A new perspective on analyst sophistication: Errors and dubious judgments in analysts' DCF valuation models

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Abstract

We argue that sell-side equity analysts make a startling number of mistakes and questionable judgments in their DCF equity valuation models. For a sample of 120 analyst reports issued 2012-2013, we estimate that the median analyst makes five DCF theoretic or implementation errors and five dubious DCF modeling judgments. We assess the economic significance of analysts' DCF mistakes by recalculating their target prices after correcting for major errors. Doing so increases analysts' estimated target prices by a median (mean) of 37% (29%). We conclude that with regard to valuing firms' equity, sell-side analysts are less sophisticated, and more optimistic, than prior research has supposed.

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1. Introduction

Sell-side equity analysts are usually viewed by academics and investors as being sophisticated economic agents—intelligent, knowledgeable, competitive, and well incentivized to analyze and predict the levels and risks of the cash flows of the firms they follow in a sophisticated manner. As such, the view that the financial expertise of sell-side equity analysts will be apparent in their written reports to investors would seem to be obvious.

In this study, we argue that at least with respect to constructing and executing a DCF equity valuation model, such a view is markedly wrong. We base this claim on the analyses we conduct on a stratified random sample of 120 sell-side analyst reports containing DCF valuations of various kinds, each of which was issued in 2012 or 2013 by a U.S. brokerage house. After setting out a template of the data and formulae that we define to be the correct approach to constructing and executing a DCF equity valuation model, we grade analysts' DCFs. In our grading, we identify conceptual and implementation errors as well as dubious judgments.

After tallying the grades, we estimate that sell-side analysts make a median of five DCF theoretic and/or implementation errors, and five dubious DCF modeling judgments. Examples of errors include using materially too large or too small of a risk free rate; assuming an impossibly high growth rate in free cash flows beyond the terminal year; failing to apply a mid-year adjustment factor to yearly free cash flows; and not scaling up the estimated equity value from the valuation date to the target price date. Examples of dubious judgments are setting the terminal year far too close to the report date; providing no justification for or detail behind the WACC that is used; and when such detail is provided, assuming an equity weight that is more than 20% away from the weight implied by the equity value obtained from the DCF itself.

Not every aspect of analysts' DCF modeling is rife with errors or dubious judgments. For example, we find evidence that sell-side analysts understand that as they forecast out in time toward the terminal year, the rates of growth in the firm's revenues, EBIT, depreciation, working capital, CAPEX and free cash flows should in expectation decline, and that the firm's effective tax rate should in expectation tend toward the combined stated federal and state tax rate. However, even in these directionally correct results, we observe that most analysts are optimistic (sometimes absurdly so) in that the median rates of growth they forecast to occur in the terminal year are frequently implausibly large. We find that one consequence of this optimism is that analysts' forecasted ROEs increase, not decrease, toward the terminal year, rising to an economically questionable mean of almost 20% in the terminal year itself.

We also report evidence that is partially consistent with the hypothesis that more sophisticated analysts or analyst teams make fewer DCF errors or dubious judgments. When we regress DCF error rates and dubious judgment rates on proxies for analyst sophistication, we observe that some of our proxies (those based on the quantity of information analysts provide as to how they arrive at their WACC, their forecasted free cash flows and equity value, and their forecasts of future financial statements) load significantly in the predicted negative direction.

One criticism of our study could be that we are merely identifying many small errors that in aggregate impart little or no bias into the key output of analysts' DCF valuation models, namely their target prices. We seek to address this concern by calibrating the economic significance of analysts' DCF modeling mistakes after recalculating target prices corrected for five major errors. For the smallish subset of firms where this is feasible, we find that three of the five errors have material mean effects on target prices and the annualized expected return AER embedded in them when corrected: too high risk free rates (14% increase in AER), end of year rather than mid-year discounting (5% increase in AER), and not scaling up equity value from the valuation date to the target price date (12% increase in AER). Overall, we estimate that correcting analysts' major errors in aggregate increases analysts' AERs by a median (mean) of 37% (29%), which we posit is an economically significant amount. We conclude that with regard to valuing firms' equity, not only are sell-side equity analysts markedly less sophisticated than prior research has supposed, but they are also more optimistic since the correct translation of the free cash flow and WACC information they forecast and use in their DCF models yields estimates of the firms' future stock prices that are far higher than those in their stated target prices, which in their uncorrected forms per se have been found to be quite optimistic.

Our study contributes to several literatures. First, by grading how well they convert their financial forecasts and other data into projected future equity values, we add to the research that has studied how equity analysts transform information into target prices (Bandyopadhyay, Brown and Richardson, 1995; Block, 1999; Bradshaw 2002, 2004; Demirakos, Strong and Walker, 2004). In this way, our paper also seeks to respond to the long-standing calls made by Schipper (1991), Brown (1993), Ramnath, Rock and Shane (2008), Bradshaw (2011) and Groysberg and Healy (2013) that researchers look inside the 'black box' of sell-side analysts and illuminate their decision processes. Although we do not conduct the most direct approach to understanding how sophisticated analysts are in constructing and executing their DCF model (for example, we do not employ real-time process tracing on analysts while they are constructing their DCF models, or examine analysts' actual working model files (Markou and Taylor, 2014)), what we do by studying directly and in detail the content of analysts' written DCF models yields new insights as compared to the classic large-scale database approach of indirectly examining the correlations between inputs, outputs and conditioning variables. As such, in our quantitative analysis of analysts' actual DCF models, our study complements work by Asquith, Mikhail and Au (2005) that catalogs the contents of analyst reports, and by Brown, Call, Clement and Sharp (2013) who employ survey data to examine the inputs that sell-side analysts use in their decisions and the incentives that motivate those decisions.

We also add to the research literature on optimism in analysts' forecasts by showing that with regard to target prices, analysts are far more optimistic than previously thought. Prior work has found that analysts' 12-month ahead target prices are upward biased by an average of 15% for U.S. firms and 18% for non-U.S. firms (Bradshaw, Brown and Huang, 2013; Bradshaw, Huang and Tan, 2013). We estimate that the expected returns in the target prices that analysts *should* report based on the free cash flows they forecast and the discount rates they use are far more optimistic, being at least twice those of the target prices they actually do report. Also, relative to most research that studies analyst optimism, such as biases in analysts' short-term earnings forecasts, we argue that not only are we better able to measure the economic magnitude of the particular aspect of optimism we study, but we think there are fewer competing explanations for the optimism we document, such as the conflict-of-interest argument (Francis and Philbrick, 1993; Lin and McNichols, 1998; Ertimur, Muslu and Zhang, 2011) since it is hard to argue that analysts deliberately make as many errors or dubious judgments as they do.

Third, we add to the literature on analyst sophistication. Historically, such research has focused on analysts' earnings forecasts, and has concluded that analysts exhibit financial sophistication in the sense that their short-term earnings forecasts tend to be more accurate than those of time-series models. However, recent work has both challenged this widely held belief (Bradshaw, Drake, Myers and Myers, 2012), and broadened beyond it by starting to indirectly investigate the degree of sophistication reflected in analysts' cash flow and accrual forecasts (Givoly, Hayn and Lehavy, 2013a, 2013b; Call, Chen and Tong, 2013a, 2013b) and target prices (Dechow and You, 2013), using large-scale archival analysis. Our study contributes to these new directions by directly showing that while analysts display certain aspects of what would be expected in competently forecasting long-term financial statement data, they are surprisingly unsophisticated with regard to the basic skill of constructing and executing a DCF equity valuation model. Moreover, we argue that the benchmarks we use for determining if analysts are or are not sophisticated are relatively objective—few would disagree with the economic assumptions underlying DCF, and we seek to be generous in how far we allow analysts to depart from correctly following the contents and mechanics of DCF valuation before we grade them as having made an error or a dubious judgment.

Fourth, we add a new dimension to the literature on implementing equity valuation models. Some prior work in this area has at times heatedly debated how and why large-sample implementations of the free cash flow, residual income and dividend discount models yield at times vastly different results, even though the models are theoretically all isomorphic to the underlying principle of the present value of expected future dividends and should therefore yield the same output equity value given the same inputs (Penman and Sougiannis, 1998; Francis, Olsson and Oswald, 2000; Lundholm and O'Keefe, 2001a, 2001b; Penman, 2001). Other work has emphasized the importance of high quality forecasts of future cash flows to obtaining a high quality estimate of equity value (Palepu, Bernard and Healy, 1996; Brealey and Myers, 2013; Lundholm and Sloan, 2013). Our contribution is to highlight the importance of users implementing their DCF model correctly, regardless of what is input into the model. Our results suggest that even if the fundamental financial statement data that sell-side analysts input into their DCF valuation model is of very high quality, the output target price can be enormously wrong if analysts make simple implementation errors of the kind we document, such as not discounting annual free cash flows mid-year, or not scaling up their initial valuation from the valuation date to the target price date.[1]

Lastly, we contribute to the literature on asset pricing in finance. Although asset pricing is key to many aspects of finance, and DCF valuation key to many aspects of asset pricing, few scholars have explored whether analysts make mistakes in how they arrive at their estimates of equity value, and if so, which kinds of errors. Moreover, the evidence that has been reported by is for the most part anecdotal.[2] Our paper is the first to adopt a conventional academic approach

[1] Brealey and Myers (2013) state that "[I]t's easy for a discounted cash flow business valuation to be mechanically perfect and practically wrong." Based on our empirical results, it seems to be easy for analysts to be both mechanically wrong and practically wrong.

[2] For example, Tham and Velez-Pareja (2004) list nine errors they propose users might make in DCF models, but provide no evidence on how empirically common or important the mistakes are. Mauboussin (2006, pp. 2, 5) details a "list of the most frequent [8] errors we see in DCF models" identified from "various sellside reports" but does not report sample statistics, nor economic significance of the errors. Petersen and Plenborg (2009) study three general and non-public valuation spreadsheets they obtained from Danish brokers. Fernandez (2013) classifies 119 (often overlapping) types of errors in the company valuations performed by financial analysts, investment banks and financial consultants obtained in his capacity as a consultant in company acquisitions, sales, mergers, and arbitrage processes. Lundholm and Sloan (2013, p.239) note with regard to the DCF-to-all-investors model that "Unfortunately, because the computation of the free cash flow to all investors is rather involved and because "all investors" models require a weighted-average cost of capital that is consistent with the other costs of capital, it is the

to evaluating the sophistication with which analysts construct and execute DCF equity valuation models in that we use a stratified, random, recent and reasonably-sized sample, together with a clearly defined set of grading criteria. At the same time, however, we readily acknowledge that in constructing and executing our study, we like the analysts we grade have had to make judgments. Although we seek to clearly define what we grade to be an analyst error versus a dubious judgment, we readily grant that readers may disagree with our grading criteria, and in this sense our results undoubtedly contain a level of subjectivity and even error.

The remainder of our paper proceeds as follows. In section 2 we present our sample selection criteria and provide descriptive statistics on the brokers, analysts and in sampled reports. In section 3 we make clear how we grade analysts' DCF valuation models, and report what we estimate to be present in terms of graded errors and dubious judgments. In section 4 we estimate the effects of correcting five major errors on the annualized expected returns embedded in analysts' target prices. In section 5 we develop and test the hypothesis that more sophisticated analysts make fewer errors and dubious judgments, using proxies we create for analyst sophistication based on the forecasted financial statements that often accompany analysts' DCFs. In section 6 we expand our investigation of analysts' financial sophistication into how well their financial statement forecasts conform to the economic forces that affect firms in the long run. We conclude in section 7 by presenting and discussing the questions that we argue that our findings raise for future research, and conclude our study.

2. Sell-side equity analyst reports that contain DCF equity valuation models

2.1 Sample selection

Table 1 shows the criteria we employed to obtain our sample of 120 DCF-based sell-side equity analyst reports. Since the contents of analysts' reports are not available in machine readable form that we are aware of, we searched Investext to identify analyst reports in 2012-13 that contained the keywords "DCF" or "discounted cash flow" in their Table of Contents (panel A). We then retained only those reports that were for companies, for the U.S., and provided by brokers. From the resulting set of 9,436 analyst reports in 2012-13, we selected five at random from each of the 24 months ending Dec. 2013. After inspecting each report, we determined that a few did not contain sufficient DCF information, or the right kind of DCF information, to be

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rare user who can successfully compute the DCF-to-all-investors model without error. By automating the required computations, *eVal* makes sure you don't mess up along the way."

useful. Panel B lists the reasons that led us to make exclusions. After randomly choosing replacements for excluded reports, we converged to 120 DCF-based sell-side equity analyst reports spread evenly by month Jan. 2012 - Dec. 2013.

In panel C of Table 1 we report the frequency with which each of seven types of DCF models was present in the 120 sampled reports. Of DCF models, 109 are built around estimating the cash flows to all investors, with just three directly focused on cash flows to equity investors. In nine reports we judged there to be too little information to readily classify the DCF model. Within the DCF-to-all-investors category of models, over half employ the 'workhorse' NOPAT approach that is commonly taught in MBA finance classes. In the NOPAT approach, forecasted free cash flows are arrived at by first forecasting net operating profit after adjusted taxes, then adding both forecasted depreciation and the forecasted change in working capital, and subtracting forecasted capital expenditures.

