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Evaluating cross-sectional forecasting models for implied cost of capital

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Abstract The computation of implied cost of capital (ICC) is constrained by the lack of analyst forecasts for half of all firms. Hou et al. (J Account Econ 53:504–526, 2012, HVZ) present a cross-sectional model to generate forecasts in order to compute ICC. However, the forecasts from the HVZ model perform worse than those from a naïve random walk model and the ICCs show anomalous correlations with risk factors. We present two parsimonious alternatives to the HVZ model: the EP model based on persistence in earnings and the RI model based on the residual income model from Feltham and Ohlson (Contemp Account Res 11:689–732, 1996). Both models outperform the HVZ model in terms of forecast bias, accuracy, earnings response coefficients, and correlations of the ICCs with future returns and risk factors. We recommend that future research use the RI model or the EP model to generate earnings forecasts.

Keywords Earnings forecasts · Cross-sectional models · Implied cost of capital

JEL Classification G12 · G31 · G32 · M40 · M41

1 Introduction

Cost of equity plays a central role in valuation, portfolio selection, and capital budgeting. Therefore, measuring and validating cost of equity metrics has been the

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subject of much research. Inferring cost of equity from realized returns is problematic because the correlation between expected returns and realized returns is weak (Elton 1999). Prior research has often documented a weak or even non-existent relation between conventional measures of risk (e.g., β) and realized returns (Fama and French 1992). This has led to the use of implied cost of capital (ICC), which is the discount rate that equates current stock price to the present value of expected future dividends.

Prior literature has taken different approaches towards measuring ICC. Gebhardt et al. (2001) and Claus and Thomas (2001) use variants of the residual income model to solve for the discount rate that equates price to the sum of book value and the present value of future abnormal earnings. Gode and Mohanram (2003) and Easton (2004) develop proxies based on the abnormal earnings growth model of Ohlson and Juettner-Nauroth (2005). The common feature of all these approaches to measuring ICC is a reliance on analysts' EPS forecasts. This causes two shortcomings for researchers looking to obtain a reliable proxy for expected returns. First, analyst forecasts are available only for a subset of firms, with almost half of all firms not having analyst coverage in most years. This problem is not trivial because most of the firms without analyst coverage are typically small and young firms—the kind of firms that would be of the greatest interest to researchers examining issues related to information asymmetry, earnings quality, and disclosure where an ICC approach is used most often. Second, an extensive literature has shown that the ICC proxies derived from analyst forecasts are unreliable showing weak correlations with future returns (Easton and Monahan 2005) and anomalous correlations with risk factors.

A recent paper by Hou et al. (2012), henceforth HVZ, offers an interesting approach towards addressing these shortcomings. HVZ run cross-sectional regressions using lagged information to estimate future earnings for horizons of 1–5 years. Their model builds on models in Fama and French (2000, 2006) and regresses future earnings on total assets, dividends, earnings, and accruals. They use the earnings forecasts from the model to generate ICC estimates based on the approaches in prior literature. HVZ show that their model addresses the shortcomings of relying on analyst forecasts, by providing reliable ICC estimates for a wide cross-section of firms. They show that the model-based ICC generally outperforms the ICC derived from analysts' forecasts. Not surprisingly, the HVZ model has been used in recent research on accounting based valuation (Chang et al. 2012) and ICC (e.g., Jones and Tuzel 2012; Lee et al. 2011; Patatoukas 2011).

Given the growing attention to the HVZ model, it is imperative to test the model for the following reasons. First, HVZ test only one model and do not benchmark it against other cross-sectional models. Although the authors show that their ICC estimates are correlated with future returns at the portfolio level, they do not examine the relation between ICC estimates and future returns at the firm level like the prior studies (Gebhardt et al. 2001; Gode and Mohanram 2003). In addition, their ICC estimates show many anomalous relations with risk factors, including negative correlations with systematic and idiosyncratic risk.

Second, a recent paper by Gerakos and Gramacy (2013) shows that the HVZ model underperforms a naïve random walk (RW) model that simply sets future earnings to past earnings. However, a RW model is impractical for many implied cost of capital metrics that anchor on estimates of short term growth. The level of forecast errors reported in the HVZ model is also rather high—the mean absolute error (scaled by price) for 1-year-ahead earnings is 0.084 for firms with analyst coverage (Table 3 of HVZ, p. 9). If one assumes an average P/E ratio of 12, this represents an absolute error that is on average equal to the estimate of earnings itself. More importantly, their model generates larger forecast errors for firms without analyst coverage where the need for a forecasting model is crucial. Our partition results indicate that the average absolute forecast error for 1-year-ahead earnings for this group generated by the HVZ model is more than twice as large as that for firms with analyst coverage.

The goal of this paper is to build better cross-sectional models to forecast future earnings (EPS). We present and test two parsimonious alternatives to the HVZ model. The first model (EP model) forecasts earnings as a function of past earnings, allowing for the differential persistence of profits and losses. The second model (RI model) is motivated by the residual income valuation models in Ohlson (1995), Feltham and Ohlson (1995, 1996) and incorporates book value and accruals in addition to earnings. We benchmark the HVZ model, and our two proposed models against a naïve RW model.

We test the HVZ model and the above three alternative models along the following dimensions. We first evaluate the four models on the basis of forecast accuracy and bias. We then look at the earnings response coefficients (ERC), measured as the correlation between forecast surprise and future abnormal returns. Finally, we examine the properties of the ICC obtained by applying forecasts from these models to the commonly used ICC proxies, in terms of correlations with realized returns as well as correlations with risk factors.

We find that both the RI model and the EP model outperform the HVZ model in terms of forecast accuracy, forecast bias, and ERC. On average, the forecasts for the whole Compustat population from the RI model are 28–38 % more accurate than the forecasts from the HVZ model for the 1-year-ahead to 3-year-ahead forecast horizons. The improvement is as large as 45 % in small firms and firms without analyst coverage, where model-based forecasts are more relevant and important. On average, the ERCs of the RI and the EP forecasts are 18–85 % larger than the ERCs of the HVZ forecasts, indicating that the RI and the EP forecasts better represent market expectations. Consistent with Gerakos and Gramacy (2013), we find that the HVZ model significantly underperforms the naïve RW model in terms of forecast accuracy, bias, and ERC, in the full sample as well as in the subsamples of small firms and firms without analyst coverage. On average, the absolute forecast errors from the RW model are 13–37 % smaller than the forecast errors from the HVZ model.

We examine the correlation between ICCs derived from the forecasts and future returns along two dimensions—return spreads between ICC quintiles and firm level regressions of future returns on ICC. We find that both the EP model and the RI model outperform the HVZ model in terms of portfolio return spreads. Firm-level regressions indicate that the HVZ model produces ICC metrics with the weakest correlation with future realized returns, while the ICC metrics from the RI model show the strongest correlations with future returns.

We also examine the correlation between the ICC measures and risk factors, consistent with the analyses in Gebhardt et al. (2001), Gode and Mohanram (2003), and Botosan and Plumlee (2005). We find that the ICCs based on the RI model show expected correlations with most risk factors. In contrast, the ICCs based on the HVZ model always show an anomalous negative correlation with systematic risk (β) and an insignificant correlation with idiosyncratic risk and analyst following.

To summarize, we provide two models (RI and EP) that outperform the HVZ model on all dimensions: forecast accuracy, bias, ERC, and correlations of ICC proxies with future returns and risk factors. In addition to their superior performance, both models are grounded in prior theoretical and empirical research in accounting and are relatively parsimonious. Between the two models, the RI model performs marginally better on most dimensions. We recommend that future research use this model as the appropriate cross-sectional model to forecast future earnings.[1]

The rest of the paper is organized as follows. Section 2 discusses the HVZ model and the alternative models developed in this paper. Section 3 describes data selection and empirical execution. Section 4 compares the models on forecast accuracy, bias, and ERC. Section 5 examines the properties of ICC estimates derived from the forecasts. Section 6 discusses the results of sensitivity analyses. Section 7 concludes.

2 The models

2.1 The HVZ model

The model developed by Hou et al. (2012) is an extension of the cross-sectional profitability models in Fama and French (2000, 2006), Hou and Robinson (2006), and Hou and van Dijk (2012). The model is specified as:

$$E_{t+\tau} = \alpha_0 + \alpha_1 * A_t + \alpha_2 * D_t + \alpha_3 * DD_t + \alpha_4 * E_t + \alpha_5 * NegE_t + \alpha_6 * AC_t + \varepsilon \quad (1)$$

where $E_{t+\tau}$ is earnings in year t + τ (τ = 1 to 5); A_t is total assets; D_t is dividends; DD_t is an indicator variable for dividend paying firms; E_t is earnings; $NegE_t$ is an indicator variable for loss firms; and AC_t is working capital accruals. The regression is estimated using the previous 10 years of data, ensuring no look-ahead bias (i.e., the regression for 1-year-ahead earnings in year t uses data from year t − 10 to t − 1, and 2-year-ahead regression uses data from year t − 11 to t − 2, etc.). Consistent with HVZ, we estimate the regression at the dollar level with unscaled data.[2] Earnings for the next 5 years are estimated by using the coefficients from the above regressions and year t data for each firm. The main advantage of the cross-sectional

1 We observe that parsimonious models in general outperform complex models. For example, we test the forecast model of Abarbanell and Bushee (1997), which is based on the forecast approach by analysts, a model that forecasts future sales growth and profit margins, and a model that combines RI and HVZ. None of these more complex models outperforms the EP or the RI models.

2 We estimate the HVZ model at the dollar level as it is specified in their paper. We also perform robustness test by estimating their model at the per-share level. The inference still holds.

approach is that it does not impose any survivorship requirement as time series models do. "Appendix 1" provides details of the empirical execution for the HVZ model and the models introduced in this paper.

2.2 The RW model

We include RW model as the naïve benchmark. Although the forecasts from the RW model are not suitable for estimating ICC because they do not allow for growth in earnings, the model provides an intuitive benchmark against which to evaluate other earnings forecast models. The RW model does not rely on any parameters. It is specified as:

$$E_{t+\tau} = E_t + \varepsilon \tag{2}$$

2.3 The EP model

The earnings persistence (EP) model allows for growth in earnings, and hence the forecasts generated by this model can be used for ICC estimation. The model is specified as:

$$E_{t+\tau} = \beta_0 + \beta_1 * NegE_t + \beta_2 * E_t + \beta_3 * NegE * E_t + \varepsilon \tag{3}$$

We include the indicator for negative earnings (NegE) and its interaction term with earnings (NegE*E) to allow for different persistence of profit and loss (Li 2011). We estimate the regression using the same approach of HVZ—i.e., we use lagged 10 years of data to estimate the models using all firms with available data and then apply the regression coefficients to firm-specific data to estimate the expected values for each firm. We run the regression at the per-share level by scaling all variables by the number of shares outstanding.

