A Comparison of Residual Income and Comparable Firm Valuation of Initial Public Offerings[†]

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ABSTRACT: The aim of this study is to assess the relative predictive ability of residual income valuation against the popular alternative of comparable firm valuation for predicting the offer and initial day market prices of IPO firms. The results show that the residual income model outperforms a number of comparable firm multiples in predicting the offer and the initial day market price. The results suggest that fundamental valuation is a valuable tool in the IPO context for investors even when there is limited data available for estimating these models.

Keywords: *residual income, comparable firm valuation, initial public offerings.*

1. Introduction

This study examines the relative predictive ability of residual income and comparable firm valuation approaches for predicting the offer and initial day market prices of Initial Public Offerings (IPO). IPOs are often cited amongst the examples where valuation is crucial to the success of the transaction (see for example Bhojraj and Lee 2002). This study compares the more theoretically sound residual income valuation approach with the popular alternative of comparable firm valuation at the IPO stage.

Theoretically, all valuation relevant data can be used to estimate the present value of the firm's discounted expected future cash flows. Within the IPO context however many young firms do not pay dividends prior to their IPO. With no dividend history, forecasts of future dividends and estimates from dividend discount models would be highly problematic[1]. Similarly, firm value can be expressed in terms of free cash flows (e.g. Feltham and Ohlson 1995; Penman and Sougiannis 1998). For young growth firms however the free cash flow is likely to be negative over short horizons requiring subjective forecasts of the timing, amount and growth in free cash flows. Discounted cash flow analysis is also likely to be imprecise.

Given the severe difficulties in estimating the dividend discount and the free cash flow valuation models in the IPO context, this paper focuses on the residual income and comparable firm valuation methods. Residual income valuation estimates value directly from the information contained in the target firms' financial data (Ohlson 1995; Feltham and Ohlson 1995). A popular alternative at the IPO is to estimate value using information contained in comparable firms' financial information (Kim and Ritter 1999; Purnanandam and Swaminathan 2002). The research question posed is therefore; do residual income methods of valuation have superior forecasting ability in predicting offer and initial day market prices for firms at the IPO stage over comparable firm methods?

Residual income models have been found to perform well (lower forecast error) relative to dividend and free cash flow based value estimates of value (Bernard 1995; Penman and Sougiannis 1998; Francis et al. 2000). Recently, Courteau et al. (2003) compare valuation accuracy of 'direct valuation' versus 'industry multiplier' approaches for a sample of firms followed by Valueline. They find that the direct approach generates the lowest forecast errors and highest explanatory power. Based

[1] For our sample 82% of the firms did not pay dividends prior to going public.

upon the prior research in a more general setting, we would expect that residual income models would tend to perform better than models using comparables within the IPO context.

This study uses a sample of 2008 U.S. domestically traded IPOs that first listed on an exchange during 1980-2001. We estimate residual income models[2] along with comparable firm valuations for each firm in the sample. The estimates of these models are compared using a regression framework, where we compare model fit and the bias in the estimates. Specifically, regression analysis is used to assess the relative strength of the association between the predictions of the valuation models and the observed offer value of equity.

In applying valuation models to an IPO context many strong assumptions are required. In valuing an IPO the forecast growth is likely to be a major issue and therefore the estimates of growth in earnings and terminal value are particularly important. We therefore examine a range of assumptions regarding growth prospects of the firm. In advising on the pricing of IPOs investment bankers have information other than accounting data such as the canvassing of market demand. While this study compares alternate valuation models using a subset of publicly available accounting data, consistent with previous studies of this type, the set of data is less than that available for each individual IPO. The data and methods used represent a lower bound on the importance of the methods and available data in the pricing of IPOs. The availability of other data, and potentially superior analysis skills, allow investment bankers and other participants to more accurately estimate offer price ranges.

The results suggest that both residual income and comparable firm approaches are useful in explaining the cross-sectional variance in the capitalization of the IPO firm at the offer price. On average, residual income valuation models tend to outperform comparable firm valuation models at the task of predicting the offer value and the market value at the end of the initial day. Comparison of non-nested models tests suggests that none of the models holds the capacity to encompass all of the alternative models.

The remainder of this paper is presented as follows. Section 2 relates the current study to prior literature. Section 3 outlines the valuation models tested in this

[2] For convenience the differing assumptions and simplifications from a theoretically consistent residual income valuation are referred to as 'models'. All assumptions and simplifications are however less than ideal implementations of the residual income model.

study. Section 4 includes detailed discussion of estimation issues. The testing procedures used to compare models are reported in section 5. Section 6 presents the empirical analysis. Section 7 presents further analysis and section 8 provides concluding remarks.

2. Relation to prior research

Most firms conducting initial public offerings in the U.S. are relatively young companies for which discounted cash flow analysis is very imprecise. The use of accounting numbers in conjunction with comparable firm multiples is viewed as a common and popular choice for obtaining a valuation for an IPO (see for example Bhojraj and Lee 2002; Kim and Ritter 1999).

Whilst there is a large literature on IPO underpricing[3], relatively few studies consider the valuation of IPOs relative to comparable firms or fundamental values. Kim and Ritter (1999), Purnanandam and Swaminathan (2002), and How, Lam and Yeo (2002) document that comparable firm valuation models can be used to estimate values that are associated with offer prices.

Despite being widely used, Kim and Ritter (1999) document that the comparable firm multiple approach have only modest predictive ability. They find that while multiples can be improved by the use of forward looking estimates and other adjustments, a large proportion of cross-sectional variation in IPO value is unexplained. Kim and Ritter interpret their results to be consistent with the value added by investment bankers in pricing issues, and they leave as an open question the extent to which how much of this improvement is due to superior fundamental analysis and how much is due to canvassing market demand.

Using comparable firm ratios to value IPOs, Purnanandam and Swaminathan (2002) suggest that IPO firms are overvalued by approximately fifty percent in comparison to their industry peers. Surprisingly, they find a positive association between overvaluation relative to industry peers and first-day underpricing that is followed by subsequent underperformance of the IPO.

Recent literature in accounting has advocated the benefits of residual income based value estimates. For example, Bernard (1995) found that the residual income forecasts with book value substantially outperformed dividend forecasts. Penman and

[3] Ritter (2002) and Ritter and Welch (2002) provide reviews of the IPO literature.

Sougiannis (1998) compared the valuation estimates of dividend, free cash flow and residual income. They find that the residual income model consistently outperformed the dividend and the free cash flow model in terms of signed prediction errors. Building on the work of Penman and Sougiannis (1998), Francis et al. (2000) compare the relative ability of the dividend, free cash flow and residual income models as ex ante predictors to explain the cross-sectional variation in the contemporaneous market prices. They use forecast variables based on the Value Line forecasts of earnings, dividends and cash flow. They also find that the residual income model outperforms the other models.

Prior studies that have compared 'direct valuation' with 'comparable firms' approaches include Kaplan and Ruback (1995) who find that both approaches are value-relevant using a sample of highly leveraged transactions. Courteau et al. (2003) compare valuation accuracy of direct valuation versus industry multiplier approaches for a sample of firms followed by Valueline. They find that the direct valuation methods generate the lowest mean squared errors, tightest inter-percentile ranges and highest regression explanatory power. Based upon the prior research in a more general setting, we would expect that within the IPO context residual income models would tend to perform better than models using comparables. Given however the large number of assumptions and estimates needed to implement residual income models in the IPO context, that depart from the theoretically optimal values, evidence is needed to consider the practicality of using this framework within the IPO context.

3. Valuation models

All of the following valuation models are used to predict the offer prices and the market prices of a cross-section of IPOs. Each model's estimate is calculated using only ex-ante data.

3.1 The residual income model (RIM)

Following Ohlson (1995; as restated by Penman 1997, page 306) the value of the firm can be expressed as:

$$RIV_t = B_t + \sum_{\tau=1}^{T} \rho^{-\tau} E_t\left(\tilde{X}_{t+\tau} - (\rho - 1)\tilde{B}_{t+\tau-1}\right) \qquad (1)$$

where, X refers to earnings, B refers to book value, and ρ refers to the discount rate (one plus the adjusted rate of return). Under the assumptions relating to clean surplus

relationships, equation (1) is shown to hold where, the horizon of the model $T \to \infty$ such that $\rho^{-T} E_t\left(\tilde{B}_{t+T}\right) \to 0$.

To specify the residual income model within a finite forecast horizon a terminal value is required. Following Penman (1997), assuming a terminal value in *T* periods beyond the current period *t*, equation 1 can be expressed as follows:

$$RIV_t = B_t + \sum_{\tau=1}^{T} \rho^{-\tau} E_t\left(\tilde{X}_{t+\tau} - (\rho - 1)\tilde{B}_{t+\tau-1}\right) + \rho^{-T} E_t\left(\tilde{P}_{t+T} - \tilde{B}_{T+t}\right) \quad (2)$$

The term $\rho^{-T} E_t\left(\tilde{P}_{t+T} - \tilde{B}_{T+t}\right)$ refers to the present value of the difference in the price of the security subsequent to the forecasting period and the end of period book value[4]. The residual income model expression in equation (2) requires forecasts of price in the terminal value. Penman (1997) highlights the need for consistency in the determination of terminal value relative to the combination of flows and stocks used in the model. At this point we simply redefine the terminal value in equation (2) as a single term and consider alternate specifications for estimating the terminal value below.

