Pergamon

The International Journal of Accounting
37 (2002) 157–182

The International Journal of Accounting

A test of the Ohlson (1995) model: Empirical evidence from Japan

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Abstract

This paper investigates the validity of the Ohlson [Contemp. Account. Res. 11 (1995) 661] information dynamics (Linear Information Model: LIM) and attempts to improve the LIM. The difficulty concerning the empirical tests of the LIM lies in identifying ν_t, which denotes information other than abnormal earnings. Recent papers, such as those of Myers [Account. Rev. 74 (1999) 1], Hand and Landsman [The pricing of dividends in equity valuation. Working paper, University of North Carolina, 1999], and Barth et al. [Accruals, cash flows, and equity values. Working paper (January) (July), Stanford University, 1999], all try to specify ν_t by using various accounting information. Instead of tackling this difficult task, this paper focuses on serial correlation in the error terms caused by omitting the necessary variable ν_t from the regression equation. The results indicate that adjustment for serial correlation leads to an improvement of the LIM.

Keywords: Ohlson (1995) model; Information dynamics; Other information ν_t; Serial correlation; Durbin's alternative test; GLS

1. Introduction

The work of Ohlson (1995) has attracted considerable attention among accounting researchers since its publication. This seminal paper consists of two main parts: the residual

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PII: S0020-7063(02)00150-4

income valuation model (RIV) and the linear information dynamics. The RIV expresses firm value as the sum of the book value of equity and the present value of future abnormal earnings.[1] However, the RIV is an application of the Dividend Discount Model and its development cannot be attributed to Ohlson (1995).[2] Both Dechow, Hutton, and Sloan (1999) and Lo and Lys (2000) point out that the real contribution of Ohlson comes from his modeling of the linear information dynamics.

The linear information dynamics attempts to identify the mechanism of abnormal earnings and links current information to future abnormal earnings, which allows the development of a valuation model of a firm. However, empirical testing of the Ohlson (1995) linear information dynamics (the Linear Information Model: hereafter LIM) is not easy, because the LIM contains the troublesome variable ν_t. This variable denotes information other than abnormal earnings that has yet to be captured in current financial statements but affects future abnormal earnings. It is often unobservable or very difficult to observe because of its inherent properties. However, ν_t plays an integral role in the LIM and seems to hold the key to the improvement of the LIM. Recent papers, therefore, attempt to specify ν_t by using a number of accounting variables (e.g., Barth, Beaver, Hand, & Landsman, 1999; Dechow et al., 1999; Hand & Landsman, 1998, 1999; Myers, 1999).

This paper tries to improve the Ohlson (1995) LIM without tackling the difficult task of specifying other information ν_t. The Ohlson (1995) LIM assumes that ν_t follows a first-order autoregressive process, AR(1). Omitting this AR(1) variable, ν_t, from regression equations will cause serial correlation in the regression error terms. Based on this presumption, the error-term serial correlation is tested using Durbin's alternative statistics. Serial correlation is detected in about 40% of the sample. The problem of serial correlation in the error terms is rectified by using generalized least squares (GLS). The results generate some improvement in the Ohlson (1995) LIM. This modified LIM is also tested using stock market data. The results of the tests generally support the superiority of the modified LIM over other LIMs that omit the other information term, ν_t.

In addition, the results of this research reveal some interesting similarities to those reported in Barth et al. (1999), Dechow et al. (1999), and Hand and Landsman (1998, 1999). The persistence coefficient of abnormal earnings has almost the same value for each of the prior studies and this paper. Further, the coefficient on book value of equity is negative in this study, which is consistent with previous studies.

The remainder of this paper proceeds as follows. Section 2 reviews the RIV and the LIM. Section 3 conducts empirical tests on the LIM. Section 4 derives the valuation models of the LIMs with testing based on stock market data, and Section 5 concludes the paper.

[1] Abnormal earnings are defined as accounting earnings minus a charge for the cost of capital.

[2] See Lo and Lys (2000) and Palepu, Bernard, and Healy (1996, chap. 7-17) for the historic details of the model.

2. Background

2.1. Residual income valuation model

The Dividend Discount Model defines the value of a firm as the present value of the expected future dividends.

$$V_t = \sum_{i=1}^{\infty} E_t\left[\frac{d_{t+i}}{(1+r)^i}\right], \tag{1}$$

where V_t = value of a firm at date t; $E_t[d_{t+i}]$ = the expected dividends received at date $t+i$; r = the discount rate that is assumed to be constant.

The clean surplus concept dictates that entries to retained earnings are limited to record only periodic earnings and dividends. Then, the relation between book value of equity, earnings, and dividends can be expressed as follows.

$$b_t = b_{t-1} + x_t - d_t, \tag{2}$$

where b_t = book value of equity at date t; x_t = earnings for period t; d_t = dividends paid at date t.

Book value of equity at date $t-1$ multiplied by the capital cost is considered "normal earnings" of the firm. Then, earnings for the period t minus "normal earnings" can be defined as "abnormal earnings."[3]

$$x_t^{\mathrm{a}} \equiv x_t - rb_{t-1}, \tag{3}$$

where x_t^{a} = abnormal earnings for period t.

Simple algebraic manipulation allows Eqs. (2) and (3) to be rewritten as:

$$d_t = x_t^{\mathrm{a}} + (1+r)b_{t-1} - b_t.$$

Using this expression to replace d_{t+i} in Eq. (1) yields the RIV,

$$V_t = b_t + \sum_{i=1}^{\infty} E_t\left[\frac{x_{t+i}^{\mathrm{a}}}{(1+r)^i}\right]. \tag{4}$$

The RIV implies that a firm's value equals its book value of equity and the present value of anticipated abnormal earnings. One of the interesting properties of the RIV is that a firm's value based on the RIV will not be affected by accounting choices.[4]

[3] The terminology is confusing. When it is incorporated into the valuation model, it is usually "residual income," such as "residual income valuation model". But, when it is referred to as earnings, it is either "residual income" or "abnormal earnings". It seems that the term "abnormal earnings" is more commonly used. The terms "residual income valuation model" and "abnormal earnings" are used in this paper.

[4] See Lundholm (1995) and Palepu et al. (1996, chap. 7-5) for the details of this particular property of RIV.

2.2. Linear information model

The LIM was originally proposed in Feltham and Ohlson (1995) and Ohlson (1995). The LIM is an information dynamics model that describes the time-series behavior of abnormal earnings. Dechow et al. (1999) emphasize that the real achievement of Feltham and Ohlson (1995) and Ohlson (1995) is that the LIM creates a link between current information and a firm's intrinsic value.

2.2.1. Ohlson (1995) LIM

The Ohlson (1995) LIM assumes that the time-series behavior of abnormal earnings follows:

$$x^{a}_{t+1} = \omega_{11}x^{a}_{t} + \nu_t + \varepsilon_{1t+1}, \tag{5a}$$

$$\nu_{t+1} = \gamma\nu_t + \varepsilon_{2t+1}, \tag{5b}$$

where x_t^{a} = abnormal earnings for period t ($x_t^{a} \equiv x_t - rb_{t-1}$); ν_t = information other than abnormal earnings; ω_{11} = persistence parameter of abnormal earnings x_t^{a} ($0 \le \omega_{11} < 1$); γ = persistence parameter of other information ν_t ($0 \le \gamma < 1$); ε_{1t}, ε_{2t} = error terms.

The Ohlson (1995) LIM assumes that the source of abnormal earnings is monopoly rents. Although monopoly rents may persist for some time, market competition will force returns toward the cost of capital in the long run. Therefore, the persistence parameter ω_{11} is predicted to lie in the range $0 \le \omega_{11} < 1$.

Combining the RIV in Eq. (4) with the Ohlson (1995) LIM in Eqs. (5a) and (5b) yields the following valuation function:[5]

$$V_t = b_t + \alpha_1 x^{a}_{t} + \beta_1\nu_t,$$

where

$$\alpha_1 = \frac{\omega_{11}}{1 + r - \omega_{11}}$$

$$\beta_1 = \frac{1 + r}{(1 + r - \omega_{11})(1 + r - \gamma)}.$$

2.2.2. Feltham and Ohlson (1995) LIM

Feltham and Ohlson (1995) assume the following four equations with some relabeling for simplicity.[6]

$$x^{a}_{t+1} = \omega_{11}x^{a}_{t} + \omega_{12}b_t + \nu_{1t} + \varepsilon_{1t+1}, \tag{6a}$$

[5] See Ohlson (1995), Appendix 1, for the demonstration of this result.