2.4 The RI model

One potential drawback of the HVZ model is its reliance on dividends as opposed to earnings and book values. Miller and Modigliani (1961) prove that, ignoring taxes and contracting costs, dividends are irrelevant for asset pricing. As an alternative to the traditional dividend discount valuation models, the residual income valuation model derives the relation between price, book value, and earnings. The residual income valuation model was developed in early work by Preinreich (1936), Edwards and Bell (1961), and Peasnell (1982) and formalized more recently in a series of papers by Ohlson (1995) and Feltham and Ohlson (1995, 1996).

Ohlson (1995) presents a basic model where future residual income depends on current residual income and other information. Feltham and Ohlson (1995) introduce the balance sheet effect of conservatism, which can mechanically increase future residual income because of lower book values. Feltham and Ohlson (1996) further introduce the income statement effect of conservatism through capital expenditures (accruals), which will depress future residual income. Feltham and

Ohlson (1996) express future residual income using the following equation (notation simplified):

$$RI_{t+1} = \omega_1 * RI_t + \omega_2 * B_t + \omega_3 * capx_t + \varepsilon \tag{4}$$

where B is book value; capx is capital expenditures; and RI is residual income. In Eq. (4), ω_1 and ω_2 are expected to be positive and lie between 0 and 1, while ω_3 is expected to be negative. As the definition of residual income implies that $RI_t = E_t - r^*B_{t-1}$ and $RI_{t+1} = E_{t+1} - r^*B_t$, we can substitute for RI_t and RI_{t+1} in Eq. (4) and solve for E_{t+1}:

$$E_{t+1} = \omega_1 * E_t + (\omega_2 + r) * B_t + (-\omega_1 * r) * B_{t-1} + \omega_3 * capx_t + \varepsilon \tag{5}$$

Based on Eq. (5), our procedure to estimate future earnings is

$$E_{t+1} = \chi_0 + \chi_1 * E_t + \chi_2 * B_t + \chi_3 * B_{t-1} + \chi_4 * capx_t + \varepsilon \tag{6}$$

In Feltham and Ohlson (1996), capital expenditures refer to all expenditures on assets (not just PP&E as capital expenditures normally pertain to). Accordingly, we set capx to total accruals (TACC from Richardson et al. 2005). We modify Eq. (6) by introducing an interaction term between E_t and a loss dummy (NegE*E). We also remove book value in year $t - 1$ to reduce additional data requirement.[3] The equation we estimate is hence:

$$E_{t+\tau} = \chi_0 + \chi_1 * NegE_t + \chi_2 * E_t + \chi_3 * NegE * E_t + \chi_4 * B_t + \chi_5 * TACC_t + \varepsilon \tag{7}$$

We expect the coefficients χ_2 and χ_4 to be positive representing the persistence of earnings, χ_3 to be negative representing the lower persistence of losses (Li 2011), and χ_5 to be negative representing the effects of conservatism. We estimate the regression on per-share level using the same cross-sectional approach of HVZ.

3 Data and empirical execution

3.1 Data

Our estimation sample includes all firms on the Compustat fundamentals annual file up to 2012. We collect stock returns from the CRSP monthly return file and analyst information from the I/B/E/S summary file. The earnings number we estimate is the earnings before special and extraordinary items.[4] "Appendix 1" provides the variable definitions for each model. To minimize the effect of outliers, we winsorize all variables annually at the 1st and 99th percentiles.

[3] The model including B_{t-1} produces similar results.

[4] This represents a departure from HVZ as they estimate earnings before extraordinary items, without excluding special items. We exclude special items because they are less predictable by nature. We perform a robustness test using earnings before extraordinary items. The forecast errors are bigger for all models. However, the inferences do not change as the rank ordering of the models in terms of forecast accuracy and ERCs is unaltered.

3.2 Earnings forecasts for year t + 1 to year t + 5

We follow the methodology in HVZ to estimate the cross-sectional forecast models and the predicted earnings for year t + 1 to year t + 5. Specifically, for each year between 1969 and 2012, we estimate the three cross-sectional models (HVZ, EP and RI) using all available observations over the past 10 years. For example, if 2000 is the year t, we use data from 1990 to 1999 to estimate the coefficients that will be used to compute the earnings of 2001 (year t + 1). Similarly, we use data from 1989 to 1998 to estimate the coefficients that will be used to compute the earnings of 2002 (year t + 2). This ensures that the earnings forecasts are strictly out of sample. We estimate each model as of June 30 of each year. To further reduce look-ahead bias, we assume that financial information for firms with fiscal year ending (FYE) in April to June is not available on June 30. In other words, only the financials of firms with FYE from April of year t − 1 to March of year t are used for estimation of year t. For each firm and each year t in our sample, we compute earnings forecasts for year t + 1 to year t + 5 by multiplying the independent variables in year t with the pooled regression coefficients estimated using the previous 10 years of data. This method only requires a firm have non-missing independent variables in year t to estimate its future earnings. As a result, the survivorship bias is kept to a minimum. We set the missing value of AC and TACC to zero. However, the results are robust without this requirement.

3.3 Forecast bias and accuracy

Our first set of performance measures used to evaluate the models is forecast bias and accuracy. Forecast bias is the difference between actual earnings and earnings forecasts. We scale bias by end-of-June market value of equity if the model forecasts dollar earnings (the HVZ and RW models) or by end-of-June stock price if the model forecasts earnings per share (the EP and RI models). Forecast accuracy is defined as the absolute value of forecast bias.

3.4 Earnings response coefficient

The second performance measure is the ERC of the forecasts. We estimate the ERC using the sum of the quarterly earnings announcement returns (market-adjusted, from day − 1 to day + 1) over the next 1, 2, and 3 years on firm-specific unexpected earnings (i.e., the forecast bias) measured over the same horizon.[5] We standardize the unexpected earnings so that they have unit variance each year. As a result, the ERCs are comparable among all model-based forecasts.

[5] We also perform robustness test by estimating the cumulative ERC the same way as the "Annual ERC" in HVZ. Specifically, we estimate ERCs by regressing the buy-and-hold returns over the next 1, 2, and 3 years on the unexpected earnings over the same horizon. The tenor of the results does not change.

3.5 Estimating the ICC metrics

We use forecasts from the three cross-sectional models (HVZ, EP and RI) to estimate implied cost of capital using the four commonly used ICC metrics. We use two ICC metrics based on the abnormal earnings model of Ohlson and Juettner-Nauroth (2005)—the Gode and Mohanram (2003) implementation of the full model (ICC_{GM}) and a simplified version based on the price earnings to growth ratio (ICC_{PEG}). We also use two ICC metrics based on the residual income valuation model—the Gebhardt, Lee, and Swaminathan model (ICC_{GLS}) and the Claus and Thomas model (ICC_{CT}). The details of the empirical execution are presented in "Appendix 2". Consistent with the common approach in the literature, we use the average of the ICCs derived from the four individual methods as our ICC metric. To allow for comparison across time, we adjust stock returns and ICCs for the risk-free rate.

4 Comparison of the forecast accuracy, bias and ERC of the models

4.1 Coefficient estimates of the three cross-sectional models

Panel A of Table 1 presents the average coefficients and the time-series t-statistics from the HVZ model estimated each year from 1969 to 2012 using the appropriately lagged 10 years of data. To conserve space, we only report the results for t + 1, t + 2, and t + 3 earnings regressions (those for t + 4 and t + 5 regressions are available upon request). The magnitude of the coefficients and the adjusted R^2 are generally consistent with the results in HVZ.

Panel B of Table 1 presents the average coefficients and the corresponding time-series t-statistics from the EP model. The magnitude of the coefficient on E_t is slightly less than 1, and as expected, losses are less persistent. The model explains approximately 68.1, 51.5, and 41.5 % of the variations in EPS in year t + 1, t + 2, and t + 3, respectively. Although the adjusted R^2 of the HVZ model is higher than that of the EP model, this is mainly due to the fact that the HVZ model is estimated at the dollar level and the inherent heteroskedasticity of the regression boosts adjusted R^2. If the HVZ model is estimated at the per-share level, the adjusted R^2 declines to 67.0, 50.5, and 41.4 % (untabulated) for t + 1, t + 2, and t + 3 regressions, respectively.

Finally, Panel C of Table 1 presents the average coefficients and the corresponding time-series t-statistics from the RI model. All coefficients have signs consistent with the theoretical prediction from the residual income valuation model. In addition to the positive coefficient on earnings and negative coefficient on the loss interaction, the regression has a positive average coefficient for book value and a negative coefficient for accruals.

The three cross-sectional models produce non-missing 1-, 2-, and 3-year-ahead earnings forecasts for 179,362 firm-year observations from 1969 to 2012.

Table 1 Coefficient estimates from the three cross-sectional earnings models, 1969–2012

Panel A: The HVZ model

	Intercept	A_t	D_t	DD_t	E_t	$NegE_t$	AC_t	Adj. R^2 (%)
E_{t+1}	0.3462	0.0018	0.2109	1.3629	0.8715	1.2460	−0.0405	89.6
	(3.73)	(11.88)	(11.05)	(6.38)	(84.03)	(5.08)	(−6.37)	
E_{t+2}	0.9587	0.0034	0.2937	2.2667	0.8365	2.4850	−0.0549	84.0
	(8.38)	(11.83)	(8.32)	(6.58)	(46.48)	(7.60)	(−5.01)	
E_{t+3}	2.2031	0.0051	0.3149	2.6674	0.8378	2.5332	−0.0585	80.1
	(8.92)	(10.34)	(5.33)	(8.79)	(29.11)	(7.46)	(−4.39)	

Panel B: The EP model

	Intercept	$NegE_t$	E_t	$NegE{*}E_t$	Adj. R^2 (%)
E_{t+1}	0.1495	−0.1229	0.9614	−0.7096	68.1
	(13.02)	(−4.58)	(204.78)	(−19.77)	
E_{t+2}	0.2873	−0.1717	0.9846	−1.1451	51.5
	(11.23)	(−5.88)	(154.65)	(−17.03)	
E_{t+3}	0.4498	−0.2125	0.9992	−1.4155	41.5
	(11.24)	(−5.31)	(118.66)	(−19.97)	

Panel C: The RI model

	Intercept	$NegE_t$	E_t	$NegE{*}E_t$	B_t	$TACC_t$	Adj. R^2 (%)
E_{t+1}	0.0914	−0.1087	0.8649	−0.5436	0.0167	−0.0034	68.1
	(6.04)	(−3.98)	(109.26)	(−15.26)	(15.66)	(−2.28)	
E_{t+2}	0.1855	−0.1475	0.8280	−0.8601	0.0294	−0.0217	52.1
	(6.83)	(−4.78)	(86.93)	(−11.91)	(20.70)	(−10.07)	
E_{t+3}	0.2993	−0.2518	0.8105	−1.3241	0.0409	−0.0413	42.5
	(7.59)	(−5.51)	(69.57)	(−6.54)	(21.94)	(−13.38)	

Each model is estimated annually from 1969 to 2012 using previous 10 years of data. The average coefficients and the time-series t-statistics (in parentheses) are reported for the HVZ model (Panel A), the EP model (Panel B), and the RI model (Panel C). "Appendix 1" provides the definitions of the variables in each model

4.2 Forecast accuracy of the four models

To evaluate the performance of the cross-sectional earnings models, we first compare their forecast accuracy. We perform the analysis using the sample of firm-year observations with non-missing t + 1, t + 2, and t + 3 forecast bias for all four models from 1969 to 2008. The period ends in 2008 because we require non-missing realized earnings in the future 3 years to calculate forecast bias and accuracy. The sample includes 119,653 firm-year observations. Table 2 reports the comparison of forecast accuracy.

