Estimating Tobin’s Q for the Listed Firms in Korea, 1980~2005: Comparing Alternative Approaches and an Experiment with Investment Functions

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I. Motive & Background

The value has to measure accurately!

- In many empirical studies, Tobin’s Q has been adopted as a key independent or a dependent variable (Morck et al., 1988, Lang and Stultz, 1994, Baek et al., 2004, Kang et al., 2006, Kim, 2009)
  - Those papers use only M/B ratio, proxy of the Tobin’s Q for difficulty in estimating the value (Black et al., 2003, Drobetz et al., 2004, Yoon et al., 2005, Bae et al., 2008)
  - And also focus on specific short term periods of time (Kang et al, 2004)
  - Especially, there has been very little attempt to estimate Tobin’s Q over a long-term period in Korea
What is Tobin Q and How can we measure?

Tobin Q = \( \frac{\text{firm market value}}{\text{the replacement cost of its assets}} \)

- Firm market value = (stock market value + debt market value)
- The replacement cost of its assets: the amount that an entity would have to pay to replace(or buy) the firm’s asset at the present time

There is a difficulty in calculating diverse facts which is considered according to characteristics of each asset of the firm

- Proxy of Tobin’s Q using in empirical study: Market to Book ratio
  - Stock market value: market capitalization of ending period
  - Debt market value: book value of total liabilities in balance sheets
  - Replacement cost of assets: book value of total assets in balance sheets
II. Main Purpose

◆ To estimate an accurate Tobin’s Q, the value of Korean listed firm over the longest period 1980~2005 according to method defined by Tobin(1969)
  - Basically, we follow methods of Lindenberg and Ross(1981) and Hoshi and Kashyap(1990), which further develop the methodology of Tobin(1969)
    ✓ with estimating market values of debt, preferred stocks and replacement cost of assets
    ✓ in estimating replacement cost of assets
    ✓ we apply annual average depreciation rate using not change in accumulated depreciation but accumulated depreciation itself

◆ Comparing several alternative series and experiments
  - comparing trends of the firm value by each method

◆ Suggesting preferable estimation method by estimating investment function
Basically, MB1 and MB2 are market-to-book ratios:

$$MB1 = \frac{\text{market value of stock} + \text{book value of liabilities}}{\text{book value of assets}}$$

$$MB2 = \frac{\text{market value of stock} + \text{market value of liabilities}}{\text{book value of assets}}$$

TQ2 is better index in terms of calculating values of preferred stocks because prices of preferred stocks are not easily available due to less frequent transactions.

$$TQ2 = \frac{\text{market value of stock} + \text{market value of liabilities}}{\text{replacement costs of assets}}$$

where market value of stocks = ① + ②, and

① = (year end price of common stocks × number of outstanding common stocks)

② = (dividend of preferred stocks × dividend ratio of preferred stocks) × number of outstanding preferred stocks
IV. Methods to Estimate Tobin’s Q (1)

Market value of stocks

- MB1, MB2: Market capitalization of common stock and preferred stock at year-end

  ✓ In case using market capitalization, the price of preferred stock is unclear because of non-tradability or very low trading volume
  ✓ So, we divide dividends of preferred stocks by the average dividend ratio of preferred stocks in order to calculate the price following Lindenberg and Ross (1981) and Summers (1981)

- TQ2: (common stock price * numbers) + (preferred stock price * numbers)
  where, preferred stock price = dividend/average dividend rate
IV. Methods to Estimate Tobin’s Q (2)

**Market value of liabilities**

= present value of principal of the debt + present value of interest payments  
= (a+b+c+d+e)

- We categorize liabilities into non-interest-bearing liabilities and interest-bearing liabilities following Kim et al.(1996) and Hong et al.(2007)

✓ non-interest-bearing L.(a) = (total current liabilities−short term borrowings − current portion of long term liabilities) + (total non current liabilities − bonds − long term borrowings)

✓ short term L.(b)= (short term borrowings + current portion of long term borrowings + short term borrowing in foreign currency + bank overdraft + short term borrowing notes + short term borrowing shareholders, officials, employee + short term borrowing related parties + short term borrowing others)