[6] Although Feltham and Ohlson (1995) use operating assets and operating earnings instead of book value of equity and earnings, both result in the same abnormal earnings. For further details, see Myers (1999, Note 6) and Penman and Sougiannis (1998, pp. 350–351).

$$b_{t+1} = \omega_{22} b_t + \nu_{2t} + \varepsilon_{2t+1}, \tag{6b}$$

$$\nu_{1t+1} = \gamma_1 \nu_{1t} + \varepsilon_{3t+1}, \tag{6c}$$

$$\nu_{2t+1} = \gamma_2 \nu_{2t} + \varepsilon_{4t+1}, \tag{6d}$$

where ω_{11} = persistence parameter of abnormal earnings x_t^a; $(0 \leq \omega_{11} < 1)$; ω_{12} = conservatism parameter $(0 \leq \omega_{12})$; ω_{22} = growth parameter of book value of equity $(0 \leq \omega_{22} < 1 + r)$; ν_{1t}, ν_{2t} = information other than abnormal earnings; γ_1, γ_2 = persistence parameter of ν_{1t} and ν_{2t}, respectively $(0 \leq \gamma_1, \gamma_2 < 1)$; ε_{1t}, ε_{2t}, ε_{3t}, ε_{4t} = error terms.

The Feltham and Ohlson (1995) LIM assumes that abnormal earnings are generated from two sources. The first source is monopoly rents. Since market competition is expected to force returns toward the cost of capital in the long run, ω_{11} is predicted to lie in the range $0 \leq \omega_{11} < 1$. The second source is accounting conservatism. Accounting conservatism generally depresses the valuation of assets below their market value, which generates abnormal earnings that can be calculated by multiplying the difference between market value and book value of equity by the cost of capital. Therefore, under conservative accounting, ω_{12} is predicted to be $0 \leq \omega_{12}$.[7]

Combining the RIV in Eq. (4) with the Feltham and Ohlson (1995) LIM in Eqs. (6a)–(6d) yields the following valuation function:[8]

$$V_t = b_t + \alpha_1 x_t^a + \alpha_2 b_t + \beta_1 \nu_{1t} + \beta_2 \nu_{2t},$$

where

$$\alpha_1 = \frac{\omega_{11}}{1 + r - \omega_{11}}, \quad \alpha_2 = \frac{(1+r)\omega_{12}}{(1 + r - \omega_{11})(1 + r - \omega_{22})},$$

$$\beta_1 = \frac{1 + r}{(1 + r - \omega_{11})(1 + r - \gamma_1)}, \quad \beta_2 = \frac{(1+r)\omega_{12}}{(1 + r - \omega_{11})(1 + r - \omega_{22})(1 + r - \gamma_2)}.$$

Thus, the Feltham and Ohlson (1995) LIM and the Ohlson (1995) LIM allow us to obtain the valuation functions of a firm without requiring either explicit forecasts of future dividends or additional assumptions about the calculation of terminal value. However, whether or not the LIM characterizes reality with reasonable accuracy is purely an empirical matter.

In the next section, I test the validity of the Ohlson (1995) LIM and the Feltham and Ohlson (1995) LIM after transforming them to empirically testable forms.

[7] Feltham and Ohlson (1995) characterize $(0 < \omega_{12})$ as conservative accounting, $(0 = \omega_{12})$ as unbiased accounting, and $(0 > \omega_{12})$ as aggressive accounting.

[8] See appendix in Feltham and Ohlson (1995) for the demonstration of this result.

3. Empirical tests on LIM

3.1. Model development

3.1.1. LIM1 and LIM2: based on the Ohlson (1995) model

It is challenging to test the Ohlson (1995) LIM in Eqs. (5a) and (5b) without any modification, because other information ν_t is unobservable or difficult to measure. Therefore, LIM1 assumes ν_t to be zero and omits it from the model. However, omitting a relevant variable, just because it is unobservable, leads to model misspecification. Therefore, LIM2 assumes ν_t to be a constant. The parameters of the models LIM1 and LIM2 are estimated using OLS regression.

$$\text{LIM1}: \; x^{\mathrm{a}}_{t+1} = \omega_{11} x^{\mathrm{a}}_t + \varepsilon_{t+1}$$

$$\text{LIM2}: \; x^{\mathrm{a}}_{t+1} = \omega_{10} + \omega_{11} x^{\mathrm{a}}_t + \varepsilon_{t+1}$$

3.1.2. LIM3 and LIM4: based on the Feltham and Ohlson (1995) model

Again, estimating the Feltham and Ohlson (1995) LIM in Eqs. (6a)–(6d) without any modification is difficult, because it contains other information ν_{1t}, which is unobservable. Therefore, LIM3 assumes ν_{1t} to be zero, and LIM4 assumes ν_{1t} to be a constant. The parameters of LIM3 and LIM4 are estimated by OLS using the following forms:

$$\text{LIM3}: \; x^{\mathrm{a}}_{t+1} = \omega_{11} x^{\mathrm{a}}_t + \omega_{22} b_t + \varepsilon_{t+1}$$

$$\text{LIM4}: \; x^{\mathrm{a}}_{t+1} = \omega_{10} + \omega_{11} x^{\mathrm{a}}_t + \omega_{22} b_t + \varepsilon_{t+1}$$

3.1.3. LIM5 and LIM6: higher-order autoregression of x_t^a

The Ohlson (1995) LIM assumes that abnormal earnings x_t^{a} is the first-order autoregressive process AR(1). However, in reality, abnormal earnings x_t^{a} might follow a higher-order autoregressive process AR(p). It is possible that the next-period abnormal earnings are affected not only by current-period abnormal earnings but also by past-period abnormal earnings. Therefore, LIM5 examines the second-order autoregressive process of abnormal earnings AR(2), and LIM6 examines the third-order autoregressive process of abnormal earnings AR(3). The parameters of LIM5 and LIM6 are estimated by OLS.

$$\text{LIM5}: \; x^{\mathrm{a}}_{t+1} = \omega_{11} x^{\mathrm{a}}_t + \omega_{12} x^{\mathrm{a}}_{t-1} + \varepsilon_{t+1}$$

$$\text{LIM6}: \; x^{\mathrm{a}}_{t+1} = \omega_{11} x^{\mathrm{a}}_t + \omega_{12} x^{\mathrm{a}}_{t-1} + \omega_{13} x^{\mathrm{a}}_{t-2} + \varepsilon_{t+1}$$

3.1.4. LIM7: serial correlation in the error terms

The models, LIM1–6, are all based on the assumption of ν_t being zero or a constant because of the difficulty in specifying ν_t. However, omitting a necessary variable just because it is unobservable may lead to misspecification of the LIM causing ν_t to be absorbed in the error term. As can be seen in Eqs. (5b) and (6c), both Ohlson (1995) and Feltham and Ohlson (1995) assume that ν_t follows a first-order autoregressive process with $0 \leq \gamma < 1$. If this assumption is true, the residuals of LIM1–6 would show positive serial correlation.

The Durbin–Watson (DW) test is employed to examine serial correlation in the error terms of LIM1–6. However, the DW test should not be used when there is no constant term in the model, and its statistic is known to exhibit a bias toward 2 when lagged dependent variables are included as regressors (Johnston & DiNardo, 1997, pp. 178–184). To guard against these problems, the Durbin's alternative test is primarily used.

Hypothesis testing for serial correlation in the error terms is:

$$\mathrm{H}_0: \ u_{t+1} = \rho u_t + \varepsilon_{t+1} \qquad \rho = 0$$

$$\mathrm{H}_1: \ u_{t+1} = \rho u_t + \varepsilon_{t+1} \qquad \rho > 0.$$

The null hypothesis is that there is no serial correlation in the error terms and the alternative hypothesis is that there is positive serial correlation in the error terms.

LIM7 is a modified version of LIM1 and corrects serially correlated errors. Therefore, only a portion of the LIM1 sample, the part significant under the Durbin's alternative test, comprises the sample for LIM7. The parameters of LIM7 are estimated using a generalized least squares grid-search method (GLS-GRID).[9]

$$\text{LIM7}: \ x^{\mathrm{a}}_{t+1} = \omega_{11} x^{\mathrm{a}}_t + u_{t+1} \text{ and } u_{t+1} = \rho u_t + \varepsilon_{t+1}.$$

3.2. Data

3.2.1. Sample selection

The sample selection requirements are as follows:

(i) the firms are listed on the Tokyo Stock Exchange (TSE) or Osaka Stock Exchange (OSE),
(ii) the accounting period ends in March,
(iii) banks, securities firms, and insurance firms are excluded,
(iv) a minimum of 27 consecutive years of accounting data is available for each firm included in the sample, and
(v) book value of equity is not negative in any year.