At time *t* prior to the IPO an empirical implementation of equation (2) can be stated with parameters that must be estimated for empirical testing. We define *t* to represent the information available to the investor one month prior to the IPO. The financial data used is the most recent year-end figures available prior to the IPO on the *Compustat* database[5]. For the discount rate and the required rate of return, time varying interest rates are used. The rates are taken as the most recent month end rates from the term-structure of the treasury bonds (at the 1 year through 5 year points from the curve). We consider variations of the following residual income model using data available prior to the IPO:

$$\hat{RIV}_t = B_t + \sum_{\tau=1}^{T} \rho_{t+\tau}^{-\tau}\left(\hat{X}_{t+\tau} - (\rho_{t+\tau} - 1)\hat{B}_{t+\tau-1}\right) + \rho_{t+T}^{-T}\left(\hat{TV}\right) \quad (3)$$

where, *B* refers to book value of common equity (*Compustat* data item #60) at time t taken as the most recent observation of book value from the Compustat data file that

[4] In Ohlson (1995) the model assumes that the premium converges to zero. See Ohlson and Zhang (1997) for an analysis of the error introduced by the truncation.

[5] *Compustat* occasionally uses a backfilling procedure to update new firms to their database. Whenever information is restated to the SEC, *Compustat* uses the restated disclosures, creating a potential bias when the information used in this study would be different to the original information used by market participants in their valuation estimates at the time of the IPO. This is a limitation of the study and the results should be interpreted with this limitation in mind.

is in the year prior to the issue. Estimated future book values are consistent with the clean-surplus method: $B_t = B_{t-1} + X_t - D_t$, using forecasts of earnings and an estimate of dividends based on the firm's current dividend payout ratio[6], $\hat{X}_{t+\tau}$ is estimated future earnings at time ($t+\tau$), $\hat{TV}$ refers to the estimated terminal value. The discount rates (ρ) refer to one plus the constant yield to maturity from the term-structure of Treasury bonds plus an equity premium of 6%[7].

The appropriate horizon prior to estimating a terminal value is an unresolved issue in an IPO context. While in theory consistent formulation for the forecast horizon and terminal value will result in equivalent forecasts, empirically the forecast horizon is used to model a growth period prior to a terminal value often assuming different growth assumptions. For firms with higher than average potential growth a longer earnings growth period prior to the estimation of a perpetuity based terminal value may be appropriate. As we have no basis for choosing a specific horizon we estimate values at T=3 and T=5 (c.f. Penman and Sougiannis 1998) with emphasis placed on the three year horizon in reporting results[8]. The methods for estimating future earnings, terminal values and discount rates are each discussed in detail below.

3.2 The earnings capitalisation model

We also examine a naïve earnings capitalisation model. The earnings capitalisation model used in this study assumes that investors use an earnings multiple to estimate the market to book premium. Under such assumptions, the valuation is derived from the addition of book value to a perpetuity of earnings.[9] The model, *ECAP*, is calculated as:

$$ECAP = B_t + (\rho_t - 1)^{-1} X_t \qquad (4)$$

[6] Where dividends paid prior to the IPO are zero, we estimate the future dividends to be zero over the forecast horizon period. In sensitivity analysis (not reported), we estimated the dividend payout ratio using the dividend payout ratio of the S&P 500. The outcome of this sensitivity test did not significantly alter the results reported in this paper.

[7] In a prior draft, we presented results with no equity premium in the discount rate. The prior draft therefore reported different levels in model fit, however, the main findings of the paper are unchanged.

[8] The alternate forecast horizons are considered in the sensitivity analysis.

[9] Estimates from this 'rule-of-thumb' could possibly be equated to a theoretically consistent residual income model for very specific dynamics regarding implied growth in residual income. This is beyond the scope of this study and we merely include this model as a naïve model of direct valuation based upon minimal accounting information.

where, B refers to the most recent observation of book value, X refers to the most current observation of earnings and ρ refers to the interest rate on the one-year constant yield to maturity treasury bond plus 6%.

3.3 Comparable Firm Valuation

Based on the work of Kim and Ritter (1999) and Purnanandam and Swaminathan (2002) we calculate the following selection of comparable firm price multiples: price-to-earnings, price-to-sales, price-to-EBITDA, market to book and market-to-adjusted book value. IPO firms are typically smaller and newer than firms in an industry making the selection of matching firms difficult. The method used to select comparable firms is similar to that of Purnanandam and Swaminathan (2002). The system is based on matching comparable firms on the basis of similarity in operating risks, profitability and growth (c.f. Bhojraj and Lee 2002). In this way the indirect valuation method is related more closely to the concepts of fundamental analysis (direct valuation techniques). The advantage of the algorithm is that it will choose the closest matching firm given the industry, sales and profitability (defined as the ratio of EBITDA to sales). The limitations of the method are that the comparable firm is chosen mechanically, losing the accuracy obtained from more careful analyst selected firms; that the comparison is limited to a single company; and that the comparable firm is selected from the same industry where industry may not be well defined or may not be the best proxy for the risks faced by the firm.

3.3.1 Price to Earnings

A valuation can be derived using the price to earnings ratio of a comparable firm. Price to earnings ratios are included as they are popular amongst market participants and practitioners, they are also commonly found in the valuation literature (see for example, Kim and Ritter 1999; Purnanandam and Swaminathan 2002; Lui et al. 2002). The offer value of equity, defined as the capitalisation of the offer price, can be estimated using the product of the earnings of the IPO and the price to earnings ratio of the comparable firm.

$$PE = X_i * \left(\frac{MVE}{X} \right)_{comp} \tag{5}$$

X_i = the earnings of the IPO firm (*Compustat* data item #18), $(MVE/X)_{comp}$ = the ratio of the comparable firm's market value of equity[10] to earnings, The earnings, *X*, of the comparable firm is taken as the most recent fiscal year end prior to the float.

3.3.2 Price to Sales

A valuation of the IPO firm can also be derived using the price to sales ratio of the comparable firm. Price-to-sales ratios are included in the study as they perform well in the IPO context and sales information is commonly available within the IPO context (see Kim and Ritter 1999; and Purnanandam and Swaminathan 2002). The offer value of equity is estimated as product of the IPO firm's sales and the price to sales ratio of the comparable firm.

$$PS = S_i * \left(\frac{MVE}{S} \right)_{comp} \quad (6)$$

where, S_i = the sales of the IPO firm (*Compustat* data item #12), $(MVE/S)_{comp}$ = the ratio of the comparable firm's market value to sales.

3.3.3 Price to EBITDA

The ratio of price to Earnings before Interest, tax, depreciation and amortisation (EBITDA) is examined as EBITDA is a measure of the operating cash flow of the firm, and EBITDA may be assumed to be less affected by accounting distortions than earnings (Purnanandam and Swaminathan 2002). The offer value of equity, can be estimated using the product of the EBITDA of the IPO and the price to EBITDA ratio of the comparable firm:

$$PEBITDA = ebitda_i * \left(\frac{MVE}{ebitda} \right)_{comp} \quad (7)$$

where, $ebitda_i$ = the EBITDA of the IPO firm from the *Compustat* file for the fiscal year prior to listing (*Compustat* data item #18 + data item #15 (interest expense) + data item #14 (depreciation and amortisation)). $(MVE/ebitda)_{comp}$ = the ratio of the comparable firm's market value to earnings.

3.3.4 Price to Book Value

The book value of the firm is the basis for abnormal earnings in the residual income model (see Ohlson 1995 and above). The ratio of the market to book value therefore could be seen as the market's expectations of the firm's abnormal earnings ability, that is, the firm's growth potential. The offer value of equity can be estimated

[10] Where *MVE* is calculated as the product of the price and the number of shares outstanding from the *CRSP* database on the last day of the month prior to the floatation date of the IPO firm.

using the product of the pre-IPO book value of the IPO firm and the market to book value ratio of the comparable firm:

$$MB = B_i * \left(\frac{MVE}{B} \right)_{comp} \quad (8)$$

where, B_i = the book value of the IPO firm (*Compustat* data item #60). $(MVE/B)_{comp}$ = the ratio of the comparable firm's market to book value.

In addition to the limitations with respect to the comparable selection procedure noted above, we also must acknowledge that analysts would be expected to make adjustments to multiples to account for remaining differences between the IPO and comparable firm. We have not accounted for such adjustments within the models estimated and our results must be interpreted with respect to this limitation.

4. Implementing the Residual Income Model in the IPO Context

The implementation of the residual income model presented as equation (3) requires a number of important assumptions and simplifications to be implemented within the IPO context. Assumptions must be made to estimate expected earnings, risk-adjusted rates of return, terminal values and future book values. All of these assumptions and simplifications make the empirical estimates less than ideal and hence the need for empirical testing as to whether these implementations of the residual income model are useful in this context. Because assumptions regarding expected growth in earnings are expected to be crucial for estimating IPO value, we first discuss this issue first followed by the issues of risk-adjusted discount rates, terminal value estimation, and scaling for expected IPO proceeds.

4.1 Growth in Expected Earnings

In valuing an IPO the assumptions regarding expected growth are critical to forecasting value. Unfortunately analysts' forecasts for IPO earnings are generally not available and have been rarely used in studies of initial public offerings[11]. Very few IPOs have a time series of earnings available to implement sophisticated time series analysis of earnings. Due to this paucity of forecast data we consider four techniques for estimating growth: a perpetuity approach, extrapolating previous rates of return,

[11] One exception is the study of Kim and Ritter (1999) who obtained a small number of IPO forecasts from a boutique investment company. They found that implementing comparables using these forecasts reduced the pricing errors of the models. However, for our larger sample, forecasts are not available for a comprehensive number of IPOs.

growth estimates based on industry ROE and inferred growth expectations from recent IPOs.

