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Kalman Filter Estimation of a Company's Intangible Assets

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Abstract

A company's market value-added, which equals the excess of a company's market capitalization over its book value, is used as one of the measures for intangible assets valuation in accounting literature. One problem with the approach is that the valuation results are affected by severe fluctuations in capital markets. In this paper, we propose an approach using the Kalman filter for intangible assets valuation. We apply this method to data of Korean electronic companies.

Keywords: Intangible Assets, Kalman Filter, Valuation

1. Introduction

As intangible assets have become more important sources of value-added in this era of knowledge economy, several valuation methods have been developed. Among them, the market capitalization (MC) method, the return on assets (ROA) method and the direct intellectual capital (DIC) method are common examples. See Wesphal's internet site [3] for more discussion.

The MC method basically assumes that a company's market value-added (MVA), the difference between its market value and book value, is its intellectual capital. The approach is intuitive and simple to calculate and apply, but it is subject to severe volatility due to fluctuations in capital markets. The ROA method assumes that the excess of a company's ROA over its industry average reflects its excess intangible assets. This method is also intuitive and easy to apply, but it can only measure a company's excess intangible assets over its

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industry average, not the level of intangible assets. The DIC method is based on identifying various components of a company's intangible assets and then directly evaluating each component. It is complex and expensive to implement because a large number of components have to be identified and individually measured. Additionally, it requires inside information on target firms for calculation.

A state space model, a generalization of latent variable models to a dynamic framework, is the only one to allow statistical inference on time series models with unobserved state variables. Since Harvey (1981) introduced the Kalman (1960) filter to economists as the estimation tool of state space models, the state space model and the Kalman filter have found a wide range of applications in econometrics. For example, the Kalman filter is used by Engle and Watson (1981) for wage rates, Antoncic (1986) for ex ante real interest rates [4)], Burmeister and Wall (1982) and Burneister, Wall, and Hamilton (1986) for expected inflation, Kim and Nelson (1989) for a time-varying monetary reaction of the Federal Reserve, Engel and Kim (1999) for long-run real exchange rate, and Luginbuhl and Vos (1999) for GDP. For more surveys, refer to Engle and Watson (1987), Harvey (1981,1989), Tanizaki (1996), and Kim and Nelson (1999), the last being a particularly excellent source of classical and Gibbs-sampling approaches for state-space models with Markov switching.

This paper proposes an approach using a state space model and the Kalman filter for intangible assets valuation that overcomes the weaknesses of the valuation methods stated above. Our model follows the line of the MC method. However, instead of directly estimating a company's MVA for intangible assets valuation, the model separates MVA into a permanent and a transitory component and identifies the components individually using the Kalman filter. Because capital market fluctuation effects are filtered out in the permanent component, the latter will allow more stable valuations of intangible assets. Besides, like the MC method, our approach is intuitive and simple to calculate and apply. We apply our method to data of Korean electronic companies. We find that our approach results in reliable valuations of intangible assets.

In the next section, we briefly describe the state space model for intangible assets valuation. In Section 3, we demonstrate the approach by applying it to data of Korean electronic companies.

2. Model

A company's MVA (market value-added), q_t, is assumed to consist of a permanent component, y_t, and a transitory component, x_t:

4. An ex ante real interest rate equals nominal interest rates minus an expected inflation rate.

$$q_t = y_t + x_t .$$

For the two components, we consider three models:

$$\text{Model 1:} \quad \begin{cases} y_t = \beta_t y_{t-1} + \eta_t \\ x_t = \varepsilon_t \end{cases}$$

$$\text{Model 2:} \quad \begin{cases} y_t = \beta_{1t} y_{t-1} + \beta_{2t} y_{t-2} + \eta_t \\ x_t = \varepsilon_t \end{cases}$$

$$\text{Model 3:} \quad \begin{cases} y_t = \beta_t y_{t-1} + \eta_t \\ x_t = \gamma_t x_{t-1} + \varepsilon_t \end{cases}$$

in which the noise terms, η_t and ε_t, follow the process

$$\begin{pmatrix} \eta_t \\ \varepsilon_t \end{pmatrix} \sim i.i.d.N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_\eta^2 & 0 \\ 0 & \sigma_\varepsilon^2 \end{pmatrix} \right)$$

Model 1 assumes AR(1) for a permanent component and white noise process for a transitory component. Model 2 assumes AR(2) and white noise, respectively. Model 3 assumes AR(1) for both components.

