Multiples and Their Valuation Accuracy in European Equity Markets[*]

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Abstract

In spite of their widespread use in practice, accounting-based market multiples are subject of surprisingly few academic studies. As a contribution to close this gap, we examine the accuracy of different types of multiples in European equity markets. We find that multiples generally approximate market values reasonably well. In terms of relative accuracy, our results show: (1) Equity value multiples outperform entity value multiples. (2) Knowledge-related multiples are more accurate than traditional multiples. (3) Forward-looking multiples, in particular the two-year forward-looking price to earnings (P/E) multiple, outperform trailing multiples. These empirical findings are significant in magnitude, robust to the use of different performance measures, and constant over time. In an out-of-sample test using a U.S. dataset, our results for European data are confirmed. This supports the relevance of our findings for practical purposes.

JEL-Classification: G15, G24, M41.

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1 Introduction

Accounting-based market multiples are most commonly applied to corporate valuation. These multiples are ubiquitous in analysts' reports and investment bankers' fairness opinions. They also appear in valuations associated with transactions of corporate control. The Multiples Valuation Method (MVM) is very intuitive. Unlike the Dividend Discount Model (DDM), the Discounted Cash Flow (DCF) approach, or the Residual Income Model (RIM) Model, the MVM does not require detailed multi-year forecasts of dividends, free cash flows or residual incomes. Instead, the firm being valued gets associated with a peer group of firms considered to be comparable. A simple analysis of the stock prices of the firms in the peer group leads to a certain ratio which will then be used as a multiplier of the target firm's value driver. Despite the widespread use of the MVM, only limited theory is available to support the application. Studies on the empirical accuracy are scarce, and with a few exceptions, the literature gives no support on why certain multiples should be chosen in specific contexts.

This paper investigates the empirical accuracy of the MVM using a broad European dataset. We explore the properties of various types of multiples and aim to give recommendations regarding three choices which must be made for the MVM: (1) Should a multiple concentrate on the equity value or on the entity value of the firm? (2) Should a multiple relate on knowledge-related value drivers or on traditional ones? (3) Should forward-looking multiples be preferred to trailing multiples? An innovation in our analysis is the focus on European data. Nevertheless, we also consider U.S. data to validate our results and to make them comparable to existing studies (which are typically based on U.S. data).

2 Literature overview

Multiples are subject of surprisingly few academic studies. Among the first studies, Alford (1992) uses P/E multiples to test the effects of different methods of identifying comparable firms based on industry membership and proxies for growth and risk on the accuracy of valuation estimates: The outcome of the MVM is compared to observed market prices of common stock. He finds that valuation accuracy increases when the fineness of the industry definition used to identify comparable firms is narrowed from

1-digit to 2-digit and 3-digit industry codes, but there are no further improvements when 4-digit industry codes are considered. He also finds that adding controls for earnings growth, leverage, and size does not significantly reduce valuation errors.

Kaplan & Ruback (1995) investigate properties of the DCF model in the context of private equity transactions. While they conclude that DCF valuations approximate transaction values reasonably well, they also find that simple enterprise value to earnings before interest, taxes, depreciation, and amortization (EV/EBITDA) multiples result in similar valuation accuracy. Gilson, Hotchkiss & Ruback (2000) compare the market value of firms that recognize bankruptcy to value estimates from the DCF model and the MVM. As in Kaplan & Ruback (1995), the DCF and the multiples approach have about the same degree of valuation accuracy.

In a more general context, Liu, Nissim & Thomas (2002) investigate the performance of multiples for the U.S. equity market. They find that multiples based on earnings forecasts explain stock prices well for a large fraction of firms. That is, inverse P/E multiples using two-year earnings per share (EPS) forecasts generate valuations within twenty percent of observed prices for almost sixty percent of firm years. The authors also compare their results with the performance of the RIM. Against their intuition, the RIM performs worse than the multiples approach. In a recent study, Liu, Nissim & Thomas (2007) extend their analysis and examine the performance of earnings versus cash flow multiples in a more international setting. Across ten countries, they find that multiples based on earnings measures outperform those based on operating cash flow and dividends. Moving from trailing numbers to forecasts improves the valuation accuracy, with the greater improvement being observed for earnings.