= interest expenses of short term liabilities ( = short term liabilities \[\frac{\text{interest expenses}}{\text{interest expenses}}\] + book value of short term liabilities)  
\[\frac{\text{short term liabilities}}{1 + \text{CD interest rate}}\]
✓ long term domestic L.(c) = (long term borrowings + long term borrowings related parties + long term borrowings shareholders, officials, employee)  

   = (i) + (ii)

(i) = \left[ \frac{\text{long term domestic interest expenses} \left(= \frac{\text{long term liabilities}}{\text{interest expenses}} \right)}{\text{commercial bank interest rate}} \right] \times \left[ 1 - \frac{1}{(1 + \text{commercial bank interest rate})^3} \right]

(ii) = \frac{\text{book value of long term liabilities}}{(1 + \text{commercial bank interest rate})^3}

✓ bond(d) = (iii) + (iv) = 

(iii) = \left[ \frac{\text{bond expenses} \left(= \frac{\text{bond}}{\text{interest expenses}} \right)}{\text{interest rate of 3-year bond}} \right] \times \left[ 1 - \frac{1}{(1 + \text{interest rate of 3-year bond})^3} \right]

(iv) = \frac{\text{bond book value}}{(1 + \text{interest rate of 3-year bond})^3}

✓ long term foreign L.(e) = (long term borrowings in foreign currency + overseas loans)  

   = (v) + (vi)

(v) = \left[ \frac{\text{interest expenses of long term foreign liabilities} \left(= \frac{\text{long term foreign liabilities}}{\text{interest expenses}} \right)}{\text{LIBOR rate + 1.5%}} \right] \times \left[ 1 - \frac{1}{(1 + \text{LIBOR rate + 1.5%})^5} \right]

(vi) = \frac{\text{book value of long term foreign liabilities}}{(1 + \text{LIBOR rate + 1.5%})^5}
IV. Methods to Estimate Tobin's Q (3)

◆ **Replacement costs of assets**

- **Assets**: quick assets, intangible assets, investment assets, total inventory, and tangible assets
  - Tangible assets: land, buildings, structures, machinery & equipment, vehicle & transportation equipment, tools, furniture & fixtures, tangible assets other

- We follow Kim et al. (1996) and Hong et al. (2007) when estimating replacement costs for total inventory and tangible assets

- We have tried two different approaches to estimate the replacement costs of assets:
  - TQ2_A and TQ2_B
  - TQ2_A uses the economic depreciation rate ($\delta$) by Hyun and Pyo (1997)
  - TQ2_B uses the annual average depreciation rate ($\delta'$)
Method A (TQ2_A)

🔹 Estimating replacement cost only for eight tangible assets and total inventory

: using book value in other assets

: with economic depreciation rate (δ) by Hyun and Pyo (1997)

✓ Replacement cost of total inventory are obtained from equation (1) or equation (2)

: if the change in the value of total inventory is non-negative, \( \Delta \text{inv}_t = B_{\text{inv}}_t - B_{\text{inv}}_{t-1} \geq 0 \), then \( \text{Minv}_t = \text{Minv}_{t-1} \times \left( \frac{P_t}{P_{t-1}} \right) + \Delta \text{inv}_t \) (1)

: if the change in the value of total inventory is negative, then \( \text{Minv}_t = (\text{Minv}_{t-1} + \Delta \text{inv}_t) \times \left( \frac{P_t}{P_{t-1}} \right) \) (2)

✓ Replacement cost of land are obtained from equation (3) or equation (4)

: if the change in the value of land is non-negative, \( \Delta \text{land}_t = B_{\text{land}}_t - B_{\text{land}}_{t-1} \geq 0 \), then \( \text{Mland}_t = \text{Mland}_{t-1} \times \left( \frac{P_t}{P_{t-1}} \right) + \Delta \text{land}_t \) (3)