Panel A of Table 2 reports the time-series averages of the mean and median absolute forecast error for the HVZ, RW, EP, and RI models in the full sample. A larger number indicates a less accurate earnings forecast. The RI model produces the most accurate forecasts for all three forecast horizons with the lowest average absolute forecast error. The EP model has the second best forecast accuracy, while the HVZ model generates the least accurate forecasts among the four models. For example, the mean absolute forecast error of the RI model is 0.073 (t = 15.80) for 1-year-ahead forecasts, while the corresponding mean absolute forecast error of the EP, RW and HVZ models is 0.073 (t = 15.77), 0.088 (t = 12.32), and 0.101 (t = 15.09), respectively. Compared to the forecasts of the HVZ model, the forecasts of the RI model are on average 28 % more accurate. At the 1-year-ahead

Table 2 Absolute forecast error of the cross-sectional earnings models and the random walk model

Panel A: Full sample of 119,653 firm-year observations (1969–2008)

	E_{t+1}		E_{t+2}		E_{t+3}	
	Mean	Median	Mean	Median	Mean	Median
HVZ	0.101***	0.034***	0.151***	0.057***	0.203***	0.079***
	(15.09)	(14.83)	(15.59)	(16.75)	(16.42)	(17.86)
RW	0.088***	0.028***	0.102***	0.043***	0.128***	0.056***
	(12.32)	(22.96)	(18.11)	(26.33)	(20.50)	(23.32)
EP	0.073***	0.028***	0.101***	0.045***	0.133***	0.061***
	(15.77)	(21.61)	(18.95)	(22.04)	(17.42)	(19.71)
RI	0.073***	0.027***	0.099***	0.044***	0.126***	0.059***
	(15.80)	(22.58)	(20.55)	(23.81)	(20.64)	(21.38)
Comparison						
HVZ–RW	0.013**	0.006***	0.049***	0.014***	0.075***	0.023***
	(2.14)	(3.97)	(6.14)	(6.47)	(7.46)	(8.66)
HVZ–EP	0.028***	0.006***	0.050***	0.012***	0.070***	0.018***
	(6.36)	(4.04)	(7.00)	(5.43)	(7.20)	(6.37)
HVZ–RI	0.028***	0.007***	0.052***	0.013***	0.077***	0.020***
	(6.21)	(4.23)	(7.22)	(5.79)	(8.16)	(7.41)
RW–EP	0.015***	0.000	0.001	−0.002**	−0.005	−0.005**
	(3.91)	(0.40)	(0.23)	(−2.32)	(−0.85)	(−2.23)
RW–RI	0.015***	0.001	0.003	−0.001	0.002	−0.003
	(4.10)	(0.43)	(1.19)	(−1.65)	(0.37)	(−1.42)
EP–RI	0.000	0.001***	0.002**	0.001***	0.007***	0.002***
	(0.29)	(3.53)	(2.17)	(3.57)	(3.42)	(4.20)

Panel B: Nonparametric test of forecast accuracy for the full sample

	Most accurate forecast			Least accurate forecast		
	E_{t+1}	E_{t+2}	E_{t+3}	E_{t+1}	E_{t+2}	E_{t+3}
HVZ	0.278	0.254	0.225	0.355	0.379	0.380
RW	0.312	0.343	0.383	0.311	0.279	0.303
EP	0.212	0.208	0.203	0.165	0.189	0.191
RI	0.198	0.194	0.189	0.168	0.152	0.126

Table 2 continued

Panel C: Partition analysis of mean absolute forecast error by analyst coverage

	No coverage (N = 50,242)			With coverage (N = 69,411)		
	E_{t+1}	E_{t+2}	E_{t+3}	E_{t+1}	E_{t+2}	E_{t+3}
HVZ	0.149***	0.227***	0.315***	0.062***	0.085***	0.107***
	(14.28)	(16.05)	(16.58)	(11.69)	(16.49)	(22.14)
RW	0.124***	0.144***	0.177***	0.078***	0.083***	0.101***
	(10.63)	(12.75)	(14.34)	(9.50)	(14.68)	(17.54)
EP	0.105***	0.141***	0.189***	0.057***	0.075***	0.094***
	(12.77)	(15.91)	(14.57)	(13.58)	(20.74)	(28.24)
RI	0.106***	0.138***	0.177***	0.057***	0.074***	0.092***
	(12.47)	(15.90)	(16.94)	(13.43)	(20.11)	(28.56)
Comparison						
HVZ–RW	0.025***	0.083***	0.138***	−0.016***	0.002	0.006**
	(4.23)	(9.26)	(11.30)	(−5.07)	(1.42)	(2.17)
HVZ–EP	0.044***	0.086***	0.126***	0.005***	0.010***	0.013***
	(9.62)	(10.34)	(9.81)	(4.09)	(5.11)	(5.70)
HVZ–RI	0.043***	0.089***	0.138***	0.005***	0.011***	0.015***
	(9.22)	(11.05)	(11.81)	(4.33)	(6.01)	(6.93)
RW–EP	0.019***	0.003	−0.012	0.021***	0.008**	0.007*
	(3.23)	(0.41)	(−0.98)	(4.98)	(2.63)	(2.05)
RW–RI	0.018***	0.006	0.000	0.021***	0.009***	0.009**
	(3.10)	(0.97)	(0.04)	(5.08)	(3.09)	(2.70)
EP–RI	−0.001	0.003	0.012**	0.000	0.001**	0.002***
	(−1.51)	(1.15)	(2.70)	(0.62)	(2.13)	(5.11)

Table 2 continued

Panel D: Partition analysis of mean absolute forecast error by size

	Small firms (N = 59,819)			Large firms (N = 59,834)		
	E_{t+1}	E_{t+2}	E_{t+3}	E_{t+1}	E_{t+2}	E_{t+3}
HVZ	0.167***	0.251***	0.339***	0.035***	0.052***	0.067***
	(14.01)	(14.03)	(14.81)	(20.75)	(26.10)	(26.14)
RW	0.135***	0.151***	0.187***	0.041***	0.053***	0.069***
	(11.14)	(15.32)	(17.24)	(17.32)	(27.31)	(27.21)
EP	0.112***	0.151***	0.200***	0.035***	0.052***	0.066***
	(14.25)	(17.01)	(15.40)	(22.05)	(25.74)	(24.98)
RI	0.111***	0.146***	0.186***	0.035***	0.051***	0.065***
	(14.18)	(18.45)	(18.69)	(22.27)	(26.23)	(25.54)
Comparison						
HVZ–RW	0.032***	0.100***	0.152***	−0.006***	−0.001	−0.002
	(2.85)	(6.24)	(7.54)	(−5.41)	(−1.13)	(−1.43)
HVZ–EP	0.055***	0.100***	0.139***	0.000	0.000	0.001
	(6.49)	(7.09)	(7.29)	(0.24)	(0.43)	(0.70)
HVZ–RI	0.056***	0.105***	0.153***	0.000	0.001	0.002**
	(6.32)	(7.26)	(8.17)	(0.11)	(1.12)	(2.07)
RW–EP	0.023***	0.000	−0.013	0.006***	0.001	0.003*
	(3.57)	(0.10)	(−1.09)	(5.14)	(1.40)	(1.81)
RW–RI	0.024***	0.005	0.001	0.006***	0.002*	0.004***
	(3.78)	(1.04)	(0.05)	(5.11)	(1.95)	(2.79)
EP–RI	0.001	0.005**	0.014***	0.000	0.001***	0.001***
	(0.35)	(2.07)	(3.29)	(0.98)	(3.77)	(5.49)

Panel A reports the time-series averages of the mean and median absolute forecast error for the three cross-sectional earnings models and the random walk model and their pair-wise comparisons. The time-series t-statistics are reported in the parentheses. ***, **, * denote significance at 0.01, 0.05, and 0.10 level, respectively. Absolute forecast error is the absolute value of forecast bias, which is the difference between actual earnings and model-based earnings forecasts scaled by the end-of-June market value of equity (HVZ and RW) or by the end-of-June stock price (EP and RI). The results are based on the sample of 119,653 firm-year observations with non-missing t + 1, t + 2, and t + 3 forecast bias from all models. Panel B reports the nonparametric test of forecast accuracy. The numbers represent the proportion of observations for which each model produces the most and least accurate forecast. Panel C reports mean absolute forecast error by partition of analyst coverage. A firm is covered by analysts if there is one FY1 consensus forecast on I/B/E/S for year t + 1. Panel D reports mean absolute forecast error by partition of firm size. Each year, observations are sorted into two equal-sized groups based on their end-of-June market value of equity

forecast horizon, the RI model and the EP model have similar forecast accuracy. However, as the forecast horizon increases, the RI model produces more accurate forecasts than the EP model. For example, the mean 3-year-ahead absolute forecast error is 0.126 (t = 20.64) for the RI model and 0.133 (t = 17.42) for the EP model, with the difference significant at 1 % level. The corresponding values for the RW and HVZ models are 0.128 (t = 20.50) and 0.203 (t = 16.42), respectively. At the

3-year-ahead forecast horizon, the RI model generates forecasts that are on average 38 % more accurate than the forecasts from the HVZ model. It is also worth noting that the absolute forecast error of the RW model is on average 13–37 % smaller than the HVZ model.

In terms of the median absolute forecast error, both the RI model and the RW model produce the most accurate forecasts for all three horizons, with none of the differences between the two models being statistically significant. The EP model generally underperforms those two in all horizons, expect for 1-year-ahead forecast where its accuracy is indistinguishable from that of the RW model. Finally, the HVZ model consistently has the worst forecast accuracy among the four models—its pairwise differences with the other three models are all significant at 1 % level.

We also adopt an alternative nonparametric measure to evaluate forecast accuracy. Specifically, we examine how often each model produces the most and the least accurate forecast. As the results in Panel B of Table 2 show, the RW model produces 31.2 % of the most accurate forecasts for year t + 1, 34.3 % for year t + 2, and 38.3 % for year t + 3. The HVZ model ranks the second: 27.8 % for t + 1, 25.4 % for t + 2, and 22.5 % for t + 3. However, both models are also more likely to produce the least accurate forecast: the HVZ (RW) model produces 35.5 % (31.1 %) of the least accurate forecasts for year t + 1, 37.9 % (27.9 %) for year t + 2, and 38.0 % (30.3 %) for year t + 3. respectively. The results suggest that, although the RI and the EP models do not always produce the best forecast, the forecast errors from these two have less variance than the forecast errors from the HVZ or the RW models.