2.2 Descriptive statistics on brokers, analysts and firms

In Table 2 we provide descriptive statistics for the brokers, analysts and firms covered in the sample of 120 DCF-based equity analyst reports. Panel A shows that the reports come from a wide range of brokers, 37 in all, with the largest numbers coming from prominent and well known brokers. Panel B indicates that the reports are authored or coauthored by 180 different analysts, of whom 60 hold the CFA professional qualification and 8 have a PhD. Of reports, 90% are updates rather than initiations, and the average number of pages in a report is 14.5. Lastly, panel C shows that the firms in the reports are widely spread across 26 of the 48 Fama-French industries, range greatly in market cap (between \$5 million and \$238 billion), and at the report date have been publicly traded between zero and 88 years.

3. Grading analysts' DCF valuation models

3.1 Prototypical timeline involved in a DCF equity valuation model

In Figure 1 we display the prototypical timeline involved in constructing and executing a DCF valuation model for a 12/31 fiscal year-end firm. The timeline centers on the analyst's report date, which without loss of generality we take to be 9/24/12. Other key dates in the timeline are 9/24/13 (the date the assumed 12-month target price applies to), 12/31/12 (the fiscal year-end of the first year of the forecast horizon that the analyst projects free cash flows for), and

12/31/11 (the most recent fiscal year-end for which actual annual free cash flows are known, and the valuation date of the DCF model).

3.2 Our definition of a condensed correctly structured and executed DCF-to-all-investors equity valuation model

In Figure 2 we lay out what we define for the purposes of this study to be a correctly structured and executed DCF-to-all-investors equity valuation model. We refer to Figure 2 as our condensed DCF model. We emphasize that what we lay out in the condensed DCF model is not 100% correct in that it deliberately differs in several ways from what we do take to be 100% correct, namely the DCF-to-all-investors equity valuation model detailed by Lundholm and Sloan in their textbook *Equity Valuation and Analysis with eVal* (2013, 3rd ed.). We detail out the differences in the Notes to Figure 2.

We adopt a less than fully correct DCF valuation model against which to grade analysts for two main reasons. First, most of the differences (detailed in the Notes to Figure 2) are in expectation likely to occur infrequently and be economically small. Second, it is rare for analysts to include the items represented by these differences in their models, and we wish to avoid biasing our study in favor of concluding that analysts construct and execute DCF valuation models in an unsophisticated manner. Thus, if analysts are aware of the differences but rationally choose to exclude them because they are infrequent and immaterial, then we risk downwardly bias our assessment of analyst sophistication if we were to include the differences in our grading template. Conversely, if analysts are not aware that the differences exist but we grade analysts under the presumption that they should be aware, then we risk concluding that analysts are unsophisticated based on a large number of economically small aspects of DCF modeling and execution, rather than on economically or theoretically important errors.

3.3 Descriptive statistics on key components of analysts' DCF valuation models

Before grading analysts' DCF models, we entered the information underlying the DCF models into Excel templates similarly laid out to those shown in Figure 2.[3] Figure 2 adopts the DCF-to-all-investors approach of valuing equity that is commonly taught in undergraduate and MBA classes and in-house broker training courses. Although not all analysts follow the DCF-to-

[3] In a few cases, an analyst report contains more than one DCF model, typically because the analyst presents multiple DCF-based valuation scenarios for the same firm. If this occurs, we input and use the scenario associated with the target price most emphasized by the analyst.

all-investors approach, where a different approach is used we conform the information provided by the analyst into the template laid out in Figure 2. We record one DCF per analyst report, and place each firm's completed template on a separate tab within our Excel data file. Table 3 then gives descriptive statistics on the key components of the DCF models.

In panel A of Table 3 we describe analysts' stated target prices, target price horizons, and the annualized expected returns embedded in them. In panel B we report when the terminal year occurs and the assumed post-terminal year perpetual growth in annual free cash flows. In panel C we present analysts' assumptions regarding WACC and its components. We focus on these aspects of the full set of DCF information analysts may provide, rather than on free cash flows, terminal values, the components of free cash flows, enterprise value or equity value because these are all denominated in unscaled dollars, not percent.

The first numerical column in each panel is NOBS, the number of valid observations per variable. It can be seen from the dispersion in NOBS that analysts vary greatly in the quantity and type of relevant DCF model information that they report. For example, while all 120 DCF-based analyst reports contain a target price (panel A), just 15 explicitly disclose the horizon underlying the risk free rate assumed within WACC (panel C). We return to analyzing the quantity of analysts' disclosures about and surrounding their DCF models in section 5.

Panel A shows that for the 111 analyst reports that provide both a stated analyst target price and a target price horizon, the mean (median) annualized expected return embedded in stated target prices is 18% (13%). Of individual expected returns, 77% are positive. The mean return of 18% compares to the 24% reported by Bradshaw, Brown and Huang (2013) for U.S. firms during the period 2000-2009, the 16% reported by Joos and Piotroski (2013) for Morgan Stanley reports issued 2007-2012.

Panel B reveals that both WACC and its components vary widely in magnitude across analysts' DCF models. The maximum WACC of 21% is five times that of the minimum WACC of 4.5%; RF varies between 0.2% and 5.0%; betas range between 0.55 and 2.50; the annual market risk premium varies between 4% and 11%; and the weight on equity in calculating WACC ranges from 14% to 100%.

Panel C presents similarly diverse numbers to those in panels A and B. The post-terminal year perpetual annual rates analysts explicitly assume that free cash flows (and implicitly assume all key balance sheet and income statement numbers) will grow by vary between -100% and

15%.[4] Likewise, the number of years in analysts' forecasts of future free cash flows including the terminal year range between a low of 1 year and a high of 16 years, with the median analyst DCF model setting the terminal year 8 years out from the forecast date.

3.4 Identifying errors and dubious judgments in analysts' DCF valuation models

The extremes reported in Table 3 in the components of analysts' DCF valuations point to the possibility that some of them are errors, and/or some are economically dubious judgments. However, without specificity as to what is theoretically correct and what is economically sensible, we cannot appropriately identify which analyst assumptions are errors or dubious judgments, and which are merely aggressive or conservative positions taken by the analyst.

Table 4 lists the errors that we grade analysts on, both with respect to the numerator-oriented level, growth and timing of free cash flows aspects of analysts' DCF models (panel A), and with respect to the denominator-related discount rate aspects of valuation (panel B). The errors identified in Table 4 are following in Table 5 by the list of potential dubious judgments that we grade analysts on, spanning both numerator and denominator aspects of DCF. We identify errors and dubious judgments using only those observations for which there is sufficient data available to make a determination of whether there is error or dubious judgment.

In Tables 4 and 5 we grade analysts' DCF models based on what we define for purposes of this study to be the economically sensible cutoff values (or range of cutoff values) for certain of the condensed DCF model elements shown in Figure 2, and for certain of the theoretically oriented inter-relationships between them. In openly defining what we grade to be an analyst error versus a dubious judgment, we fully concede that at times we are overlaying our judgment into what is versus what is not an error, and what is versus what is not a dubious judgment. This is important to emphasize because we recognize that some readers may disagree with a variety of our grading criteria. In this sense, our results undoubtedly contain a level of subjectivity.

For example, we grade the analyst as having made an error in their risk free rate RF assumption if their RF is more than +/- 30 bps away from the 10-year Treasury rate on the analyst report date (error code 2.1, panel B of Table 4). An example of a cutoff value that leads us to conclude that the analyst has made a dubious judgment is an annual market risk premium in excess of 9% (dubious judgment code 3.2, Table 5). An example of an error based on a theoretic

[4] A post-terminal year perpetual growth rate of -100% is how we code free cash flows that are assumed by the analyst to cease after the terminal year. An example of this can be found in the report on Gilead Sciences done by Deutsche Bank on 11/13/2012.

inter-relationship between elements of the condensed DCF model is that we define an erroneous analyst terminal value as one that is more than +/-3% away from the terminal value that we calculate from the analyst's terminal year free cash flow forecast, given the analyst's WACC and forecasted perpetual growth rate (error code 1.3.2, panel A of Table 4).

Although different types of analyst errors may be positively correlated, our goal is to identify errors that are as much as possible independent of one another.[5] We provide our justifications for the critical values and theoretically oriented interrelationships between DCF elements that are central to Tables 4 and 5 in Appendix 1. In Appendix 2 we illustrate specifics of our error and dubious judgment grades (along with disclosure scores that we develop and discuss in section 5.2) for three different sample analyst reports.[6]

3.5 Errors in analysts' DCF valuation models

3.5.1 Errors having to do with the numerator-oriented level, growth and timing of free cash flows aspects of analysts' DCF models

In panel A of Table 4, we catalog the 15 errors that we grade analysts on with regard to the upper half of Figure 2, namely the numerator-oriented level, growth and timing of free cash flows aspects of their DCF models. The errors range from incorrectly deriving free cash flows from underlying financial statement forecasts, to adding total rather than just non-operating cash to enterprise value, to using too high or too low an effective tax rate in the terminal year. Rather than describing the results of grading analysts on every error, we sample three we consider noteworthy.

First, the most common error analysts make is projecting implausibly large rates of revenue growth in the terminal year (error code 1.8.1). Based on their DCF model annotations, we estimate that analysts make this error 50% of the time. We define the error rate of a graded item as the number of graded errors divided by NOBS, the number of observations for which we can cleanly tell whether an error has or has not taken place. Since NOBS is rarely equal to 120, the number of analyst reports in our sample, when we state that "we estimate that analysts make a given error Z% of the time", we intend this to pertain to the population of all analyst reports that satisfy our sample selection criteria laid out in Table 1. This means that we also assume that

[5] For example, it is not necessarily the case that an analyst whose forecasted revenue growth rate in the terminal year T is excessively high must also have an excessively high forecasted CAPEX growth rate in year T.

[6] Between them, the DCF portions of the three sample reports span 12 of the 15 numerator-related errors listed in Table 4 panel A; 11 of the 13 denominator-related errors listed in Table 4 panel B; and 13 of the 20 dubious judgments listed in Table 5.

the decision by an analyst to report or not report the information we need to determine if an error has been made is uncorrelated with the probability that the analyst has made an error.

Second, the least common error analysts make is converting dollar equity value into per share equity value (error code 1.6.2), which we estimate occurs 4% of the time. Lastly for panel A, the error that ex-ante we propose is most likely to be economically material is overestimating the perpetual growth rate in free cash flows beyond the terminal year (error code 1.3). Based on our maximum allowable terminal growth rate cutoff of 5% per year, we estimate that just 7% of analysts err in what they assume for this important variable.[7] Overall, we note that both the median (mean) error rates across all 15 potential errors listed in panel A are 23% (25%).

3.5.2 Errors having to do with the denominator-related discount rate aspects of valuation

In panel B of Table 4, we catalog the 13 potential errors we propose analysts may make with regard to the lower half of Figure 2, namely those involving the denominator-related discount rate aspects of valuation. The errors range from assuming that the before-tax cost of debt is zero, to using an equity weight in calculating WACC that is inconsistent with the equity value obtained from the analyst's actual DCF valuation, to several types of incorrect discounting of future free cash flows (including not discounting them at all). Rather than discuss the results pertaining to each and every error, we highlight a subset.

The most common error analysts make in discounting is not scaling up their estimated equity value from the valuation date to the target price date (error code 2.8). We estimate that analysts make this error 93% of the time. In contrast, the least common mistake analysts make is assigning no weight to preferred stock in calculating WACC even though the firm has preferred stock outstanding (error code 2.4.2). We estimate this occurs just 3% of the time.[8] We also note three errors that ex-ante we posit will likely be economically material: [1] the already mentioned

[7] We view 5% as conservative in grading errors for the projected rate of growth in post-terminal year free cash flows because 5% is 2% larger than the value assumed by Lundholm and Sloan in *Equity Valuation and Analysis with eVal* (2013, 3rd ed., p.174), the source of our assumed 100% correctly structured and executed DCF-to-all-investors equity valuation model. Lundholm and Sloan state that they use 3% as the default terminal value for sales growth (and therefore free cash flows also). Their reasoning is that "Historically, the annual growth rate in the U.S. economy, as measured by the nominal GDP growth rate, has averaged around 6%, composed of roughly 4% real growth and 2% price inflation. However, the financial crisis of 2007-2008 sent both real growth and inflation plummeting into negative territory, albeit briefly. The long-term forecasts from the Congressional Budget Office and the Federal Reserve at the end of 2010 put real growth at 2-3% and inflation at 1-2%. So, in most cases a terminal sales growth rate forecast should fall between 3% and 5% … We use 3% as the default terminal value for Sales Growth in *eVal*." Also, our sample of analyst reports is from 2012-13, very close in time to 2010. If we use Lundholm and Sloan's cutoff of 3%, then we estimate a much larger analyst error rate of 32%.