Consistent with the results of Liu, Nissim & Thomas (2002 and 2007), Kim & Ritter (1999) conclude how IPO prices are set using multiples. They show that forward-looking P/E multiples outperform all other multiples in accuracy. In fact, two-year EPS forecasts dominate one-year EPS forecasts, which in turn dominate current EPS. Lie & Lie (2002) examine the accuracy of a conventional list of multiples for the universe of firms within the Compustat North America database. In line with the preceding studies, they also report superior performance of forward-looking P/E multiples compared to all other multiples.

3 Methodology

3.1 Definition and categorization of multiples

Following Penman (2004), we define a (market) multiple as the ratio of a market price variable (such as the stock price, the market capitalization, or the whole enterprise value) to a particular value driver (such as earnings, revenues, or the work force) of a firm. This definition enlightens that the MVM finds prices (in a particular market setting, reflecting the current market sentiment) rather than values (which are defined as prices in a perfect market and therefore estimated on the basis of "long-term data" and "typical conditions").

A multiple is called to be consistent, if there is an accepted economic model which explains (under certain assumptions) a proportional relationship between the value driver and value. For example, Gordon's growth model comes up with the notion that the value of equity $v_{i,t}^{equity}$ of firm i at time t equals the expected next dividend d_{t+1} divided by the difference between the discount rate r and the growth rate g. Thus, value is equal to the product of the expected next dividend (value driver) and the constructed multiple $m = 1/(r-g)$

$$v_{i,t}^{equity} = \frac{E\left[d_{t+1}\right]}{r-g} = m \cdot E\left[d_{t+1}\right] \qquad (1)$$

Here, the multiple depends only on the risk of the firm (which is reflected in the cost of capital) and the growth rate. The underlying belief of the MVM is that multiples are the same within a group of comparable firms and within a certain time window. Thus, the size of the multiple must not be inferred from a model like Gordon's. It can be empirically determined by observing the actual market prices and value drivers for a few firms which are, by a precedent analysis, identified as comparable. The resulting synthetic multiple is then used to estimate the value of the target firm for which only the value driver is known. If the actual price of the target firm can be observed, the difference between the actual price and the value estimated using the MVM serves to assess the accuracy of the method. The accuracy determines the performance of the MVM.

Our analysis attempts to find multiples which are both consistent and accurate (high performance).

The MVM requires four steps. Step 1 is the selection of the kind of value under interest (such as equity or entity) and of the value driver (such as earnings or cash flows). Step 2 identifies the group of comparable firms, the peer group. Together with the market price variables, the value drivers form the basis for the calculation of the corresponding multiples of the comparables. Step 3 aggregates these individual multiples into a single number. This procedure is carried out by estimating synthetic peer group multiples according to a chosen statistical measure of central tendency. Step 4 determines the value estimation for the target firm by taking the product of the synthetic peer group multiple and the value driver of the firm being valued.

The general definition of a multiple allows for a variety of different multiples. In order to analyze specific characteristics of multiples, we use a two dimensional categorization scheme as shown in *Figure 1*. The first dimension refers to the numerator of the ratio and differentiates between equity value and entity value multiples. Equity value multiples are based on the stock price or the market capitalization of a firm, whereas entity value multiples are based on the enterprise value of a firm. Formally, an equity value multiple $\lambda_{i,t}^{equity}$ of firm i at time t is

$$\lambda_{i,t}^{equity} = \frac{p_{i,t}^{equity}}{x_{i,t}} \tag{2}$$

where $p_{i,t}^{equity}$ is the current market value of common equity and $x_{i,t}$ is the underlying value driver of the multiple. Similarly, an entity value multiple $\lambda_{i,t}^{entity}$ of the same firm at time t can be written as

$$\lambda_{i,t}^{entity} = \frac{p_{i,t}^{entity}}{x_{i,t}} = \frac{p_{i,t}^{equity} + \hat{p}_{i,t}^{net\ debt}}{x_{i,t}} \tag{3}$$

where $p_{i,t}^{entity}$ is the current enterprise value which equals the sum of the market value of common equity $p_{i,t}^{equity}$ and an estimator of the market value of net debt $\hat{p}_{i,t}^{net\ debt}$, and $x_{i,t}$ is again the value driver.[1] The origin of the value driver $x_{i,t}$ in the financial statement constitutes the main differentiation criteria for the second dimension of the categorization framework, where we distinguish (1) accrual flow, (2) book value, (3) cash flow, (4) knowledge-related, and (5) forward-looking multiples. The first three types of multiples are referred to as traditional or trailing multiples.

