* 1982):

$$\mathrm{E}\left(\exp(-u_{i\,t})|\epsilon_{i\,t}=\hat{\epsilon}_{i\,t}\right)=\exp\left(-0.5\left(2\check{\mu}_{i\,t}-\check{\sigma}_{i\,t}^{2}\right)\right)\frac{\Phi\left(\frac{\check{\mu}_{i\,t}}{\check{\sigma}_{i\,t}}-\check{\sigma}_{i\,t}\right)}{\Phi\left(\frac{\check{\mu}_{i\,t}}{\check{\sigma}_{i\,t}}\right)}. \tag{31}$$

Data Back

Taiwanese manufacturing firms between 1989 and 1996. N=184, T=8 (unbalanced panel).

- This period chronicles important financial reforms in the Taiwanese markets, thus providing a unique opportunity to test the financing constraint hypothesis. If the hypothesis was true, we expect to see
  - ◇ the effect of financing constraints attenuates over time
  - ◇ "underprivileged" firms benefit the most from the financial reforms

- Cash flow has first order as well as second order effects on constraints.
- Both cash flow and total assets are important in explaining the constraint.

Is u_{it} significant?

- Why?
  - ◇ Whether the model is misspecified. see model
  - ◇ Whether the financing constraint is a statistically important phenomenon in explaining the investment behavior.
- How?
  - ◇ A likelihood ratio test against the frontier-only model (the null).
- Results?

- The null hypothesis of no effect from $\mathbf{u_{it}}$ are rejected at the 1% significant level for all the models.

Post Estimation Analysis - Overview of IEI

Figure 2: The Distribution of IEI

Evaluating Sorting Criteria Used in the Literature Back

- Total Assets
- Retention Ratios: $100\times$(net income after dividend)/(net income).
- Interest Coverage Ratio: $100\times$(interest expenses)/(net income $+ 0.75\times$interest expenses).
- Debt to Asset Ratios: $100\times$(total liability)/(asset).

A good sorting criterion should be significantly and monotonically related to the degree of financing constraint (i.e. IEI).

Sorting

Financing Constraint: 70

Figure 3: The Monotonicity of Various Sorting Criteria.

Taiwan Data

Table 5: The Effects of Financial Liberalization on Firms of Different S
A Comparison of Investment Efficiency Index Across Time

year	all firms	small firms	medium firms	large firms	# of
1989	0.580	0.497	0.596	0.635	101
1990	0.578	0.525	0.596	0.605	115
1991	0.604	0.537	0.620	0.646	131
1992	0.606	0.546	0.625	0.644	148
1993	0.598	0.512	0.663	0.623	173
1994	0.622	0.572	0.662	0.638	184
1995	0.631	0.604	0.627	0.666	184
1996	0.603	0.527	0.625	0.666	184
# of obs	1220	412	402	406	

Financing Constraint: 74

+0.10 +0.067 +0.061

Figure 4: Small firms gained more from financial liberalization.