Panel C of Table 2 reports the time-series averages of the absolute forecast error in the subsamples partitioned by analyst coverage. A firm is considered as covered by analysts if there is one FY1 consensus forecast on I/B/E/S for year t + 1. The results show that the mean absolute forecast error is much bigger for firms without analyst coverage, consistent with the presumption that these firms are generally smaller and their earnings are harder to forecast. The EP and the RI models continue to outperform the HVZ model in both subsamples, and the improvements are more pronounced in the subsample of firms without analyst coverage. For example, for firms without analyst coverage, the differences in mean absolute forecast error between the RI model and the HVZ model are 0.043 (or 29 % improvement) for the 1-year-ahead forecasts and 0.138 (or 44 % improvement) for the 3-year-ahead forecasts. For firms with analyst coverage, the corresponding differences in mean absolute forecast error are 0.005 (or 8 % improvement) and 0.015 (or 14 % improvement), respectively. The RW model still significantly outperforms the HVZ model in the subsample of firms without analyst coverage. In the subsample of firms with analyst coverage, the RW model outperforms the HVZ model for year t + 2 and t + 3 forecasts.

For the subsample of firms with analyst coverage, researchers have two options to estimate ICC metrics. First, they can use a model-based approach as in HVZ. Second, they can correct the predictable biases in the forecasts as Mohanram and Gode (2013) do, who show that the error correction procedure dramatically improves the performance of ICC metrics. However, for the subsample of firms without analyst coverage, researchers must use a model-based approach to generate forecasts. Hence, model-based earnings forecasts are much more crucial for firms without analyst coverage. In this important group, the HVZ model significantly underperforms not only the RI and the EP models but also the naïve RW model.

Panel D of Table 2 reports the time-series averages of the mean absolute forecast error in the subsamples partitioned by firm size. Each year, observations are sorted into two equal-sized groups based on their end-of-June market value of equity. The results show that in both subsamples the RI model has the most accurate forecasts. Relative to the HVZ model, the improvement of the RI model in forecast accuracy is more pronounced in small firms. For example, in small firms the differences in mean absolute forecast error between the RI model and the HVZ model are 0.056 (or 34 % improvement) for the 1-year-ahead forecast and 0.153 (or 45 % improvement) for the 3-year-ahead forecast. The corresponding differences in the large firm are 0.000 and 0.002 (or 3 % improvement), respectively. The EP model also outperforms the HVZ model in both subsamples, but the improvements are relatively smaller than those of the RI model. Finally, the naïve RW model continues to outperform the HVZ model in small firms, whose earnings are more difficult to forecast.

In summary, the results in Table 2 show that both the RI and the EP models outperform the HVZ model in terms of forecast accuracy. The improvement is more significant in the groups of firms where model-based forecasts are more relevant and important, i.e., small firms and firms without analyst coverage. In addition, the HVZ model also significantly underperforms the naïve RW model in the full sample as well as in the subsamples of small firms and firms without analyst coverage.[6]

4.3 Forecast bias of the four models

Table 3 reports the comparison of forecast bias of the four models. Forecast bias is the difference between the actual earnings and the earnings forecasts, scaled by end-of-June market value of equity (the HVZ and RW models) or end-of-June stock price (the EP and RI models). A negative bias indicates that the forecast is higher than the actual. Panel A of Table 3 reports the time-series averages of the mean and median forecast bias for the four models in the full sample as well as their pair-wise comparisons. Mean forecast biases for the HVZ, EP and RI models are negative and statistically significant for all forecast horizons. In contrast, mean forecast biases for the RW model are positive and statistically significant for all forecast horizons. This is because the naïve RW model does not allow for growth in earnings. The magnitude of the forecast bias of the HVZ model is significantly larger than all other models.

Panel B of Table 3 reports the time-series averages of the mean forecast bias in the subsamples partitioned by analyst coverage. The mean forecast bias of the RI model is generally the smallest in magnitude among all models in both subsamples.

[6] We further partition our sample into four time periods (1969–1978, 1979–1988, 1989–1998, and 1999–2008). We do not observe any systematic changes in forecast accuracy of the HVZ, EP and RI models. However, the forecast accuracy of the RW model deteriorates over time. This is not surprising as the naïve model is not well suited for more complex operations.

However, its 1-year-ahead forecast bias has larger magnitude than the RW model for firms with analyst coverage. In both subsamples, the HVZ model produces more biased forecast than the other three models.

Panel C of Table 3 reports the time-series averages of the mean forecast bias in the subsamples partitioned by firm size. For large firms, the mean forecast biases of the EP and RI models are all statistically insignificant, while the mean forecast biases of the HVZ model are all significantly negative. For small firms, the mean forecast biases of the HVZ, EP and RI models are all significantly negative, with the forecasts of the HVZ model being the most biased.

In summary, forecasts from the RI model generally are the least biased for the whole population as well as in the partitions by analyst coverage and by firm size. In contrast, forecasts from the HVZ model generally are the most biased, especially for firms without analyst coverage and small firms.

Table 3 Forecast bias of the cross-sectional earnings models and the random walk model

Panel A: Full sample of 119,653 firm-year observations (1969–2008)

	E_{t+1}		E_{t+2}		E_{t+3}	
	Mean	Median	Mean	Median	Mean	Median
HVZ	−0.056***	−0.013***	−0.092***	−0.027***	−0.133***	−0.043***
	(−7.86)	(−4.82)	(−8.33)	(−6.68)	(−9.72)	(−8.37)
RW	0.007**	0.008***	0.027***	0.015***	0.040***	0.022***
	(2.20)	(7.34)	(5.76)	(7.38)	(6.15)	(7.10)
EP	−0.020***	0.000	−0.032***	−0.006**	−0.052***	−0.015***
	(−5.27)	(0.13)	(−5.19)	(−2.17)	(−5.66)	(−3.75)
RI	−0.013***	0.002	−0.019***	−0.003	−0.034***	−0.010***
	(−3.50)	(1.32)	(−3.55)	(−1.18)	(−4.40)	(−2.80)
Comparison						
HVZ–RW	−0.063***	−0.021***	−0.119***	−0.042***	−0.173***	−0.065***
	(−9.35)	(−7.27)	(−10.42)	(−9.14)	(−11.36)	(−10.23)
HVZ–EP	−0.036***	−0.013***	−0.060***	−0.021***	−0.081***	−0.028***
	(−6.49)	(−6.53)	(−6.60)	(−7.13)	(−6.53)	(−6.90)
HVZ–RI	−0.043***	−0.015***	−0.073***	−0.024***	−0.099***	−0.033***
	(−7.62)	(−7.00)	(−7.92)	(−7.67)	(−8.16)	(−7.69)
RW–EP	0.027***	0.008***	0.059***	0.021***	0.092***	0.037***
	(10.48)	(6.96)	(11.30)	(8.99)	(11.27)	(10.53)
RW–RI	0.020***	0.006***	0.046***	0.018***	0.074***	0.032***
	(8.01)	(6.05)	(10.60)	(8.76)	(11.16)	(10.46)
EP–RI	−0.007***	−0.002***	−0.013***	−0.003***	−0.018***	−0.005***
	(−8.26)	(−8.46)	(−8.17)	(−6.76)	(−7.91)	(−7.50)

Table 3 continued

Panel B: Partition analysis of mean forecast bias by analyst coverage

	No coverage (N = 50,242)			With coverage (N = 69,411)		
	E_{t+1}	E_{t+2}	E_{t+3}	E_{t+1}	E_{t+2}	E_{t+3}
HVZ	−0.085***	−0.153***	−0.239***	−0.018***	−0.023***	−0.032***
	(−9.06)	(−11.42)	(−13.07)	(−4.69)	(−4.49)	(−5.21)
RW	0.015***	0.042***	0.050***	0.000	0.014***	0.024***
	(3.22)	(5.57)	(5.41)	(0.01)	(2.99)	(3.89)
EP	−0.021***	−0.043***	−0.086***	−0.016***	−0.018***	−0.025***
	(−4.27)	(−4.85)	(−5.77)	(−4.86)	(−4.42)	(−5.08)
RI	−0.005	−0.017**	−0.048***	−0.013***	−0.014***	−0.019***
	(−0.96)	(−2.10)	(−4.13)	(−4.24)	(−3.46)	(−3.82)
Comparison						
HVZ–RW	−0.100***	−0.195***	−0.289***	−0.018***	−0.037***	−0.056***
	(−11.35)	(−13.80)	(−15.25)	(−13.21)	(−14.08)	(−14.11)
HVZ–EP	−0.064***	−0.110***	−0.153***	−0.002*	−0.005*	−0.007*
	(−8.08)	(−9.46)	(−9.75)	(−1.71)	(−2.02)	(−1.95)
HVZ–RI	−0.080***	−0.136***	−0.191***	−0.005***	−0.009***	−0.013***
	(−8.72)	(−10.48)	(−11.51)	(−3.26)	(−3.68)	(−3.70)
RW–EP	0.036***	0.085***	0.136***	0.016***	0.032***	0.049***
	(9.14)	(10.61)	(9.98)	(8.81)	(10.25)	(11.02)
RW–RI	0.020***	0.059***	0.098***	0.013***	0.028***	0.043***
	(5.21)	(9.81)	(10.28)	(7.88)	(9.39)	(10.29)
EP–RI	−0.016***	−0.026***	−0.038***	−0.003***	−0.004***	−0.006***
	(−7.33)	(−7.34)	(−7.11)	(−9.96)	(−11.73)	(−11.90)

Table 3 continued

Panel C: Partition analysis of mean forecast bias by size

	Small firms (N = 59,819)			Large firms (N = 59,834)		
	E_{t+1}	E_{t+2}	E_{t+3}	E_{t+1}	E_{t+2}	E_{t+3}
HVZ	−0.108***	−0.178***	−0.260***	−0.005**	−0.006*	−0.006*
	(−8.03)	(−8.58)	(−10.02)	(−2.46)	(−1.93)	(−1.75)
RW	0.008*	0.040***	0.055***	0.005***	0.014***	0.024***
	(1.77)	(5.44)	(5.67)	(2.75)	(4.90)	(6.18)
EP	−0.038***	−0.061***	−0.101***	−0.002	−0.003	−0.004
	(−6.23)	(−6.00)	(−6.40)	(−0.92)	(−0.92)	(−1.10)
RI	−0.024***	−0.037***	−0.066***	−0.001	−0.002	−0.002
	(−4.09)	(−4.19)	(−5.16)	(−0.57)	(−0.50)	(−0.61)
Comparison						
HVZ–RW	−0.116***	−0.218***	−0.315***	−0.010***	−0.020***	−0.030***
	(−9.14)	(−10.21)	(−11.18)	(−10.92)	(−11.16)	(−11.49)
HVZ–EP	−0.070***	−0.117***	−0.159***	−0.003***	−0.003***	−0.002
	(−6.40)	(−6.69)	(−6.74)	(−5.72)	(−3.10)	(−1.45)
HVZ–RI	−0.084***	−0.141***	−0.194***	−0.004***	−0.004***	−0.004**
	(−7.56)	(−8.05)	(−8.43)	(−6.24)	(−3.81)	(−2.47)
RW–EP	0.046***	0.101***	0.156***	0.007***	0.017***	0.028***
	(10.17)	(10.93)	(10.73)	(9.74)	(11.86)	(13.29)
RW–RI	0.032***	0.077***	0.121***	0.006***	0.016***	0.026***
	(7.53)	(10.21)	(10.65)	(9.18)	(11.45)	(13.00)
EP–RI	−0.014***	−0.024***	−0.035***	−0.001***	−0.001***	−0.002***
	(−7.86)	(−7.76)	(−7.50)	(−5.50)	(−5.06)	(−5.47)