A state space model consists of two set of equations: measurement equations, which describe how the observations are related to the state variables and transition equations, which describe the evolution of the state variables. Models 1, 2 and 3 are specified in the state space form as follows:

$$\text{Model 1:} \quad \begin{cases} \text{measurement equation}: \quad q_t = (1 \;\; 0) \begin{pmatrix} y_t \\ y_{t-1} \end{pmatrix} + \varepsilon_t \\ \text{transition equation}: \quad \begin{pmatrix} y_t \\ y_{t-1} \end{pmatrix} = \begin{pmatrix} \beta_t & 0 \\ 1 & 0 \end{pmatrix} \begin{pmatrix} y_{t-1} \\ y_{t-2} \end{pmatrix} + \begin{pmatrix} 1 \\ 0 \end{pmatrix} \eta_t \end{cases}$$

$$\text{Model 2:} \quad \begin{cases} \text{measurement equation}: \quad q_t = (1 \;\; 0) \begin{pmatrix} y_t \\ y_{t-1} \end{pmatrix} + \varepsilon_t \\ \text{transition equation}: \quad \begin{pmatrix} y_t \\ y_{t-1} \end{pmatrix} = \begin{pmatrix} \beta_{1t} & \beta_{2t} \\ 1 & 0 \end{pmatrix} \begin{pmatrix} y_{t-1} \\ y_{t-2} \end{pmatrix} + \begin{pmatrix} 1 \\ 0 \end{pmatrix} \eta_t \end{cases}$$

$$\text{Model 3:} \quad \begin{cases} \text{measurement equation}: \quad q_t = (1 \;\; 1) \begin{pmatrix} y_t \\ x_t \end{pmatrix} \\ \text{transition equation}: \quad \begin{pmatrix} y_t \\ x_t \end{pmatrix} = \begin{pmatrix} \beta_t & 0 \\ 0 & \gamma_t \end{pmatrix} \begin{pmatrix} y_{t-1} \\ x_{t-1} \end{pmatrix} + \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} \eta_t \\ \varepsilon_t \end{pmatrix} \end{cases}.$$

In application, one model will be selected for each company based on the log likelihood ratio.

3. Estimation

The model described in Section 2 is applied to yearly data of Korean electronic companies. Companies that have been listed on the Seoul Stock Exchange for 10 or more years were selected for application. The number of selected companies is fifteen. Each company's data period is from the listed year to 1996. A company's market value is defined as the stock price times the number of issued stocks plus debt. Book value is defined as the total value of assets listed in the company's account book. The stock prices used in the calculation were based on the closing prices at settling day.

Table 1 presents the results of the estimations, where the best model is selected based on the log of likelihood. For almost all companies, Model 1 is the best model among the three. Model 3 is the best model for two companies [5].

To demonstrate the results of intangible assets valuation of the MC method and our approach, we plotted both valuation results for three companies: Daewoo Electronics; Maxon Telecom; and Samwha Electric. Figures 1, 2 and 3 show the results [6]. In each figure, qt denotes the MC method's results and yt denotes our results. For all three companies, the estimated values of intangible assets show smoother movements in our approach than in the MC method. The same behavior is observed in the other companies' valuations as well.

From the results stated above, a question may be raised that our approach really separates the permanent component and the transitory component of the MVA. In other words, does our approach really filter out the effects of capital market fluctuation, not just smooth the result of the MC method? Unfortunately, it is not possible to get a definitive answer to this question because we do not have observations of companies' intangible assets values to compare. However, we shall present some evidence that our approach is, at least, plausible. To investigate the question, we set up a regression model

$$\Delta P_t = \alpha_o + \alpha_1 \Delta TA_t + \alpha_2 \Delta y_t + \alpha_3 \Delta(q_{t-1} - y_{t-1}) + e_t, \quad (1)$$

where $\Delta P_t = P_t - P_{t-1}$ = change in stock price, ΔTA_t = change in tangible assets, Δy_t = change in intangible assets estimated by our approach and $\Delta(q_{t-1} - y_{t-1})$ = the difference between lagged values of intangible assets estimated by the MC method and our approach. If our approach really filters out

5. The three models showed almost the same results for intangible assets valuation for all analyzed companies.
6. The results for the remaining companies are available at http://bh.knu.ac.kr/~khjeong/intangible.hwp