[8] This error is rare in large part because firms rarely have preferred stock. If analysts do not mention preferred stock in their DCF models, we assume that this is because they are aware the firm has no preferred stock.

error of not scaling up estimated equity value from the valuation date to the target price date (error code 2.8, error rate = 93%); [2] using an RF is more than +/- 30 bps away from the 10-year Treasury Bill yield on the date of the analyst's report (error code 2.1, error rate = 84%); and [3] discounting annual free cash flows as if they occur at year end rather than mid-year (error code 2.7, error rate = 83%). Lastly, we note that the median and mean error rates across all 13 of the error codes listed in panel B are 32% and 20%, respectively.

3.6 Dubious judgments in analysts' DCF valuation models

In Table 5 we lay out the 20 dubious judgments that we propose analysts may make in executing their DCF models. They range from assuming an implausibly large beta, to not providing the reader of the report with any valuation parameter sensitivity analyses, to providing little or no information about the components of WACC or providing very little in the way of forecasted future financial statement data for the reader of the report. As with Table 4, rather than discuss each and every dubious judgment, we highlight a few examples.

The most common type of dubious judgment occurs in the area of analysts treating all of a firm's cash as a financial asset, rather than their estimating some portion of the cash to be operating in nature (dubious judgment code 3.10.1). We estimate that this dubious judgment happens 95% of the time.[9] Another common type of dubious judgment occurs in the area of the net financial asset/liability adjustments analysts make to enterprise value in order to arrive at equity value (dubious judgment code 3.10.2), which we estimate happens 54% of the time.[10] In contrast, the least common area for a dubious judgment to occur is analysts setting their actual or implied target price date prior to their report date, which we estimate happens only 2% of the time (dubious judgment code 3.11.3). We also note three types of dubious judgment that we posit have the potential to be economically significant. First, we estimate that 18% of the time analysts employ an excessively large market risk premium, which we define as one greater than 9% (dubious judgment code 3.2). Second, 42% of the time the valuation date lies beyond the analyst report date (dubious judgment code 3.11.1). Third, in 26% of analysts' DCF models, the

[9] We note that one reason for the high rate of our grading dubious judgments in the area of cash is that at least one large brokerage in our dataset instructs its analysts to treat all cash as a financial asset and not to attempt to extract an estimate of operating cash. As such, our estimated dubious judgment rate of 95% with regard to analysts treatment of cash may overstate the degree to which they would make a dubious judgment if left to themselves.

[10] Examples of adjustments to enterprise value that we define as dubious judgments include adding more cash of financial assets (or subtracting materially more or less debt or financial liabilities) than shown on the firm's balance sheet at the effective valuation date; adding rather than subtracting debt; not adjusting for minority interest or preferred stock when shown on the firm's balance sheet at the effective valuation date; adding assets or subtracting liabilities that we judge to be operating rather than financial in nature; and subtracting a 'public market discount'.

ROE embedded in forecasts of terminal year financial statements (that typically but not always accompany analysts' DCF models) is less than 5% or greater than 25%, both of which we assume to be economically implausible (dubious judgment code 3.7). Overall, we note that dubious judgments are not uncommon, as the mean and median rates at which they occur per Table 5 are 23% and 16%, respectively.

3.7 Errors and dubious judgments aggregated within and across analysts

Having described the types of errors and dubious judgments we grade individual analysts on in their DCF equity valuation models, and the absolute and relative frequencies with which we estimate each occurs across analysts, we turn to aggregating errors and dubious judgments within and then across analysts, and by broker. The results are reported in Table 6.

Table 6 panel A shows that in our sample of 120 broker reports issued between Jan. 2012 and Dec. 2013, sell-side analysts make an estimated mean (median) of 5.4 (5) errors and 4.5 (5) dubious judgments in constructing and executing their DCF equity valuation models. When scaled by the number of errors and dubious judgments for which analysts provide sufficient information for us to grade them on, we estimate that analysts' mean (median) error rate is 32% (32%) and their mean (median) rate of making dubious judgments is 41% (40%). Panel B lists the mean number of errors and dubious judgments, and the mean error and dubious judgment rates, by broker. Inspection of the means reported in Panel B indicates that the valuation models shown in the sell-side equity analyst reports published by large brokers contain similar numbers and rates of errors and dubious judgments to those of small brokers.

The magnitudes of these statistics lead us to infer that sell-side equity analysts make a disturbingly large number of mistakes in their DCF equity valuation models. Of course, it is unreasonable to suppose that in their DCF models, analysts never make mistakes or dubious judgments. This said, sell-side equity analysts have been widely seen by academics as sophisticated economic agents. Given their responsibilities and the nature of their employers, they are intelligent, knowledgeable, competitive and well incentivized to analyze and predict the levels and risks of the cash flows of the firms they follow. As such, even though we are mindful that we do not have a perfect benchmark to judge analysts' DCF modeling abilities against, we argue that it is very surprising that analysts make as many errors and dubious judgments in their DCF equity valuation models as we estimate they do. We return to discuss some of the implications of our findings, and questions that arise from them, in section 7.

4. Economic magnitude of analysts' errors

One criticism that could legitimately be made against our inference that analysts make a alarmingly large number of errors and dubious judgments in their DCF equity valuation models is that we merely identify a variety of small errors that in aggregate impart little or no bias into the key output of analysts' DCF valuation models, namely target prices. We speak to this concern by calibrating the economic significance of analysts' DCF modeling mistakes after recalculating analysts' stated target prices and the annualized expected returns (AERs) embedded in them to correct for each of five major types of errors.

The errors we correct are those where [i] the analyst's post-terminal year growth rate in free cash flows g exceeds 5%; [ii] the analyst incorrectly includes FCFs that occurred prior to the valuation date, or makes incorrect adjustments to ENTVAL in arriving at EQVAL; [iii] the analyst's RF is more than +/- 30 bps away from the 10-year Treasury Bill yield on analyst's report date; [iv] the analyst's FCF are discounted end-of-year, not mid-year; and [v] the analyst does not scale up EQVALPS from the valuation date to the target date. We focus on these errors because based on the formulae underlying DCF valuation, we judge them to be the most likely to yield material changes in analysts' target prices when the errors are corrected.

Table 7 reports the results of correcting each error in a mutually exclusive manner. In measuring the average effects of correcting a given error, we include both observations where we can identify that analysts have made an error and observations where they have not. For example, in correcting what we judge to be analysts' errors about g, the post-terminal year growth rate in free cash flows, we take the 109 analyst reports that per panel B of Table 3 disclose g, and recalculate the analyst's target price after reducing to 5% all values of g > 5%. This turns out to be feasible for 57 of the initial 109 observations.

We estimate that correcting errors [i] and [ii] yields no materailly positive or negative material changes in the AERs implied by corrected target prices. In contrast, correcting error [iv] increases AERs by a mean and median of 5% (viz., about half the mean value of RE reported in panel C of Table 3), while the largest impacts on AERs come from correcting errors [iii] and [v]. Thus, we estimate that changing RF to the 10-year Treasury yield on the analyst report date when RF is more than +/- 30 bps away from the 10-year Treasury yield on the analyst report date increases AERs by a mean (median) of 14% (21%). We also estimate that scaling up EQVALPS from the valuation date to the target price date for the 93% of the time that this is not done by the analyst increases AERs by a mean (median) of 12% (11%).

Lastly, we provide a crude estimate of what might happen to analysts' AERs if all five errors [i] - [v] were corrected simultaneously. We do so by imposing two additional assumptions. First, we assume that the mean and median AERs we estimate from correcting any one error can be added together to arrive an unbiased estimate of the mean and median AER that would be obtained if all five errors were simultaneously corrected. And second, we assume that the errors we can identify in analysts' DCF models because the analyst shows us enough information to be able to grade them generalize to analyst reports where the analyst does not show us enough information to be able to grade that aspect of their report. Given these assumptions, the last line of Table 7 indicates that we estimate that correcting for all five types of errors where present would increase analysts' target prices by a median (mean) of 37% (29%). We argue this is an economically material amount.

In total, the results we report in Tables 3-7 lead us to conclude that at least with regard to valuing equity, not only are sell-side analysts markedly less sophisticated than prior research has supposed, but they are also more optimistic in that the correct translation of the fundamental free cash flow and WACC information that they place into their DCF valuation models yields estimates of the relevant firms' future stock prices that are far higher than those obtained from analysts' stated target prices, which prior research has found to be quite optimistic to begin with.

5. Explaining variation in error rates and dubious judgment rates in analysts' DCF models

In this section we test the hypothesis that, holding constant analysts' poor average sophistication in constructing and executing DCF valuation models, more sophisticated analysts will nevertheless exhibit lower error rates and dubious judgment rates than will less sophisticated analysts. We first develop several proxies for analyst sophistication, and then use the proxies in cross-sectional regressions. Our proxies center on the quantity of information analysts disclose about the inputs to, and the contents of, their DCF model by leveraging the idea that more sophisticated analysts will seek to separate themselves from less sophisticated analysts by disclosing more information about their DCF models to investors because their knowledge is greater and they are more confident in what they know.

5.1 Scoring the quantity of disclosure about the inputs to, and the contents of, DCF models

We create four DCF disclosure scores, each of which is aimed at measuring how much of several types of information analysts provide in their reports about their DCF models. For each type of score, a higher value captures the notion that the analysts responsible for the higher value are disclosing to investors a greater fraction of the total information the investors wish to see. We argue that by supplying investors with more of what they demand, analysts with higher DCF disclosure scores will be seen as more sophisticated and in equilibrium will indeed be more sophisticated because the degree to which they are sophisticated is, as we have shown earlier in our paper, readily estimable by grading their DCF models.

5.1.1 Forecasted financial statements

We begin with a measure of the quantity of fundamental financial statement data that analysts generate and that is therefore available for input into their DCF models. Our proxy for this is the number of forecasted future financial statements that analysts do (or do not) include in their reports. Many academics and practitioners argue that in-depth and high-quality forecasted financial statements are critical to achieving a sophisticated equity valuation.[11] Along with their DCF models, analysts' commonly provide at least one year's worth of one or more forecasted income statements, balance sheets and statements of cash flow.

Table 8 provides descriptive statistics on the number and type of annual financial statements forecasted by analysts in our sample of 120 reports issued Jan. 2012 - Dec. 2013. Lines 1a and 1b show that for the sample as a whole, analysts forecast a mean of 3.7 years' worth of full annual income statements. The minimum is zero years, the maximum is 11 years, and at least one year of full income statements is forecasted 92% of the time (110 out of 120 reports). We define a full financial statement as one that contains all or almost all of the lines that would be expected to be present in that financial statement as disclosed in the typical 10-K, keeping in mind the firm's industry. In line 1b, we note that for the 10 reports that do not contain one or more forecasted full annual income statements, it is sometimes the case that the analyst forecasts a 'mini' or partial annual income statement, which we define as one that contains only a few of the lines typically present in a full annual income statement.

Although not as prevalent as income statements, lines 2a-3b show that full balance sheets and statements of cash flow are each forecasted in about 56% of reports. Across all 120 sample analyst reports, the mean number of years of both forecasted full balance sheets and statements of cash flow is about 2.3. This is smaller than the 3.7 years' worth of forecasted full annual income statements in part because it is less likely that an analyst will forecast full versions of

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[11] For example, Lundholm and Sloan in the preface to their book *Equity Valuation and Analysis with eVal* (2013, pp.xii) state that "Our overriding theme [in this book] is that good forecasts of the future financial statements are the key input to a good valuation … [O]ur main point [is] that the key to good valuations is good forecasts."

these financial statements. Lines 2b and 3b indicate that when no full balance sheets and statements of cash flow are forecasted, the mean number of mini balance sheets and statements of cash flow that are forecasted is small, amounting to one year or less.

5.1.2 DCF disclosure scores

We score analysts on how much information they disclose to investors through their forecasted financial statements by awarding three (one) points for each forecasted annual full (mini) income statement, balance sheet, and statement of cash flows, and then dividing the sum by nine times T, where the number of years ahead to the terminal year in the DCF model. Since T can exceed the number of years the analyst forecasts future financial statements for, the disclosure quality score for forecasted financial statements can exceed 100%. At the same time, because T may not be shown in the analyst's DCF model (e.g., the analyst simply states what WACC is and what their estimated equity value per share is, and no more), there are some reports for which a forecasted financial statements score cannot be calculated.