3.2 Hypotheses

Equity value versus entity value multiples

One of the first questions is how the chosen market price variable – market capitalization (equity value) or enterprise value (market capitalization plus book value of net debt) – determines the accuracy of the MVM. When working with entity value multiples, one should preserve consistency by "matching" the economic meaning of the numerator with that of the denominator. Entity value multiples should utilize value drivers in the denominator which are defined on an enterprise level. Equity value multiples should be constructed from value drivers that are defined on an equity holder's level. Otherwise, the multiple may be incomparable with economic reasoning, although it could lead to acceptable results in practice. The principle of consistency is often violated, however. P/SA, P/EBIT(DA), or P/OCF multiples are widely used for equity valuations.[2] The level of debt, or more precisely the capital structure, can create problems that impact the consistency of equity value multiples.

In a Modigliani & Miller (1958) world without taxes, costs of financial distress, and other agency costs, different capital structures across firms affect equity value multiples, if they are not defined on an equity holder's level. In such a world, managers can control specific equity value multiples by swapping debt for equity and thereby varnish the attractiveness of their firm to investors. In a real world setting, taxes, costs of financial distress, and agency costs exist, shaping tradeoffs between debt and equity and making

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[1] Net debt is defined as total debt less cash & equivalents plus preferred stock. Since the market value of net debt $p^{net\ debt}$ is usually not publicly available, we approximate $p^{net\ debt}$ with the book value of net debt $b^{net\ debt}$ and write $\hat{p}^{net\ debt}$ to indicate the approximation.

[2] In our empirical study, we ignore the matching principle for equity value multiples to directly compare the empirical performance of equity value versus entity value multiples.

capital structure value relevant. The tax benefits of higher leverage are opposed by an increasing probability of default and costs of financial distress. As a compensation for the increase in risk and the decrease in flexibility, shareholders demand higher returns and the value decreases (see Myers (1977)). The consideration of agency costs favors the use of debt over equity (see Ross (1977) or Myers (1984)). If capital structure matters, financing decisions influence the value of a firm and thus both equity value and entity value multiples. Entity value multiples are less affected because they are defined on an enterprise level. Consistent entity value multiples are difficult to establish, however. The reason is that we cannot observe the enterprise value of a firm since the true value of debt is not established through market prices. In the MVM the value of net debt is therefore measured by its book value. This approximation can produce uncontrollable uncertainty, especially in a changing interest rate and default risk market environment. Moreover, the composition and calculation of net debt in the balance sheet can vary significantly across firms, producing even more noise. Needless to say that firms belonging to the same peer group can have different kinds of debt and levels of cash & equivalents. There may also be differences in the treatment of pension liabilities, employee stock options, or capitalized leases. Some firms have preferred stock or off-balance sheet items such as operating leases and special purpose entities.

Taken together, when comparing the features of equity value versus entity value multiples, the latter appeal in the view of consistency because they are less affected by capital structure. Equity value multiples can compensate for this theoretical drawback in practice because the market capitalization in the numerator can be directly observed from market prices and therefore does not suffer from uncontrollable uncertainty. The fact that firms from the same industry tend to operate at similar debt levels, gives equity value multiples another advantage. This leads to *Hypothesis 1: Equity value multiples outperform entity value multiples in valuation accuracy.*

Knowledge-related versus traditional multiples

For the proposition of *Hypothesis 2* and *Hypothesis 3*, we shift the attention to the denominator of a multiple as a ratio and specific value drivers in different industries. Throughout the last two decades, the corporate landscape has changed with the achievements and developments in information and internet technology. Nowadays, investing in research and development (R&D) is a major indicator of productivity, particularly for firms in science-based industries. From an accounting perspective, R&D differs from other capital inputs such as physical property, plant and equipment, inventory, or project financing. While most accounting standards mandate the capitalization and periodic depreciation of physical forms of long-term investment, R&D is in most cases immediately expensed in financial statements. This produces earnings figures which underestimate "true" earnings (e.g., Lev & Sougiannis (1996), Aboody & Lev (1998 and 2000), or Eberhart, Maxwell & Siddique (2004)). Consequently, adding back R&D expenditures to EBIT or net income yields earnings figures of "higher quality" in the perspective of corporate valuation.