4.1.1 Growth modelled as a perpetuity in residual income

The first specification for future growth is a simple model assuming that the observed residual income prior to IPO is earned in perpetuity (*RIV–P*). This approach is similar to the first residual income model reported by Frankel and Lee (1998; p289). The difference is that we estimate the perpetuity at time t , the month prior to the IPO. The model is calculated from book value, earnings and the discount rate (as defined above) as:

$$RIV\text{–}P = B_t + (\rho - 1)^{-1}[X_t - (\rho - 1)B_t] \quad (9)$$

An advantage of this model is the simplicity of estimation, but this simplicity comes with a departure from the theoretically consistent model underlying the residual income model. This method could be considered a naïve extrapolation of prior period abnormal income into the future at a continued rate.

4.1.2 Growth estimates based on continued growth over the forecast horizon

The second specification and third specifications of the residual income model, assume that IPO firms experience continued growth in ROE for a period of a few years following the IPO (the length of this horizon is discussed below). As our sample is restricted to those IPO firms with at least one year of positive earnings history, we use the previous year rate of return as a guide to future return on equity. We estimate the prior period book value from the book value prior to the IPO using the clean-surplus method and use this to calculate ROE using the most recently reported earnings prior to the IPO. We then apply a continued ROE to the extrapolated estimate of book value through the forecast horizon of the model. The first of these models is presented with continued growth through three forecast periods and then a perpetuity based on the third period residual income. This model is called residual income value with continued growth with perpetuity in terminal value (*RIV –CGP*).

The second model is presented with continued growth over the three year horizon and then uses a linear fade to industry median in the terminal value. The second model attempts to capture mean reversion in abnormal earnings and follows Lee et al. (1999). This model is called residual income value with continued growth with linear fade to industry median terminal value (*RIV– CGF*).

These models are still likely to underestimate expected growth to the extent that IPO firms achieve higher ROE through economies of scale or through undertaking higher NPV activities funded from the IPO proceeds. To the extent, however, that IPOs self select to go public during periods of abnormally strong performance (Ritter 1984; Loughran and Ritter 1995; Lowry and Schwert 2002), or manipulate accruals to present abnormally good performance (Teoh et al., 1998), these model may not result in unduely high estimates of earnings growth.

4.1.3 Growth estimates based on industry growth in ROE

In the prior model ROE is held constant, however, the residual income model easily accommodates changes in assumptions regarding expected earnings (Lee et al. 1999; Francis et al. 2000). One source of information regarding expected earnings growth is to examine the trend in ROE for similar firms in the industry. In implementing this model it is recognised that by using an average ROE for the industry this method is explicitly including some industry related information into the valuation model but we are still primarily using a direct approach to estimate value from this data.

In order to estimate potential growth in earnings, we calculate expected earnings using the coefficients from a linear regression of current ROE on lagged ROE from that IPO's industry[12] using data available up to the fiscal year end prior to the issue of the IPO. This method is similar to that of Lee et al. (1999), who used this approach when analyst forecasts were unavailable. Specifically for each industry and for each year in the sample we run the following regression model:

$$ROE_t = \delta_0 + \delta_1 ROE_{t-1} + e_t \quad (9)$$

The estimated coefficients from these models ($\hat{\delta}_0$ and $\hat{\delta}_1$) are then applied to the current *ROE* of the IPO to produce one to five period ahead forecasts of *ROE*:

$$\hat{X}_{t+1} = \left[\hat{\delta}_0 + \hat{\delta}_1 ROE_t\right] B_t \quad (10)$$

where, $\left[\hat{\delta}_0 + \hat{\delta}_1\right]$ refer to the estimated coefficients from equation (5) used to linearly extrapolate future IPO earnings using average industry growth rates.

We use these growth assumptions to estimate two residual income models. The first estimates mean industry growth in *ROE* over a three year horizon with a perpetuity of third year residual income (*RIV - IGP*). The second estimates the model

[12] Industry groupings are defined following the 48 industry classification scheme outlined in Fama and French (1997).

over a three year horizon and linearly fades third year *ROE* to median industry *ROE* (*RIV – IGF*).

In implementing the above model it is recognised that by using an average ROE for the industry this method is assuming that the IPO firm performance will tend to be consistent with the industry average. In the IPO context firms self-selecting to go public are likely to be systematically different from the industry average and this may impact the speculation regarding the IPO firms' future growth prospects. To address this self-selection effect the next model estimates growth expectations based upon the expected growth reflected in recent IPOs.

4.1.4 Implied growth estimates based on similar recent IPO

There is considerable evidence that IPOs cluster during 'hot IPO markets' (Lowry and Schwert 2002). By estimating expected growth based upon information contained in recent IPOs this method potentially captures part of the speculation surrounding an IPO firm's growth prospects. We use a 'reverse engineering' approach similar to that adopted by Easton et al. (2002) to estimate forecast growth in residual income given an observed market price of a recent IPO. We match each IPO to the ten most recent IPO firms.

Following Easton et al. (2002), the RIV estimate for a firm *j*, can be expressed in terms of an unknown growth rate *g*, as follows:

$$P_t = B_t + \left(X_{cT} - (R-1)B_t\right)/(R-G) \qquad (11)$$

where $R = (1+\rho)^T$ is one plus the T year expected return on equity and X_{cT} refers to the aggregate T year cum-dividends earnings, and $G = (1+g)^T$ refers to one plus the expected growth rate in the T year residual income. We do not however have analysts forecasts of earnings and so we use historical earnings for the prior year. We estimate the implied growth rates using the initial day market prices for the matching IPO firms.

From the ten possible matches we select three matching firms based on the proximity in residual income[13]. We then substitute these rates of growth as the expected growth in residual income for our IPO firms using the right hand side of equation (11) to generate three estimates of the offer price. The average of these three prices is taken as the forecast of the offer price (*RIV–Implied*). In addition to the

[13] We only include firms that have the same sign (i.e. positive with positive and negative with negative) residual income. This makes the estimates plausible as including positive IPOs with negative matching IPOs will result in negative prices.

caveats in Easton et al. (2002; page 663), we recognise that the estimation of these implied growth rates will introduce an idiosyncratic error from the choice of a recent IPO firm and that this method for estimating growth incorporates comparable firm information.

4.2 Risk adjusted rates of return

The residual income model would ideally be estimated with risk adjusted expectations of future abnormal earnings (Ohlson, 1995). Typically the residual income value requires the estimated future flows of abnormal income to be discounted to present value using a rate that equates to the riskiness of future cash-flows to investors. Whilst Frankel and Lee (1998) find that the choice of discount rate has little effect on their cross-sectional analyses, Lee et al. (1999), find that the residual income model is improved through the addition of time-varying interest rates. As our sample period spans a period of twenty years we use time-varying interest rates.

As the basis for the expected return we use the term-structure of interest rates for the treasury constant yield to maturity bond series. Following the term-structure, we match the appropriate discount rates for the future flows being discounted. Specifically, we match the N^{th} year treasury constant yield to maturity bond rate to the $t+N$ future flow. For example, the flow at $t+3$ is discounted using the 3 year treasury constant yield to maturity bond rate. In addition we add to the base rate a risk-adjustment for equity.

Whilst the best proxy for the risk adjustments to the discount rate would include a firm-specific risk adjustment using estimates such as market betas, firm-specific risk adjustments of this kind are unavailable for IPO firms. Instead, we apply a constant risk premium of 6% above the term-structure of interest rates (c.f. Penman and Sougiannis 1998)[14]. We consider the term-structure of interest rates as appropriate rates as they match the discount rates with the time of the future flows being discounted.

4.3 Terminal value estimation

The expected growth reflected in the terminal value is a significant assumption. Courteau et al. (2001) find that 'price based' estimates of terminal value outperform 'perpetuity based' models of terminal value. However, because a future

[14] Easton et al. (2002) provide market wide estimates of the risk premium, they suggest that the risk premium is likely to be closer to 3-4%. In sensitivity analysis we varied the premium from 0% to 6%, the rankings of the models are not affected by this adjustment, as the rates are lowered however, the model fit slightly improves for models using the residual income approach.

stock price forecast is not available in the IPO setting we follow previous research in adopting non-price based expressions of the terminal value (e.g. Frankel and Lee 1998; Francis et al. 2001). Nevertheless we acknowledge that the perpetuity models of terminal value are less than ideal. Where investors do consider the estimated future price in forming their estimates of the IPO value, our models will not capture this and the resulting models will be biased against finding superiority using the residual income approach.

We therefore consider two measures that proxy post-horizon growth in residual income. Specifically, we consider the perpetuity approach of Penman and Sougiannis (1998), and a mean reversion assumption in post horizon growth to industry averages as per Lee et al. (1999).