Panel A reports the time-series averages of the mean and median forecast bias for the three cross-sectional earnings models and the random walk model and their pair-wise comparisons. The time-series t-statistics are reported in the parentheses. ***, **, * denote significance at 0.01, 0.05, and 0.10 level, respectively. Forecast bias is the difference between actual earnings and model-based earnings forecasts scaled by the end-of-June market value of equity (HVZ and RW) or by the end-of-June stock price (EP and RI). The results are based on the sample of 119,653 firm-year observations with non-missing $t + 1$, $t + 2$, and $t + 3$ forecast bias from all models. Panel B reports mean forecast bias by partition of analyst coverage. A firm is covered by analysts if there is one FY1 consensus forecast on I/B/E/S for year $t + 1$. Panel C reports mean forecast bias by partition of firm size. Each year, observations are sorted into two equal-sized groups based on their end-of-June market value of equity

4.4 ERC of model-based forecasts

A higher ERC suggests that the market reacts more strongly to the unexpected earnings generated from the model. In other words, the earnings forecasts from the model may represent a better approximation of market expectations. Table 4 reports the time-series averages of the ERCs for all models. We estimate the ERC by regressing the sum of the quarterly earnings announcement returns (market-adjusted, from day -1 to day $+1$) over the next 1, 2, and 3 years on firm-specific unexpected earnings (i.e., the forecast bias) measured over the corresponding horizon.

Panel A presents the ERCs for the entire sample. The ERCs for 1-, 2-, and 3-year-ahead forecasts from the RI model are 0.042 (t = 18.02), 0.064 (t = 13.83), and 0.085 (t = 13.57), respectively, which are the highest among all models. The EP model ranks the second with the corresponding ERCs of 0.040 (t = 19.19), 0.062 (t = 14.39), and 0.083 (t = 12.90), respectively. The ERCs of the RI and the EP forecasts are 18–85 % larger than those of the HVZ forecasts. Surprisingly, even the naïve RW model outperforms the HVZ model for all forecast horizons. For example, the ERC of the 3-year-ahead forecast is 0.046 (t = 7.66) for the HVZ model and 0.078 (t = 12.20) for the RW model, with the difference significant at the 1 % level. In addition, the adjusted R-squares of the HVZ model are also significantly lower than those of the other three models. The evidence indicates that, compared with the HVZ forecasts, the RI and the EP forecasts better represent market expectations.

Panel B of Table 4 reports the time-series averages of the ERCs in the subsamples partitioned by analyst coverage. For firms without analyst coverage, the ERCs of the HVZ forecasts are the lowest among all models for all three forecast horizons, while the ERCs of the forecasts of the other three models are virtually indistinguishable. For firms with analyst coverage, the HVZ, EP and RI forecasts produce similar ERCs

Table 4 Earnings response coefficient of the model-based earnings forecast, 1969–2008

Panel A: Full sample

	E_{t+1}		E_{t+2}		E_{t+3}	
	ERC	Adj. R^2 (%)	ERC	Adj. R^2 (%)	ERC	Adj. R^2 (%)
HVZ	0.034***	2.5***	0.041***	2.0***	0.046***	1.6***
	(13.31)	(7.07)	(9.23)	(5.33)	(7.66)	(5.27)
RW	0.035***	4.5***	0.057***	5.3***	0.078***	5.3***
	(13.33)	(6.02)	(13.07)	(6.55)	(12.20)	(7.06)
EP	0.040***	5.0***	0.062***	4.9***	0.083***	4.7***
	(19.19)	(7.13)	(14.39)	(6.32)	(12.90)	(6.83)
RI	0.042***	5.2***	0.064***	5.2***	0.085***	5.0***
	(18.02)	(7.27)	(13.83)	(6.45)	(13.57)	(7.05)
Comparison						
HVZ–RW	−0.001	−2.0***	−0.016***	−3.3***	−0.032***	−3.7***
	(−0.92)	(−3.35)	(−4.10)	(−4.93)	(−6.00)	(−5.76)
HVZ–EP	−0.006***	−2.5***	−0.021***	−2.9***	−0.037***	−3.1***
	(−3.45)	(−4.36)	(−6.67)	(−5.35)	(−8.81)	(−6.00)
HVZ–RI	−0.008***	−2.7***	−0.023***	−3.2***	−0.039***	−3.4***
	(−3.67)	(−4.51)	(−6.73)	(−5.49)	(−8.81)	(−6.14)
RW–EP	−0.005**	−0.5	−0.005	0.4	−0.005	0.6
	(−2.19)	(−1.20)	(−1.14)	(0.58)	(−0.86)	(1.38)
RW–RI	−0.007**	−0.7	−0.007	0.1	−0.007	0.3
	(−2.48)	(−1.51)	(−1.65)	(0.13)	(−1.28)	(0.76)
EP–RI	−0.002*	−0.2	−0.002	−0.3*	−0.002	−0.3*
	(−1.69)	(−1.61)	(−1.26)	(−1.72)	(−0.61)	(−1.87)

Table 4 continued

Panel B: Partition analysis of ERC by analyst coverage						
	No coverage			With coverage C		
	E_{t+1}	E_{t+2}	E_{t+3}	E_{t+1}	E_{t+2}	E_{t+3}
HVZ	0.037***	0.034***	0.025**	0.049***	0.080***	0.112***
	(9.62)	(6.88)	(2.09)	(7.58)	(7.61)	(9.21)
RW	0.041***	0.059***	0.082***	0.038***	0.061***	0.089***
	(11.35)	(11.71)	(9.72)	(7.95)	(8.39)	(8.55)
EP	0.044***	0.062***	0.074***	0.043***	0.072***	0.106***
	(14.00)	(11.99)	(9.58)	(9.78)	(11.70)	(13.45)
RI	0.045***	0.064***	0.079***	0.044***	0.073***	0.105***
	(13.91)	(12.43)	(11.61)	(9.02)	(10.34)	(13.04)
Comparison						
HVZ–RW	−0.004*	−0.025***	−0.057***	0.011**	0.019***	0.023***
	(−1.71)	(−5.48)	(−3.80)	(2.49)	(3.00)	(3.04)
HVZ–EP	−0.007***	−0.028***	−0.049***	0.006*	0.008	0.006
	(−2.84)	(−6.29)	(−5.25)	(1.74)	(1.29)	(0.74)
HVZ–RI	−0.008***	−0.030***	−0.054***	0.005	0.007	0.007
	(−2.98)	(−6.34)	(−4.94)	(1.36)	(1.46)	(1.04)
RW–EP	−0.003	−0.003	0.008	−0.005	−0.011*	−0.017**
	(−1.22)	(−0.63)	(0.72)	(−1.04)	(−2.00)	(−2.09)
RW–RI	−0.004	−0.005	0.003	−0.006	−0.012**	−0.016**
	(−1.58)	(−1.27)	(0.34)	(−1.13)	(−2.25)	(−2.22)
EP–RI	−0.001	−0.002	−0.005	−0.001	−0.001	0.001
	(−1.23)	(−1.34)	(−1.25)	(−1.00)	(−0.37)	(0.29)

Table 4 continued

Panel C: Partition analysis of ERC by size

	Small firms			Large firms		
	E_{t+1}	E_{t+2}	E_{t+3}	E_{t+1}	E_{t+2}	E_{t+3}
HVZ	0.033***	0.040***	0.043***	0.087***	0.149***	0.206***
	(11.71)	(8.31)	(7.04)	(14.66)	(18.86)	(16.53)
RW	0.033***	0.053***	0.073***	0.070***	0.106***	0.146***
	(12.64)	(11.81)	(10.05)	(12.57)	(14.17)	(12.87)
EP	0.039***	0.058***	0.079***	0.058***	0.099***	0.143***
	(16.20)	(12.40)	(11.70)	(14.96)	(17.09)	(17.00)
RI	0.040***	0.061***	0.081***	0.059***	0.099***	0.141***
	(15.55)	(12.10)	(12.09)	(15.41)	(17.09)	(17.90)
Comparison						
HVZ–RW	0.000	−0.013***	−0.030***	0.017***	0.043***	0.060***
	(0.10)	(−3.16)	(−5.31)	(3.63)	(6.30)	(6.94)
HVZ–EP	−0.006**	−0.018***	−0.036***	0.029***	0.050***	0.063***
	(−2.50)	(−5.06)	(−8.20)	(5.92)	(7.54)	(6.07)
HVZ–RI	−0.007***	−0.021***	−0.038***	0.028***	0.050***	0.065***
	(−2.77)	(−5.36)	(−8.31)	(5.65)	(7.66)	(6.78)
RW–EP	−0.006**	−0.005	−0.006	0.012***	0.007	0.003
	(−2.62)	(−1.23)	(−0.86)	(2.80)	(1.29)	(0.38)
RW–RI	−0.007***	−0.008*	−0.008	0.011**	0.007	0.005
	(−2.85)	(−1.78)	(−1.40)	(2.64)	(1.49)	(0.76)
EP–RI	−0.001	−0.003	−0.002	−0.001	0.000	0.002
	(−1.62)	(−1.52)	(−0.92)	(−0.93)	(0.14)	(0.82)

Panel A reports the time-series averages of the earnings response coefficients (ERC) for the forecasts from the three cross-sectional earnings models and the random walk model and their pair-wise comparisons. The time-series t-statistics are reported in the parentheses. ***, **, * denote significance at 0.01, 0.05, and 0.10 level, respectively. The ERC is estimated by regressing the sum of the quarterly earnings announcement returns (market-adjusted, from day − 1 to day + 1) over the next 1, 2, and 3 years on firm-specific unexpected earnings (i.e., the forecast bias) measured over the same horizon. We standardize the unexpected earnings so that they have unit variance each year. The results are based on the sample of 119,653 firm-year observations with non-missing t + 1, t + 2, and t + 3 forecast bias from all models. Panel B reports mean ERC by partition of analyst coverage. A firm is covered by analysts if there is one FY1 consensus forecast on I/B/E/S for year t + 1. Panel C reports mean ERC by partition of firm size. Each year, observations are sorted into two equal-sized groups based on their end-of-June market value of equity

for all horizons, with none of the pair-wise differences being statistically significant except for the difference between HVZ and EP in year t + 1 forecast.