Next, we score analysts on the quantity of information they provide to investors about how they arrive at their forecasted annual future free cash flows. We award one point for each of the following 10 lines in Figure 2 that are explicitly or implicitly forecasted by the analyst: EBITDA, depreciation & amortization, EBIT, taxes on EBIT, NOPAT, depreciation & amortization (again), Δ working capital, after tax operating cash flows, CAPEX, and free cash flows. We then divide the sum by 10, the maximum number of lines.[12]

Third, we measure the quantity of analysts' disclosures about their WACC. We do so by awarding one point for each of the 11 components used in calculating WACC as shown in the lower right hand side of Figure 2: RF horizon, RF, beta, market risk premium, RE, equity weight, RD before tax, tax rate, RD after tax, debt weight, and WACC. We divide the sum by 11.[13]

Lastly, we score analysts on how much data they provide investors about how they convert their forecasted future free cash flows into equity value per share. In this regard, and in strong though not complete parallel with what is shown in the lower left hand side of Figure 2, we award one point for each of 12 items when explicitly shown on the analyst's DCF: Horizon year (maximum of 1 pt), PV of FCF in each individual year in forecast horizon (maximum of 1

[12] An explicit forecast occurs when the analyst writes a number down for a given line. An implicit forecast occurs when the analyst does not write a number down for a given line, but the number for the given line can be deduced from other lines the analyst has explicitly forecasted.

[13] In the few cases where the firm has preferred stock, we score one additional point for the interest rate on preferred and one point for the weight on preferred, and increase the denominator to 13.

pt), total PV of all forecasted FCFs, terminal value, PV of terminal value, enterprise value, cash, debt, equity value, shares used to deflate equity value, equity value per share, and date that the forecasted equity value per share applies to. The resulting sum is divided by 12.[14]

In Table 9 we provide descriptive statistics on the distribution of the four scores across our sample of analyst reports. Holding constant the large dispersion that is present in all types of score, we observe a separation of scores into two groups: On the one hand, information to do with deriving FCF and then converting the FCF into EQVALPS, where the median disclosure scores are 85% and 78%, respectively. On the other hand, forecasted financial statement and WACC information, with much lower median disclosure scores of 33% and 32%, respectively. In part, these findings indicate that analysts are much more willing to provide investors with information about the numerator aspects of their DCF models (viz., deriving FCF and converting the FCF into EQVALPS) than about the denominator aspects (viz., WACC information). Whether this is because analysts are more confident predicting the levels of future free cash flows than their riskiness, or whether it reflects differential strategic behavior in light of the availability of their reports to competitor analysts, is difficult to determine.

5.2 Do more sophisticated analysts make fewer errors and fewer dubious judgments?

We now turn to using all four of the disclosure scores developed in section 5.1 as proxies for analyst sophistication in testing the hypothesis that more sophisticated analysts will manifest lower DCF error rates and dubious judgment rates than less sophisticated analysts. We do so by regressing DCF error rates and DCF dubious judgment rates on the four disclosure scores and five supplementary variables.[15] We predict that each disclosure score will be negatively associated with analysts' error rates and dubious judgment rates. The supplementary variables we include are a dummy variable for there being at least one CFA on the analyst team, the number of pages in the analyst report, the number of analysts on the analyst team, the number of years the firm had been publicly traded as of the report date, and the prominence of the brokerage firm. We predict a negative coefficient on each of these latter variables.[16]

[14] In the few cases where the firm has preferred stock and/or minority interest, we score one additional point for preferred stock and one additional point for minority interest, and increase the denominator to a maximum of 14.

[15] To maximize the number of regression observations, we replace the nine missing values of the disclosure scores covering forecasted financial statements with the mean score value of 44% (see Table 9, NOBS = 111 not 120).

[16] The reasoning behind our sign predictions is straightforward. We expect analysts with a CFA qualification to be more sophisticated in DCF modeling; more pages in the analyst report to reflect more detailed and therefore more sophisticated analysis; more analysts on the analyst team to increase the probability that team members will match to their sub areas of expertise including DCF modeling; more prominent brokerage firms to employ more financially

We present the results of estimating the two regressions in Table 10. We find that while four of the eight estimated coefficients on the disclosure scores are reliably negative at the 5% one-tailed significance level. Moreover, the adjusted R^2 of 30% in the dubious judgment regression indicates that the disclosure scores in aggregate explain a material fraction of the cross-sectional variation in analysts' DCF dubious judgment rates. We therefore interpret Table 10 as generally supportive of the hypothesis that more sophisticated analysts make fewer mistakes and dubious judgments than do less sophisticated analysts.

6. Analysts' sophistication with regard to long-run economic forces

In this section we conclude our empirical assessment of the sophistication of DCF equity analysts by studying how well the long-run economic forces that are expected to govern firms' activities show up in the forecasted financial statements that we documented in section 5.1.1 often accompany analysts' DCF valuation models. If analysts are only somewhat sophisticated, then we expect to observe that the rates of growth in all the financial statement lines that they forecast going out in time through to their DCF terminal year will on average decline. If analysts are very sophisticated, then we further expect to observe that their forecasted rates of growth in the terminal year will not exceed the expected perpetual rate of worldwide economic growth.

In Figure 3 we display the trajectories of the medians of key ratios extracted from analysts' forecasted financial statements in event time relative to analysts' DCF terminal year (where available). Panel A shows the median rates of growth in certain dollar-denominated financial statements variables, while panel B reports the median values of the percentage-based ROE and the effective tax rate variables.

Looking first at panel A, it can clearly be seen that the median rates of growth in all five dollar-denominated financial statement variables on average decline as the terminal year approaches. This is consistent with analysts being sufficiently sophisticated to recognize the economic reality that in the long run, high rates of projected firm growth and all its correlates must in expectation decline and converge toward a figure no larger than the expected rate of nominal growth in the world economy. Also consistent with such an sophistication view is the result in panel B where the median effective tax rate increases as the terminal year approaches.

sophisticated analysts; and more mature firms to be easier to model and so provide fewer opportunities for analysts to make errors or dubious judgments on. We measure broker prominence by the log of the number of times the broker appears in our sample.

However, Figure 3 reports evidence that we view as being inconsistent with many analysts being highly sophisticated in their understanding of long-run economic forces. First, pivoting on our assumption expressed in the cutoff in error code 1.3 (Table 4, panel A) that during our 2012-13 sample period the correct expected perpetual rate of annual worldwide economic growth should not exceed 5%, panel A shows that the median analyst projection of the rate of growth in long-term free cash flows is more than 5%. Second, even where the median rates of projected growth in revenues, depreciation, EBIT and CAPEX are smaller than 5%, less than but still close to 50% of individual analysts' projections exceed 5%. Taken together, the evidence in panel A leads us to conclude that close to 50% of analysts in our sample are optimistic and only partially reflect the realities of long-run economic forces in their DCF forecasts.

The evidence we present in panel B regarding where analysts project ROE will be as time increases from the forecast date toward the terminal year echoes this conclusion.[17] Specifically, panel B shows that median ROE is forecasted to *increase* as the terminal year approaches, rising from a linearly fitted value of 12.5% nine years before the terminal year to 18.4% in the terminal year. We argue that this is not what would be expected to be observed in a random sample of publicly traded firms and given a mean forecasted cost of equity of 11.1% (Table 3, panel C). We interpret the gap of 7.3% between 18.4% and 11.1% as indicating that analysts on average are inappropriately optimistic and partially unsophisticated about the projected long-run profitability of the companies they follow.[18] As such, we also propose that the evidence in Figure 3 is consistent with the results in Table 7 where we estimated that analysts are markedly more optimistic than previously assumed because the correct translation of the fundamental free cash flow and WACC information that they place into their DCF valuation models yielded estimates of the relevant firms' future stock prices that were far higher than those obtained from analysts' stated target prices, which prior research has found to be quite optimistic to begin with.

[17] We define ROE as annual net income divided by end of year shareholder equity.

[18] This would not necessarily be true for a sample heavily concentrated in intangible intensive firms such as pharmaceuticals, or a sample tilted toward newly listed firms. For such firms, it might reasonably be expected that the expensing required of most intangible assets under U.S. GAAP, combined with successful intangible-intensive companies being those that create natural monopolies for themselves, would lead to ROEs that both increased toward the terminal year, and at the terminal year were higher than RE (Lundholm and Sloan, 2013, Ch. 4).

7. Conclusions and questions for future research

In this study, we have sought to determine how well sell-side equity analysts construct and execute the DCF valuation models that they frequently include in their reports to investors. Using a stratified random sample of 120 analyst reports containing DCF valuation models from Investext that were issued during Jan. 2012 - Dec. 2013, we estimate that analysts make a median of five errors and five dubious judgments in their DCF models. As such, and subject to the caveat that our results are to some degree predicated on our judgments as to what is a DCF error and what is not, we conclude that the number of errors and dubious judgments that we estimate sell-side equity analysts make are startlingly high. Most academics and investors see sell-side analysts as being sophisticated economic agents. Although such sophistication may be present in the many and rich non-DCF valuation parts of their reports, we find a marked lack of sophistication in analysts' ability in the DCF valuation part of their reports to construct and execute a DCF equity valuation model.

In order to estimate the economic magnitude of their lack of DCF valuation sophistication, we show that the errors that analysts make are not small and mean zero in their effect on analysts' target prices. Specifically, we estimate that recalculating analysts' stated target prices after correcting for five major and common errors overall increases target prices by about one third. This leads us to conclude that sell-side equity analysts are both less sophisticated and more optimistic than prior research has supposed. This conclusion is bolstered by additional results we find using the forecasted financial statements that analysts often include in their DCF-oriented reports—namely that analysts only partially reflect in their financial forecasts the economic realities that affect long-run forecasts. In particular, analysts are too optimistic about the rates of growth they are forecasting for revenues and free cash flows in the DCF terminal year, with the improper result that the ROEs they forecast increase over time and rise to a level that is implausibly higher than firms' cost of equity capital.

Looking to the future, we suggest that our study raises a number of disquieting questions. For example, why do sell-side analysts make so many mistakes and dubious judgments in their DCF valuation models? How do they continue to do so, given the repeated nature of the task, and the fact that their errors are on display for their clients, their bosses and colleagues at competing sell-side brokerages to see? Do buy-side analysts make similar numbers of errors and dubious judgments (Crawford, Gray, Johnson and Price, 2013; Groysberg, Healy, Serafeim and Sahnthikumar, 2013)? Are analysts just poorly trained—and if so, is that the fault of their academic teachers, or poor in-house training? Or do they not care because the importance of financial models to them and their compensation has fallen over time (Bradshaw, 2011)? Why don't brokerage firms make their analysts use correct and uniform valuation templates, such as those available for little or no cost from websites such as www.lundholmandsloan.com and www.wallstreetprep.com? Would analysts revise and/or reverse engineer their free cash flow and/or cost of capital inputs if they were aware of their mistakes in combining them into a valuation, such that they ended up back at their original error-riddled target price? Do sophisticated consumers of analysts' reports such as institutional investors and corporate CFOs not realize that analysts make so many DCF valuation mistakes and dubious judgments? Or are they quite aware of, and therefore largely discount analysts' DCF models and price targets? But then why do stock prices move when analysts change their price targets? Do investment banks and corporate CFOs make the same kinds of mistakes and dubious judgments as analysts when evaluating M&A targets for their clients or for their own organization? Do hedge funds or other types of sophisticated investors exploit analysts' erroneously executed DCF valuations? And are the brokerage firms that employ analysts who make large numbers of DCF modeling errors exposing themselves to heretofore-unrecognized legal risks? Given the central importance of accurate valuation in economics and finance, we believe that these questions are worthy of future research, particularly because the answers should be useful to both academics and practitioners.

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APPENDIX 1

Justifications for the set of critical values and theoretically oriented interrelationships between DCF elements covered in Tables 4 and 5

In grading analysts' DCF models, on many occasions we employ a +/- 3% cutoff between what the analyst reports and what we calculate based on the raw data analysts' provide on their DCF model page(s) before we assign an error as having occurred. We do not require an exact match to allow for the fact that what analysts show on their DCF model page(s) is often rounded up or down relative to the exact underlying calculations.

<u>*Panel A: Error cutoffs*</u>

1.2 t_0 is the valuation date, defined as the beginning of Year 1 of the analyst's valuation horizon. Thus, in Figure 2 we have t_0 = 12/31/2011 because Year 1 = 2012 and the firm's fiscal year-end is 12/31. We typically identify t_0 based on determining the date that yields us the closest correspondence between what analysts' show PV(FCF[1-T]) to be or calculate to be, and what we calculate PV(FCF[1-T]) to be based on what analysts show on their DCF model page(s) with regard to FCF[1-T], WACC and cash flow timing.

1.3 We use 5% as the cutoff above which we grade analysts as assuming an erroneously high g, the growth rate in post-terminal value FCF (and all other financial statement variables). This is 2% higher than in *Equity Valuation and Analysis with eVal* (2013, 3rd ed., p.174), the source of our assumed 100% correctly structured and executed DCF-to-all-investors equity valuation model. Lundholm and Sloan state that they use 3% as the default terminal value for sales growth (and therefore free cash flows also). Their reasoning is that "Historically, the annual growth rate in the U.S. economy, as measured by the nominal GDP growth rate, has averaged around 6%, composed of roughly 4% real growth and 2% price inflation. However, the financial crisis of 2007-2008 sent both real growth and inflation plummeting into negative territory, albeit briefly. The long-term forecasts from the Congressional Budget Office and the Federal Reserve at the end of 2010 put real growth at 2-3% and inflation at 1-2%. So, in most cases a terminal sales growth rate forecast should fall between 3% and 5% … We use 3% as the default terminal value for Sales Growth in *eVal*." We use 5% rather than 3% in order to seek to be conservative in estimating that analysts make an error in this important area of valuation.