4.3.1 Perpetuity approach (PTV)

Following the specification of the terminal value in Penman and Sougiannis (1998; p.352) the post-horizon value is estimated as a perpetuity of final-period abnormal earnings beyond period (t=t+T). The terminal value is calculated as:

$$\rho_{t+T}^{-T}\left(\hat{TV}\right) = \rho_{t+T}^{-T}\left[(\rho - k)^{-1}\left(\hat{X}_{t+T} - (\rho - 1)\hat{B}_{t+T}\right)\right] \quad (12)$$

where, k refers to the forecast growth rate in residual income in perpetuity. When k is set to one, then the terminal value is equivalent to a perpetuity of the final period residual earnings (e.g. Penman and Sougiannis 1998; Frankel and Lee 1998). Following Penman and Sougiannis (1998) and Frankel and Lee (1998) we estimate the terminal value letting k = 1. This perpetuity based terminal value is used with both the continued growth estimates (*RIV–CGP*) and industry growth estimates (*RIV–IGP*).

4.3.2 Mean-reversion in earnings approach (FTV)

In order to capture potential mean-reversion in longer-term earnings, we adopt a linear fade from the forecast return on equity industry to the median industry ROE following the approach taken in Lee et al. (1999). Using the industry mean ROE at time t-1 prior to the IPO, we linearly fade the IPO expected growth to the industry mean for the post-horizon growth rates. This method attempts to capture the mean-reversion in ROE. To construct this terminal value, we include additional flow terms that fade the final ROE term to the median ROE for the industry and a final period perpetuity that earns the industry median ROE. This linear fade based terminal value is used with both the continued growth estimates (*RIV–CGF*) and industry growth estimates (*RIV–IGF*).

5. Methodology

In this section we briefly discuss the choice of tests used to examine the association between the various model forecasts and the observed offer prices. In the first section, we assume that the offer price is an adequate representation of intrinsic value (e.g. Beneviste and Spindt 1989; and Welch 1989). In the subsequent analysis, we control for the systematic underpricing in the offer price by using the market value of equity at the close of the first day as the measure of value.

5.1 Offer Value

The regression models used in this study relate the actual offer value of equity to the forecasts of offer value of equity. The parameters are estimated for each of the models using the same cross-section of IPO firms. The explanatory power of the models is then compared and some measures of bias discussed. This technique is similar to that of Kaplan and Ruback (1995) who use regression analysis to examine the relationship between the transaction value and the model estimated transaction value[15]. Formally, we estimate models of the following form:

$$OVE_i = \beta_0 + \beta_1 FOVE_{i,m} + e_i \qquad (13)$$

where, OVE_i refers to the offer value of equity, calculated as the offer price (*SDC* data item USPR) multiplied by the number of shares outstanding on the day of the IPO (taken as the number of shares outstanding, variable *shrout* from the *CRSP* database). $FOVE_{i,m}$ refers to the forecast offer value of equity from model *m* for each IPO, *i*.

We estimate the coefficients of equation (13) using OLS. Consistent with most studies using IPO data the residuals are skewed due to the impact of outliers on the analysis. To mitigate the impact of outliers on the residuals we estimate this specification after taking the log of OVE_i and $FOVE_{i,m}$. We subsequently consider alternate econometric specifications.

The model is run once for each valuation model. The models can be ranked using the R-square from each regression as they are all explaining the same variable, being the actual offer value of equity (*OVE*). The diagnostic measures derived from the regression analysis, that is, the adjusted R-square, AIC, MSE and Theil's *U*-statistic, will provide rankings that will indicate the IPO valuation model that best predicts the actual offer value of equity.

[15] Kaplan and Ruback (1995) examined the transaction value of leveraged buyouts, we differ in our approach as we are estimating the value of the company rather than the transaction.

A further measure of forecast accuracy is given by Theil's *U*-statistic, which is also known as the inequality coefficient. The statistic is found by taking the square root of the ratio of the MSE to the average squared actuals:

$$TheilU_m = \sqrt{\frac{MSE_m}{\frac{1}{n}\sum(OVE_i)^2}} \tag{14}$$

$$MSE_m = \frac{1}{n}\sum_{t=1}^{n}(\hat{OVE}_{i,m} - OVE_i)^2 \tag{15}$$

Theil's *U*-statistic is minimised at zero for a perfect forecast, so that the ranking of the forecasts is based on the minimum Theil's *U*-statistic (see Maddala 1977).

If the estimated values from the valuation model are unbiased estimates of the actual offer value then the coefficient estimates for the intercept should be zero and the slope should equal unity. Where the intercept is significantly different from zero, the model is biased, the difference in the intercept can be considered as the average misvaluation of the model. Bias can arise from both a poorly specified model and from measurement error introduced when implementing the models.

5.2 Market Value at end of first day

There is an extensive literature on the underpricing of IPOs. Due to underpricing the market prices observed on the first day of trading can be considered a better indication of firm vale than the offer price (Ritter and Warr 2002; Ritter and Welch 2002). Where initial day returns are due to the market correcting for mispricing bias at the offer, errors in forecasting the offer price may be associated with subsequently observed underpricing. We therefore also consider the models accuracy at predicting the market price at the end of the first day.

Replacing OVE with MVE in equation (13) allows for the following specification:

$$MVE_i = \alpha_0 + \alpha_1 FOVE_i + u_i \tag{16}$$

where, *MVE* refers to the market value of equity, defined as the product of the number of shares outstanding and the market price at the close of the initial day of trade. We use the same forecast values (*FOVE*) as in equation (13) above.

6. Data and empirical results

6.1 Data and Sample

This study uses a sample of 2008 US domestically operating firms with an IPO between 1980-2001. The sample of IPOs is taken from the Thompsons Financial Securities new issues database (*SDC*)[16]. There are 8161 firms contained in the *SDC* database for new issues during this period. Table 1 outlines the selection criteria used to obtain the final sample. For inclusion within the final sample the IPO must be a common stock offering and satisfy the data availability requirements for all the valuation models.

Specifically, firms are included only if they meet the following criteria. Firstly, the IPO must be listed on the *CRSP* database. The IPO the IPO must be issued as common stock[17] must be raising greater than five-million dollars with an offer price greater than five-dollars. Firms must have information on the preliminary offer price range, the final offer price and the initial-day market prices. The firms must also have positive sales, earnings and book value information available at the offer stage. Consistent with prior literature, loss firms are excluded from the sample (Kim and Ritter 1999; Purnanandam and Swaminathan 2002). The number of shares, IPO dates and SEC filing dates information is required as well as four-digit SIC codes as a proxy for industry (see below). The final requirement is that the IPO listed on the New York Stock Exchange (NYSE), the American Exchange (AMEX) or the National Association of Securities Dealers Automatic Quotations (NASDAQ) exchange. Firms with missing data are eliminated from the sample.

The loss in observations due to the screening of data is consistent with studies that require financial data available prior to the IPO (see for example Purnanandam and Swaminathan 2002; Teoh et al. 1998; and Neill et al. 1995 amongst others). The results must however be interpreted with respect to the limitation of data availability. In particular, the availability of data for the year prior to the IPO and the elimination of IPOs with losses in the year prior to going public are likely to result in the elimination from the sample of the youngest, most speculative companies going public. Kim and Ritter (1999) document that the comparables models have the highest valuation errors for young firms and this is consistent with these types of IPOs being the most difficult to value. The likely impact on our comparison between models is

[16] Where appropriate corrections to the *SDC* database have been made as outlined at Jay Ritter's web-page (http://bear.cba.ufl.edu/ritter/*SDC*COR.PDF).
[17] ADRs, REITs, Class A shares, non-voting shares and closed end funds are excluded from the sample.

however uncertain. Our results must be interpreted with respect to our sample representing a sample of less speculative IPOs.

6.2 Descriptive Statistics

The descriptive statistics for selected variables observed for the sample IPO firms are presented in Table 2. Panel A displays the descriptive statistics for the financial information available to investors at the time of the offer price being announced. Consistent with other studies of IPOs the sample is skewed with respect to size. On average the companies have pre-IPO total assets worth $US 711 million however the median total assets is only 31 million. The financial performance of the companies pre-IPO is widely dispersed. Sales of the companies on average in the year prior to IPO was 273 million (median 45 million).

Due to our data restrictions excluding IPOs with losses in the year prior to the IPO our sample is more profitable than an unrestricted sample of IPOs. Earnings before extraordinary items is on average 13 million (median 2.4 million) and EBITDA) is on average 29.9 million (median 5.3 million).

The offer price was on average $12.71 with a median of $12 and is highly clustered towards this median. As the valuation of the firm on a per share basis is not only highly clustered but also arbitrarily defined[18] the offer value of equity is used in the analysis. The mean offer capitalisation is 247 million, with a median of 78 million.

Panel B of Table 2 presents the descriptive statistics following the offer. The mean gross proceeds of the issue of the sample is 65.4 million (median 25 million). The market capitalisation calculated as the initial day closing price by the number of shares outstanding has a mean of 307 million (median 86 million).

Underpricing is defined as the unadjusted return made from purchasing a share at the offer price and selling at the closing price of the initial day. The mean (raw) underpricing for this sample is 13%.

Panel C displays the descriptive statistics for the estimates of the offer value of equity from the various models. The estimates are on average highly right-skewed and adding industry information into the forecasts of the residual income approach leads to large positive outliers in the model. Comparison of the models shows that the median values for the indirect methods are much closer to the actuals than are the

[18] As the split of the firm is arbitrary in most cases, the economic meaning of a per share valuation is not directly meaningful.

fundamental method estimates[19]. The number of large extreme values in the distributions of many of the valuation model estimates indicates the need to consider the sensitivity of the results to inclusion of outliers. Analysis is presented before and after the removal of outliers.