[9] The maximum likelihood method (ML) is commonly used to deal with the problem of serial correlation in the error terms. However, ML is known to have a small sample bias when lagged endogenous variables are included in the model. Therefore, GLS is used in this paper.

Table 1
Sample firms

Panel A: Data years of sample firms[a]

Available data years	No. of firms	%
27 years	6	0.9
28 years	46	6.8
29 years	30	4.5
30 years	9	1.3
31 years	3	0.4
32 years	5	0.7
33 years	7	1.0
34 years	294	43.6
35 years	274	40.7
Total	674	100.0

Panel B: Stock markets listed[b]

Stock Market	No. of firms	%
TSE, first section	503	74.6
TSE, second section	116	17.2
OSE, first section	18	2.7
OSE, second section	37	5.5
Total	674	100.0

[a] Available data years for 674 sample firms. Data source is NIKKEI-ZAIMU DATA.

[b] TSE and OSE stand for Tokyo Stock Exchange and Osaka Stock Exchange. The first section has more stringent criteria for listing than the second section. Therefore, the first section usually lists bigger firms than the second section.

The data source is NIKKEI-ZAIMU DATA. As of March 1998, there were 1705 firms that met requirements (i), (ii), and (iii), of which 750 firms also satisfy requirement (iv). Requirement (v) reduces the sample to 674 firms.[10]

The parameters for each of the LIMs for each firm are estimated from the earliest year in which data are available to years ending 1991 to 1998. For example, Fujitsu's accounting data are available for 35 years since 1964. First, the parameters of LIM1–7 are estimated using data from 1964 to 1991. Next, the parameters of LIM1–7 are estimated using data from 1964 to 1992, then from 1964 to 1993, and so on, until 1998. Thus, eight sets of parameters of LIM1–7 are estimated for the periods 1964–1991, 1964–1992, 1964–1993, 1964–1994, 1964–1995, 1964–1996, 1964–1997, and 1964–1998. Requirement (iv) guarantees that the parameters are estimated using at least 18 years of necessary data. Requirement (v) is necessary because firms with negative book value of equity generate negative normal earnings.

Panel A of Table 1 presents the number of years of historical accounting data available. The weighted average is 33.6 years. Panel B of Table 1 presents the stock markets on which

[10] This 27-year requirement limits the generality of this paper because of potential survivorship bias. There is a tradeoff between stable parameters and survivorship bias. This problem is discussed in Morel (1999, Note 7).

sample firms are listed as of March 1998. About three-quarters of the sample firms are listed on the TSE first section. Thus, the sample firms for which the LIM is appropriate are likely to be large firms. The question of whether the selected sample represents a fair cross-section of Japanese firms remains unsolved, though the study certainly provides insight into the impact on large Japanese firms.

3.2.2. Estimating the cost of capital and the computation of abnormal earnings

In defining abnormal earnings, most prior research uses a constant discount rate of 12% or an industry risk premium estimated by using methods similar to those reported in Fama and French (1997). One of the few exceptions is Abarbanell and Bernard (2000) in which beta (CAPM) is used to allow for the time-varying and firm-specific discount rate. Following Abarbanell and Bernard, the discount rate is estimated for each firm-year.

$$r_{jt} = rf_t + \beta_{jt}[0.02],$$

where r_{jt} = estimated cost of capital for firm j in May of year t; rf_t = an interest rate of long-term national bonds (10 years) in May of year t;[11] β_{jt} = estimated CAPM beta for firm j in May of year t.

The CAPM beta is estimated using a rolling regression procedure with a 60-month window against the NIKKEI 225 Index.[12] The market risk premium is assumed to be 2%. The results presented later are qualitatively similar when market risk premium is assumed to be 4% and 6%.

The computation of abnormal earnings is as follows. (After this subsection, subscript j, which denotes a sample firm, will be omitted for ease of exposition.)

$$x^{a}_{jt} \equiv x_{jt} - r_{jt}b_{jt-1},$$

where x_{jt} = income before extraordinary items, net of tax, for firm j for period t; r_{jt} = estimated cost of capital for firm j in May of year t; b_{jt} = book value of equity for firm j at date t.

Strictly speaking, excluding extraordinary items from net income violates the clean surplus relation that underlies the theoretical development of RIV. However, including extraordinary items in the calculation of abnormal earnings makes the estimation of the LIM unstable due to their nonrecurring nature. Therefore, consistent with many prior studies in the United States, income before extraordinary items, net of tax, is used instead of net income.[13] Moreover, tax applicable to extraordinary items is not reported in the income statement in Japan, so income before extraordinary items, net of tax, is estimated using the formula below.

$$\text{ECO (net of tax)}_t = \text{ECO}_t \times \{1 - (\text{CorpTR}_t + \text{ResidentTR}_t)\} \qquad (t = 1964 - 1998),$$

[11] Since 10-year national bonds are not available before 1971, 7-year national bonds are used before 1971 and government-guaranteed bonds are used before 1965.

[12] Where monthly returns are not available for 60 months, due to the lack of stock price data, the beta is assumed to be equal to one.

[13] See Barth et al. (1999), Dechow et al. (1999), Hand and Landsman (1998, 1999), and Myers (1999) for further discussion.

where ECO_t = earnings from continuing operations for year t; $CorpTR_t$ = corporation tax rate for year t; $ResidentTR_t$ = residents' tax rate for year t.[14]

3.3. Results of LIM1–7

3.3.1. Descriptive statistics

Table 2 presents descriptive statistics for each of the variables used in estimating LIM1–7. The mean (median) abnormal earnings over the sample period is ¥37.1 (31.9) million given an assumed market risk premium of 2%. When the 4% and the 6% market risk premium are used, abnormal earnings become predominantly negative with the mean (median) of −¥669.5 (−44.9) million and −¥1376.1 (−137.1) million, respectively. Table 2 also reveals that the mean (median) estimated cost of capital over the sample period is 7.95% (8.80%).

3.3.2. Results of LIM1–6

Panels A and B of Table 3 report the results for LIM1 and LIM2, respectively. As predicted, the persistence coefficients on abnormal earnings, ω_{11}, are positive and their t statistics are statistically significant in both LIM1 and LIM2. The estimates of ω_{11} for LIM1 and LIM2 are 0.73 and 0.67, respectively, both of which are comparable with prior research in the US.[15] The coefficient, ω_{10}, is a constant in LIM2 and it is not statistically significant. The assumption of LIM2 that other information ν_t is a constant, does not seem to be appropriate. The fact that both DW statistics and Durbin's alternative statistics calculated with LIM2 are worse than those of LIM1 supports this view. Other information ν_t does not appear to be absorbed in a constant. The Adj. R^2 for LIM1 and LIM2 is .43 and .41, respectively. These values, however, cannot be compared unconditionally, because LIM1 is the regression equation with no constant term. Still, there does not seem to be much difference between LIM1 and LIM2 in terms of Adj. R^2.[16]

Panels C and D of Table 3 report the results of LIM3 and LIM4, respectively. Both Panels C and D reveal negative coefficients on book value of equity, ω_{22}, though they are not statistically significant. As explained in Section 2.2, the coefficient on book value of equity ω_{22} is predicted to take a positive value under conservative accounting. The finding in this

[14] Residents' tax is levied by local municipalities. The rate differs across regions. The standard tax rate is used in this study. Corporation business tax is ignored, because it was included in general and administrative expenses until 1999.

[15] The persistence parameter ω_{11} in LIM2 is 0.62 in Dechow et al. (1999) and 0.66 in Barth et al. (1999). The Adj. R^2 is .34 and .40, respectively.

[16] In estimating the regression equation with no constant term, R^2 requires special attention. In the case of LIM1, R^2 can be defined as either $\sum \hat{x}_t^{a^2} / \sum x_t^{a^2}$ or the correlation coefficient of x_t^a and $\hat{x}_t^a$. The latter definition of R^2 is used in this paper, because R^2 is the correlation coefficient of x_t^a and $\hat{x}_t^a$ with or without a constant term. Therefore, the comparison of the competing models is possible at least from this perspective. The meaning of the Adj. R^2 in regression equations will vary depending on whether the model includes a constant term or not.