1.8.1 We use min(2g, 6%) as the cutoff above which we deem analysts' terminal year revenue growth,
1.8.2 CAPEX growth, and FCF growth to be erroneous to allow some headroom in the growth rate in
1.8.6 analysts' forecasted financial statements and/or FCF components relative to g.

1.8.4 We use +/- 50% as the cutoff between CAPEX and D&A in the terminal year to allow for the possibility that substantial differences between CAPEX and D&A in the terminal year may not be erroneous because management might still be able or planning to set CAPEX to a level starting the year after the terminal year that would equate CAPEX and D&A.

1.8.5 We set the lower cutoff for terminal year ETR at 25% to conservatively allow for the possibility that the firm will be able to avail itself of permanent U.S. and/or foreign tax benefits.

2.1 We select the 10-year Treasury yield as the correct RF horizon to follow Lundholm and Sloan (2013, p.218). Like Lundholm and Sloan, we judge the 10-year yield to well balance the mix of very short term horizons and very long term horizons in the DCF model. The 10-year rate is also very commonly used in practice. We apply +/- 30 bps as the error determination cutoffs to allow for analysts being slow to update their DCF models if interest rates suddenly change.

2.2 Given that we observe a mean RE of approximately 11%, we use +/- 30 bps as our cutoff bounds to conform to our general +/- 3% cutoff.

2.3.2 We use the same tax rate cutoff bounds as in 1.8.5 because WACC will in large part apply to long term FCF. As such, the tax rate should be that which is expected to apply in the long run, and since in the firm will only exist in the long run if it is profitable, in the long run the most likely tax rate the firm will face is the sum of the statutory federal rate plus a weighted average of state tax rates (net of federal tax benefits).

2.3.4 We use +/- 20 bps as our cutoff bounds rather than +/- 30 bps as in RE because before-tax RD is typically about 2/3rds the size of RE.

2.4.1 We apply cutoffs of +/- 10% rather than 0% to allow for rounding related slippage between analysts' calculations and our own.

Panel B: Dubious judgment cutoffs

We acknowledge that the cutoffs we use in grading analysts as having made a dubious judgment are more subjective than those we use for grading errors. Below we provide explanations for the areas of DCF model judgment that may be less familiar to readers.

3.6 We set the minimum horizon for a non-dubious terminal year horizon at 4 years in light of the arguments made by many academics and practitioners that T needs to be set a fair way out into the future, not close to the valuation date. For example, Lundholm and Sloan (2013) set T to be 11 years in *eVal*. In the earlier 2007 edition of their textbook (in which they set the default T at an even higher 23 years), they state that "you should be very cautious about using the perpetuity formula too soon … Because year T is the starting value for an infinite stream of future values, even a small error in the year T cash flow or residual income gets greatly amplified, resulting in a big mistake in the valuation." (p.222).

3.11.1
3.11.3 Setting the valuation date t_0 after the report date is not necessarily fatal, but is dangerous because it may be the case that the firm is reasonably forecasted to undertake material operating, financing or investing actions between t_0 and the report date. Ditto with regard to setting t_0 after the target price date.

3.11.2 Setting t_0 more than 400 calendar days prior to the report date is dubious because it compounds the effects of the error that analysts make 93% of the time by not scaling up their EQVALPS from t_0 to the target price date (error code 2.8, Table 4 panel B).

3.12.1
3.12.2
3.12.3
3.12.4 We subjectively set a cutoff of 20% for each of the four disclosure scores we compute, discuss and use in section5.1.2 and 5.2. We do so based on what we propose is the reasonable argument that the investor reading the analyst's report will value knowing at least 20% of what could be disclosed (given the assumed DCF-to-all-investors valuation framework laid out in Figure 2).

APPENDIX 2

Analyst DCF-to-all-investors as-reported example #1: Level 3 Communications (3/16/12, Cowen & Company)

Error and dubious judgment codes as defined in Table 4 and Table 5

Errors		Dubious judgments	
1.8.1		3.2	
1.8.2		3.4	
1.8.5		3.5.2	
1.8.6		3.10.1	
2.1		3.10.2	
2.2			
2.4.1			
2.5			
2.8			
Number	9	Number	5
Rate	43%	Rate	25%

DCF model disclosure quality scores:

Forecasted financial statements	67%
Deriving FCF	40%
WACC	73%
Converting FCF to EQVALPS	92%

Implied date of analyst's DCF model t_0: 20111231

Chart 9: Level 3 DCF

($mn)	2011	2012E	2013E	2014E	2015E	2016E	Terminal Value
Revenue	$4,387	$6,557	$6,934	$7,356	$7,826	$8,349	
EBITDA	959	1,471	1,789	2,064	2,267	2,499	19,988
CFO	388	790	1,072	1,388	1,600	1,833	
Capex	498	787	832	883	978	1,044	
Free Cash Flow	(110)	3	240	506	622	790	
Cash Flow Growth		103.1%	7036.0%	110.5%	23.0%	27.0%	
Year	0.0	0.5	1.5	2.5	3.5	4.5	4.5
Present Value Discount Factor	1.00	1.04	1.13	1.23	1.34	1.46	1.46
Present Value of Free Cash Flow	(110)	3	212	410	463	541	13,682

Today	
Total PV of Free Cash Flow	$1,518
Terminal Value	$13,682
Sum of DCFs	$15,200
less net debt and preferred stock	$7,519
plus other cash	$0
Private market value	$7,681
less 10% public / private discount	$768
Public equity value	$6,913
Shares Outstanding	212
Fair Value Price	**$32.68**

Current Price	$26.60

WACC	8.8%
Terminal EBITDA Multiple	8.0
Risk Free Rate	3.5%
Beta	1.2
Equity Premium	9.2%
Cost of Debt	7.9%
Percentage of Capital	85.8%
Cost of Equity	14.2%
Percentage of Capital	14.2%

APPENDIX 2 (continued)

Analyst DCF-to-all-investors as-reported example #2: Google (1/23/13, Pivotal Research Group)

Error and dubious judgment codes as defined in Table 4 and Table 5

Errors		Dubious judgments	
1.1		3.6	
1.3		3.8	
1.4		3.10.1	
1.5		3.10.2	
1.6.1		3.11.3	
1.8.1		3.12.3	
1.8.2			
1.8.3			
1.8.4			
1.8.5			
1.8.6			
2.6			
2.7			
2.8			
Number	14	Number	7
Rate	74%	Rate	50%

DCF model disclosure quality scores:

Forecasted financial statements	33%
Deriving FCF	100%
WACC	9%
Converting FCF to EQVALPS	92%

Implied date of analyst's DCF model t_0: 20131231

GOOGLE DISCOUNTED CASH FLOW MODEL In $mm Except Per Share Data	FY12A	FY13E	FY14E	FY15E	FY16E	FY17E
Ex-MMI						
Operating Income	13,835.0	14,643.5	15,182.9	15,321.1	15,463.4	15,832.5
Net Interest and Other Income	625.0	650.0	700.0	800.0	900.0	1,000.0
Income Before Income Taxes	14,460.0	15,293.5	15,882.9	16,121.1	16,363.4	16,832.5
Provision For Income Taxes	(2,815.2)	(3,211.6)	(3,335.4)	(3,385.4)	(3,436.3)	(3,534.8)
• Assumed Tax Rate	19.5%	21.0%	21.0%	21.0%	21.0%	21.0%
Legacy Google Net Income	11,644.8	12,081.9	12,547.5	12,735.7	12,927.1	13,297.7
D&A	2,445.5	3,122.9	3,720.0	4,464.0	5,356.8	6,428.2
Stock-Based Compensation Expense	2,500.0	3,072.0	3,608.4	4,034.8	4,477.5	4,925.3
Capital Expenditures / Acquisitions	(13,841.0)	(7,000.0)	(7,900.0)	(8,800.0)	(9,700.0)	(10,600.0)
• Total Company CapEx / Acquisitions	(13,841.0)	(7,000.0)	(7,900.0)	(8,800.0)	(9,700.0)	(10,600.0)
Changes in Cash Flows	2,749.3	11,276.7	11,975.9	12,434.4	13,061.4	14,051.1
NPV of Future Cash Flows			11,107.4	10,696.3	10,420.9	10,397.5
Sum of Future Cash Flows		42,622.1				
NPV of Terminal Value		172,025.7				
• Terminal Value:		264,163.1				
Value of Future Cashflows		214,647.7				
Plus: 2013E Cash+ Marketable Securities		59,364.7				
Plus: Motorola Stand-Alone Value		8,000.0				
Value of Cashflows, Cash and Investments		282,012.5				
Less: 2013E Debt		(5,537.0)				
2013E Common Equity Value		276,475.5				
Shares Outstanding 2013E		338.4				
Equity Value 2013E (Per Share)		**820.0**				
Current Equity Value (Per Share)		702.9				
2013E Equity Value Premium Vs. Current Price		**17%**				

KEY ASSUMPTIONS	
Near-Term Discount Rate	*7.8%*
Terminal EV/FCF Multiple	*18.8x*
Long-Term Growth Rate	*6.0%*
Long-Term Discount Rate	*11.3%*

APPENDIX 2 (continued)

Analyst DCF-to-all-investors as-reported example #3: MoSyS (4/19/13, Feltl and Company)

Error and dubious judgment codes as defined in Table 4 and Table 5

Errors		Dubious judgments	
1.7.1		3.1	
1.8.2		3.3	
1.8.4		3.10.1	
1.8.5		3.11.2	
1.8.6		3.12.1	
2.1			
2.2			
2.3.1			
2.3.2			
2.3.3			
2.4.3			
2.5			
2.7			
2.8			
Number	14	Number	5
Rate	54%	Rate	26%

DCF model disclosure quality scores:	
Forecasted financial statements	13%
Deriving FCF	100%
WACC	100%
Converting FCF to EQVALPS	83%

Implied date of analyst's DCF model t_0: 20121231

MoSyS (NASDAQ: MOSY)
DCF Valuation
$ in millions, unless otherwise noted

	CY13E	CY14E	CY15E	CY16E	CY17E
	1	*2*	*3*	*4*	*5*
Free cash flow calculation					
Operating Profit (EBIT)	($23)	($24)	($13)	$2	$25
Less: Taxes *(assumes zero taxes)*	$0	$0	$0	$0	$0
NOPAT (Net Operating Profit After Taxes)	**($23)**	**($24)**	**($13)**	**$2**	**$25**
Less: CAPEX	$0	$0	$1	$1	$2
Less: Changes in working capital	$1	$0	($2)	($2)	($2)
Add: Stock compensation	$4	$4	$4	$4	$4
Add: Depreciation & Amortization	$2	$2	$1	$1	$1
Unlevered Free Cash Flow	**($18)**	**($18)**	**($7)**	**$7**	**$29**

DCF Enterprise Value Calculation	
Terminal Value Calculation	
Terminal value growth rate	**0.60%**
Projected FCF	$29
Discount Rate (WACC)	**8.00%**
Terminal enterprise value	$397
Implied Term. Value FCF multiple	13.6x

Cost of Capital Assumptions	
Beta	2.00x
Market Return	5.00%
Risk Free Rate (5 yr Treas.)	0.8%
Tax Rate	0.0%
Cost of Debt	0.00%
Cost of Equity	8.00%
% of Debt	**0.00%**
% of Equity	**100.00%**
WACC	**8.00%**

Discounted Cash Flow at WACC		CY13E	CY14E	CY15E	CY16E	CY17E
Unlevered free cash flow		($17)	($16)	($6)	$5	$20
Terminal value						$270
Total Discounted Cash Flows	**$257**	($17)	($16)	($6)	$5	$290

Summary Valuation	
DCF Enterprise Value	$257
Less: Net Debt *(FY14 est.)*	($36)
Equity Value	$293
Diluted shares (FY14 est., incl. est. share offering in 1HCY14)	45
DCF value per diluted share	$6.50
Estimated DCF Value of MOSY	**$6.50**
Current share price	$4.31
Variance from Feltl and Company PT	51%

DCF Value Per Share			
Terminal		WACC	
Growth	7.00%	8.00%	9.00%
0.70%	$7.90	$6.60	$5.60
0.60%	$7.80	**$6.50**	$5.50
0.50%	$7.60	$6.40	$5.50

Source: Feltl and Company estimates

Feltl and Company Research Department MoSys, Inc. (MOSY) Page 4

TABLE 1

Selection criteria used in arriving at 120 DCF-based analyst reports taken from Investext (5 analyst reports per month, all dated Jan. 2012 – Dec. 2013), and the frequency of the general types of DCF models created and used by analysts in the sampled reports.

Panel A: Investext search criteria

Keyword(s):	DCF or ("discounted cash flow*") in **Table of Contents**
Report type:	**Company**
Geography:	**United States**
Contributor:	**Non-broker research excluded**

Panel B: Sample refinement criteria. Where an analyst report was excluded for one of the reasons below, another analyst report adhering to the Investext search criteria in panel A was selected at random from the same month as the excluded report.