: if the change in the value of land is negative, then \( \text{Mland}_t = \left\{ \text{Mland}_{t-1} \times \left( \frac{P_t}{P_{t-1}} \right) \right\} + (\Delta \text{land}_t \times g) \) (4)

\[ g = (1 + P_{t-4})(1 + P_{t-3})(1 + P_{t-2})(1 + P_{t-1})(1 + P_t) \]

✓ Replacement cost of tangible assets other than land are obtained from equation (5)

\[ \text{Mtanas}_t = \left\{ \text{Mtanas}_{t-1} \times \left( \frac{P_t}{P_{t-1}} \right) + \Delta \text{tanasi} + \text{Dep} \right\} \times (1 - \delta) \] (5)
Method B (TQ2_B)

- Estimating replacement cost only for eight tangible assets and total inventory using a similar process to that in method A.

: However, tangible assets are depreciated by the annual average depreciation rate ($\delta'$), as in Kim et al. (1996) and Hoshi and Kashyap (1990).

: Because economic depreciation rate in method A was derived from estimation of capital stocks in the 1980s by Hyun and Pyo (1997) and did not consider diversity of depreciation rate of the tangible assets by firm.

: Annual average depreciation rate ($\delta'$) uses the change in the amount of accumulated depreciation for individual tangible assets, 

$$\delta' = \frac{1}{n} \times \sum \left\{ \frac{Dep}{(Stand_{i} + Dep)} \right\}$$  \hspace{1cm} (6)

- Negative depreciation rates were obtained for many firms and many years before the crisis of 1997 in using annual average depreciation rate, $\delta'$.

: That phenomenon can be explained by divestiture (selling off assets on a large scale).

- However, Korean manufacturing firm was blamed for over-investment before crisis.

- We can solve the problem which annual average depreciation rate is negative and consider diversity of depreciation rate by using the amount of accumulated depreciation itself rather than the change in the amount.
◆ Korea Information System (KIS Value II) : 1980~2005

◆ Bank of Korea Statistics DB (http://ecos.bok.or.kr/) and Monthly Bulletin (josa-tongge-wolbo)

◆ Monthly Economy Bulletin by Ministry of Strategy and Finance (gyengje-tongge-wolbo)

◆ Land Price Statistics by Ministry of Construction and Transportation (jiga-donghyang)

◆ Top 30 Business Groups Lists by Korea Fair Trade Commission (KFTC)

◆ Korea’s Fifty Major Financial Groups by Management Efficiency Research Institute

◆ Korea Standard Industry Classification code
V. Comparison of Four Estimation Methods

\[
MB1 = \frac{\text{(market capitalization at year-end + book value of liabilities)}}{\text{book value of assets}}
\]

\[
MB2 = \frac{\text{(market capitalization at year-end + market value of liabilities)}}{\text{book value of assets}}
\]

\[
TQ2_A = \frac{\left(\text{(the number of total outstanding shares} \times \text{stock price at year-end)} + \text{(market value of liabilities)}\right)}{\text{replacement costs of assets based on economic depreciation rates}}
\]

\[
TQ2_B = \frac{\left(\text{(the number of total outstanding shares} \times \text{stock price at year-end)} + \text{(market value of liabilities)}\right)}{\text{replacement costs of assets based on annual average depreciation rates}}
\]

◆ **MB1 uses the book values, it might overestimate firm value \( \Rightarrow \) MB1 > MB2**

◆ **TQ2_A or TQ2_B is better than MB1 or MB2, as they consider market values of both debts and assets**

◆ **Of the two methods TQ2_A and TQ2_B, TQ2_B is a better choice**
  
  ; TQ2_A method uses an economic depreciation rate
  
  ; So, TQ2_A tends to overestimate the value of replacement cost of assets and did not accommodate diversity of depreciation rate of the tangible assets by each firm
  
  ; The estimates using TQ2_A method are the lowest since 1990
Characteristics of estimates by TQ2_B method

◆ Stable and below 1 during most of the period except the mid-1980s

; Estimates by TQ2_B methods show that Tobin’s Q measure is stable and well below 1 or 0.6 during most of the period except the mid-1980s

; Of course, there are some unstable fluctuation caused by the higher volatility of stock prices in the mid-1980s
VI. Comparison of Chaebol and Non–chaebol firms

Except MB1, three of the approaches show that before the crisis of 1997, stand-alone firms had a higher firm value than group affiliates.