Table 2
Descriptive statistics on variables, 1965–1998 (in ¥ millions)[a]

Description	Variable	Mean	Standard deviation	1Q	Median	3Q
Book value of equity	b	38,482	105,153	2603	8426	29,404
Net income	x	2840	8497	180	666	2171
Abnormal earnings	x^a	37.1	4964.0	− 339.9	31.9	399.0
Cost of capital (%)	r	7.95	1.95	6.42	8.80	9.13

[a] Each variable has a total of 21,986 firm-year observations.

paper is not consistent with current conservative accounting practice. Similar results are reported in prior US research and they are statistically significant.[17]

The sample used in this study is limited to large firms that have been in operation for a long time. Since large Japanese firms tend to possess land and securities that were acquired a long time ago, these assets are recorded at historical costs and should depress the book value of equity, which generates abnormal earnings. Therefore, ω_{22} is predicted to be positive in this study in contrast to the US studies that reports a negative coefficient. However, the finding here does not support this theory.

The coefficient on abnormal earnings, ω_{11}, is positive in both LIM3 and LIM4 and their t statistics are statistically significant. The coefficient ω_{10} is a constant in LIM4 and is not statistically significant. The Adj. R^2 for LIM3 and LIM4 is .47, which indicates a slight improvement compared with the Adj. R^2 of LIM1 and LIM2. However, considering that the number of explanatory variables is increased in LIM3 and LIM4, the difference is statistically small. After all, no improvement is observed by adding book value of equity, b_t, to LIM1 and LIM2 as an explanatory variable.

Panels E and F of Table 3 indicate that the results for LIM5 and LIM6 are similar to those for LIM1–4, which show that only ω_{11} is statistically significant. Still, one noticeable finding is that both DW statistics and Durbin's alternative statistics show no evidence of statistically significant serial correlation in the error terms in LIM5 and LIM6. The negative sign of ω_{12} is also noteworthy. An explanation for these findings is as follows.

The Ohlson (1995) model assumes

$$x^a_{t+1} = \omega_{11} x^a_t + \nu_t + \varepsilon_{1t+1} \qquad (0 \leq \omega_{11} < 1), \tag{5a}$$

$$\nu_{t+1} = \gamma \nu_t + \varepsilon_{2t+1} \qquad (0 \leq \gamma < 1). \tag{5b}$$

[17] In this study, the estimate of ω_{22} and its (t statistic) in LIM4 are − 0.03 (− 1.54). Hand and Landsman (1998) report − 0.02 (− 2.6), Myers (1999) reports − 0.005 (t statistic unknown), Dechow et al. (1999) report − 0.09 (− 77.64), Hand and Landsman (1999) report − 0.006 (− 1.4), and Barth et al. (1999) report − 0.07 (− 7.81).

Table 3
Results of LIM1–6 estimation[a]

(Panel A) LIM1: $x^{a}_{t+1}=\omega_{11}x^{a}_{t}+\varepsilon_{t+1}$

	ω_{11}			DW	D-alt	Adj. R^2
Mean	0.73			1.62	1.28	.43
(*t*-stat)	(6.06)					

(Panel B) LIM2: $x^{a}_{t+1}=\omega_{10}+\omega_{11}x^{a}_{t}+\varepsilon_{t+1}$

	ω_{10}	ω_{11}		DW	D-alt	Adj. R^2
Mean	12.9	0.67		1.61	1.46	.41
(*t*-stat)	(− 0.09)	(4.95)				

(Panel C) LIM3: $x^{a}_{t+1}=\omega_{11}x^{a}_{t}+\omega_{22}b_{t}+\varepsilon_{t+1}$

	ω_{11}	ω_{22}		DW	D-alt	Adj. R^2
Mean	0.63	− 0.01		1.63	1.44	.47
(*t*-stat)	(4.34)	(− 1.04)				

(Panel D) LIM4: $x^{a}_{t+1}=\omega_{10}+\omega_{11}x^{a}_{t}+\omega_{22}b_{t}+\varepsilon_{t+1}$

	ω_{10}	ω_{11}	ω_{22}	DW	D-alt	Adj. R^2
Mean	445.6	0.58	− 0.03	1.64	1.49	.47
(*t*-stat)	(1.20)	(3.79)	(− 1.54)			

(Panel E) LIM5: $x^{a}_{t+1}=\omega_{11}x^{a}_{t}+\omega_{12}x^{a}_{t-1}+\varepsilon_{t+1}$

	ω_{11}	ω_{12}		DW	D-alt	Adj. R^2
Mean	0.90	− 0.26		1.92	0.06	.47
(*t*-stat)	(4.63)	(− 1.28)				

(Panel F) LIM6: $x^{a}_{t+1}=\omega_{11}x^{a}_{t}+\omega_{12}x^{a}_{t-1}+\omega_{13}x^{a}_{t-2}+\varepsilon_{t+1}$

	ω_{11}	ω_{12}	ω_{13}	DW	D-alt	Adj. R^2
Mean	0.90	− 0.28	0.04	1.93	0.00	.47
(*t*-stat)	(4.24)	(− 0.93)	(0.18)			

[a] A total of 5392 estimated parameters and *t* statistics are obtained from 674 sample firms for 8 years from 1991 to 1998. Figures in the table are the mean of the 5392 estimated parameters and *t* statistics. DW and D-alt. denote the Durbin–Watson statistic and Durbin's alternative statistic.

However, ν_t is ignored in LIM1: $x^{a}_{t+1}=\omega_{11}x^{a}_{t}+\varepsilon_{t+1}$ because it is unobservable. Then, ν_t will be absorbed in the error term in LIM1. Since ν_t is assumed to be the first-order autoregressive process, the error terms in LIM1 would be serially correlated as follows:

$$x^{a}_{t+1} = \omega_{11}x^{a}_{t} + u_{t+1}, \tag{7a}$$

$$u_{t+1} = \rho u_t + \varepsilon_{t+1} \qquad (0 \le \rho < 1). \tag{7b}$$

Rewriting Eq. (7a) at date $t-1$ as

$$x^{a}_{t} = \omega_{11}x^{a}_{t-1} + u_t. \tag{7c}$$

Multiplying Eq. (7c) by ρ, then subtracting the equation from Eq. (7a) yields

$$x^{a}_{t+1} - \rho x^{a}_{t} = \omega_{11}(x^{a}_{t} - \rho x^{a}_{t-1}) + u_{t+1} - \rho u_t. \tag{7d}$$

Substituting Eq. (7b) into Eq. (7d) and rearranging the equation results in

$$x_{t+1}^{\mathrm{a}} = (\omega_{11} + \rho)x_t^{\mathrm{a}} - \rho\omega_{11}x_{t-1}^{a} + \varepsilon_{t+1}. \tag{8}$$

Since both ρ and ω_{11} are assumed to take positive values, the coefficient on x_{t-1}^{a} is expected to be negative.

Thus, first-order serial correlation in the error terms is removed in LIM5 and LIM6 by adding an additional lagged variable x_{t-1}^{a} to LIM1. The results of LIM5 and LIM6 show much improvement in both DW statistics and Durbin's alternative statistics over the earlier models, and the coefficients on x_{t-1}^{a} are negative. These findings appear to reinforce the validity of the Ohlson (1995) model.

Finally, the difference from the results reported in prior research in the US for LIM5 and LIM6 should be noted. While the results of LIM1–4 are similar to those of the US research, the results of LIM5–6 are not. To highlight the difference, the results of LIM5–6 are compared with those reported in the US in Table 4.

Table 4 reveals that the coefficient on x_{t-1}^{a}, ω_{12}, is negative in both LIM5 and LIM6. On the other hand, in the US research, the ω_{12} coefficients are positive and their t statistics show that they are all statistically significant. However, as explained previously, ω_{12} may take a negative value when other information ν_t is omitted from the regression equation.

3.3.3. Results of LIM7

The Ohlson (1995) LIM attempts to model the mechanism of abnormal earnings. LIM1 is the simplest form of all and assumes the first-order autoregressive process of abnormal earnings. LIM2–6 are all attempts to improve on LIM1, but they do not perform well in general. It is presumed that the poor performance may be attributed to the omission of ν_t. This variable plays an integral part in the Ohlson (1995) model, but it is often omitted in empirical research because of the difficulty of the observation.