Base sample:	139 analyst reports	
Excluded:	No FCF shown in DCF model	7
	DCF covers only part of company	5
	Firm is non-U.S. company	3
	Firm is a financial company	2
	DCF is acquisition-oriented	1
	Other	1
Final sample:	120 analyst reports (5 per month)	

Panel C: Frequency of the general types of DCF models used by analysts in sample reports

DCF to all investors		# reports
1.1	NOPLAT + depn. +/- ΔWCap - CAPEX	60
1.2	Adj. EBITDA - cash taxes +/- ΔWCap - CAPEX	18
1.3	CFOPS + (1 - tax rate)(int exp) - CAPEX	7
1.4	NI +/- adjustments - CAPEX	13
1.5	Unlevered FCFs given, but no derivation	11
DCF to equity		
2.1	Levered FCFs	2
Dividend discount model		
3.1	Dividends to equity	1
Insufficient or no information		
4.1	Usually no FCFs provided at all	8
		120

TABLE 2

Descriptive statistics on the brokers, analysts and firms in the 120 DCF-based analyst reports sampled from Investext; see Table 1 for sample selection criteria.

Panel A: Number of sampled analyst reports by authoring broker

Total = 120 analyst reports from 37 different U.S. brokers that contribute to Investext					
Morgan Stanley	17	Maxim Group	3	Feltl & Company	1
JP Morgan	11	Oppenheimer	3	HSBC Global Research	1
Deutsche Bank	9	Piper Jaffray	3	Indaba Global Research	1
Jefferies	7	Pivotal Research Group	3	Leerink Swann	1
Cowen	7	Susquehanna	3	Miller Tabak	1
Credit Suisse	6	Brean Capital	2	Morgan Keegan	1
BMO Capital Markets	5	Caris	2	National Alliance Securities	1
Barclays	3	Indigo Equity Research	2	Norne Securities	1
Canaccord Genuity	3	KLR Group	2	Sephirin Group	1
Cantor Fitzgerald	3	Ladenburg Thalmann	2	Wedbush	1
Craig Hallum	3	Stonegate Securities	2	Wunderlich Securities	1
Evercore Partners	3	Buckingham Research	1	Zephirin Group	1
Macquarie	3				

Panel B: Number of reports analyst is author on, analyst professional qualifications, and number of analysts on the analyst team

Analyst is author on:	
One report	120
Two reports	34
Three reports	22
Four reports	2
Five reports	1
Six reports	1
# different analysts	180
# analyst-reports	273

Professional qualification	#
CFA	60
CPA	1
MD	3
PhD	8
# analyst-reports	72

# analysts on team	
Min.	1
Mean	2.2
Max.	5
% of reports with ≥ 1 CFA on analyst team	42%

Type of report	#
Update / revision	108
Initiation	12

# pages in analyst report	
Min.	5
Mean	14.5
Max.	40

Panel C: Industry, market cap and publicly traded age of firms covered in analyst reports

Industry	#
Business services	25
Pharmaceuticals	16
Communications	7
Avg. per other (23)	3.1

Market cap ($ mil)	
Min.	$ 5
Median	$ 5,648
Mean	$ 19,129
Max.	$ 237,851

# years firm listed	
Min.	0
Median	14
Mean	19
Max.	88

TABLE 3

Descriptive statistics on key valuation components disclosed in the DCF models in 120 analyst reports sampled from Investext, Jan. 2012 – Dec. 2013. In the panels, NOBS is the number of analyst reports for which there is valid data; T is the terminal year in the analyst's DCF model; and g the analyst's stated post-terminal year perpetuity growth rate.

Panel A: Analysts' reported target prices, target price horizons, and the annualized expected stock returns embedded in analysts' reported target prices

	NOBS	Min.	10th pctile	50th pctile	Mean	90th pctile	Max.
Current stock price	120	$ 0.26	$ 8.87	$ 33.71	$ 61.10	$ 85.07	$ 726.71
Target stock price	120	$ 2.00	$ 10.00	$ 34.20	$ 70.23	$ 95.00	$ 850.00
Horizon (months)	111	3.5	10	12	12	12	15
Annualized expected return embedded in target stock price	111	-51%	-12%	13%	18%	36%	411%

Panel B: When the terminal year occurs (T), and the annual growth rate in free cash flows assumed by the analyst to occur in perpetuity after the terminal year (g)

TV element	NOBS	Min.	10th pctile	50th pctile	Mean	90th pctile	Max.
T	111	1	4	8	8	11	16
g	109	-100%	0%	3.0%	1.7%	5.0%	15%

Panel C: Analysts' assumed WACC and components of WACC

WACC component	NOBS	Min.	10th pctile	50th pctile	Mean	90th pctile	Max.
RF horizon (yrs)	15	5	10	10	11	10	30
RF	58	0.2%	1.8%	3.3%	3.1%	4.0%	5.0%
BETA	56	0.55	0.72	1.20	1.18	1.50	2.50
MKTPREM	55	4%	4.5%	6.5%	6.8%	10%	11%
RE	57	7.8%	8.4%	11%	11%	14%	23%
EQWEIGHT	58	14%	60%	83%	82%	100%	100%
RD (before-tax)	42	0%	0%	5.0%	5.1%	8.0%	11.2%
Tax rate on RD	44	0%	15%	35%	31%	40%	40%
RD (after-tax)	42	0%	0%	3.5%	3.7%	6.3%	8.3%
DEBTWEIGHT	55	0%	0%	18%	19%	40%	86%
WACC	120	4.5%	7.5%	10%	10%	13%	21%

TABLE 4

Types and frequency of errors made in the DCF models of 120 analyst reports sampled from Investext, Jan. 2012 – Dec. 2013

Panel A: Errors having to do with the numerator-oriented level, growth and timing of free cash flows in analysts' DCF models

#	Error code	Error category	Description of error having to do with level, growth and timing of free cash flows in analyst's DCF model.	NOBS	Error rate
1.	1.1	FCF derivation	Analyst's derivation of FCF from their underlying financial statement forecasts has ≥ 1 error. For example, analyst's DCF always shows ΔWCAP = zero or no ΔWCAP each year 1-T when adjusting NOPLAT to derive FCF[1-T].	98	15%
2.	1.2	FCF[1-T]	Analyst includes FCF[0] in the calculation of EQVAL at t_0	110	16%
3.	1.3	TV_g	Analyst's assumed post-terminal year T perpetual growth rate in free cash flows g > 5%	109	7%
4.	1.4	TV_$	Analyst's TV is more than +/- 3% away from the TV obtained by correctly using the FCF[T], WACC and g information provided by the analyst.	73	25%
5.	1.5	ENTVAL	Analyst's ENTVAL is more than +/- 3% away from the ENTVAL obtained by correctly using the FCF[1-T], TV, WACC and g provided by the analyst.	61	26%
6.	1.6.1	EQVAL	Analyst's EQVAL is more than +/- 3% away from the EQVAL obtained by correctly using the ENTVAL and ADJ to ENTVAL provided by the analyst.	62	31%
7.	1.6.2	EQVALPS	Analyst's EQVALPS is more than +/- 3% away from the EQVALPS obtained by correctly using the EQVAL and SHS provided by the analyst.	113	4%
8.	1.7.1	SHS	Analyst's SHS is more than +/- 3% away from outstanding [fully diluted] common shares per Compustat at end of fiscal period prior to date of analyst's report when analyst's DCF they are using outstanding [fully diluted] common shares.	93	15%
9.	1.7.2	DILUTION	Analyst's SHS in DCF model is not fully diluted, and is more than +/- 3% away from the fully diluted SHS per firm's most recent financial statements as of the analyst's report date.	113	6%
10.	1.8.1	At T	Analyst's % revenue growth in year T > min(2g, 6%)	76	50%
11.	1.8.2	At T	Analyst's % growth in CAPEX in year T > min(2g, 6%)	87	39%
12.	1.8.3	At T	Analyst's % revenue growth in year T > (analyst's % growth in CAPEX in year T + 3%)	67	33%
13.	1.8.4	At T	CAPEX[T] > (1.5 x D&A[T]) or < (0.5 x D&A[T])	66	32%
14.	1.8.5	At T	Analyst's ETR[T] is < 25% or > 40%	71	30%
15.	1.8.6	At T	Analyst's % FCF growth in year T > min(2g, 6%)		

Mean	23%
Median	25%

Notes: i. FCF = unlevered free cash flow; FCF[1-T] = FCF for years 1 - terminal year T out from the valuation date; ΔWCAP = annual change in non-cash working capital.
ii. TV = analyst's terminal value; ENTVAL = analyst's enterprise value; EQVAL = analyst's equity value; EQVALPS = EQVAL per common share.
iii. SHS = shares used by analyst in deflating EQVAL to arrive at EQVALPS; CAPEX = annual capital expenditures forecasted by analyst.
iv. D&A = annual depreciation + amortization forecasted by analyst; ETR = firm's effective tax rate implicit in analyst's financial statement or DCF forecasts.

TABLE 4 (continued)

Panel B: Errors having to do with the denominator-related discount rate aspects of analysts' DCF models

#	Error code	Error category	Description of error having to do with the discount rates and discounting methods in analyst's DCF model.	NOBS	Error rate
1.	2.1	RF	Analyst's RF is more than +/- 30 bps away from the 10-year Treasury yield on the date of the analyst's report.	58	84%
2.	2.2	RE	Analyst's RE is more than +/- 30 bps from the RE obtained by correctly using CAPM components provided by analyst.	48	13%
3.	2.3.1	RD	Analyst's before-tax RD is zero.	42	14%
4.	2.3.2	RD	Analyst's tax rate applied to before-tax RD < 25% or > 40%	44	20%
5.	2.3.3	RD	Analyst's after-tax RD is zero.	42	17%
6.	2.3.4	RD	Analyst's RD is more than +/- 20 bps from the RD obtained by correctly using the components provided by the analyst.	34	3%
7.	2.4.1	WACC	Analyst's EQWEIGHT is more than +/- 10% away from the EQWEIGHT implied by the ratio of the analyst's EQVAL to the analyst's [ENTVAL - EQVAL].	56	30%
8.	2.4.2	WACC	Analyst assigns no weight to preferred stock in calculating WACC, even though the firm's financial statements show that the firm has preferred stock.	62	3%
9.	2.4.3	WACC	Analyst's WACC is more than +/- 30 bps away from the WACC obtained by correctly using the RE, RD, EQWEIGHT and DEBTWEIGHT information provided by the analyst.	37	22%
10.	2.5	PV(FCF[1-T])	Analyst's PV(FCF[1-T]) is more than +/- 3% away from the PV(FCF[1-T]) obtained by correctly using the analyst's FCF[1-T] and WACC.	75	13%
11.	2.6	PV(TV)	Analyst's PV(TV) is more than +/- 3% away from the PV(TV) obtained by correctly using the analyst's TV and WACC, and the T stated by the analyst or inferred from the analyst's FCF[1-T] and stated PV(FCF[1-T]).	76	24%
12.	2.7	MID_YEAR	Analyst's FCF are discounted explicitly at the end of the year or as if the FCF occur at the end of the year, not evenly over the year.	111	83%
13.	2.8	SCALE_UP	Analyst does not grow EQVALPS from the valuation date to the target date using RE.	103	93%
				Mean	32%
				Median	20%

Notes: v. RF = risk-free rate; RE = cost of equity; RD = cost of debt; WACC = after-tax weighted average cost of capital.
vi. EQWEIGHT = weight applied to RE in calculating WACC; DEBTWEIGHT = weight applied to after-tax RD in calculating WACC.
vii. PV(z) = present value of z, using WACC.