Panel C of Table 4 reports the time-series averages of the ERCs in the subsamples partitioned by firm size. For small firms, both the EP model and the RI model produce the highest ERCs, while the HVZ model has the lowest ERCs. In large firms, however, the HVZ model outperforms the other three models, while the RW model is the second best choice.

To summarize, the forecasts from the EP and RI models represent a better approximation of the market expectations than the forecasts from the HVZ model, both in the full sample and in partitions where model-based forecasts are more important. Furthermore, the forecasts of the HVZ model underperform the forecasts of the naïve RW model as proxies for the market expectations in small firms and in firms without analyst coverage.

5 Properties of ICC estimates from the models

5.1 Relation with future returns: portfolio tests

In each year, we divide the sample into quintiles based on the ICC metrics. We then compare the equally weighted mean returns to each of the quintiles, focusing on the spreads between the lowest and the highest quintiles. The returns are measured annually for the first 3 years after portfolio formation, with the compounding period starting 4 months after the end of the prior fiscal year.[7] To allow for a comparison across time, we subtract the risk-free rate (R_F) from both the annual buy-and-hold returns and the ICC metrics.

Table 5 presents the pooled results of our portfolio tests using annual quintiles. Panel A presents the returns over the future 3 years for the quintiles formed on the composite ICC metric (average of ICC_{GM}, ICC_{PEG}, ICC_{GLS} and ICC_{CT}) for each forecasting model (HVZ, EP and RI). Panel B reports the pair-wise comparisons of the return spreads between the lowest and the highest quintiles.

The first column in Panel A provides the mean ICC for each quintile for each of the models. As the results indicate, the mean level of ICC is generally higher for the HVZ model, especially for the higher quintiles. This may be related to the higher bias in the HVZ model reported earlier. The HVZ model is more likely to have negative forecast errors, i.e., more likely to generate higher forecasts of earnings, which would naturally lead to higher values of ICC.

The first set of rows in Panel A of Table 5 presents the returns and return spreads for the HVZ model. Consistent with their reported results, the return spreads for the 3 years are economically meaningful and statistically significant (5.49, 6.66, and 4.49 %, respectively). The realized returns also increase monotonically from the lowest ICC quintile to the highest ICC quintile for all 3 years.

The next set of rows of Panel A presents the return spreads for the EP model. The model generates higher return spreads than the HVZ model. For instance, the return spreads for the EP model are 7.41, 7.87, and 7.13 % for the 3 years respectively, while the corresponding spreads for the HVZ model are 5.49, 6.66, and 4.49 %, with the difference in spreads being statistically significant in year t + 1 and year t + 3 (see Table 5, Panel B). Thus the EP model presents itself as a superior alternative to the HVZ model, consistent with the results for forecast bias, accuracy, and ERC.

[7] This represents a departure from HVZ, who form calendar time portfolios starting on July 1. The advantage of our approach is that the financial statement information is equally timely for all observations. The disadvantage is the fact that the compounding period may not be identical for all firms in our sample. As a robustness test, we carry out all tests in a subset of firms with December fiscal year-ends (over 60 % of the sample) and find virtually identical results.

Table 5 Return spreads for quintiles of implied cost of capital using model-based forecasts

Panel A: Mean return spreads (%)

Model	Quintile	ICC	RET_1–R_F	RET_2–R_F	RET_3–R_F
HVZ	1	−0.73	5.21	4.96	5.36
	2	2.16	6.47	7.60	8.27
	3	5.19	8.38	8.21	8.71
	4	9.19	8.97	9.60	9.69
	5	22.08	10.70	11.62	9.85
	5–1	22.81***	5.49***	6.66***	4.49***
	(t-stat)	(290.82)	(8.29)	(9.68)	(6.76)
EP	1	0.47	5.14	4.79	5.48
	2	2.41	7.50	7.91	7.73
	3	3.84	8.50	9.15	8.67
	4	5.67	9.75	9.38	9.82
	5	12.38	12.55	12.66	12.61
	5–1	11.91***	7.41***	7.87***	7.13***
	(t-stat)	(212.74)	(11.54)	(11.53)	(9.90)
RI	1	0.05	4.91	4.78	5.24
	2	2.28	6.62	7.57	8.38
	3	3.95	8.10	9.00	8.81
	4	5.79	9.92	10.23	10.33
	5	11.26	13.30	12.64	12.26
	5–1	11.21***	8.39***	7.86***	7.02***
	(t-stat)	(236.45)	(13.24)	(11.79)	(10.16)

Panel B: Comparison of mean return spreads (%) across models

	RET_1–R_F	RET_2–R_F	RET_3–R_F
HVZ–EP	−1.92**	−1.21	−2.64***
(t-stat)	(−2.08)	(−1.25)	(−2.69)
HVZ–RI	−2.90***	−1.20	−2.53***
(t-stat)	(−3.17)	(−1.24)	(−2.63)
EP–RI	−0.98	0.01	0.11
(t-stat)	(−1.09)	(0.02)	(0.12)

Firms are divided into quintiles each year based on the implied cost of capital metric (ICC) computed for each of the three models (i.e., HVZ, EP and RI). See “Appendix 1” for details of the model estimation and “Appendix 2” for ICC estimation. Panel A presents the pooled equally weighted average of buy-and-hold returns for the first 3 years after portfolio formation, adjusted for the risk-free rate (RET_1–R_F, RET_2–R_F, and RET_3–R_F, respectively) for quintiles based on ICC as well as the spread between the extreme quintiles. Panel B reports the pair-wise comparisons the spreads. Figures in parentheses represent t-statistics, calculated using a pooled estimate of standard error. ***, **, * denote significance at 0.01, 0.05, and 0.10 level, respectively

The final set of rows of Panel A of Table 5 presents the return spreads for the RI model, which are quantitatively similar to those of the EP model. For instance, the RI model produces return spreads of 8.39, 7.86, and 7.02 % for the next 3 years. This compares favorably with the returns spreads of 5.49, 6.66, and 4.49 % for the HVZ model (differences significant for year t + 1 and year t + 3).

The return spreads for the ICC metrics, especially those from the EP and RI models, compare favorably with the results shown in prior literature (Gode and Mohanram 2003, Gebhardt et al. 2001). They are also comparable to the results using adjusted forecasts shown in Mohanram and Gode (2013).

5.2 Relation with future returns: firm level tests

In addition to the portfolio tests, we perform firm level tests to measure the relation between the ICC metrics generated by the models and future returns. For each year, we estimate cross-sectional univariate regressions with the future returns as the dependent variable and the ICC metric as the independent variable.[8] The benchmark coefficient is 1, where the realized return is on average equal to the ICC proxy. We present the Fama and MacBeth (1973) coefficients and t-statistics in Table 6. Panel A presents the regression results for the ICC metrics derived from each of the three models. Panel B compares the coefficients on the ICC metrics across the models.

The first set of columns of Panel A presents the regression for year t + 1. As the results indicate, the ICC metric based on the HVZ model has the lowest correlation with future realized returns with a coefficient of 0.314. In comparison, the ICC metric based on the EP model has a coefficient of 0.569, while the ICC metric based on the RI model has a coefficient of 0.649. The next set of columns presents the regressions for year t + 2 and suggests a similar pattern, with the coefficient on ICC for the HVZ model at 0.256 trailing that for the EP model (0.544) and the RI model (0.579). Finally, the last set of columns suggests that the pattern persists for year t + 3. The coefficient on ICC for the HVZ model is 0.147, while the coefficients on ICC for the EP model and the RI model are 0.559 and 0.573, respectively.

As the comparison in Panel B suggests, the differences in the coefficients on ICC between the HVZ model and the other two models are statistically significant for year t + 3. In year t + 1 and year t + 2, the differences appear to be economically significant. For instance, the coefficient of the RI model or the EP model is more than twice as large as the coefficient of the HVZ model in year t + 2. However, the differences are statistically insignificant. Finally, the ICC based on the RI model appears to have slightly stronger correlations with future realized returns than the ICC based on the EP model.[9]

[8] Easton and Monahan (2005) recommend running regressions with the ICC measure and proxies for cash flow news and discount rate news. However, these proxies require forecast revisions, which are not feasible to estimate for cross-sectional models. Hence, we only run univariate regressions.

[9] A concern might be that the lower coefficients on the HVZ model in the return regressions might arise mechanically due to the greater magnitude and greater spread of the ICC estimates generated from the HVZ model. To account for this, we perform the following sensitivity test. We standardize all the ICC measures each year by subtracting the minimum and then dividing by the range (maximum–minimum) for ICC using that method in that year. In other words, we set each ICC = (ICC − min)/(max − min). We then re-estimate the regressions using the standardized ICC measures. We continue to find the weakest relation between ICC from the HVZ model and future returns. For instance, for 1-year-ahead returns, the average coefficients on ICC_{HVZ}, ICC_{EP}, and ICC_{RI} from the Fama–MacBeth regressions are 0.230, 0.331, and 0.411, respectively. For 2-year-ahead returns, the average coefficients on ICC_{HVZ}, ICC_{EP}, and ICC_{RI} are 0.190, 0.360, and 0.342, respectively. For 3-year-ahead returns, the average coefficients on ICC_{HVZ}, ICC_{EP}, and ICC_{RI} are 0.120, 0.309, and 0.298, respectively.