Table 4
Comparison of LIM5–6 and US results[a]

Regression model: $x_{t+1}^{\mathrm{a}} = \omega_{10} + \omega_{11}x_t^{\mathrm{a}} + \omega_{12}x_{t-1}^{\mathrm{a}} + \omega_{13}x_{t-2}^{\mathrm{a}} + \omega_{14}x_{t-3}^{\mathrm{a}} + \varepsilon_{t+1}$

	ω_{10}	ω_{11}	ω_{12}	ω_{13}	ω_{14}	Adj. R^2
LIM5		0.90	− 0.26			.47
		(4.63)	(− 1.28)			
LIM6		0.90	− 0.28	0.04		.47
		(4.24)	(− 0.93)	(0.18)		
Hand and Landsman (1998)	n/a	0.55	0.04			.32
		(8.8)	(2.1)			
Dechow et al. (1999)	− 0.01	0.59	0.07	0.01	0.01	.35
	(− 12.36)	(68.31)	(7.50)	(0.86)	(1.59)	
Hand and Landsman (1999)	n/a	0.61	0.14			.45
		(10.0)	(3.0)			

Sources: Dechow et al. (1999, p. 17), Hand and Landsman (1998, p. 37, 1999, p. 30).

[a] The coefficient on each variable appears in the top row, and the corresponding t statistic appears in parentheses in the bottom row.

Table 5
Number of LIM1 observations that are significant in tests of serial correlation in the errors[a]

Estimation years	No. of observations	No. of AR(1) observations	%
1965–1991	674	188	27.9
1965–1992	674	253	37.5
1965–1993	674	272	40.4
1965–1994	674	274	40.7
1965–1995	674	272	40.4
1965–1996	674	286	42.4
1965–1997	674	285	42.3
1965–1998	674	272	40.4
Total	5392	2102	39.0

[a] Durbin's alternative statistic is used to test for serial correlation in LIM1 errors. The number of degrees of freedom = the number of observations − 2, and the significance level is 5% using a one-tailed test.

However, as ν_t does seem to hold the key to the improvement of the LIM, recent research in the US attempts to specify ν_t. Myers (1999) uses order backlog, Hand and Landsman (1998, 1999) use dividends, Barth et al. (1999) use accruals and cash flows, and Dechow et al. (1999) use the absolute value of abnormal earnings, the absolute value of special accounting items, the absolute value of accounting accruals, dividends, an industry-specific variable, and analysts' earnings forecasts as proxies for ν_t. In this paper, LIM1 is adjusted to remove serial correlation from the residuals. In effect, LIM7 tries to circumvent the difficulty of specifying ν_t by correcting serial correlation in the error terms in LIM1 that could arise from the omission of ν_t.

Durbin's alternative statistic is used to test for serial correlation in the errors. The significance level is 5% using a one-tailed test.[18] Table 5 shows that, of the entire sample of 5392 firm-year observations in LIM1, 2102 observations are significant in the test for serial correlation, which is about 40% of the entire sample.[19] Panel A of Table 6 shows the results of estimating the parameters of LIM7 by GLS-GRID using the 2102 observations. To highlight the difference between LIM7 and LIM1, the results of LIM1 estimation using the same 2102 observations are shown in Panel B of Table 6. The Adj. R^2 increases from .48 in LIM1 to .53 in LIM7, and Durbin's alternative statistic also improves from 2.71 in LIM1 to 0.09 in LIM7 indicating that serial correlation is removed from the error terms.

[18] The Durbin's alternative test is a test of the coefficient β_1 in $\hat{u}_{t+1} = \beta_1 \hat{u}_t + \beta_2 x^a_{t-1} + \varepsilon_{t+1}$ in the case of LIM1. Therefore, the number of degrees of freedom is the number of observations minus two.

[19] Myers (1999) notes that the mean (median) DW statistic for LIM2 and LIM4 is 1.895 (1.942) and 1.937 (1.958), respectively, and there are few firms with DW statistics far from 2. These results are inconsistent with the findings in this paper. One possible explanation for this inconsistency is that Myers used the DW statistic to test for serial correlation in the error terms, which is known to have a bias toward 2 when lagged endogenous variables are included in the models.

Table 6
Results of LIM7 estimation[a]

(Panel A) LIM7: $x^a_{t+1}=\omega_{11}x_t^a+u_{t+1}$, $u_{t+1}=\rho u_t+\varepsilon_{t+1}$					
	ω_{11}	ρ	DW	D-alt	Adj. R^2
Mean	0.52	0.50	1.72	0.09	.53
(t-stat)	(2.04)	(1.88)			
(Panel B) LIM1: $x^a_{t+1}=\omega_{11}x_t^a+\varepsilon_{t+1}$					
	ω_{11}		DW	D-alt	Adj. R^2
Mean	0.75		1.31	2.71	.48
(t-stat)	(6.27)				

[a] The comparison of the parameters between LIM1 and LIM7 with regard to the 2102 firm-year observations in Table 5 is reported. Figures in the table are the mean of the 2102 estimated parameters and t statistics. DW and D-alt denote the Durbin–Watson statistic and the Durbin's alternative statistic.

3.4. Stationarity of abnormal earnings

Tests of the stationarity of abnormal earnings are of particular interest in the investigation of the validity of the Ohlson (1995) model. The Ohlson (1995) model assumes that abnormal earnings converge eventually due to market competition. If abnormal earnings follow a random-walk process, the validity of the Ohlson (1995) model is in doubt. Therefore, the stationarity of abnormal earnings for the 674 firms is investigated using the Augmented Dickey–Fuller (hereafter ADF) test. The problem of the ADF test is that the actual data-generating process is unknown. Therefore, three types of unit root tests are conducted in this paper:

$$\text{(No Constant or Trend)}\quad \Delta x_t^a = \gamma x_{t-1}^a + \sum_{p=2}^{4} \beta_p \Delta x_{t-p+1}^a + \varepsilon_t,$$

$$\text{(With Constant)}\quad \Delta x_t^a = \alpha_0 + \gamma x_{t-1}^a + \sum_{p=2}^{4} \beta_p \Delta x_{t-p+1}^a + \varepsilon_t,$$

$$\text{(With Constant and Trend)}\quad \Delta x_t^a = \alpha_0 + \alpha_1 t + \gamma x_{t-1}^a + \sum_{p=2}^{4} \beta_p \Delta x_{t-p+1}^a + \varepsilon_t.$$

Column (i) of Table 7 shows the results of the ADF test on the stationarity of abnormal earnings x_t^a. Maximum lags are set at 3 and optimal lags are chosen using the AIC. The column reveals that 61.7% of the sample firms reject the null hypothesis of a unit root at the 10% level when neither constant nor time trend is added. However, when both a constant and a time trend are added to the model, only 28.9% of the sample firms reject the null of a unit root. This may be due to misspecification of the simpler model or it may be

Table 7
Stationarity of abnormal earnings using the ADF test[a]

Model[b]	(i) x_t^{a} [c] Percentage of observations rejected at the 10% level	(i) x_t^{a} [c] Percentage of observations rejected at the 5% level	(ii) Δx_t^{a} [c] Percentage of observations rejected at the 10% level	(ii) Δx_t^{a} [c] Percentage of observations rejected at the 5% level
τ (No Constant or Trend)	61.7	44.5	96.7	93.6
τ_{μ} (With Constant)	34.3	22.7	87.1	79.1
τ_{τ} (With Constant and Trend)	28.9	19.7	71.2	54.2

Maximum lags are set at three and optimal lags are chosen using the AIC.

[a] A total of 674 firms are used to test the stationarity of their abnormal earnings.

[b] Three types of unit root tests are performed:

$$\text{(No Constant or Trend)}\quad \Delta x_t^{\mathrm{a}} = \gamma x_{t-1}^{\mathrm{a}} + \sum_{p=2}^{4} \beta_p \Delta x_{t-p+1}^{\mathrm{a}} + \varepsilon_t,$$

$$\text{(With Constant)}\quad \Delta x_t^{\mathrm{a}} = \alpha_0 + \gamma x_{t-1}^{\mathrm{a}} + \sum_{p=2}^{4} \beta_p \Delta x_{t-p+1}^{\mathrm{a}} + \varepsilon_t,$$

$$\text{(With Constant and Trend)}\quad \Delta x_t^{\mathrm{a}} = \alpha_0 + \alpha_1 t + \gamma x_{t-1}^{\mathrm{a}} + \sum_{p=2}^{4} \beta_p \Delta x_{t-p+1}^{\mathrm{a}} + \varepsilon_t.$$

[c] (i) x_t^{a} tests the stationarity of abnormal earnings.
(ii) Δx_t^{a} tests the stationarity of first-differenced abnormal earnings.

due to the decrease in the degrees of freedom caused by adding extra regressors to the model.[20]

First-differenced abnormal earnings Δx_t^{a} are also tested for stationarity and the results are shown in Column (ii) of Table 7. This reveals that 96.7% of the sample firms reject the null hypothesis of a unit root at the 10% level when neither constant nor time trend is added. Even when these are added, 71.2% of the sample firms reject the null hypothesis.