TABLE 5

Types and frequency of the dubious judgments made in the DCF models of 120 analyst reports from Investext, Jan. 2012 – Dec. 2013

#	Dubious judgments: Code	Label	Description of dubious judgment having to do analyst's DCF model.	NOBS	Dubious judgment rate
1.	3.1	BETA	Analyst's beta > 2.0	56	4%
2.	3.2	MKTPREM	Analyst's market risk premium > 9%	55	18%
3.	3.3	RE	Analyst's cost of equity < 8%	57	5%
4.	3.4	EQWEIGHT	Analyst's weight applied to RE in calculating WACC < 50%	58	5%
5.	3.5.1	WACC	Analyst's WACC < 7%	120	6%
6.	3.5.2	WACC	Analyst's WACC is constant over time when analyst's EQWEIGHT is more than +/- 20% away from the EQWEIGHT implied by the ratio of the analyst's EQVAL to the analyst's [ENTVAL - EQVAL].	56	14%
7.	3.6	TV_T	Analyst's terminal year is 4 years or less from valuation date t_0	111	14%
8.	3.7	LRROE	ROE[T] implicit in analyst's forecasted financial statements or DCF model < 5% or > 25%	19	26%
9.	3.8	TVFRAC	Analyst's TV accounts for > 85% of ENTVAL.	106	22%
10.	3.9	SENSITIVITY	Analyst provides no sensitivity analysis of effects of WACC, g or future FCF on EQVALPS.	120	48%
11.	3.10.1	CASH	Analyst adds total cash, not the operating component of total cash, to ENTVAL.	109	95%
12.	3.10.2	NET_FA	Analyst's adjustments to ENTVAL for net financial assets, contingent equity claims, minority interest and preferred stock in arriving at EQVAL are dubious (e.g., not subtracting minority interest, or adding rather than subtracting debt).	112	54%
13.	3.11.1	TIMING	$t_0 > t_{report}$	111	42%
14.	3.11.2	TIMING	$t_{report} > t_0$ + 400 calendar days.	111	3%
15.	3.11.3	TIMING	$t_0 > t_{tpx}$	103	2%
16.	3.11.4	TIMING	No t_{tpx} date provided by analyst in DCF or broker in disclosure section of analyst's report.	120	8%
17.	3.12.1	DISCLOSURE	Analyst's disclosure score regarding forecasted financial statements < 20%	111	27%
18.	3.12.2	DISCLOSURE	Analyst's disclosure score regarding derivation of FCF < 20%	120	19%
19.	3.12.3	DISCLOSURE	Analyst's disclosure score regarding WACC < 20%	120	48%
20.	3.12.4	DISCLOSURE	Analyst's disclosure score regarding converting FCF to EQVALPS < 20%	120	4%
				Mean	23%
				Median	16%

Notes: i. Valuation date t_0 is the date that best reconciles the analyst's forecasted FCF and TV with their present values and the analyst's ENTVAL.
ii. ROE[T] = implicit ROE in terminal year T, defined as net income in year T ÷ shareholder equity at end of year T.
iii. ENTVAL = analyst's enterprise value; EQVAL = analyst's equity value.
iv. t_0 = Effective date on which analyst's valuation is centered (viz., beginnning of Year 0 in Figure 2 = 12/31/11).
v. t_{report} = Date of analyst's report (viz., 9/24/12 in Figure 2).
vi. t_{tpx} = Date to which analyst's price target applies (viz., 6/30/13 in Figure 2).
v. Disclosure scores are defined and tabulated in Table 9.

TABLE 6

Numbers and rates of errors and dubious judgments made in the DCF models of 120 analyst reports sampled from Investext, Jan. 2012 – Dec. 2013. Rates are calculated per analyst report based on the numbers of error or judgment categories (see Tables 4 and 5) for which determining whether an error or dubious judgment has been made is possible.

Panel A: Errors and dubious judgments across all 120 observations

	NOBS	Min.	10th pctile	50th pctile	Mean	90th pctile	Max.
Number of errors per analyst	120	0	2	5	5.4	8	14
Number of gradeable errors per analyst	120	1	10	17	17.5	26	28
Error rate	120	0%	15%	32%	32%	47%	100%
Number of dubious judgments per analyst	120	1	2	5	4.5	6	8
Number of gradeable dubious judgments per analyst	120	7	13	15	15.8	19	20
Dubious judgment rate	120	5%	15%	29%	29%	43%	62%

Panel B: Errors and dubious judgments averaged by broker

Broker	Number of reports in sample	Mean number of errors	Mean number of dubious judgments	Mean error rate	Mean dubious judgment rate
Morgan Stanley	17	4.4	3.7	27%	25%
JP Morgan	11	5.4	3.7	38%	24%
Deutsche Bank	9	7.0	4.9	33%	30%
Jefferies	7	5.3	4.1	42%	30%
Cowen	7	5.9	5.1	32%	33%
Credit Suisse	6	5.3	5.2	30%	31%
BMO Capital Markets	5	4.4	4.4	30%	34%
Barclays	3	6.3	5.3	29%	32%
Canaccord Genuity	3	4.3	5.7	30%	38%
Cantor Fitzgerald	3	5.3	6.0	35%	40%
Craig Hallum	3	4.3	5.0	23%	36%
Evercore Partners	3	6.7	2.3	24%	12%
Macquarie	3	6.0	7.0	34%	42%
Maxim Group	3	5.0	4.0	34%	31%
Oppenheimer	3	5.3	2.3	25%	12%
Piper Jaffray	3	8.7	4.3	43%	25%
Pivotal Research Gp	3	7.3	6.7	39%	48%
Susquehanna	3	5.0	5.3	40%	38%
Brean Capital	2	5.5	7.0	29%	37%

Broker	Number of reports in sample	Mean number of errors	Mean number of dubious judgments	Mean error rate	Mean dubious judgment rate
Caris	2	4.5	5.5	25%	39%
Indigo Equity Research	2	2.5	3.0	31%	30%
KLR Group	2	3.0	2.0	20%	13%
Ladenburg Thalmann	2	7.0	3.5	45%	27%
Stonegate Securities	2	5.0	4.5	20%	29%
Buckingham Research	1	4.0	7.0	50%	50%
Feltl & Company	1	14.0	5.0	54%	26%
HSBC Global Research	1	1.0	5.0	11%	38%
Indaba Global Research	1	5.0	5.0	21%	26%
Leerink Swann	1	5.0	6.0	42%	43%
Miller Tabak	1	6.0	4.0	33%	29%
Morgan Keegan	1	4.0	5.0	15%	26%
National Alliance Sec.	1	6.0	3.0	35%	20%
Norne Securities	1	6.0	4.0	25%	21%
Sephirin Group	1	4.0	3.0	33%	21%
Wedbush	1	4.0	2.0	20%	13%
Wunderlich Securities	1	7.0	4.0	28%	21%
Zephirin Group	1	3.0	2.0	20%	14%

TABLE 7

Estimated impacts on the annualized expected return implied by the target prices in 120 analyst reports sampled from Investext, Jan. 2012 – Dec. 2013, before versus after major errors in analysts' DCF models are corrected.

Annualized expected return (AER):	NOBS	Median	Mean	Std.dev.
AER embedded in uncorrected target price	111	13%	18%	48%
Δ AER from correcting target price for these errors:				
i. Analyst's post-terminal year growth rate g > 5%	57	0%	-2%	20%
ii. Analyst incorrectly includes FCF prior to valuation date, or makes incorrect adjustments to ENTVAL in arriving at EQVAL.	120	0%	0%	23%
iii. Analyst's RF is more than +/- 30 bps away from the 10-year Treasury Bill yield on analyst's report date.	18	21%	14%	29%
iv. Analyst's FCF are discounted end-of-year, not mid-year.	111	5%	5%	3%
v. Analyst does not scale up EQVALPS from the valuation date to the target date.	103	11%	12%	8%
All errors i. - v. combined by summing the median and mean percentages columns.		37%	29%	

TABLE 8

Distribution of the type and number of forecasted annual financial statements in 120 analyst reports containing DCF models sampled from Investext, Jan. 2012 – Dec. 2013.

			Number of years forecasted					
#	Type of forecasted annual financial statement	NOBS	Min.	10^{th} pctile	50^{th} pctile	Mean	90^{th} pctile	Max.
1a.	Full I/S	120	0	2	3	3.7	8	11
1b.	Mini or partial I/S (when no full I/S provided)	10	0	0	3	2.1	3	3
2a.	Full B/S	120	0	0	2	2.3	6	11
2b.	Mini or partial B/S (when no full B/S provided)	54	0	0	0	0.7	3	3
3a.	Full SCF	120	0	0	2	2.2	6	11
3b.	Mini or partial SCF (when no full SCF provided)	52	0	0	0	1.0	3	6
4.	≥ 1 full set of {B/S, I/S, SCF}	120	49% of firms have ≥ 1 full set of {B/S, I/S, SCF}					

Note: We define a mini financial statement as one that contains only a few of the lines that would typically be present in a full financial statement. One example of a mini SCF would be an SCF that presents only net income, cash from operations, cash from investing, and cash from financing lines.

TABLE 9

Distribution of disclosure quality scores of the inputs to, and the contents of, DCF equity valuation models in 120 analyst reports sampled from Investext, Jan. 2012 – Dec. 2013, and the correlations between the scores.

Panel A: Descriptive statistics on disclosure quality scores

#	Disclosure quality score for:	NOBS	Min.	10th pctile	50th pctile	90th pctile	Max.
A.	Forecasted financial statements	111	4%	9%	33%	100%	233%
B.	Deriving FCF	120	0%	10%	85%	100%	100%
C.	WACC	120	9%	9%	36%	91%	100%
D.	Converting FCF to EQVALPS	120	0%	66%	81%	92%	92%
	Total disclosure quality score (equally-weighted avg. of A-D)	120	9%	34%	57%	78%	110%

Panel B: Pearson correlations between the scores

	Pearson correlations	B.	C.	D.
A.	Forecasted financial statements	-0.01	0.04	-0.21
B.	Deriving FCF		0.13	0.31
C.	WACC			-0.03
D.	Converting FCF to EQVALPS			

Notes: Disclosure quality scores are computed as follows:

A. Forecasted financial statements: 3 (1) points are scored for each annual full (mini) B/S, I/S and SCF forecasted by the analyst. The sum is then divided by 3 x 3 x T. Since T sometimes exceeds the number of years the analyst forecasts future financial statements for, the disclosure quality score for forecasted financial statements can exceed 100%. Also, because T may not be shown in the analyst's DCF model (e.g., the analyst simply states what WACC is and what their estimated equity value per share is), there are some reports for which the score cannot be calculated.

B. Deriving FCF: 1 point is scored for each of the following 10 lines that are explicitly or implicitly forecasted by the analyst in their DCF-to-all-investors model: EBITDA, depreciation & amortization, EBIT, taxes on EBIT, NOPAT, depreciation & amortization (again), Δ working capital, after tax operating cash flows, CAPEX, and free cash flows. The sum is then divided by 10. An explicit forecast occurs when the analyst writes a number down for a given line. An implicit forecast occurs when the analyst does not write a number down for a given line, but the number for the given line can be deduced from other lines the analyst has explicitly forecasted.

C. WACC: 1 point is scored for each of the 11 components used in calculating WACC per panel C of Table 3. The sum is then divided by 11.

D. Converting FCF to EQVALPS. 1 point is scored for each of the following 12 items when explicitly shown on the analyst's DCF: Horizon year (max of 1 pt), PV of FCF in each individual year in forecast horizon (max of 1 pt), total PV of all forecasted FCFs, terminal value, PV of terminal value, enterprise value, cash, debt, equity value, shares used to deflate equity value, equity value per share, and date that the forecasted equity value per share applies to. The sum is then divided by 12.

TABLE 10

Regressions of the error rates and dubious judgment rates made by analysts in their DCF models in 120 analyst reports sampled from Investext, Jan. 2012 – Dec. 2013, on hypothesized explanatory variables.

		Dependent variable			
	Pred. coef	DCF model error rate		DCF model dubious judment rate	
Independent variables	sign	Coef.	t-stat.	Coef.	t-stat.
Forecasted financial statements disclosure score	-	0.00	0.02	-0.05	-1.85
Deriving FCF disclosure score	-	0.06	1.54	-0.05	-1.85
WACC disclosure score	-	-0.11	-3.04	-0.15	-6.09
Converting FCF to EQVALPS disclosure score	-	-0.08	-1.12	-0.02	-0.35
CFA on analyst team? (y=1, n=0)	-	-0.01	-0.50	0.01	0.76
# pages in analyst report	-	0.00	-0.15	0.00	-1.13
# analysts on analyst team	-	0.02	0.99	0.00	0.09
ln(1 + # years firm has been publicly listed)	-	-0.02	-1.49	0.01	1.10
Prominence of brokerage firm	-	-0.01	-0.56	-0.02	-1.10
Adjusted R-squared		5%		30%	
F-stat (significance)		1.7 (0.10)		6.6 (< 0.001)	
# obs.		120		120	

FIGURE 1

Prototypical timeline in DCF valuation model in a sell-side equity analyst company report. Dates are illustrative only, and assume a 12-month ahead target price horizon.