Table 6 Regression of future returns on implied cost of capital using model-based forecasts

Panel A: Univariate regression of future returns on ICC

Model	$RET_1–R_F$			$RET_2–R_F$			$RET_3–R_F$		
	Intercept	ICC	Adj. R^2 (%)	Intercept	ICC	Adj. R^2 (%)	Intercept	ICC	Adj. R^2 (%)
HVZ	0.047*	0.314***	1.0	0.057**	0.256***	0.7	0.063**	0.147*	0.7
	(1.72)	(3.42)		(1.98)	(3.16)		(2.19)	(1.80)	
EP	0.040	0.569***	1.5	0.048*	0.544**	1.0	0.050**	0.559**	1.2
	(1.58)	(2.59)		(1.89)	(2.46)		(1.99)	(2.48)	
RI	0.038	0.649***	1.5	0.049*	0.579***	1.0	0.053**	0.573***	1.2
	(1.47)	(2.81)		(1.88)	(2.73)		(1.99)	(2.79)	

Panel B: Comparison of coefficient on ICC across the models

	$RET_1–R_F$	$RET_2–R_F$	$RET_3–R_F$
HVZ–EP	−0.255	−0.288	−0.412*
(t-stat)	(−1.07)	(−1.22)	(−1.72)
HVZ–RI	−0.335	−0.323	−0.426*
(t-stat)	(−1.35)	(−1.42)	(−1.92)
EP–RI	−0.080	−0.035	−0.014
(t-stat)	(−0.25)	(−0.11)	(−0.05)

Panel C: Regression of future returns on all ICC metrics

	Intercept	ICC_{HVZ}	ICC_{EP}	ICC_{RI}	Adj. R^2 (%)
$RET_1–R_F$	0.035	0.075	−0.257	0.972***	2.3
	(1.40)	(0.78)	(−0.69)	(2.84)	
$RET_2–R_F$	0.042*	0.053	−0.109	0.808**	1.9
	(1.70)	(0.54)	(−0.26)	(2.43)	
$RET_3–R_F$	0.048*	−0.102	−0.210	1.057***	2.2
	(1.86)	(−0.94)	(−0.41)	(2.61)	

Panel A presents univariate Fama and MacBeth (1973) regressions of future realized returns on metrics of implied cost of capital (ICC) computed for each of the three models. See "Appendix 1" for details of the model estimation and "Appendix 2" for ICC estimation. The dependent variables are the buy-and-hold returns for the first 3 years after portfolio formation, adjusted for the risk-free rate ($RET_1–R_F$, $RET_2–R_F$, and $RET_3–R_F$, respectively). Panel B reports the pair-wise comparisons of the coefficients on ICC. Figures in parentheses represent t-statistics, calculated using a pooled estimate of standard error. Panel C reports Fama and MacBeth regressions of future realized returns on the three ICC metrics (i.e., ICC_{HVZ}, ICC_{EP}, and ICC_{RI}). ***, **, * denote significance at 0.01, 0.05, and 0.10 level, respectively

As an alternative to comparing mean coefficients across different sets of regressions, we also run a "horse race" between the ICC metrics by regressing realized returns on all three metrics (labeled ICC_{HVZ}, ICC_{EP}, and ICC_{RI}). The results are presented in Panel C of Table 6. As the results suggest, ICC_{RI} is the clear winner, with a significant coefficient that approaches the benchmark of 1 for all 3 years. The coefficients on ICC_{HVZ} and ICC_{EP} are insignificant for all 3 years.

To summarize, the firm level regressions confirm the results from the portfolio tests. The ICC estimates derived from the EP and the RI models show stronger correlations with realized returns than the ICC estimates from the HVZ model. The

RI model appears to perform marginally better than the EP model. Researchers wishing to choose between these two models will have to make a tradeoff between the greater parsimony of the EP model and the slightly stronger results of the RI model.

5.3 Relation with risk factors

Prior research has evaluated ICC metrics either by evaluating their correlation with realized returns or by analyzing their correlation with risk proxies such as systematic risk, idiosyncratic risk, size, book-to-market, and growth (Gebhardt et al. 2001; Gode and Mohanram 2003; Botosan and Plumlee 2005).[10] Our results thus far have shown that the ICC metrics from the EP and RI models outperform the ICC metrics from the HVZ model as far as the correlation with realized returns is concerned. We now examine the correlation of the ICC metrics with risk factors to ensure that this superior performance is not coming at the expense of anomalous correlations with risk factors.

We use the following risk factors from prior research: (1) systematic risk (β), calculated using monthly returns over the lagged 5 years (ensuring that at least 24 observations are available); (2) firm size (LMCAP), the logarithm of market capitalization at the time of the forecasts; (3) book-to-market ratio (BM); (4) idiosyncratic risk (IDIO), the standard deviation of the prior year's monthly returns; (5) earnings volatility (STDNI), the standard deviation of net income (IBQ) scaled by total assets (ATQ) measured over the previous 8 quarters; (6) leverage (D2A), the ratio of total debt (DLTT + DLC) to total assets (AT); and (7) analyst following (LFOLLOW), the logarithm of 1 + number of analysts following the stock. We expect ICC to be positively related to β, BM, IDIO, STDNI, and D2A and negatively related to LMCAP and LFOLLOW.

We estimate three specifications—the first with only β like the CAPM model, the second with β augmented with size (LMCAP) and book-to-market (BM) like the Fama and French (1992) model, and the final specification with all the proposed risk factors. Regressions are estimated annually and aggregated using the Fama and MacBeth (1973) procedure.

The results are presented in Table 7. At the outset, we note that all proxies correlate strongly in the expected direction with four of the above seven factors—positively as expected with book-to-market (BM), earnings volatility (STDNI), and leverage (D2A) and negatively as expected with size (LMCAP). Our discussion will hence focus on the three remaining risk proxies—β, IDIO, and LFOLLOW—where we find variations among the three forecasting models.

The first set of rows in Table 7 present the regressions for the ICC metric computed from the HVZ model. The results suggest an anomalous negative correlation between ICC_{HVZ} and β in all specifications and an insignificant

[10] Easton and Monahan (2010) argue that the latter approach is logically inconsistent as ICC metrics are estimated precisely because of the flaws in conventional measures of risk that often rely on ex post returns. We present these results to ensure a comparison between our results and those presented in HVZ.

Table 7 Implied cost of capital metrics and risk factors

Metric	Intercept	β (+)	LMCAP (−)	BM (+)	IDIO (+)	STDNI (+)	D2A (+)	LFOLLOW (−)	Adj. R^2 (%)
ICC_{HVZ}	0.080***	−0.010***							1.4
	(10.47)	(−3.31)							
	0.193***	−0.017***	−0.028***	0.044***					56.0
	(15.08)	(−11.21)	(−15.72)	(17.81)					
	0.181***	−0.018***	−0.027***	0.043***	0.027	0.013***	0.017***	−0.000	57.2
	(13.40)	(−10.48)	(−15.25)	(18.08)	(1.57)	(2.58)	(5.12)	(−0.37)	
ICC_{EP}	0.046***	0.003*							0.9
	(24.04)	(1.71)							
	0.090***	0.000	−0.012***	0.025***					41.5
	(20.86)	(0.42)	(−15.24)	(22.10)					
	0.045***	−0.008***	−0.008***	0.027***	0.222***	0.028***	0.026***	−0.001**	47.3
	(8.91)	(−7.00)	(−12.00)	(20.27)	(9.26)	(5.72)	(10.04)	(−2.03)	
ICC_{RI}	0.048***	−0.001							2.1
	(20.58)	(−0.70)							
	0.061***	−0.002***	−0.008***	0.038***					57.4
	(13.41)	(−2.63)	(−9.98)	(24.21)					
	0.038***	−0.007***	−0.006***	0.038***	0.115***	0.034***	0.019***	0.000	60.9
	(8.97)	(−6.09)	(−10.00)	(24.44)	(5.10)	(3.73)	(7.38)	(1.48)	

This table presents firm level regressions of the ICC metrics on the following risk factors: β (systematic risk), LMCAP (size), BM (book-to-market), IDIO (idiosyncratic risk), STDNI (earnings volatility), D2A (leverage), and LFOLLOW (analyst coverage). β is calculated using monthly returns over the lagged 5 years (ensuring that at least 24 observations are available). LMCAP is the logarithm of market capitalization at the time of the forecasts. IDIO is the standard deviation of the prior year's monthly returns. STDNI is the standard deviation of net income (IBQ) scaled by total assets (ATQ) measured over the previous 8 quarters. D2A is the ratio of total debt (DLTT + DLC) to total assets (AT). LFOLLOW is the logarithm of 1 + number of analysts following the stock. See "Appendix 1" and B for details of the model estimation and ICC estimation. Regressions are estimated using the Fama and MacBeth (1973) procedure. Figures in parentheses are t-statistics. ***, **, * denote significance at 0.01, 0.05, and 0.10 level, respectively correlation with both idiosyncratic risk (IDIO) as well as analyst following (LFOLLOW).

The next set of rows presents the results for the EP model. In the univariate regression, the coefficient on β is positive and statistically significant (0.003, t-stat 1.71). In the full specification, we find a strong positive correlation as hypothesized between ICC_{EP} and IDIO (0.222, t-stat 9.26) and a significant negative correlation as hypothesized between ICC_{EP} and LFOLLOW (−0.001, t-stat −2.03). However, the coefficient on β in the full specification is anomalously negative (−0.008, t-stat −7.00).

Finally, the last set of rows presents the results for the RI model. The coefficient on β is insignificant in the univariate regression (−0.001, t-stat −0.70). In the full specification, we find a strong positive coefficient on IDIO (0.115, t-stat 5.10) but an insignificant positive coefficient on LFOLLOW (0.000, t-stat 1.48). Similar to the other two measures, the coefficient on β in the full specification is anomalously negative (−0.007, t-stat −6.09).

To summarize, the EP model shows the strongest correlations with risk factors, with six of the seven risk factors (all except β) loading significantly and in the correct direction. The RI model ranks the second, with five of the seven risk factors (all except β and LFOLLOW) loading significantly and in the correct direction. The HVZ model ranks the third, with three risk factors either not loading or loading anomalously (β, LFOLLOW, and IDIO). The risk regressions hence confirm that the superior performance of the RI model and the EP model in particular is not coming at the expense of anomalous correlations with risk factors.

6 Sensitivity analysis

We perform several sensitivity tests to verify the robustness of our results. These results are not tabulated for brevity but are discussed below.

The relation between our prediction variables and future earnings could vary not only through time but also across industries. We examine this possibility by estimating regressions by industry and by year, where industry is defined according to the 48 industry classifications in Fama and French (1997). Interestingly, we find that estimating the regressions at the industry-year level increases forecast errors for all models. In addition, estimating regressions by industry-year slightly reduces our sample size because certain industries do not have sufficient historical data. Hence it appears that the parsimonious approach used here as well as in the HVZ paper is preferable.

The evidence in the paper indicates that firm size is an important determinant of the relation between our prediction variables and future earnings. Consequently, we estimate each model by size deciles and year. The size deciles are determined using the end-of-June market value of equity each year. This modification marginally improves the forecast accuracy of all models but has almost no impact on the performance of the ICC metrics. This confirms the validity of the parsimonious approach of running annual cross-sectional regression for the entire population.

One concern that may affect the comparison of the HVZ model with the EP and RI models is that the HVZ model is estimated at the dollar level, while the EP and RI models are estimated at the per-share level. We perform robustness test by estimating the HVZ model at the per-share level. We find that this improves HVZ's forecast accuracy and ERC. However, it still significantly underperforms the other three models in terms of forecast accuracy and ERC performance. For example, the 1-year-ahead to 3-year-ahead earnings forecasts for the whole Compustat population from the RI model are on average 6–15 % more accurate than the forecasts from the per-share HVZ model. The improvement can be as large as 20 % for firms without analyst coverage or for small firms. In addition, we also estimate all models by scaling the variables by total assets or market capitalization, and the inference does not change. Hence the superiority of the EP and the RI models is not an artifact of the differences in scaling.

The RW model does not have intercept, which may drive the differences in forecast accuracy between it and the other three models. To address this issue, we estimate the HVZ, RI and EP models without intercept. This improves the forecast accuracy for all three models. As a result, the EP model not only outperforms the RW model in mean forecast accuracy but also reports comparable median forecast accuracy. However, the ranking of the four models in terms of forecast accuracy does not change.