[20] Qi, Wu, and Xiang (2000) conduct Phillips–Perron unit root test for abnormal earnings without a time trend using 95 firms as a sample. They report that 78.9% of their sample firms reject the null of a unit root. However, when a time trend is added to the model, they report that the rejection rate drops to 66%.

These results are difficult to interpret. However, for some firms, the possibility of their abnormal earnings following a random-walk process appears reasonable.[21,22]

4. Empirical tests of the valuation models using stock market data

The time-series behavior of abnormal earnings was investigated in the previous section. LIM1 assumes the first-order autoregressive process of abnormal earnings, and adding extra regressors to the model, such as book value of equity and additional lags of abnormal earnings, does not lead to the improvement over what is obtained by LIM1. However, when serial correlation in the error terms of LIM1 is corrected in LIM7, some improvement in explanatory power is observed.

In this section, the theoretical values for LIM1, LIM2, and LIM7 are derived and these competing models are evaluated by comparing their theoretical values to the stock market values in Japan. In assessing the competing models, certain criteria are required. This paper uses two criteria for the assessment of the models based on the two-dimensional framework suggested by Lee, Myers, and Swaminathan (1999).[23] The first criterion is the models' ability

[21] Although it is often argued that heteroskedasticity is less of a concern in time-series data than in cross-sectional data (Gujarati, 1995, p.359), there are some studies in which deflated variables are used in time-series regressions to mitigate heteroskedasticity (e.g., Bar-Yosef, Callen, & Livnat, 1996; Dechow et al., 1999; Morel, 1999). Therefore, LIM1–7 are tested for heteroskedasticity in the errors using the Lagrangian Multiplier heteroskedasticity test. The results show that, of the total 37,744 observations, 5554 reject the null hypothesis of homoskedasticity in the errors at the 5% level, which is one seventh of the total sample. Thus, heteroskedasticity in the errors does not appear to pose a material problem in the estimation of LIM1–7.

[22] In choosing the order p in an autoregressive model AR(p), which is exactly the case of LIM1, LIM5, and LIM6, it is much more common to use the Final Prediction Error (FPE) (Akaike, 1969, 1970) or the Akaike Information Criteria (AIC) (Akaike, 1973) than R^2 and Adj. R^2. Therefore, LIM1–7 are evaluated using the AIC. The results indicate that there is not much difference in the mean AIC between the models LIM1–4, which implies that adding a constant term and/or book value of equity to LIM1 does not enhance LIM1. LIM7 appears to be better than LIM1 in terms of the AIC with a difference of 6.8 in the mean AIC. The most noticeable finding, however, is the difference between LIM1, LIM5, and LIM6. LIM1, LIM5, and LIM6 assume that abnormal earnings follow the AR(1), AR(2), and AR(3) processes, respectively, and their mean AIC is 438.1, 422.1, and 408.3, respectively. The mean AIC becomes smaller as the order of autoregressive process becomes higher. This implies that a multilagged formulation is more appropriate than the single lagged formulation of the Ohlson (1995) information dynamics. Similar findings are reported in Bar-Yosef et al. (1996), Morel (1999), and O'Hanlon (1994, 1995). Bar-Yosef et al. and Morel test the lag structure of the Ohlson (1995) information dynamics using the FPE and the AIC_C (Hurvich & Tsai, 1989, 1991), respectively. Their findings support a multilagged information dynamic rather than the single lagged information dynamic of the Ohlson (1995) model. O'Hanlon tries to identify the time-series properties of abnormal earnings using an Autoregressive Integrated Moving Average (ARIMA) process and finds that all firms' abnormal-earnings series cannot be characterized into a particular class of time-series process.

[23] The two dimensions suggested by Lee et al. (1999) are tracking ability and predictive ability. Tracking ability investigates the time-series relation between stock price and estimated value, and predictive ability examines the predictive power for future returns. Although this paper focuses on the cross-sectional relation between stock price and estimated value, the basic idea of the two-dimensional framework is the same.

to explain contemporaneous stock prices. If the stock market in Japan reflects the true value of a firm correctly, the best model will be the one that explains contemporaneous stock prices best. This is accomplished by regressing actual stock prices on theoretical stock prices based on the competing models. The Adj. R^2 values obtained from the models are compared. It is assumed that the higher the Adj. R^2, the more explanatory power the model has over contemporaneous stock prices.

The second criterion is the models' ability to predict future stock returns. The motive behind this is the basic idea of fundamental analysis, that is, the stock market in Japan may not correctly price the intrinsic value of a firm immediately but they will reflect it eventually.[24] First, quintile portfolios are constructed according to the ratio of a model's theoretical stock price to actual stock price. Then, a strategy is set in place where the top quintile portfolio is bought and the bottom quintile portfolio is sold. These portfolios are maintained for a certain period of time and the performance is compared. The top quintile consists of underpriced firms and the bottom quintile consists of overpriced firms relative to their theoretical firm values. The higher the future stock returns, the better the predictive ability of the model.[25]

4.1. Valuation functions of LIM1, LIM2, and LIM7

4.1.1. V_{L1} model

The V_{L1} model is the valuation model of LIM1 ($x^{\mathrm{a}}_{t+1} = \omega_{11} x_t^{\mathrm{a}} + \varepsilon_{t+1}$). Expected future abnormal earnings are $E_t[x^{\mathrm{a}}_{t+1}] = \omega_{11} x^{\mathrm{a}}_{t+i-1}$. The persistence parameter ω_{11} is the estimated coefficient on x_t^{a} in LIM1. Other information ν_t is ignored by the assumption of LIM1.

The value of a firm is expressed as

$$V_{\mathrm{L1}} = b_t + \sum_{i=1}^{\infty} \frac{\omega_{11} x^{\mathrm{a}}_{t+i-1}}{(1+r)^i}.$$

Simplifying this equation yields

$$V_{\mathrm{L1}} = b_t + \frac{\omega_{11}}{(1+r-\omega_{11})} x^{\mathrm{a}}_t.$$

The condition for convergence is $|\omega_{11}| < 1 + r$.

4.1.2. V_{L2} model

The V_{L2} model is the valuation model of LIM2 ($x^{\mathrm{a}}_{t+1} = \omega_{10} + \omega_{11} x_t^{\mathrm{a}} + \varepsilon_{t+1}$). Expected future abnormal earnings are $E_t[x^{\mathrm{a}}_{t+1}] = \omega_{10} + \omega_{11} x^{\mathrm{a}}_{t+i-1}$. The parameters ω_{10}, ω_{11} are the estimated

[24] See Malkiel (1999, p. 119) and Palepu et al. (1996, chap. 8-5) for further detail on fundamental analysis.

[25] See Frankel and Lee (1998) for further detail on this strategy.

constant and coefficient on x_t^{a} in LIM2. LIM2 assumes that other information ν_t is absorbed in a constant term ω_{10}.

The value of a firm is expressed as

$$V_{\mathrm{L2}} = b_t + \sum_{i=1}^{\infty} \frac{\omega_{10} + \omega_{11} x_{t+i-1}^{\mathrm{a}}}{(1+r)^i}.$$

Simplifying this equation yields

$$V_{\mathrm{L2}} = b_t + \frac{(1+r)\omega_{10}}{(1+r-\omega_{11})r} + \frac{\omega_{11}}{(1+r-\omega_{11})} x_t^{\mathrm{a}}.$$

The condition for convergence is $|\omega_{11}| < 1 + r$.

4.1.3. V_{L7} model

The V_{L7} model is the valuation model of LIM7 ($x_{t+1}^{\mathrm{a}} = \omega_{11} x_t^{\mathrm{a}} + u_{t+1}$, $u_{t+1} = \rho u_t + \varepsilon_{t+1}$). As can be seen in the demonstration of Eq. (8), expected future abnormal earnings are $E_t[x_{t+1}^{\mathrm{a}}] = (\omega_{11} + \rho) x_{t+i-1}^{\mathrm{a}} - \rho\omega_{11} x_{t+i-2}^{\mathrm{a}}$. The parameters ω_{11} and ρ are the estimated coefficients on x_t^{a} and u_t in LIM7. LIM7 assumes that other information ν_t is absorbed in the error term u_t. As a result, u_t follows a first-order autoregressive process.