If accounting standards change and firms capitalize R&D, it would appear as an intangible asset on the balance sheet. Examples of such assets without physical substance are brand names, copyrights, goodwill, leasehold rights, licenses, patents, or software. Some amortization may be appropriate for intangibles. Hitherto, all international accounting standards (but U.S.-GAAP) mandate the amortization of capitalized intangible assets (AIA) over their expected "useful" lives. For many intangible assets, however, law or regulation prescribe the useful amortization time based on conservative accounting. Again, reported amortization expenditures exaggerate the "true" decrease in the value of intangible assets. Both the immediate expense of R&D and the principle of systematic AIA diminish the quality of reported earnings and consequently the quality of multiples based on earnings. To correct these consequences of accounting conservatism and to produce a more reliable picture of a firm's true economic success or value, we suggest adding back R&D expenditures and/or amortization to EBIT and net income in science-based industries (i.e., all industries with a substantial exposure to intangible assets or R&D, or both of them).[3] The "and/or" decision depends on the magnitude and consistency of R&D expenditures and amortization within an industry. That is, if R&D expenditures (amortization costs) are relatively low or come with high volatility, we are better off adding back only amortization (R&D expenditures). On the other hand, if both numbers are of considerable size and stable, we should sum them up into a single number. We define the sum of R&D expenditures and amortization of intangible assets as

[3] Based on the Industry Classification Benchmark (ICB) system, our definition of science-based industries contains Oil & Gas, Basic Materials, Industrials, Health Care, Telecommunications, Utilities, and Technology.

costs for the creation and maintenance of intangible assets or short knowledge costs (KC). According to this, we argue that *knowledge-related multiples outperform traditional multiples in science-based industries (Hypothesis 2).*

Forward-looking versus trailing multiples

In the MVM, the value driver in the denominator of the ratio is often chosen to be one of the latest numbers in the financial statements for the recent fiscal quarter or year. These multiples are called trailing, because the numbers are based on historical data. If the value driver of a multiple refers to a forecast instead of a historical number, it is termed forward-looking. Since the value of a firm equals its discounted stream of expected future payoffs, forward-looking multiples may have an advantage with respect to consistency. Empirical research for the U.S. underpins that forward-looking multiples are more accurate than trailing multiples. In a sample of 142 U.S. IPOs, Kim & Ritter (1999) find that P/E multiples based on earnings forecasts for the subsequent two years outperform those based on historical earnings. As their analysis moves from trailing to one-year and to two-year ahead forward-looking multiples, the percentage of firms valued within 15 percent of their actual stock price increases from 15 percent to 19 percent and then to 36 percent. Liu, Nissim & Thomas (2002) show similar results in their broad investigation of U.S. equity markets. The median valuation error equals 23 percent for inverse P/E multiples based on historical earnings and falls to 18 percent and 16 percent when moving to one-year and two-year forward-looking multiples. The two studies are appealing because earnings forecasts should reflect future profitability and growth better than historical measures. The accuracy increases by lengthening the forecast horizon from one year to two years.

Based on the principles of valuation and on empirical evidence, we recommend forward-looking multiples whenever forecast data for the multiples is available for the entire peer group. Since analysts' practice is to make point in time estimates of earnings measures for only two years ahead, the most promising choice are forward-looking multiples processing two-year ahead forecasts. Forecasts on a broad basis are typically available for EBIT(DA), pre-tax income, and net income. *Hypothesis 3 states that forward-looking multiples outperform trailing multiples.*