The situation is reversed after the crisis, especially in TQ2_B method.

Before the crisis ⇒ FV of non–chaebol > FV of chaebol

After the crisis ⇒ FV of non–chaebol < FV of chaebol

<table>
<thead>
<tr>
<th>Year</th>
<th>MB1</th>
<th>MB2</th>
<th>TQ2_A</th>
<th>TQ2_B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>0.873</td>
<td>0.935</td>
<td>0.203</td>
<td>1.628</td>
</tr>
<tr>
<td>1981</td>
<td>0.849</td>
<td>0.899</td>
<td>0.252</td>
<td>1.624</td>
</tr>
<tr>
<td>1982</td>
<td>0.840</td>
<td>0.891</td>
<td>0.258</td>
<td>2.009</td>
</tr>
<tr>
<td>1983</td>
<td>0.856</td>
<td>0.874</td>
<td>0.337</td>
<td>1.416</td>
</tr>
<tr>
<td>1984</td>
<td>0.860</td>
<td>0.906</td>
<td>0.282</td>
<td>1.472</td>
</tr>
<tr>
<td>1985</td>
<td>0.888</td>
<td>1.003</td>
<td>0.443</td>
<td>1.477</td>
</tr>
<tr>
<td>1986</td>
<td>0.939</td>
<td>1.054</td>
<td>0.520</td>
<td>1.649</td>
</tr>
<tr>
<td>1987</td>
<td>1.024</td>
<td>1.134</td>
<td>0.571</td>
<td>0.621</td>
</tr>
<tr>
<td>1988</td>
<td>1.051</td>
<td>1.135</td>
<td>0.651</td>
<td>0.927</td>
</tr>
<tr>
<td>1989</td>
<td>1.029</td>
<td>1.118</td>
<td>0.723</td>
<td>0.710</td>
</tr>
<tr>
<td>1990</td>
<td>0.938</td>
<td>1.032</td>
<td>0.470</td>
<td>0.438</td>
</tr>
<tr>
<td>1991</td>
<td>0.866</td>
<td>0.972</td>
<td>0.368</td>
<td>0.318</td>
</tr>
<tr>
<td>1992</td>
<td>0.937</td>
<td>1.019</td>
<td>0.478</td>
<td>0.346</td>
</tr>
<tr>
<td>1993</td>
<td>1.004</td>
<td>1.081</td>
<td>0.703</td>
<td>0.540</td>
</tr>
<tr>
<td>1994</td>
<td>1.063</td>
<td>1.088</td>
<td>0.788</td>
<td>0.473</td>
</tr>
<tr>
<td>1995</td>
<td>0.949</td>
<td>0.978</td>
<td>0.575</td>
<td>0.369</td>
</tr>
<tr>
<td>1996</td>
<td>0.941</td>
<td>0.922</td>
<td>0.410</td>
<td>0.321</td>
</tr>
<tr>
<td>1997</td>
<td>0.863</td>
<td>0.897</td>
<td>0.371</td>
<td>0.290</td>
</tr>
<tr>
<td>1998</td>
<td>0.895</td>
<td>0.871</td>
<td>0.509</td>
<td>0.339</td>
</tr>
<tr>
<td>1999</td>
<td>0.817</td>
<td>0.816</td>
<td>0.429</td>
<td>0.281</td>
</tr>
<tr>
<td>2000</td>
<td>0.728</td>
<td>0.723</td>
<td>0.330</td>
<td>0.262</td>
</tr>
<tr>
<td>2001</td>
<td>0.711</td>
<td>0.801</td>
<td>0.421</td>
<td>0.325</td>
</tr>
<tr>
<td>2002</td>
<td>0.696</td>
<td>0.885</td>
<td>0.406</td>
<td>0.262</td>
</tr>
<tr>
<td>2003</td>
<td>0.689</td>
<td>0.937</td>
<td>0.406</td>
<td>0.358</td>
</tr>
<tr>
<td>2004</td>
<td>0.714</td>
<td>1.035</td>
<td>0.452</td>
<td>0.332</td>
</tr>
<tr>
<td>2005</td>
<td>0.812</td>
<td>0.899</td>
<td>0.583</td>
<td>0.453</td>
</tr>
</tbody>
</table>
Many existing studies use Tobin’s Q for estimating investment function
(Scharfstein and Stein(1998), Carpenter and Guariglia(2003), Hong et al.(2007), Choo et al.(2009))