The value of a firm is expressed as

$$V_{\mathrm{L7}} = b_t + \sum_{i=1}^{\infty} \frac{(\omega_{11} + \rho) x_{t+i-1}^{\mathrm{a}} - \rho\omega_{11} x_{t+i-2}^{\mathrm{a}}}{(1+r)^i}.$$

Simplifying this equation yields

$$V_{\mathrm{L7}} = b_t + \left\{ \frac{(1+r)(\omega_{11}+\rho) - \omega_{11}\rho}{(1+r)^2 - (1+r)(\omega_{11}+\rho) + \omega_{11}\rho} \right\} x_t^{\mathrm{a}} - \left\{ \frac{(1+r)\omega_{11}\rho}{(1+r)^2 - (1+r)(\omega_{11}+\rho) + \omega_{11}\rho} \right\} x_{t-1}^{\mathrm{a}}.$$

The conditions for convergence are $|\omega_{11}| < 1 + r$ and $|\rho| < 1 + r$.

It should be noted that computation of V_{L7} is not applicable to the entire sample, because LIM7 is a modified version of LIM1. It is applied only to the portion of the sample exhibiting serial correlation in the LIM1 error terms. Therefore, of the total 5392 firm-year observations, the V_{L7} formula only applies to 2102 firm-year observations in Table 5, while the remainder is computed using the V_{L1} formula.

These three valuation models are summarized in Fig. 1

Valuation Model	**Ohlson (1995) Linear Information Model**	**Expected future abnormal earnings x^a_{t+i} at date *t***	**Theoretical firm value at date *t***
V_{L1} (LIM1)	Other information v_t is ignored. LIM1: $x^a_{t+1} = \omega_{11}x^a_t + \varepsilon_{t+1}$	$E_t[x^a_{t+i}] = \omega_{11}x^a_{t+i-1}$	$V_{L1} = b_t + \dfrac{\omega_{11}}{(1+r-\omega_{11})}x^a_t$
V_{L2} (LIM2)	Other information v_t is a constant. LIM2: $x^a_{t+1} = \omega_{10} + \omega_{11}x^a_t + \varepsilon_{t+1}$	$E_t[x^a_{t+i}] = \omega_{10} + \omega_{11}x^a_{t+i-1}$	$V_{L2} = b_t + \dfrac{(1+r)\omega_{10}}{(1+r-\omega_{11})r} + \dfrac{\omega_{11}}{(1+r-\omega_{11})}x^a_t$
V_{L7} (LIM7)	Other information v_t is absorbed in the error term u_t, and u_t follows an AR(1) process. LIM7: $x^a_{t+1} = \omega_{11}x^a_t + u_{t+1}$, $u_{t+1} = \rho u_t + \varepsilon_{t+1}$	$E_t[x^a_{t+i}] = (\omega_{11}+\rho)x^a_{t+i-1} - \rho\omega_{11}x^a_{t+i-2}$	$V_{L7} = b_t + \left\{\dfrac{(1+r)(\omega_{11}+\rho)-\omega_{11}\rho}{(1+r)^2-(1+r)(\omega_{11}+\rho)+\omega_{11}\rho}\right\}x^a_t - \left\{\dfrac{(1+r)\omega_{11}\rho}{(1+r)^2-(1+r)(\omega_{11}+\rho)+\omega_{11}\rho}\right\}x^a_{t-1}$

Fig. 1. Summary of the LIM1, LIM2, and LIM7 valuation models that are examined in the stock price tests. Abnormal earnings for firm *j* for period *t*, $x_{jt}{}^a$, is computed as (unless necessary, subscript *j* is omitted throughout the paper for ease of exposition.)

$$x^a_{jt} = x_{jt} - r_{jt}b_{jt-1},$$

where x_{jt} = income before extraordinary items, net of tax, for firm *j* for period *t*; b_{jt} = book value of equity for firm *j* at date *t*; r_{jt} = estimated cost of capital for firm *j* at date *t*.

Expected future abnormal earnings at date *t*, $E_t[x^a_{t+i}]$ (i = 1, 2, 3...), and the condition for convergence in computing a theoretical firm value.

V_{L1} model: $E_t[x^a_{t+i}] = \omega_{11}x^a_{t+i-1}$, ω_{11} is estimated from the regression of LIM1 ($x^a_{t+i} = \omega_{11}x_t{}^a + \varepsilon_{t+1}$). The condition for convergence is $|\omega_{11}| < 1 + r$.

V_{L2} model: $E_t[x^a_{t+i}] = \omega_{10} + \omega_{11}x^a_{t+i-1}$, ω_{10} and ω_{11} are estimated from the regression of LIM2 ($x^a_{t+i} = \omega_{10} + \omega_{11}x_t{}^a + \varepsilon_{t+1}$). The condition forconvergence is $|\omega_{11}| < 1 + r$.

V_{L7} model: $E_t[x^a_{t+i}] = (\omega_{11}+\rho)x^a_{t+i-1} - \rho\omega_{11}x^a_{t+i-2}$, ω_{11} and ρ are estimated from the regression of LIM7 ($x^a_{t+i} = \omega_{11}x_t{}^a + u_{t+1}$, $u_{t+1} = \rho u_t + \varepsilon_{t+1}$). The conditions for convergence are $|\omega_{11}| < 1 + r$ and $|\rho| < 1 + r$.

4.2. Explanatory power of contemporaneous stock prices

The relative ability of the three valuation models in Fig. 1 to explain contemporaneous stock prices is tested in this subsection. Actual stock prices at the end of May are regressed cross-sectionally on theoretical stock prices for 8 years, from 1991 to 1998. The sample consists of the 674 firms selected in Section 3.2.

The theoretical stock price is computed as

$$\text{Theoretical stock price} = \frac{V_{\text{L1}}, V_{\text{L2}}, V_{\text{L7}}}{\text{Number of shares outstanding at the end of May}},$$

and the regression equation takes the form,[26]

$$\text{Actual stock price}_t = \alpha + \beta \text{Theoretical stock price}_t + \varepsilon_t.$$

$$(t = \text{the end of May, } 1991 - 1998)$$

Fig. 2 reports the results of the explanatory-power test for the three valuation models. The V_{L2} model has the lowest explanatory power with the mean Adj. R^2 of .444. It appears that the assumption of LIM2 that other information ν_t is a constant is not appropriate. Comparing the V_{L1} model and the V_{L7} model in terms of Adj. R^2 reveals that the V_{L7} model excels the V_{L1} model in 6 out of the 8 years. It appears that the V_{L7} model has more explanatory power over contemporaneous stock prices than the V_{L1} model, although the difference is subtle with the mean Adj. R^2 of .494 and .483 for the V_{L7} and V_{L1} models, respectively. However, as explained previously, less than 40% of the entire sample in the V_{L7} model (2102 observations in Table 5) is computed using the V_{L7} formula. The remainder is computed using the V_{L1} formula. Thus, the real explanatory power of the V_{L7} model is somewhat diluted. When the 2102 V_{L7} observations are matched with the V_{L1} observations, the results show that Adj. R^2 values for the V_{L7} model is higher than that for the V_{L1} model in 7 out of the 8 years with the 8-year mean Adj. R^2 of .480 and .401, respectively. Thus, the V_{L7} model appears to possess more explanatory power over contemporaneous stock prices than the V_{L1} model.