6.3 Regression Analysis

This section examines the relative ability of the models to predict the actual offer value of equity and the actual market value of equity. The regression models are estimated for each of the eleven valuation models calculated in this study. In Table 3, we document the regression coefficients with model fit statistics and measures of bias for each valuation model. Specifically, to examine model fit we present adjusted R-square ($AdjR^2$), rankings based on the adjusted R-square ($AdjR^2$ *Rank*), the Akaike Information Criterion (*AIC*), Theil's *U*-statistic (*Theil-U*), Absolute Prediction Errors (*APE*), and rankings based on the Absolute Prediction Errors (*APE Rank*)[20]. We document bias in terms of the mean Signed Prediction Error (*SPE*) and rank the models on the difference of the level of the intercept to zero (β_0 *Rank*).

6.3.1 Model Fit

In panel A of Table 3, the ranking of the valuation models for the OLS estimation of the offer value of equity is presented[21]. The three highest models in terms of model fit ($AdjR^2$ *Rank*) and valuation accuracy (*APE Rank*) are obtained using the residual income valuation approach. The highest R-square is obtained from the naïve model, being the sum of book value and a perpetuity of earnings (*ECAP*). Generally, adding complexity to the residual income model reduces the accuracy of the forecasts for IPOs. The second highest model is simply the sum of book value and a perpetuity of current period abnormal earnings (*RIV–P*), the highest ranked model that explicitly uses growth assumptions is the three-year constant ROE with an industry fade rate in the terminal value (*RIV–CGF*). All three of these models outperform the comparable firm multiples methods. Adding forecasts of growth based on industry mean growth tends to add noise to the model and lessens the accuracy of the forecasts.

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[19] The comparable firm valuation methods also have a much more clustered set of valuation estimates.

[20] Rankings were identical using the mean-square error and the Schwarz Bayesian Criterion to save space only the adjusted R-square rankings and rankings of absolute prediction errors are presented.

[21] The models were also estimated using the Weighted Least Squares approach by weighting the variables in the regression models by pre-IPO total assets of the IPO firms. The rankings of the models are unchanged suggesting that size related heteroscedastic inference is not driving the rankings of the models.

Models using the comparable firm valuation approach (PE, PS, PEBITDA, PBV) also explain variation in the offer value of equity. Where the residual income models do not correctly approximate the growth expectations of the market comparable firms models may outperform residual income models. Typically, the comparables models outperformed constant and industry based forecasting models with perpetuity terminal values.

The ranking within the indirect model categorisation is also roughly consistent with prior literature within the IPO context. The high ranking for the sales based comparable firm ratio in this study is consistent with Kim and Ritter (1999). However, this study finds that the market to book value ratio holds greater predictive ability over offer values than the sales based ratio. This result is opposite to Kim and Ritter (1999) who found the book value based ratio was the least able to predict IPO value. In results not reported the analysis of Kim and Ritter (1999) was replicated. When the models are regressed using ratio forms, the price to sales holds a much higher association than the remaining comparable firm approaches[22].

6.3.2 Growth Estimates

The inclusion of industry based growth estimates did not improve the accuracy of the residual income models. The two industry based models, one with a perpetuity terminal value (*RIV–PTV*) and the other using a fade to the industry median (*RIV–FTV*), performed the worst of all the models presented in Table 3. Where IPOs self-select from industry these results could be expected. In additional analysis, the forecast horizon was extended for the residual income models (results not reported). Extending the forecast horizon resulted in a decline in the models' accuracies which is similar to the result found in Frankel and Lee (1998) suggesting that forecast accuracy diminishes rapidly over time.

6.3.3 Bias

We measure bias in the model's predictions as the average signed prediction error and the magnitude of the intercept. The signed prediction errors (SPE) and the ranking of the models based on the size of the intercept are reported in Table 3. The tabulation of signed prediction errors reveals that ten of eleven models have negative prediction errors on average. This suggests that these models undervalue the actual offer value of the firm. This is consistent with the results of Purnanandam and

[22] The rankings by adjusted R-square are P/S (18.08), P/EBITDA (6.73), P/E (5.16), and M/B (2.67).

Swaminathan (2002) who find that comparable firm multiples approaches typically underestimate offer value.

Assuming that the theoretical value for the intercept is zero, a positive intercept suggests that the predicted valuation is less than the actual valuation on average. The intercepts for all models are positive. Ranking the models on bias as represented by the magnitude of the intercept, the comparable firm multiples marginally improve their rankings, suggesting the average undervaluation is less than that of the residual income models (excluding the *ECAP* model) as implemented in this study.

For the residual income models, the intercepts are potentially baised downwards due to the exclusion of the expected increase in the scale of the firm from IPO proceeds when forecasting future book value. Using information from proceeds from the IPO would of course bias the forecasts towards the actual offer price as the proceeds are endogenously related to the offer price. In sensitivity analysis (not reported), increasing the book values by constant amount across the models does decrease the intercepts marginally for these models[23].

6.3.4 Model Superiority

Davidson-Mackinnon (1981) *J*-tests for non-nested models can be used to examine superiority of a model over an alternative model using the encompassing principle. The test looks for the encompassment of the alternative model within the tested model. The *J*-test is performed for each model against each alternative model. The results are inconclusive, suggesting that there is no clear superior performance by any single model. Under the terminology of the *J*-test this can be interpreted that none of the models can be considered as the true model as there is no single model that encompasses all of the alternative models (see for example; Kennedy, 1998; or Gujarati, 1997). The results of the *J*-test suggest that for IPO valuation purposes, hybrid or combination models may have the potential to outperform single valuation models.

6.3.5 Sensitivity to use of Offer value

It is possible that the use of offer price results in downwardly biased estimates of firm value due to underpricing and that this might systematically impact the results reported above. We address this issue by presenting the ranking of the valuation

[23] Future research could consider more sophisticated measures of forecasting the increase in scale due to expected proceeds from the IPO and the resulting ramifications.

models using the market value of equity in panel B. We find that the results in Panel A are not driven by this bias as the rankings of the models are consistent with the rankings using offer value of equity forecasts. Instead we find that all of the models marginally decline in their ability to forecast the market value of equity. This can be seen as all the slope coefficients (β_1) decline while the intercepts (β_0) increase. As all of the models have significant positive intercepts when estimating the offer value and, with underpricing being on average an increase in the value estimated, this result is not surprising.

6.3.6 Sensitivity to outliers and measurement error

IPO studies results can be particularly sensitive to outliers. The results in Table 3 were also estimated excluding outlier observations (not reported). Outliers were removed based on r-student residuals (at t>2.6). The results of this additional testing show that rankings are unchanged with the removal of outliers. While the rankings are the same as those presented above, the slope coefficients and the model fit statistics improve marginally subsequent to the removal of outliers.

The valuation models require numerous estimates expected to contain measurement error. One technique to reduce the impact of measurement error is the use of reverse regressions [24]. Reverse regressions were also estimated (not reported). As the regressions have only a single variable on each side of the regression equation, the adjusted R-Square will not change. Examination of the slope coefficients shows that the residual income models have slope coefficients that are marginally closer to the theoretical value of unity in comparison to the alternative models, but the model rankings and other inferences are not significantly different from those reported.

6.3.7 Summary and further discussion

To summarise the results, three models from the residual income approach outperform all models from the comparable firm's multiples approach. Within this approach, simple models outperformed more complex models. Perpetuities of current period earnings (*ECAP*) and residual earnings (*RIV–P*) have the highest valuation accuracy of the models tested. In addition, a residual income model with a three period growth horizon and constant ROE that faded to industry medians in the terminal value (*RIV Continued Growth–FTV*) outperformed the remaining models.

[24] If we assume that the actual OVE values are measured without error, the slope coefficients are unbiased with upwards biased standard errors (See Gujarati, 1997).

These results suggest that continuation of a high level of ROE in the forecast model is important in the valuation of IPOs.

The results of the *J*-test are less clear, none of the models performed in a manner consistent with the ability to encompass all of the alternative models. This suggests that the models may be at least in part complimentary allowing for future research to consider hybrid models for valuing IPOs.

The relative strength of the 'continued growth' models over models using industry information is consistent with investors extrapolating prior growth. That is, IPO values are consistent with firms that self-select to go public having higher than industry average growth and investor expectations of continued high future growth. In our sample, the median ROE for the year prior to IPO is 0.387 while the median industry ROE in the year prior to IPO is 0.093. Despite growth that has been earned off a low asset base, investors apparently expect high levels of continuing growth into future periods even though the capital base will be expanding. While it is clear that predicting continuing high levels of pre-IPO ROE implicitly assumes rapid firm growth, modelling this assumption within a residual income approach still provides valuations that are significantly below offer prices.

A possible explanation for these results is provided in Loughran and Ritter (1995). Consistent with Loughran and Ritter (1995), our results suggest that on average investors extrapolate abnormally high ROE to value an IPO. Loughran and Ritter (1995) propose that firms issue within "windows of opportunity", transitory periods where investors systematically overestimate the probability of finding a "big winner". The extrapolation from periods of abnormally strong performance may not be appropriate where IPOs subsequently provide diminishing returns to scale or mean-revert towards industry earnings.