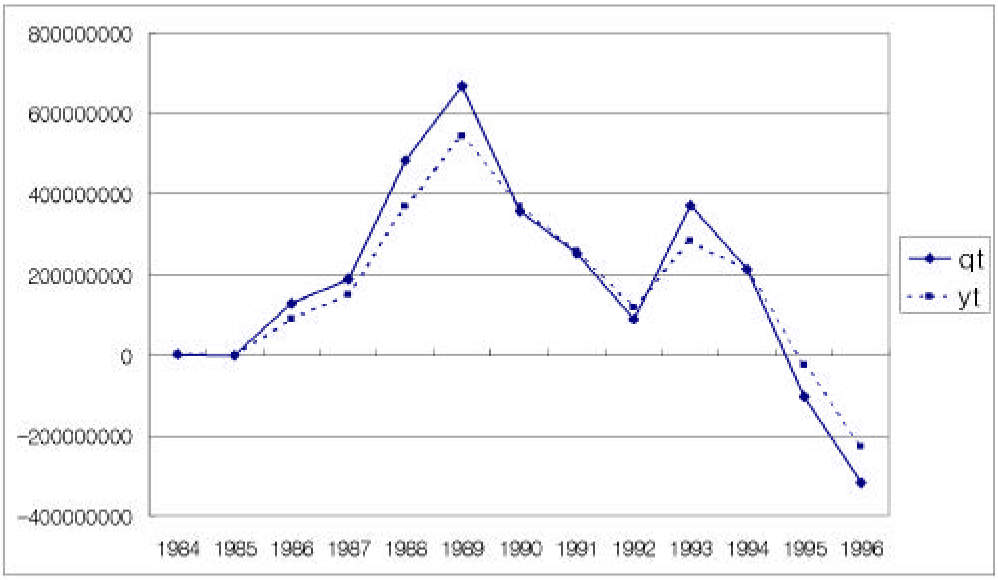
the effects of capital market fluctuation, then the last regressor of equation (1) will measure excess market valuation of intangible assets in time t-1, that is the bubble, implying that the coefficient α_3 is negative. Thus, negativeness of the coefficient α_3 indirectly validates our approach. Table 2 presents the estimation results of the regression equation (1). The table reports are the t value of the coefficient α_3 and R^2. We note that the coefficient α_3 is statistically significant for eight companies out of fifteen and is estimated to be negative for almost all except two. This indirectly validates our approach as a worthy valuation process of intangible assets.

4. Conclusions

We have introduced a new valuation approach for a company's intangible assets. Our approach is based on a state space model and the Kalman filter, in which a company's market value-added (MVA) is specified to consist of a permanent and a transitory component. The first component, identified using the Kalman filter, is employed as the estimated value of intangible assets.

Compared with existing methods, our approach has strengths in that it requires only information readily available, the valuation procedure is intuitive and the effects of capital market fluctuations are smooth. To indirectly validate our approach, we estimate a stock price change regression model, where the difference between the values of the intangible assets estimated by the MC method and our approach is one of regressors. For the regressor, we find that the coefficient is significantly negative, implying the plausibility of our approach.

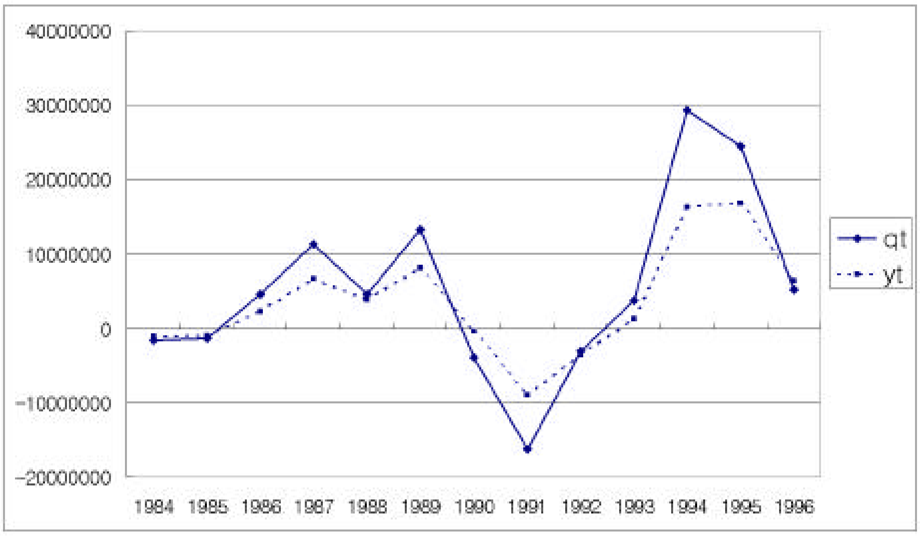
<Figure 1> Daewoo Electronics' Intangible Assets (unit: thousand won)