4.3. Predictive ability of future stock returns

The relative ability of the three valuation models in Fig. 1 to predict future stock returns is investigated in this subsection. First, quintile portfolios are formed on the basis of the ratio of the model's theoretical stock price to actual stock price at the end of May for 8 years from

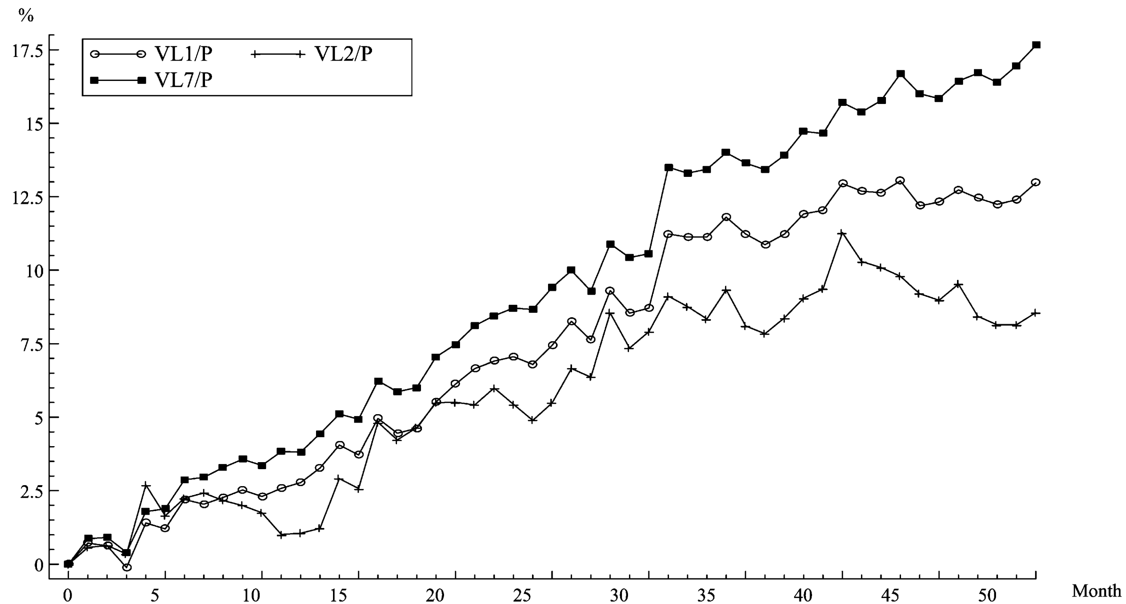
[26] Most sample firms have a par value of ¥50, but there are some sample firms whose par value is not ¥50. With regard to these firms, actual stock prices and the number of shares outstanding are converted to match other sample firms that have the par value of ¥50.

Adj.R^2	Mean	1991	1992	1993	1994	1995	1996	1997	1998
V_{L1}	0.483	0.545	0.496	0.432	0.449	0.508	0.467	0.448	0.498
V_{L2}	0.444	0.539	0.443	0.381	0.390	0.528	0.430	0.405	0.423
V_{L7}	0.494	0.531	0.475	0.435	0.511	0.528	0.488	0.469	0.503

Fig. 2. The Adj. R^2 of V_{L1}, V_{L2}, and V_{L7} by the year. Actual stock prices at the end of May are regressed cross-sectionally on theoretical stock prices of the model for 8 years from 1991 to 1998. The sample consists of 674 firms in Table 1.

$$\text{Theoretical stock price} = \frac{V_{L1}, V_{L2}, V_{L7}}{\text{Number of shares outstanding at the end of May}}.$$

$$\text{Actual stock price}_t = \alpha + \beta\,\text{Theoretical stock price}_t + \varepsilon_t. \qquad (t = \text{the end of May, } 1991 - 1998).$$



Return	0M	5M	10M	15M	20M	25M	30M	35M	40M	45M	50M
V_{L1}/P	0.0%	1.2%	2.3%	3.7%	6.1%	7.4%	8.7%	11.2%	12.9%	12.3%	13.0%
V_{L2}/P	0.0%	1.6%	1.7%	2.6%	5.5%	5.5%	7.9%	8.1%	11.3%	9.0%	8.6%
V_{L7}/P	0.0%	1.9%	3.4%	4.9%	7.5%	9.4%	10.6%	13.6%	15.7%	15.8%	17.6%

Fig. 3. Future stock returns of the V_{L1}/P, V_{L2}/P, and V_{L7}/P strategy. Quintile portfolios are formed according to the ratio of the model's theoretical stock price to actual stock price at the end of May for 8 years from 1991 to 1998. The top quintile portfolio consists of underpriced firms and the bottom quintile portfolio consists of overpriced firms relative to their theoretical firm values. The strategy is to take a long position in the top quintile portfolio and a short position in the bottom quintile portfolio. These portfolios are maintained for up to 50 months. This figure depicts the mean of the 8-year returns produced by the V_{L1}/P, V_{L2}/P, and V_{L7}/P strategy. The sample consists of 674 firms in Table 1.

$$\text{Portfolio construction criterion}_t = \frac{\text{Theoretical stock price of } V_{L1}, V_{L2}, V_{L7} \text{ in year } t}{\text{Actual stock price at the end of May of year } t} \qquad (t = \text{year } 1991 - 1998).$$

1991 to 1998. The top quintile portfolio consists of underpriced firms and the bottom quintile portfolio consists of overpriced firms relative to their theoretical firm values. The strategy is to take a long position in the top quintile portfolio and a short position in the bottom quintile portfolio, and maintain these positions for up to 50 months.[27] Higher future stock returns indicate better predictive ability of the model. The sample consists of 674 firms selected in Section 3.2 described earlier.[28]

$$\text{Portfolio construction criterion}_t = \frac{\text{Theoretical stock price of } V_{L1}, V_{L2}, V_{L7} \text{ in year } t}{\text{Actual stock price at the end of May of year } t} \qquad (t = \text{year } 1991 - 1998)$$

V_{L1}/P denotes the abovementioned trading strategy that is based on the V_{L1} model in Fig. 1. The V_{L2}/P and the V_{L7}/P strategies are formed in the same manner.

Fig. 3 illustrates the results of the V_{L1}/P, the V_{L2}/P, and the V_{L7}/P strategies. It reveals that the V_{L7}/P strategy has the greatest ability to predict future stock returns followed by the V_{L1}/P strategy and the V_{L2}/P strategy. The poor performance of the V_{L2}/P strategy seems to indicate that the assumption of LIM2, which is that other information ν_t is a constant, is not appropriate. The V_{L7}/P strategy earns higher returns than the V_{L1}/P strategy, which appears to indicate the superiority of LIM7 over LIM1 with respect to the predictive ability of future stock returns.

Thus, in terms of both explanatory power of contemporaneous stock prices and predictive ability of future stock returns, the V_{L7} model performs better than the V_{L1} model. These findings support the superiority of LIM7 over LIM1 from the perspective of the stock market in Japan.

5. Conclusions

This study examines the validity of the Ohlson (1995) information dynamics model and attempts to improve it. First, the theoretical developments of the RIV and the LIM are discussed. The LIM is then transformed to give seven empirically testable models, namely, LIM1–7. These models are tested using a sample of 674 Japanese firms.

LIM1 assumes that abnormal earnings follow a first-order autoregressive process with other information ν_t being ignored, and LIM2–6 attempt to improve on this model. The results of the tests indicate that LIM2–6 basically fail to improve on LIM1. In spite of the failure, the results of LIM2–6 coupled with those of the Durbin's alternative test help to

[27] The effects of dividends, stock splits, capital reduction, changes in par value, and issuance of new shares on stock prices are adjusted.

[28] Actual stock prices are obtained until the end of 1999. Therefore, the portfolios constructed at the end of May 1996–1998 do not have the complete stock-price data of 50 months. When stock-price data are not available, the mean returns of the month are calculated without those portfolios.

clarify the empirical problem of testing the Ohlson (1995) LIM. Although other information, ν_t, plays an integral role in the Ohlson (1995) LIM, it is often ignored or assumed wrongly to be a constant because it is unobservable. As a result, other information, ν_t, may be absorbed in the error term causing serial correlation in the errors. This suggests the need for LIM7. Instead of focusing on the difficult problem of identifying other information, ν_t, LIM7 tries to circumvent the problem by modeling serial correlation in the error terms using GLS. LIM7 is a modified version of LIM1, and the results for LIM7 indicate that LIM7 improves on LIM1 in terms of both Adj. R^2 and Durbin's alternative statistic.

Moreover, the valuation models of LIM1, LIM2, and LIM7 are derived and they are tested using Japanese stock market data from two perspectives. The first is the models' ability to explain contemporaneous stock prices and the second is the models' ability to predict future stock returns. The results from these tests indicate the superiority of the LIM7-based valuation model over the LIM1-based valuation model.

The findings of this study generally support the validity of the Ohlson (1995) model. They also indicate that the LIM can be improved by tackling the serially correlated error terms that may have been caused by the omission of ν_t.

Acknowledgments

The author gratefully acknowledges the helpful comments and suggestions of Kazuyuki Suda, Takashi Yaekura, Richard Heaney, A. Rashad Abdel-khalik (editor), anonymous referees, Atsushi Sasakura, Akinobu Syutou, and Hia Hui Ching.

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