3.3 Performance measurement

For the test of our research hypotheses, we follow the four-step MVM and require that the value of common equity $p_{i,t}^{equity}$ of firm i in year t is proportional to a specific value driver $x_{i,t}$ of the firm[4]

$$p_{i,t}^{equity} = \hat{\lambda}_{c,t}^{equity} \cdot x_{i,t} + e_{i,t} \tag{4}$$

$$p_{i,t}^{equity} = \hat{\lambda}_{c,t}^{entity} \cdot x_{i,t} - \hat{p}_{i,t}^{net\ debt} + e_{i,t} \tag{5}$$

where $\hat{\lambda}_{c,t}$ is the synthetic peer group multiple on the value driver, which is estimated on the basis of equivalent multiples observed for the comparable firms c within the peer group, and $e_{i,t}$ is the valuation error. When using entity value multiples, we also consider the value of net debt $p_{i,t}^{net\ debt}$ of firm i and deduct it on the right hand side of equation (5) to get $p_{i,t}^{equity}$. The valuation error in equation (4) and equation (5) is unlikely to be independent of value because firms with higher values are likely to have larger absolute valuation errors. Baker & Ruback (1999) and Beatty, Riffe & Thompson (1999) show that the valuation error is approximately proportional to the value. Therefore, scaling equation (4) and equation (5) by value should improve the estimation of the synthetic peer group multiple

$$\frac{\hat{\lambda}_{c,t}^{equity} \cdot x_{i,t}}{p_{i,t}^{equity}} + \frac{e_{i,t}}{p_{i,t}^{equity}} = 1 \tag{6}$$

$$\frac{\hat{\lambda}_{c,t}^{entity} \cdot x_{i,t} - \hat{p}_{i,t}^{net\ debt}}{p_{i,t}^{equity}} + \frac{e_{i,t}}{p_{i,t}^{equity}} = 1 \tag{7}$$

[4] To measure the performance of multiples, we partly adopt the methodology from Alford (1992), Lie & Lie (2002), and Liu, Nissim & Thomas (2002 and 2007).

For the estimation of the synthetic peer group multiple $\hat{\lambda}_{c,t}$, we impose the restriction that the expected scaled valuation error $E\left[e_{i,t} / p_{i,t}^{equity}\right]$ is zero. By rearranging terms in equation (6) and equation (7), we can then estimate the synthetic peer group multiple using the median as an appropriate measure of central tendency.[5] To obtain a prediction for the value $\hat{p}_{i,t}^{equity}$ of firm i, we multiply the estimator for the synthetic peer group multiple $\hat{\lambda}_{c,t}$ by the equivalent value driver $x_{i,t}$ of the firm being valued

$$\hat{p}_{i,t}^{equity} = \hat{\lambda}_{c,t}^{equity} \cdot x_{i,t} \tag{8}$$

$$\hat{p}_{i,t}^{equity} = \hat{\lambda}_{c,t}^{entity} \cdot x_{i,t} - \hat{p}_{i,t}^{net\ debt} \tag{9}$$

We evaluate the valuation accuracy of the prediction by calculating scaled absolute valuation errors

$$\left|\frac{e_{i,t}}{p_{i,t}^{equity}}\right| = \left|\frac{\hat{p}_{i,t}^{equity} - p_{i,t}^{equity}}{p_{i,t}^{equity}}\right| \tag{10}$$

To compare the performance of different multiples in terms of valuation accuracy, we examine measures of dispersion for the pooled distribution of scaled absolute valuation errors $\left|e_{i,t} / p_{i,t}^{equity}\right|$. The key performance measures are the median absolute valuation error and the fraction of absolute valuation errors below 15 percent of observed market values. By doing so, the results become comparable to related studies which focus on one of these measures to draw conclusions. Furthermore, the results should be less affected by irregularities since they are built on two, instead of one, key performance measures. To ensure reliability, we consider additional performance indicators such as the arithmetic mean, the standard deviation, quartiles ($q_{0.25}$ and $q_{0.75}$), percen-

[5] Other alternatives would be the harmonic mean or a fifty-fifty combination of the median and the harmonic mean. We report numbers using the median because, for the underlying sample, the median delivered superior results compared to the alternatives.

tiles ($q_{0.10}$ and $q_{0.90}$), and the fraction of absolute valuation errors smaller than 25 percent. Characteristics of high accuracy are on one hand small numbers for measures of central tendency (i.e., median, mean, quartiles, and percentiles) and the standard deviation, and on the other hand high numbers for the fractions of absolute valuation errors below 15 percent and 25 percent respectively. Any performance indicator is first calculated for each year. Then, the yearly numbers are aggregated using the average.