**We tried to show differences in estimated investment functions, thereby demonstrating the importance of precise estimation of Tobin’s Q**

**Investment Function :**

\[ G_{it} = \beta_0 + \beta_1 G_{it(t-1)} + \beta_2 t_{it(t-1)} + \beta_3 ind t_{it(t-1)} + \beta_4 C_{it(t-1)} + dksic + v_t + v_i + u_{it} \Lambda(1) \]

- \( G_{it} = I_{it} \div K_{it(t-1)} \): investment rate (\( I_{it} = \Delta non-current assets + depreciation \))
- \( K_{it(t-1)} \): the previous year non-current assets book value
- \( G_{it(t-1)} \): the previous year investment rate
- \( t_{it(t-1)} \): the previous year Tobin Q
- \( ind t_{it(t-1)} \): the previous year industry median Tobin Q
- \( C_{it(t-1)} = C_{F_{it}} \div K_{it(t-1)} \) (\( C_{F_{it}} \): cash flow=net income+depreciation)
- \( dksic \): KSIC two-digit (16~36) dummy ,
- \( v_t \): year dummy (1991~1996)
Results of Investment Function Estimation

Table 3B shows a marked difference in their coefficients and statistical significance; if we use TQ2, firm-level Tobin’s Q measures are not significant, while the industry median Tobin’s Q is very significant; in case using MB1 and MB2, firm-level Tobin’s Q values are very significant, while the industry median Tobin’s Q show insignificant coefficients; the coefficient of firm-level MB1 is almost 10 times larger than others.

⇒ We can propose that using the MB1 method may result in overestimation of the impact of FV on investment.

<table>
<thead>
<tr>
<th></th>
<th>Fixed Effect</th>
<th>Random Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MB1</td>
<td>MB2</td>
</tr>
<tr>
<td>_cons</td>
<td>-0.1090</td>
<td>0.1921***</td>
</tr>
<tr>
<td></td>
<td>(-0.50)</td>
<td>(3.65)</td>
</tr>
<tr>
<td>Ginv_t</td>
<td>-0.0411</td>
<td>-0.0569*</td>
</tr>
<tr>
<td></td>
<td>(-1.24)</td>
<td>(-1.70)</td>
</tr>
<tr>
<td>tq_1</td>
<td><strong>0.4156</strong>*</td>
<td>0.0486*</td>
</tr>
<tr>
<td></td>
<td>(5.51)</td>
<td>(1.80)</td>
</tr>
<tr>
<td>nd_tq_1</td>
<td>-0.1179</td>
<td>-0.0050</td>
</tr>
<tr>
<td></td>
<td>(-0.51)</td>
<td>(-0.08)</td>
</tr>
<tr>
<td>CF_1</td>
<td>0.5918***</td>
<td>0.6566***</td>
</tr>
<tr>
<td></td>
<td>(5.24)</td>
<td>(5.78)</td>
</tr>
</tbody>
</table>

1) Year dummy and industry dummy are included. Dataset consists of 1,022 firm-year observations.
2) Parentheses denote t or z-statistics of the coefficients.
3) Statistical significances at the 1%, 5%, and 10% levels are denoted by ***, **, and * respectively.
### Results of Investment Function Estimation