q_t : a company's MVA (market value-added)

y_t : a company's intangible assets estimated by our approach

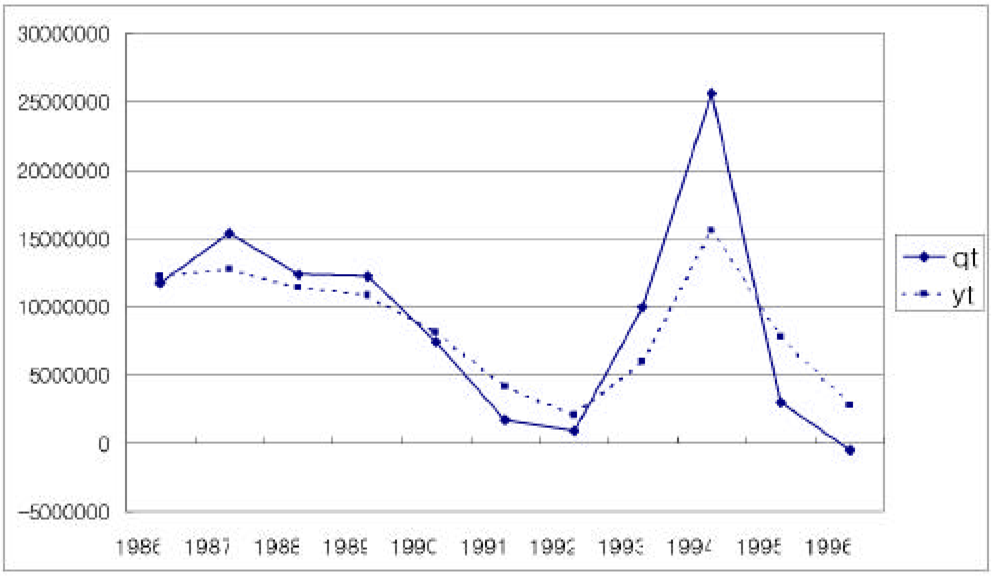
<Figure 2> Maxon Telecom's Intangible Assets (unit: thousand won)



q_t : a company's MVA (market value-added)

y_t : a company's intangible assets estimated by our approach

<Figure 3> Samwha Electric's Intangible Assets (unit: thousand won)



q_t : a company's MVA (market value-added)

y_t : a company's intangible assets estimated by our approach

<Table 1> Model Selection Results

Company	Number of Observations	Selected Model	Log Likelihood Ratio
Daewoo Electronics	13	1	-268.681
Daewoo Telecom	10	1	-195.975
Maxon Telecom	13	1	-231.437
Samsung Electro-Mechanics	17	3	-339.842
Samsung SDI	17	1	-344.910
Samsung Electronics	17	1	-389.411
Samyoung Electronics	17	1	-340.496
Samwha Electric	11	1	-190.426
Samwha Electronics	10	1	-171.738
Sunny Electronics	10	1	-169.273
LG Electronics	17	1	-369.725
Orion Electric	17	1	-329.426
Ez.com	10	1	-167.345
KEC	17	3	-309.185
Etronics	11	1	-94.734

<Table 2> Test Results of α_3 in Equation (1)

Company	t value	p value	degree of freedom	R^2
Daewoo Electronics	-2.116	0.032	9	.875
Daewoo Telecom	-1.393	0.107	6	.483
Maxon Telecom	-0.415	0.346	9	.631
Samsung Electro-Mechanics	-2.126	0.039	13	.639
Samsung SDI	-0.784	0.231	13	.694
Samsung Electronics	0.116	0.545	13	.984
Samyoung Electronics	-2.571	0.021	13	.421
Samwha Electric	-5.77	0.001	7	.983
Samwha Electronics	-14.998	0.000	6	.996
Sunny Electronics	-2.364	0.028	6	.963
LG Electronics	-1.856	0.056	13	.883
Orion Electric	-0.559	0.298	13	.306
Ez.com	-3.037	0.011	6	.929
KEC	-1.360	0.111	13	.357
Etronics	1.632	0.931	7	.337

note: R^2 is coefficient of determination.

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