7. Additional analyses

7.1 Sensitivity of the results to deflating variables to mitigate the impact of size

To examine the sensitivity of the rankings of the models to the choice of undeflated offer value of equity as the dependent variable, the analysis is re-estimated after deflating both the actual and forecast offer values by total assets[25]. These results are reported as Table 4. As would be expected the explanatory power of the models is

[25] Similar sensitivity analysis was performed using the market value of equity. No significant differences were identified.

reduced using variables deflated by total assets. Similar to the results presented above, the simple residual income based approaches outperform the comparable firm methods. The bias in the estimates in terms of the intercept is reduced in this analysis, these results suggest that some of the bias may be removed through appropriate size adjustments.

7.2 Analysis by industry

The sample is divided by industry to examine whether the main results are robust across industry sub-samples. The sample is divided by industry following the categories set out in Teoh et al. (1998) resulting in the identification of 18 industries[26].

Table 5 presents the adjusted R-square model diagnostics across industry regressions for each valuation model. The correlation coefficients between the rankings in the main analysis and the rankings for each industry sub-sample range from 0.09 to 0.95, with a median of 0.69 (not reported). The high median correlation across the industry portfolios suggests that the rankings in the main analysis are reasonably robust across different industries. However, as the rankings are not perfectly correlated, in some industries the use of the comparable firms' model may be preferred over the residual income model. For example, the Electric and Gas Services industry ranks the EBITDA and Market to Book models as the first and second valuation models.

7.3 Analysis by size quartiles

If the information provided by larger firms is on average of better quality than that for smaller firms, then there may be further size effects that could affect the valuation models' abilities to explain the variance in cross-sectional variance in offer value. Accordingly, the sample is split into four size based portfolios using the total assets of the firm prior to their issue. The results of the models across size based portfolios are presented in Table 6.

The summary results presented in Table 6 show that the model rankings from the main analysis are very similar to the model rankings across all of the size portfolios. Further investigation of the variation in adjusted R-squares across size quartiles suggests that the valuation models on average perform better in the largest

[26] The 48 industry classifications represented in the sample (using the Fama and French 1997 definitions) are too specialised to provide large enough samples to obtain meaningful regression results for each of the industries in the sample.

sample. As expected, the offer prices of larger firms hold a higher association with our valuation models.

7.4 Analysis by time period

It is possible that the composition of firms going public has changed over time (Loughran and Ritter 2002) with potentially systematic effects on our model rankings. As a sensitivity check we split the sample into the time periods documented in Loughran and Ritter (2002) and examine the valuation accuracy of the models within these time periods. We split the sample three sub-samples: firms that listed between 1980-1989, between 1990-1998 and between 1999-2001. As shown in Table 7, the results are similar to the main analysis across the first two sub-periods, with the simple *ECAP* and *RIV–P* models holding the highest level of valuation accuracy. The *PEBITDA* however, is ranked second in the 1999-2001 period. In addition, the three-period continued growth with fade to the industry median (*RIV–CGF*) drops from third in the first two sub-periods to sixth in the 1999-2001 period. These results are somewhat consistent with structural change during the 1999-2001 period, where IPOs were offered at values that may have been based more on comparables than residual income based measures of value, even for IPOs with positive earnings in the year prior to the IPO.

8. Summary and conclusions

Recent literature has advocated the benefits of residual income based value estimates. This study assesses the relative predictive ability of residual income valuation against the popular alternative of comparable firm valuation for predicting the offer and initial day market prices of IPO firms. We examine the application of residual income valuation in an IPO setting with limited information. We estimate various value estimates under alternate assumptions and simplifications.

Some residual income models of IPO value outperform the more popular comparable firms' multiples methods in predicting the offer prices of IPO firms. Residual income approaches with simple continued growth assumptions performed best, even though significant departures from theoretically consistent assumptions were made in estimating these models. Residual income approaches that attempt to capture growth by including additional industry information do not outperform less complex models. Using Davidson-MacKinnon *J*-tests (Davidson and MacKinnon 1981) none of the models holds the capacity to encompass all of the alternative

models. Similar results are reported for predicting offer prices or initial day market price.

All models tended to under-estimate the offer price. Comparable firms' multiples approaches tend to be less biased than many of our estimates from residual income models given the assumptions we made.

We provide sensitivity analysis that shows the results are generally robust to a number of alternative specifications of the tests including the exclusion of extreme observations, prediction across size quartiles, industry sub-samples and clustering by time periods. Our results must however be interpreted with respect to limitations on the availability of data to implement both the residual income and comparable firms methodologies and, in particular, significant measurement error in estimating expectations of future growth.

The implications of this study include that the indirect comparable firm pricing method often used in practice likely could be supplemented by the use of direct valuation models. The use of residual income models potentially allows value estimates that are grounded in theory. Although residual income models are generally assumed to require a substantial amount of additional data to be implemented with any advantage to accuracy, residual income models with very simple assumptions perform relatively better than indirect models in predicting variation in offer price even with limited data.

This study could be extended along a number of dimensions. Future research could consider the valuation of loss firms in the IPO context. Loss firms are difficult to measure using traditional techniques as they tend towards zero or negative value. Future research could also examine the valuation accuracy of hybrid models. It is possible that comparable firm approaches could be used to supplement the residual income valuation approach leading to more accurate valuations.

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Table 1

Sample Selection Criteria

	Exclusions	**Sample**
IPOs recognised in the *SDC Platinum New Issues* database[1]		8181
Less:		
IPOs missing pre-IPO financial data on *Compustat* or without a cusip on *SDC*[2]	4017	4164
IPOs reporting a loss in the year prior to listing	1822	2342
SDC listed IPOs with a prior listing on a foreign market	159	2183
IPOs without book value information data[3]	158	2025
IPOs without a matching comparable firm[4]	17	2008
Final Sample used in this study		2008

Notes:

[1] IPOs were identified using the original IPOs flag on the *SDC* database for domestic US issues. The IPO the IPO must be issued as common stock must be raising greater than five-million dollars with an offer price greater than five-dollars. Firms must have information on the preliminary offer price, the final offer price and the initial-day market prices.

[2] The firms must also have available revenue, sales, earnings and book value information at the offer stage. This step also excludes IPOs identified by *SDC* without a cusip number.

[3] Negative or zero book value firms were deleted from the sample.

[4] Where the IPO firm could not be matched with a comparable firm with financial data available the year prior to the listing within its industry using the Fama and French (1997) 48 industry classification system.

Table 2

Descriptive Statistics

Panel A: Offer and Financial Variables (n = 2008)

	Mean	Median	Std Dev	Skewness
Income Before Extraordinary Items ($M)	12.97	2.43	79.05	17.49
Common Equity - Total ($M)	95.72	8.70	746.42	18.57
Sales (Net) ($M)	273.06	44.56	1587.34	13.29
Assets - Total ($M)	710.99	30.97	8832.10	24.30
EBITDA ($M)	29.92	5.26	182.70	16.05
Shares filed (M)	3.83	2.05	10.07	13.74
Primary shares filed (new capital issued) (M)	3.08	1.60	9.70	15.08
Offer Value of Equity ($M)	247.39	78.22	989.88	13.39
Offer price ($)	12.71	12.00	5.43	2.89

Panel B: Market Description (n = 2008)

	Mean	Median	Std Dev	Skewness
Proceeds of the issue ($M)	65.41	25	260.13	16.92
Market capitalisation at the closing market price ($M)	306.76	85.53	1577.37	22.45
Shares outstanding at the issue (M)	14.18	6.50	37.99	11.64
First-Day Underpricing (Raw percentage[1])	0.13	0.06	0.25	6.73
First-Day Underpricing (Logistic[2])	0.11	0.06	0.17	1.77

Panel C: Valuation Model Estimates ($M) (n = 2008)[3]

	Mean	Median	Std Dev	Skewness
Residual Income Valuation Approach:				
RIV – Perpetuity	110.57	19.61	690.69	18.79
RIV – Continued Growth (PTV[4])	200.53	36.47	921.80	14.18
RIV – Continued Growth (FTV[5])	132.94	16.60	854.38	16.95
RIV – Industry Mean Growth (PTV)	6532.49	78.99	63769.48	19.22
RIV – Industry Mean Growth (FTV)	2977.53	27.95	29116.57	19.32
RIV – Recent IPO Implied Value	2918.47	107.04	50432.03	39.28
Earnings Capitalization	208.11	31.58	1351.48	16.50
Comparable Firm Valuation Approach:				
Price to Earnings estimates (PE)	324.35	51.82	2718.34	29.36
Price to Sales Estimates (PS)	302.64	57.00	1541.67	15.14
Price to Ebitda estimates (PEBITDA)	259.48	24.05	2389.71	24.70
Price to book value estimates (PBV)	337.95	52.93	4163.99	42.19

Notes: $ refers to the US Dollar (USD), M refers to millions. The offer value of equity is calculated by taking the product of the final offer price and the number of shares outstanding. The market value of equity is calculated using the closing price on the first-day of issue. [1]Raw underpricing is calculated as: (offer-market)/offer. [2]Logistic underpricing is calculated as: ln(market/offer). In both cases market is the closing price on the first day and offer is the final offer price. [3]Section 3 of the text describes the calculations of valuation models presented in panel C. [4]*PTV* refers to the use of a perpetual terminal value, [5]*FTV* refers to the use of the fade to industry median ROE in the terminal value.