4 Data and sample

The indices used in the empirical part of our study are the Dow Jones STOXX 600 and the S&P 500 index. They represent approximately 85 percent of the total market capitalization in Western Europe and 75 percent in the U.S. Hence, they are reliable proxies for the total markets. Our study concentrates mainly on the European dataset. The analysis of the U.S. dataset is used to validate the results of the European data by making an out-of-sample test. The Dow Jones STOXX 600 index contains the 600 largest stocks traded on the major exchanges of 17 Western European countries.[6] To classify firms into different industries and subindustries, we use the ICB system provided by Dow Jones and FTSE. This industry classification system consists of four levels (in increasing fineness): Ten industries, 18 supersectors, 39 sectors, and 104 subsectors, and offers four-digit industry codes for all firms within the dataset.

To construct the sample, we merge data from three sources: (1) Historical accounting numbers from Worldscope, (2) market prices from Datastream, and (3) analyst forecasts from the I/B/E/S. For the ten recent years from 1996 to 2005, we calculate up to fifty different multiples for each firm i in year t using accounting numbers and mean consensus analyst forecasts as of the beginning of January and market prices as of the beginning of April. We measure market prices four months after the fiscal year end to ensure that all year-end information is publicly available by then and is reflected in prices.

[6] The index universe is constructed by aggregating stocks traded on the major exchanges in Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the U.K.

The sample considers data that satisfies four criteria: (1) for individual firms, there are no more than two types of stock (e.g., common stock and preferred stock) traded at the domestic exchange and an unambiguous dataset is available from the aforementioned sources; (2) for individual firm years, the market capitalization is above 200 million U.S. Dollar ($) and the value of net debt is positive; (3) for individual multiples, the underlying value driver in the denominator of a multiple is positive, so that negative or infinite values are impossible; and (4) for the construction of the peer group and eventually for predicting equity values using multiples, we require the availability of at least seven comparables within the same industry definition. By doing so, statistical outliers cannot distort the empirical results. In addition, the analysis is conducted out-of-sample, which means that the target firm is not part of the peer group.

The resulting sample for the Dow Jones STOXX 600, which consists of 592 firms, is used for the descriptive statistics reported in panel B of *Table 1*. The median firm has annual sales of $3.56 billion, annual net income of $206 million, total assets of $5.83 billion, book value of common equity of $1.68 billion, and pays an annual dividend of $85 million. Thus, the median net profit margin and the median return on common equity equal 5.79 percent and 12.28 percent respectively. Firms also operate with considerable leverage at a debt to equity ratio of about two to one. However, note that all of the financial characteristics are heavily skewed to the right, as indicated by the large differences between the medians and the means. For most numbers the mean is even higher than the number for the third quartile.

Table 2 presents summary statistics of the investigated equity value multiples. The median values of common equity value multiples are 16.8 for the P/E multiple, 2.1 for the P/B multiple, and 1.1 for the P/SA multiple. Reflecting analysts' overall expectations of positive future growth, in particular earnings growth, one-year forward-looking multiples are higher than the corresponding trailing multiples but lower than the corresponding two-year forward-looking multiples. Interestingly, the median P/TA multiple is 0.6, whereas the median P/IC multiple is 1.0, which indicates that firms in Europe operate with a considerable high balance of cash & equivalents. This observation is especially evident for the second half of the time horizon of the study. Also, note that the number of observations is smaller for knowledge-related multiples and forward-looking multiples compared to traditional multiples. The former are restricted to science-based industries. Moreover, several national accounting regimes do not require firms to separately disclose their R&D and amortization expenditures in their income statement. The availability of forward-looking multiples is limited because the I/B/E/S database provides analyst forecasts only for the last six years of the study. Again, the distribution of multiples is positively skewed.

5 Results

5.1 Absolute valuation accuracy

Indicators of valuation accuracy for equity value multiples within the European sample are reported in *Table 3*. This table presents the absolute valuation accuracy and underlines, that the MVM can explain equity market values correctly: For 18 out of 27 different equity value multiples, the median absolute valuation error lies below thirty percent (first column). Half of the value predictions deliver results no more than thirty percent above or below the actual market value of common equity. Five multiples yield median absolute errors of less than 25 percent. The median errors range from 21.5 percent to 43.8 percent.