We also explore the non-regression based forecasts. Specifically, we examine the following methods: (1) multiply price with the most current EPS yield (earnings/price) for the market or the industry, (2) multiply earnings with expected GNP growth, (3) multiply book value of equity with the current ROE for the market or industry, (4) various weighted average of the first three alternatives. We find that none of these non-regression-based forecasts outperform the EP or the RI forecasts. Among these alternatives, the method using only EPS yield produces the most accurate forecast.

We also use the robust regression technique instead of OLS regression to reduce the impact of outliers on regression coefficients. Robust regression is an iterative procedure that keeps eliminating outliers and re-estimating regressions, until no further outliers are deleted. We find that the robust regression technique marginally improves the mean forecast accuracy of all models. However, the rankings of the models in terms of forecast accuracy and ERC do not change. We also find a minimal impact on the properties of the ICC metrics. Again, for reasons of parsimony, we recommend that researchers use a simple OLS regression.

A potential problem with the ERC estimation is that the magnitude of ERCs is biased downward in the presence of large forecast errors. Cheong and Thomas (2012) show that ERCs can increase dramatically when observations with extreme forecast errors are deleted. To mitigate the concern that our results of ERC comparison could be driven by the outliers in forecast errors, we truncate at 1, 5, and 10 % on each side of the forecast error distribution for each forecast model. The magnitude of the ERC estimates for all four models increases after eliminating the outliers. However, the ranking of the ERCs does not change. In fact, the significance of the differences between the ERCs actually increases.

7 Conclusion

Forecasts of future earnings are critical for empirical research in valuation, especially research using implied cost of capital. Prior research has traditionally used forecasts from analysts, which has restricted the analysis to the subset of covered firms. As a result, the most interesting firms are often omitted from the analysis. Using time series models to generate forecasts does not satisfactorily address this problem, because these models impose substantial survivorship and age requirements. A recent paper by Hou et al. (2012) addresses this problem by using a cross-sectional approach that requires only current information from firms to generate forecasts. Not surprisingly, their model has been used in recent research on accounting-based valuation (Chang et al. 2012) and ICC (e.g., Jones and Tuzel 2012; Lee et al. 2011; Patatoukas 2011).

Given the widespread adoption of the HVZ model to generate forecasts in lieu of analyst forecasts, it is crucial to evaluate the model and present alternatives to address its weaknesses. Gerakos and Gramacy (2013) show that the HVZ model performs worse than a naïve random walk model. However, a random walk model is not practical for computing ICC.

We present and evaluate two alternative models, while adopting the cross-sectional forecasting approach in HVZ. The first model (EP) is a simple earnings persistence model, which allows for differential persistence of profits and losses. The second model (RI) is motivated by the residual income valuation model in Feltham and Ohlson (1996) and forecasts future income as a function of current income, current book value of equity, and accruals. We test the HVZ model, the above two models, and the naïve random walk model on the basis of their forecast bias, accuracy, and earnings response coefficients. We also evaluate the ICC estimates generated from the HVZ, EP and RI models on the basis of their correlations with future returns and risk factors.

We find that both of our models significantly outperform the HVZ model in virtually all the dimensions we examine. Both models generate more accurate forecasts and show greater ERCs. These differences are greater in settings where model-based forecasts are likely to be the most useful—for small firms and for firms without analyst coverage. In contrast, the HVZ model performs worse than a naïve random walk model, confirming the results in Gerakos and Gramacy (2013).

In addition, the ICC proxies generated from the EP and the RI models show stronger correlations with future returns than the ICC proxies generated from the HVZ model, both at the portfolio level and at the firm level. Lastly, the ICC metrics from the EP and the RI models also show more meaningful correlations with suggested risk factors.

A question to ponder is why the forecasts from the EP and RI models perform better. One conjecture is that they rely on financial statement numbers directly such as earnings, book values, and accruals, while the HVZ model relies instead on numbers recast in terms of cash flows and dividends. This may be analogous to the results of Dechow (1994), who shows that earnings have much stronger correlation with future earnings and returns than cash flows do.

The results of our paper have crucial implications for all research where proxies for future expected earnings are required. We recommend that researchers use cross-sectional forecasting models based either on the EP or the RI models presented in this paper.

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Appendix 1: Variable definitions for models used to generate forecasts

HVZ model

$$E_{i,t+\tau} = \alpha_0 + \alpha_1 A_{i,t} + \alpha_2 D_{i,t} + \alpha_3 DD_{i,t} + \alpha_4 E_{i,t} + +\alpha_5 NegE_{i,t} + \alpha_6 AC_{i,t} + \varepsilon_{i,t+\tau}$$

Variable	Definition	Xpressfeed variable
$E_{t+\tau}$	Earnings in year t + τ	ib-spi
A_t	Total assets in year t	at
D_t	Common dividend	dvc
DD_t	A dummy variable that equals 1 for dividend payers and 0 otherwise	
$NegE_t$	A dummy variable that equals 1 for firms with negative earnings and 0 otherwise	
AC_t	Change in noncash current assets less change in current liabilities excluding change in short-term debt and change in taxes payable minus depreciation and amortization	Δ(act-che)-Δ(lct-dlc-txp)-dp

EP model

$$E_{i,t+\tau} = \beta_0 + \beta_1 NegE_{i,t} + \beta_2 E_{i,t} + \beta_3 NegE * E_{i,t} + \varepsilon_{i,t+\tau}$$

Variable	Definition	Xpressfeed variable
$E_{t+\tau}$	Earnings in year t + τ divided by number of shares outstanding in year t	$(\text{ib-spi})_{t+\tau}/\text{csho}_t$
$NegE_t$	A dummy variable that equals 1 for firms with negative earnings and 0 otherwise	
$NegE*E_t$	Interaction term of NegE and E	

RI model

$$E_{i,t+\tau} = \chi_0 + \chi_1 NegE_{i,t} + \chi_2 E_{i,t} + \chi_3 NegE * E_{i,t} + \chi_4 B_{i,t} + \chi_5 TACC_{i,t} + \varepsilon_{i,t+\tau}$$

Variable	Definition	Xpressfeed variable
$E_{t+\tau}$	Earnings in year t + τ divided by number of shares outstanding in year t	$(\text{ib-spi})_{t+\tau}/\text{csho}_t$
$NegE_t$	A dummy variable that equals 1 for firms with negative earnings and 0 otherwise	
$NegE*E_t$	Interaction term of NegE and E	
B_t	Book value of equity divided by number of shares outstanding	$\text{ceq}_t/\text{csho}_t$
$TACC_t$	Richardson et al. (2005) total accruals, i.e., the sum of the change in WC, the change in NCO, and the change in FIN, divided by number of shares outstanding	WC = (act-che)-(lct-dlc); NCO = (at-act-ivao)-(lt-lct-dltt); FIN = (ivst + ivao)-(dltt + dlc + pstk); All variables deflated by csho

Appendix 2: Computing implied cost of capital

The implied cost of equity used in this paper is computed as the average of the four commonly used metrics, ICC_{GM}, ICC_{PEG}, ICC_{GLS}, and ICC_{CT}. We briefly describe how these four metrics are computed below.

ICC based on the Ohlson and Juettner-Nauroth Model: ICC_{GM} and ICC_{PEG}

Ohlson and Juettner-Nauroth (2005) show that the implied cost of capital can be expressed as:

$$r_e = A + \sqrt{A^2 + \frac{eps_1}{P_0}(g_2 - (\gamma - 1))} \text{ where } A = \frac{1}{2}\left((\gamma - 1) + \frac{dps_1}{P_0}\right) \text{ and } g_2 = \frac{(eps_2 - eps_1)}{eps_1}$$

Gode and Mohanram (2003) make the following assumptions. They set $(\gamma - 1)$ to $R_f - 3\ \%$ where R_f is the risk-free rate. In addition, they use the average of short-term growth and analysts' long-term growth rate (LTG) instead of g_2 to reduce the impact of outliers.

If short-term growth $(\frac{eps_2}{eps_1} - 1)$ is greater than long-term growth rate $(\sqrt[4]{\frac{eps_5}{eps_1}} - 1)$, we set g_2 to equal the geometric mean of short term and long-term growth rate. If short-term growth is less than long-term growth, we set g_2 to equal the long-term growth rate. Dividends are estimated by calculating current payout for all firms, defined as dividends (DVC) divided by income before extraordinary items (IB) for firms with positive current earnings or dividends divided by 6 % of total assets (AT) for firms with negative IB.

In addition, we compute an ICC from a simplified version of the Ohlson and Juettner-Nauroth model that ignores dividends and sets ICC to the square root of the inverse of the PEG ratio. We compute ICC_{PEG} as:

$ICC_{PEG} = \sqrt{\frac{g_2}{\left(PRICE/_{eps_1}\right)}}$ where g_2 is defined as it is for the R_{GM} model

ICC based on the residual income model: ICC_{GLS} and ICC_{CT}

Gebhardt et al. (2001) use the residual income valuation model to estimate implied cost of equity. They use EPS estimates for future 2 years and the expected dividends payout (from historical data) to derive book value and return on equity (ROE) forecasts. Beyond the forecast horizon, they assume that ROE fades to the industry median by year 12. Industry median ROE is estimated as the median of all ROEs from firms in the same industry defined using the Fama and French (1997) classification over the past 5 years with positive earnings and nonnegative book values, where ROE is defined as the ratio of net income before extraordinary items (IB) to lagged total common shareholders' equity (CEQ). Abnormal earnings are assumed to remain constant at year 12 levels for perpetuity. The cost of equity is computed numerically by equating current stock price to the sum of the current book value and the present value of future residual earnings, i.e., solving for r in the equation:

$$P_0 = B_o + \sum_{\tau=1}^{12} \frac{(eps_\tau - r * B_{\tau-1})}{(1+r)^\tau} + \frac{(eps_{12} - r * B_{11})}{r(1+r)^{12}}$$

where eps is the forecasted eps (obtained either from explicit forecast or inferred from expected ROE and lagged book value); P_0 is current price per share; B_0 is current book value per share; and B_1 through B_{11} are expected future book values per share obtained through the clean surplus relation, setting payout to equal current payout. Current payout is defined as dividends (DVC) divided by income before extraordinary items (IB) for firms with positive current earnings or dividends divided by 6 % of total assets (AT) for firms with negative IB. We depart from Gebhardt, Lee, and Swaminathan by using the model forecasts explicitly for years 1 through 5 and then applying ROE convergence.

Claus and Thomas (2001) also use the residual income model to estimate the implied cost of equity. They assume that earnings grow at the analyst's consensus long-term growth rate until year 5 and at the rate of inflation thereafter. The implied cost of equity is estimated numerically by solving the following equation:

$$P_0 = B_o + \sum_{\tau=1}^{5} \frac{(eps_\tau - r * B_{\tau-1})}{(1+r)^\tau} + \frac{(eps_5 - r * B_4) * (1+g)}{(r-g)(1+r)^5}$$

where eps_0 through eps_5 are the forecasted future earnings per share; B_0 is current book value per share; and B_1 through B_4 are expected future book values per share. Consistent with Claus and Thomas (2001), g is set to $R_f - 3$ %.

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