Table 3

Ranking of Valuation Models by Comparing Forecast Values to Actual Offer Values and to Actual Market Values

Panel A: OLS Estimates of Offer Value (n=2008)

$Log(OVE)_i = \beta_0 + \beta_1 Log(FOVE)_{i,m} + e_i$

	Coefficient Estimates		Model Fit						Bias	
Model (*m*)	β_0	β_1	Adj R^2	Adj R^2 Rank	AIC	Theil - U	APE	APE Rank	SPE	Intercept (β_0)Rank
Residual Income Valuation Approach:										
RIV – Perpetuity (P)	2.747 (69.65)**	0.568 (49.03)**	0.545	2	-786	0.178	15.54%	2	-0.67%	5
RIV – Continued Growth (PTV)	2.827 (56.00)**	0.446 (35.64)**	0.387	8	-182	0.206	17.29%	8	-0.36%	7
RIV – Continued Growth (FTV)	3.015 (73.91)**	0.49 (40.68)**	0.452	3	-404	0.217	16.51%	3	-0.35%	8
RIV – Industry Mean Growth (PTV)	3.29 (74.72)**	0.254 (30.81)**	0.321	10	27	0.195	17.99%	10	-0.06%	10
RIV – Industry Mean Growth (FTV)	3.472 (88.27)**	0.263 (30.58)**	0.318	11	38	0.218	17.87%	11	0.01%	11
RIV – Recent IPO Implied Value	2.615 (47.29)**	0.387 (36.15)**	0.395	7	-207	0.205	17.06%	7	-0.14%	4
Earnings Capitalisation (ECAP)	2.296 (54.41)**	0.611 (55.97)**	0.610	1	-1086	0.165	14.24%	1	-0.42%	1
Comparable Firm Valuation Approach:										
Price to Earnings estimates (PE)	2.82 (51.25)**	0.413 (32.47)**	0.344	9	-45	0.214	18.03%	9	-0.66%	6
Price to Sales Estimates (PS)	2.444 (43.09)**	0.488 (38.14)**	0.42	5	-288	0.201	16.74%	5	-0.33%	2
Price to Ebitda estimates (PEBITDA)	3.131 (76.58)**	0.414 (37.72)**	0.415	6	-274	0.202	16.92%	6	-0.30%	9
Price to book value estimates (PBV)	2.53 (47.77)**	0.479 (39.47)**	0.437	4	-348	0.198	16.53%	4	-0.33%	3

Panel B: OLS Estimates of First Day Market Value (n=2008)

$Log(MVE)_i = \beta_0 + \beta_1 Log(FOVE)_{i,m} + e_i$

	Coefficient Estimates		Model Fit						Bias	
Model (*m*)	β_0	β_1	Adj R^2	Adj R^2 Rank	AIC	Theil - U	APE	APE Rank	SPE	Intercept (β_0)Rank
Residual Income Valuation Approach:										
RIV – Perpetuity (P)	2.864 (67.35)**	0.564 (45.15)**	0.504	2	-480	0.187	16.18%	2	-0.61%	5
RIV – Continued Growth (PTV)	2.944 (55.17)**	0.443 (33.48)**	0.358	8	41	0.213	17.71%	8	-0.33%	7
RIV – Continued Growth (FTV)	3.137 (72.02)**	0.485 (37.66)**	0.414	3	-140	0.204	17.05%	4	-0.32%	8
RIV – Industry Mean Growth (PTV)	3.412 (73.52)**	0.25 (28.83)**	0.293	10	238	0.224	18.43%	11	-0.04%	10
RIV – Industry Mean Growth (FTV)	3.595 (86.59)**	0.259 (28.44)**	0.287	11	255	0.225	18.33%	10	0.02%	11
RIV – Recent IPO Implied Value	2.710 (46.69)**	0.389 (34.62)**	0.375	7	-12	0.210	17.37%	7	-0.14%	4
Earnings Capitalisation	2.418 (52.44)**	0.607 (50.84)**	0.563	1	-729	0.176	15.02%	1	-0.39%	1
Comparable Firm Valuation Approach:										
Price to Earnings estimates (PE)	2.919 (50.64)**	0.415 (31.14)**	0.326	9	141	0.218	18.32%	9	-0.60%	6
Price to Sales Estimates (PS)	2.555 (42.59)**	0.487 (35.97)**	0.392	5	-63	0.207	17.17%	5	-0.30%	2
Price to Ebitda estimates (PEBITDA)	3.234 (75.05)**	0.415 (35.85)**	0.39	6	-63	0.208	17.31%	6	-0.28%	9
Price to book value estimates (PBV)	2.642 (47.07)**	0.477 (37.09)**	0.407	4	-114	0.205	17.02%	3	-0.31%	3

Notes:

OVE refers to the IPO firm's offer value of equity, which is calculated as the product of the offer price with the number of shares outstanding *FOVE* is the estimated offer price using the IPO valuation models. *MVE* refers to the IPO firm's market value of equity, which is calculated as the product of market price at the close of the first day of issue with the number of shares outstanding. Section 3 of the text describes the calculations of valuation models. Regression models all use the logistic form of the valuation estimates and actuals, *t*-statistics are reported under their respective coefficient estimates in brackets. *AIC* refers to the Akaike Information Criterion **p<(0.01), *p<(0.05).

Table 4

Sensitivity of Valuation Model Rankings with Forecast Values and Actual Offer Values are Deflated by Total Assets

OLS Estimates of Offer Value (n=2008)

$Log(OVE/TA)_i = \beta_0 + \beta_1 Log(FOVE/TA)_{i,m} + e_i$

	Coefficient Estimates		Model Fit						Bias	
Model (*m*)	β_0	β_1	Adj R^2	Adj R^2 Rank	AIC	Theil - U	APE	APE Rank	SPE	Intercept (β_0)Rank
Residual Income Valuation Approach:										
RIV – Perpetuity (P)	1.199 (45.78)**	0.617 (28.56)**	0.289	2	-480	0.697	31.49%	2	-28.78%	11
RIV – Continued Growth (PTV)	0.802 (35.03)**	0.403 (25.55)**	0.245	5	41	0.718	32.87%	4	-35.52%	5
RIV – Continued Growth (FTV)	0.895 (27.79)**	-0.044 (-4.90)**	0.011	10	-140	0.734	33.79%	5	-37.41%	7
RIV – Industry Mean Growth (PTV)	1.123 (41.37)**	0.449 (23.22)**	0.211	7	238	0.826	40.48%	11	-44.93%	10
RIV – Industry Mean Growth (FTV)	0.806 (30.59)**	-0.033 (-2.18)*	0.002	11	255	0.826	40.38%	10	-45.28%	6
RIV – Recent IPO Implied Value	0.447 (15.71)**	0.317 (22.13)**	0.196	8	-12	0.739	37.28%	8	-40.53%	1
Earnings Capitalisation (ECAP)	0.898 (41.54)**	0.803 (32.15)**	0.340	1	-729	0.672	30.71%	1	-25.95%	8
Comparable Firm Valuation Approach:										
Price to Earnings estimates (PE)	0.685 (29.98)**	0.382 (27.54)**	0.274	3	141	0.718	31.95%	3	-31.57%	4
Price to Sales Estimates (PS)	0.59 (24.24)**	0.453 (25.58)**	0.246	4	-63	0.750	35.10%	7	-33.87%	2
Price to Ebitda estimates (PEBITDA)	0.956 (38.25)**	0.337 (20.84)**	0.178	9	-63	0.729	37.72%	9	-38.03%	9
Price to book value estimates (PBV)	0.642 (26.52)**	0.435 (23.94)**	0.222	6	-114	0.697	34.47%	6	-35.31%	3

Notes:

OVE refers to the IPO firm's offer value of equity, which is calculated as the offer price times the number of shares outstanding *FOVE* is the forecast offer price using the IPO valuation models. *Shrout* refers to the number of shares outstanding at the end of the initial day of trading (from CRSP) and *TA* refers to the total assets at the end of the prior fiscal year. Regression models all use the logistic form of the valuation estimates and actuals, *t*-statistics are reported under their respective coefficient estimates in brackets. **p<(0.01), *p<(0.05).

Table 5

Comparison of the Ranking of Valuation Models Predictive Ability by Industry

The adjusted R-squares are presented for each industry for each valuation models.
OLS Regressions with Offer price capitalisation as the dependent variable and offer price capitalisation estimates as the independent variables are run on each industry subsample.

$Log(OVE)_i = a_0 + a_1 Log(FOVE)_{i,m} + e_i$
where, *OVE* refers to the Offer Value of Equity (offer price times the number of shares outstanding) and *FOVE* refers to the Forecast OVE produced by each valuation model.