#### <Table 3C> Estimation of investment functions: Balanced two-step GMM

<table>
<thead>
<tr>
<th></th>
<th>MB1</th>
<th>MB2</th>
<th>TQ2_A</th>
<th>TQ2_B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ginv_t</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>_cons</td>
<td>0.0307</td>
<td>0.2139***</td>
<td>0.1621***</td>
<td>0.1542***</td>
</tr>
<tr>
<td></td>
<td>(0.18)</td>
<td>(0.04)</td>
<td>(0.06)</td>
<td>(0.06)</td>
</tr>
<tr>
<td>Ginv_1</td>
<td>0.0859***</td>
<td>0.0874**</td>
<td>0.0876**</td>
<td>0.0871**</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.04)</td>
<td>(0.03)</td>
<td>(0.03)</td>
</tr>
<tr>
<td>tq_1</td>
<td>0.2924**</td>
<td>0.0008</td>
<td>-0.0230</td>
<td>-0.0123</td>
</tr>
<tr>
<td></td>
<td>(0.12)</td>
<td>(0.02)</td>
<td>(0.03)</td>
<td>(0.02)</td>
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<tr>
<td>ind_tq_1</td>
<td>-0.1520</td>
<td>-0.0061</td>
<td>0.1274</td>
<td>0.1064</td>
</tr>
<tr>
<td></td>
<td>(0.11)</td>
<td>(0.03)</td>
<td>(0.13)</td>
<td>(0.12)</td>
</tr>
<tr>
<td>CF_1</td>
<td>0.4590***</td>
<td>0.4555***</td>
<td>0.4564***</td>
<td>0.4677***</td>
</tr>
<tr>
<td></td>
<td>(0.12)</td>
<td>(0.14)</td>
<td>(0.13)</td>
<td>(0.12)</td>
</tr>
<tr>
<td>Wald chi2</td>
<td>117.46</td>
<td>73.7</td>
<td>73.32</td>
<td>73.89</td>
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<tr>
<td>Prob&gt;chi2</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
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<tr>
<td>Arellano-Bond test for AR(1)</td>
<td><strong>0.000</strong></td>
<td><strong>0.000</strong></td>
<td><strong>0.000</strong></td>
<td><strong>0.000</strong></td>
</tr>
<tr>
<td>Arellano-Bond test for AR(2)</td>
<td><strong>0.076</strong></td>
<td>0.102</td>
<td>0.111</td>
<td>0.112</td>
</tr>
<tr>
<td>Hansen test</td>
<td>0.407</td>
<td>0.388</td>
<td>0.421</td>
<td>0.399</td>
</tr>
</tbody>
</table>

1) Year dummy are included. Dataset consists of 1,022 firm-year observations.
2) Parentheses denote corrected standard error of the coefficients.
3) Statistical significances at the 1%, 5%, and 10% levels are denoted by ***, **, and * respectively.
From the estimation result of market value of Korean listed manufacturing firm 1980-2005, we find that firm market value can change according to definition of the firm value.
- Firm market value is not same book value.

The estimate by MB1, the simplest market-to-book value ratio, are close to 1.
- However, MB1 is not purely market value of the firm.
- More important, MB1 is not an unbiased estimator.

The MB2 estimates, another market-to-book value ratio using the market value of debt, are substantially lower than MB1 estimates because the market value of liabilities is significantly lower than the book value of liabilities.

Estimation of investment function using MB1 and MB2 also show that the two estimates tend to overestimate the impacts of firm-level Tobin’s Q on investment.
It seems that the estimates by TQ2_B are the most reliable measure to estimate firm market value.

- It uses the market value of liabilities and replacement costs of assets as well as the precise calculating of preferred stock.
- And also, it considers the differences in depreciation rate for different types of tangible assets and by firm.

On the whole, average firm market value of the Korean listed manufacturing firm is below one which can not retrieve replacement cost of assets of the firm.

In recently, firm market value upswing with improvement of corporate management efficiency by restructuring process.
- We also found that before the crisis of 1997, stand-alone firms had a slightly higher firm value than group affiliates.
- After the crisis, the situation is reversed.

It can be very meaningful to study whether average firm market value below one is due to undervaluation of Korean listed firm compared with foreign listed firm in capital market of developed economy.