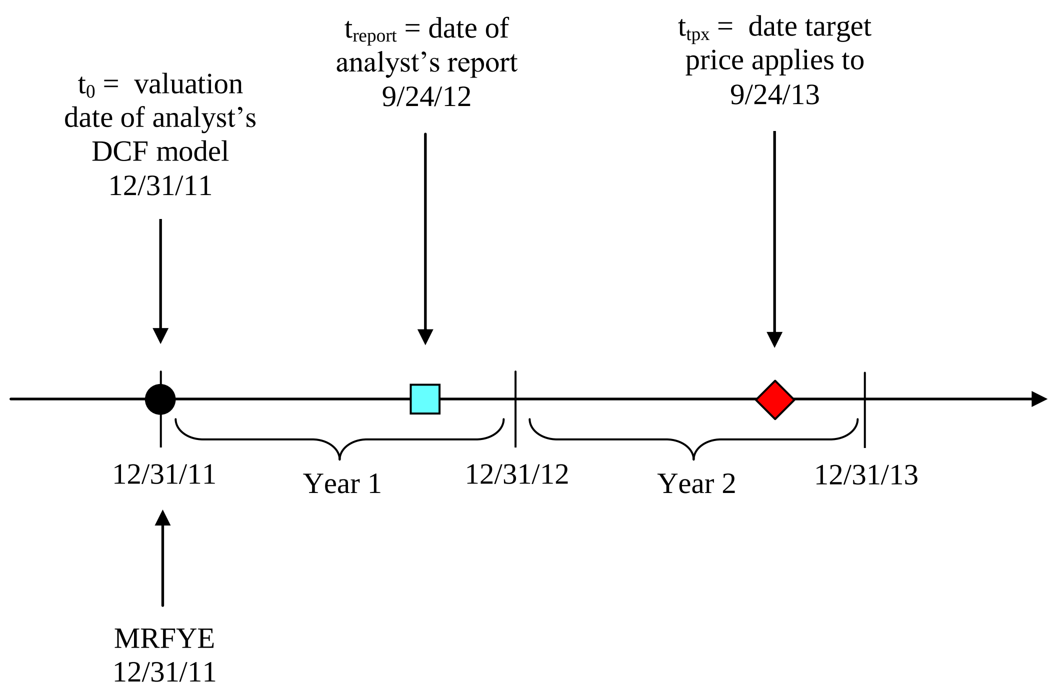


FIGURE 2

Illustration of our definition of a correctly structured and executed condensed DCF-to-all-investors equity valuation model

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10 = T
Fiscal year of forecast (FYE = 12/31)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Revenues	$ 11,000	$ 11,990	$ 12,949	$ 13,856	$ 14,687	$ 15,421	$ 16,038	$ 16,519	$ 16,850	$ 17,018
Earnings before interest, taxes, and depn, depln & amortzn (EBITDA)	$ 2,200	$ 2,398	$ 2,590	$ 2,771	$ 2,937	$ 3,084	$ 3,208	$ 3,304	$ 3,370	$ 3,404
- Depn, depln & amortzn	$ (220)	$ (240)	$ (259)	$ (277)	$ (294)	$ (308)	$ (321)	$ (330)	$ (337)	$ (340)
= Operating income (EBIT)	$ 1,980	$ 2,158	$ 2,331	$ 2,494	$ 2,644	$ 2,776	$ 2,887	$ 2,973	$ 3,033	$ 3,063
- Taxes on EBIT	$ (436)	$ (518)	$ (606)	$ (698)	$ (793)	$ (888)	$ (982)	$ (1,070)	$ (1,153)	$ (1,225)
= Unlevered net income (NOPAT)	$ 1,544	$ 1,640	$ 1,725	$ 1,796	$ 1,851	$ 1,888	$ 1,905	$ 1,903	$ 1,880	$ 1,838
+ Depn, depln & amortzn	$ 220	$ 240	$ 259	$ 277	$ 294	$ 308	$ 321	$ 330	$ 337	$ 340
- Δ Working capital	$ (50)	$ (50)	$ (48)	$ (45)	$ (42)	$ (37)	$ (31)	$ (24)	$ (17)	$ (8)
= After-tax operating cash flow	$ 1,714	$ 1,831	$ 1,936	$ 2,027	$ 2,103	$ 2,159	$ 2,195	$ 2,209	$ 2,201	$ 2,170
- CAPEX	$ (313)	$ (328)	$ (341)	$ (352)	$ (359)	$ (362)	$ (362)	$ (359)	$ (352)	$ (341)
= Free cash flow (FCF) to all investors	$ 1,402	$ 1,502	$ 1,594	$ 1,676	$ 1,744	$ 1,797	$ 1,833	$ 1,851	$ 1,849	$ 1,829
Terminal value of FCF beyond T										$ 20,493
PV of yearly FCFs years 1-T	$ 1,274	$ 1,241	$ 1,197	$ 1,144	$ 1,082	$ 1,014	$ 940	$ 862	$ 783	$ 704

PV of total FCFs years 1-T	$ 10,242
+ PV of terminal value	$ 7,891
= Enterprise value	$ 18,133
- Interest bearing debt & financial liabilities	$ (2,370)
+ Non-operating ("excess") cash & other financial assets	$ 130
- Contingent equity claims	$ (160)
- Minority interest	$ (20)
- Preferred stock	$ (100)
= Equity value at analyst valuation date before time adjustments	$ 15,613
x Adjustment factor to recognize that cash flows are mid-year	5.4%
x Adjustment to scale up equity value from valuation date to report date	7.9%
= Equity value at analyst valuation date	$ 17,749
Common shs outstanding at analyst report date	1,000
= Equity value per share at analyst report date	$ 17.75
x Adjustment to scale up equity value from report date to target price date	8.2%
= Forecasted equity value per share at analyst target price date	$ 19.21

RF Horizon (years):	10
RF:	1.7%
Beta:	1.50
Market risk premium:	6.0%
RE:	10.7%
Equity weight:	90.0%
RD (before tax):	5.8%
Tax rate:	40%
RD (after tax):	3.5%
Debt weight:	10.0%
WACC:	10.0%

Valuation date:	12/31/2011
Analyst report date:	9/24/2012
Target price date:	6/30/2013
Perpetuity growth rate in annual FCF after terminal year:	1.0%
Current stock price:	$ 17.02
Target stock price:	$ 19.21
Annualized expected return in target price:	17.1%

Note: Some numbers reflect the effects of rounding.

FIGURE 2 (continued)

Notes:

i. The DCF-to-all-investors equity valuation model in Figure 2 is stylized in that it is a deliberately condensed version of what we assume to be 100% correct, namely the DCF-to-all-investors valuation model detailed by Lundholm and Sloan in their book *Equity Valuation and Analysis with eVal* (3rd edition, 2013, especially p.154-155; p.225; pp.239-243). We adopt a less than fully correct DCF valuation model against which to grade analysts for two main reasons. First, most of the differences detailed in the Notes to Figure 2 are in expectation likely to occur infrequently and be economically small. Second, it is rare for analysts to include the items represented by these differences in their models, and we wish to avoid biasing our study in favor of concluding that analysts construct and execute DCF valuation models in an unsophisticated manner. Thus, if analysts are aware of the differences but rationally choose to exclude them because they are infrequent and immaterial, then we risk downwardly bias our assessment of analyst sophistication if we include the differences in our grading template. Conversely, if analysts are not aware that the differences exist but we grade analysts under the presumption that they should be aware, then we risk concluding that analysts are unsophisticated based on a large number of economically small aspects of DCF modeling and execution, rather than on economically or theoretically important errors.

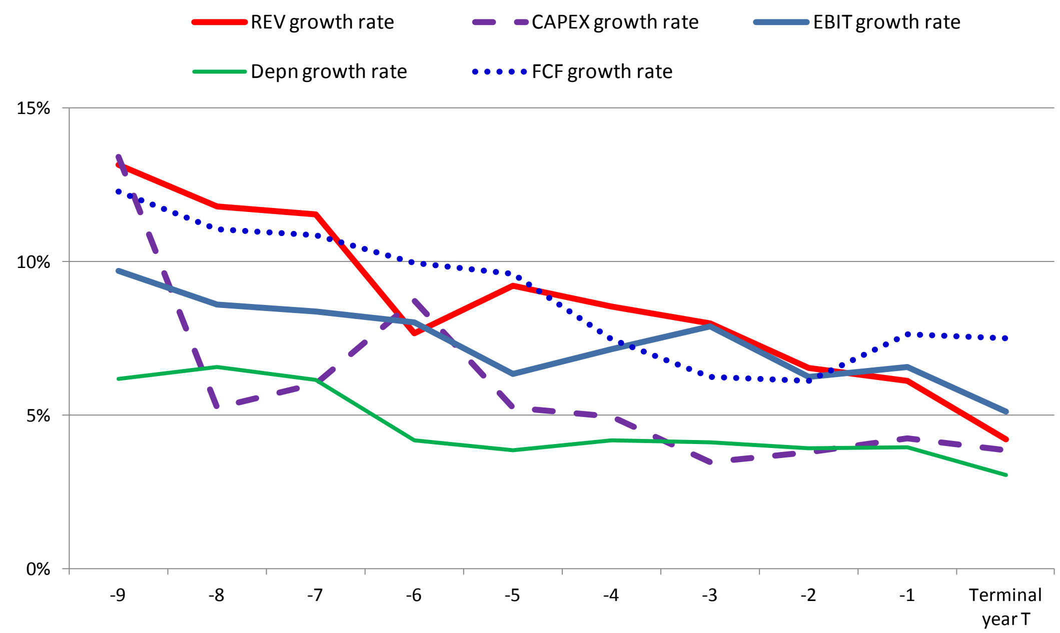
ii. The differences that we itemize between our stylized model and that of Lundholm and Sloan are as follows. We explicate the differences because if an analyst's DCF model does not conform to Lundholm and Sloan's assumed 100% correct model, but does conform to our reduced model, we do <u>not</u> grade the analyst as having made an error or dubious judgment.

- We do not include a line for the Change in Deferred Taxes after Taxes on EBIT. Some analysts address the deferred tax effect of the line Taxes on EBIT by forecasting Cash Taxes on EBIT instead of (book) Taxes on EBIT.
- We do not include lines for Non-Operating Income (Loss) or Extraordinary Items & Discontinued Operations after the Depreciation & Amortization add-back line after NOPAT.
- We do not include lines for Increase in Investments, Purchase of Intangibles, Increase in Other Assets, Increase in Other Liabilities, or Clean Surplus Plug after the CAPEX line.
- We do not include the cost of preferred stock or the cost of minority interest in calculating WACC.
- We do not mark the firm's financial assets and liabilities to their market values.
- We ignore company warrants, and ascribe no value to the conversion options embedded in convertible bonds.
- We address the contingent equity claim of employee stock options by (leniently) only grading the analyst as having made an error if the analyst arrives at their equity value per share by dividing their dollar equity value of the firm by outstanding common shares, and then only if the difference between basic and fully diluted common shares as of the most recent fiscal period prior to the report date exceeds 5% of common shares outstanding.
- We do not include information about year T+1 in Figure 2, even though a 100% correct DCF model should show year T+1 to prove out to the reader that steady state has been achieved (Levin and Olsson, 2000; Lundholm and Sloan, 2013). We do not grade analysts as having made an error if they do not show year T+1 data, although we do grade them with regard to the economic plausibility of the implied rates of growth in key financial statement variables and ratios in year T.

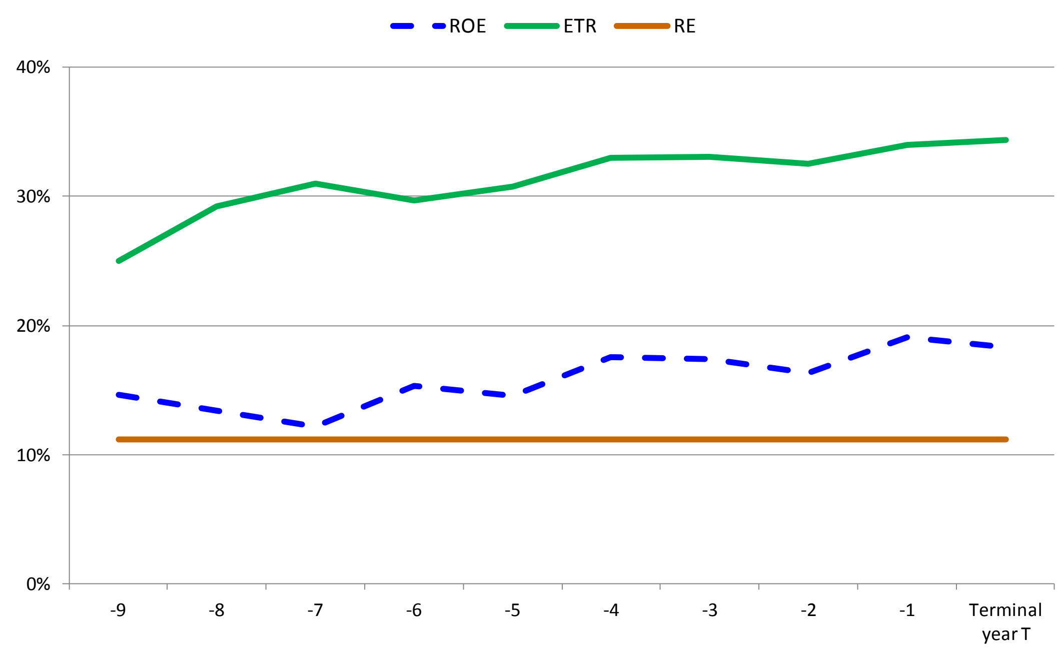
FIGURE 3

Trajectories of key financial statement ratios in event time relative to the DCF terminal year. Ratios are derived from the forecasted financial statements and/or DCF equity valuation models in 120 analyst reports sampled from Investext, Jan. 2012 – Dec. 2013.

Panel A Median rates of growth in financial statement variables



Panel B Median values of firms' ROE, effective tax rate ETR, and cost of equity capital RE



Note: The number of observations from which the median values plotted above are taken range between 12 and 108. The median number of observations in any given event year is 58.