Industry[1]	Mean	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Sample Size	Rank	*27*	*15*	*46*	*63*	*81*	*42*	*144*	*264*	*101*	*29*	*15*	*59*	*99*	*41*	*116*	*30*	*18*	*947*
Model (*m*)																			
Residual Income Valuation Approach[2]***:***																			
RIV–P		68.9%	71.5%	76.6%	54.4%	57.3%	54.1%	53.7%	53.7%	58.7%	70.4%	64.7%	64.3%	55.3%	53.4%	60.4%	42.3%	74.9%	49.2%
RIV – CGP		66.1%	53.1%	47.9%	36.0%	36.9%	35.8%	41.9%	36.4%	39.9%	70.0%	45.9%	39.1%	39.5%	30.3%	37.3%	23.7%	27.2%	35.8%
RIV – CGF		69.4%	68.9%	62.1%	41.2%	43.1%	44.8%	42.3%	45.7%	43.2%	77.6%	63.3%	50.5%	55.4%	30.3%	45.4%	25.4%	32.5%	41.6%
RIV - IGP		51.6%	53.7%	32.1%	39.3%	34.5%	31.2%	30.4%	14.4%	28.9%	44.0%	74.3%	42.1%	58.1%	36.2%	24.8%	7.4%	53.7%	36.5%
RIV – IGF		60.2%	45.4%	33.3%	41.4%	42.6%	40.6%	34.9%	12.9%	40.9%	38.5%	71.6%	40.4%	59.0%	31.1%	21.6%	8.4%	53.0%	35.7%
RIV - Implied		51.5%	75.7%	34.6%	36.7%	44.5%	32.9%	36.0%	37.9%	51.1%	49.5%	66.6%	20.1%	40.0%	25.8%	37.4%	41.1%	41.9%	36.5%
ECAP		77.1%	81.5%	79.4%	69.0%	62.7%	58.8%	56.6%	63.2%	64.8%	69.9%	74.3%	67.6%	65.2%	53.0%	65.7%	42.1%	78.6%	55.2%
Comparable Firm Valuation Approach:																			
PE		33.1%	62.2%	63.4%	5.0%	41.7%	37.2%	34.5%	35.7%	41.2%	28.2%	50.9%	36.1%	9.7%	20.8%	51.0%	9.9%	48.0%	31.8%
PS		57.6%	79.5%	61.8%	21.0%	48.1%	47.1%	41.7%	47.2%	44.1%	28.1%	57.3%	55.3%	18.7%	18.3%	39.9%	14.6%	64.0%	39.2%
PEBITDA		59.9%	82.3%	57.4%	31.5%	41.4%	32.3%	31.4%	47.0%	40.9%	33.9%	83.4%	37.4%	21.9%	24.1%	51.6%	14.2%	60.0%	38.6%
PBV		58.1%	84.6%	65.0%	22.8%	49.2%	39.8%	38.2%	47.8%	46.2%	34.5%	79.2%	50.1%	20.2%	21.9%	48.9%	17.2%	69.2%	40.7%

Notes: [1]The industry sub-samples are constructed using the portfolios of SIC numbers presented in Teoh et al (2000). The industry portfolios are oil and gas (1), food products (2), paper and paper products (3), chemical products (4), manufacturing (5), computer hardware and software (6), electronic equipment (7), transportation (8), scientific instruments (9), communications (10), electric and gas services (11), durable goods (12), retail (13), eating and drinking establishments (14), financial services (16), health (17), all others (18). [2]For models using the residual income approach, *P* stands for perpetuity, *CGP* stands for the continued growth model with perpetuity terminal value, *CGF* is the continued growth model where *ROE* is linearly faded to the industry median in the terminal value, *IGP* uses forecasts of *ROE* based the industry based mean growth with perpetuity terminal value, *IGF* uses forecasts of *ROE* based the industry based mean growth where *ROE* is linearly faded to the industry median in the terminal value, *Implied* uses the implied growth from recent IPO firms.

Table 6

Comparison of the Ranking of Valuation Models Predictive Ability by Size Quartiles

OLS Regressions with Offer price capitalisation as the dependent variable and offer price capitalisation estimates as the independent variables are run for each size quartile.

$Log(OVE)_i = a_0 + a_1 Log(FOVE)_{i,m} + e_i$
where, OVE refers to the Offer Value of Equity (offer price times the number of shares outstanding) and FOVE refers to the Forecast OVE produced by each valuation model.

	Size Quartile 1		**Size Quartile 2**		**Size Quartile 3**		**Size Quartile 4**	
Model	Adj R^2	Adj R^2 Rank	Adj R^2	Adj R^2 Rank	Adj R^2	Adj R^2 Rank	Adj R^2	Adj R^2 Rank
Residual Income Valuation Approach:								
RIV–P	14.92%	2	18.77%	2	16.09%	2	44.77%	2
RIV – CGP	8.33%	7	13.09%	4	11.86%	5	32.28%	6
RIV – CGF	6.03%	9	11.00%	6	11.81%	6	41.08%	3
RIV - IGP	5.70%	10	0.18%	10	0.82%	10	18.02%	10
RIV – IGF	2.92%	11	-0.10%	11	0.72%	11	17.49%	11
RIV - Implied	11.80%	3	15.63%	3	9.09%	9	34.82%	4
ECAP	18.11%	1	23.87%	1	19.77%	1	54.80%	1
Comparable Firm Valuation Approach:								
PE	9.77%	5	11.70%	5	13.24%	4	24.44%	9
PS	9.16%	6	7.66%	9	10.88%	7	26.57%	8
PEBITDA	8.05%	8	7.80%	8	13.67%	3	34.12%	5
PBV	10.11%	4	9.78%	7	10.31%	8	28.63%	7

Notes: The size based portfolios are selected by ranking the firms on total assets at the prior fiscal year end. For models using the residual income approach, *P* stands for perpetuity, *CGP* stands for the continued growth model with perpetuity terminal value, *CGF* is the continued growth model where *ROE* is linearly faded to the industry median in the terminal value, *IGP* uses forecasts of *ROE* based the industry based mean growth with perpetuity terminal value, *IGF* uses forecasts of *ROE* based the industry based mean growth where *ROE* is linearly faded to the industry median in the terminal value, *Implied* uses the implied growth from recent IPO firms.

Table 7

Comparison of the Ranking of Valuation Models Predictive Ability by Time Period

	1980-1989 (n=695) $Log(OVE)_i = a_0 + a_1 Log(FOVE)_{i,m} + e_i$				**1990-1998 (n=1303)** $Log(OVE)_i = a_0 + a_1 Log(FOVE)_{i,m} + e_i$				**1999-2001 (n=139)** $Log(OVE)_i = a_0 + a_1 Log(FOVE)_{i,m} + e_i$			
	a_0	a_1	Adj R^2	Adj R^2 Rank	a_0	a_1	Adj R^2	Adj R^2 Rank	a_0	a_1	Adj R^2	Adj R^2 Rank
Residual Income Valuation Approach:												
RIV– P	2.423	0.616	59.59%	2	3.057	0.481	45.97%	2	3.839	0.506	48.90%	3
	(45.15)**	(31.4)**			(56.82)**	(32.1)**			(18.45)**	(11.07)**		
RIV – CGP	2.48	0.449	41.49%	5	3.2	0.368	32.09%	8	3.95	0.431	36.19%	8
	(34.44)**	(21.79)**			(49.49)**	(23.93)**			(15.74)**	(8.54)**		
RIV – CGF	2.551	0.531	50.86%	3	3.36	0.41	39.09%	3	4.242	0.421	42.49%	6
	(43.51)**	(26.31)**			(65.48)**	(27.89)**			(21.58)**	(9.74)**		
RIV – IGP	3.108	0.227	25.90%	11	3.572	0.208	24.64%	11	4.286	0.25	27.69%	11
	(49.92)**	(15.31)**			(60.31)**	(19.91)**			(16.83)**	(7.05)**		
RIV – IGF	3.178	0.252	27.71%	10	3.759	0.212	24.95%	10	4.519	0.253	29.29%	10
	(56.03)**	(16.03)**			(74.14)**	(20.08)**			(20.71)**	(7.32)**		
RIV – Implied	2.217	0.48	39.88%	7	3.33	0.312	26.34%	9	3.717	0.446	40.41%	7
	(25.92)**	(21.07)**			(49.33)**	(20.82)**			(14.59)**	(9.33)**		
ECAP	1.984	0.657	64.61%	1	2.609	0.534	53.25%	1	3.44	0.521	54.50%	1
	(33.16)**	(34.94)**			(44.83)**	(37.14)**			(15.83)**	(12.37)**		
Comparable Firm Valuation Approach:												
PE	0.887	0.386	34.31%	9	0.887	0.319	32.10%	7	1.18	0.347	33.26%	9
	(0.89)	(18.62)**			(0.89)	(23.93)**			(1.18)	(8.02)**		
PS	2.135	0.489	38.80%	8	2.865	0.407	35.60%	5	3.497	0.465	45.79%	4
	(23.46)**	(20.6)**			(39.62)**	(25.88)**			(13.98)**	(10.41)**		
PEBITDA	2.751	0.426	39.98%	6	3.477	0.339	35.12%	6	4.045	0.423	50.49%	2
	(43.85)**	(21.12)**			(67.88)**	(25.61)**			(21.71)**	(11.43)**		
PBV	2.231	0.479	41.72%	4	2.922	0.402	37.62%	4	3.528	0.47	45.58%	5
	(27.2)**	(21.89)**			(43.31)**	(27.03)**			(14.21)**	(10.36)**		

Notes: *OVE* refers to the Offer Value of Equity (offer price times the number of shares outstanding) and *FOVE* refers to forecast value from each valuation model. For models using the residual income approach, *P* stands for perpetuity, *CGP* stands for the continued growth model with perpetuity terminal value, *CGF* is the continued growth model where ROE is linearly faded to the industry median in the terminal value, *IGP* uses forecasts of *ROE* based the industry based mean growth with perpetuity terminal value, *IGF* uses forecasts of *ROE* based the industry based mean growth where *ROE* is linearly faded to the industry median in the terminal value, Implied uses the implied growth from recent IPO firms. Section 3 of the text describes the calculations of valuation models. Regression models all use the logistic form of the valuation estimates and actuals, *t*-statistics are reported under their respective coefficient estimates in brackets.

**p<(0.01), *p<(0.05).