Presented in the second column from the right of *Table 3*, the fraction of absolute valuation errors within 15 percent of observed market values varies from 22.4 percent to 40.0 percent. As a comparison, Lie & Lie (2002) report a variation between 22.5 percent and 35.1 percent using ten different multiples for U.S. equity data. The percentage of errors smaller than 15 percent lies above thirty percent for 19 multiples. That is, thirty percent or more valuations deliver results no more than 15 percent above or below the market capitalization of the target firm.

The accentuated fields in *Table 3* indicate the best performing multiples in each category. Multiples based on value drivers closer to the bottom line of the income statement perform better than multiples based on value drivers further up in the income statement. This observation is not restricted to accrual flow multiples, but also applies to knowledge-related and to forward-looking multiples. The weak performance of the P/E multiple compared to the P/EBT multiple does not surprise because corporate tax rates vary within European countries. Thus, the comparability of net income across firms from different countries is limited. Comparing book values and earnings as the two most popular accounting value drivers, our study finds that multiples based on earnings clearly outperform those based on book values. Throughout the cross-section, book value multiples as well as cash flow multiples disappoint in their ability to explain market values. The poor performance of cash flow multiples contradicts the belief that cash flow measures are better than accrual flow measures in representing future payoffs.

Analyzing the numbers for the additional performance indicators shown in the remaining four columns of *Table 3* corroborates the findings using the key performance measures. All this supports the high accuracy of the MVM.

5.2 Equity value versus entity value multiples

The requirement of consistency favors entity over equity value multiples because they are less affected by different capital structures among comparable firms. In practice the estimation procedure of the market value of net debt involves considerable uncertainty. There is a tradeoff between the desired independence of the capital structure and noise when selecting appropriate multiples. Most prior studies cover only one of the two types of multiples and thus do not assess differences in the quality of value predictions. Studies, which consider both types (i.e., Alford (1992) and Liu, Nissim & Thomas (2002)) find evidence for the superiority of equity value multiples, but are unable to provide any rationale why such results might be observed.

Table 4 presents the results of the evaluation of equity value versus entity value multiples. To isolate the performance impact of the multiples selection to the market price variable used, we reduce the universe of multiples to those based on value drivers, which are defined on an enterprise level. Even though all of the value drivers are more appropriate for entity value multiples, the explanatory power of entity value multiples lacks in comparison to that of equity value multiples. For the comparison, we calculate absolute and relative differences in the performance of equivalent multiples. When focusing on individual multiples, the EV/IC multiple is the only entity value multiple which exhibits a lower median absolute valuation error than the equivalent equity value multiple. Its median error is 1.49 percentage points lower than that of the P/IC multiple; the difference in performance equals 4.28 percent. Although the results are a bit more favorable for the second key performance measure, equity value multiples still explain market values better than the corresponding entity value multiples. To make an overall comparison, we aggregate the numbers of the individual multiples in an average. The comparison shows that equity value multiples perform 22.51 percent better than the equivalent entity value multiples using the median error as a measure of accuracy. The relative difference shrinks to 1.22 percent when looking at the fraction of errors below 15 percent.

The results substantiate *Hypothesis 1* and allow to conclude that equity value multiples are generally more accurate than entity value multiples. The reason for this conclusion is that uncertainty in the estimation procedure of the enterprise value distorts the reliability of entity value multiples. Because of this distortion-effect we restrict the investigation of the remaining research questions to equity value multiples.

5.3 Knowledge-related versus traditional multiples

Since the establishment of the personal computer in the early 1980s and the ensuing achievements in information and internet technology, knowledge has become the main source of value generation in many business areas. Today, the success of most firms within science-based industries no longer relies on tangible assets, but rather on intangible assets and investments in R&D to create this type of assets. Although practitioners are aware of the impact, which knowledge can have on the value of a firm, knowledge-related variables do not find their way into market-based valuation so far.

In fact, valuations using accrual flow multiples frequently punish firms for operating with more intangibles or investing more in the creation of new intangibles through R&D than their peers. Such a dilution of value occurs because accounting rules mandate amortizing (writing down intangible assets) more aggressively than depreciating tangible assets and expensing R&D investments immediately in the financial statements. To overcome this side-effect of conservative accounting, we correct earnings-based accrual flow multiples for accounting costs of knowledge by adding back amortization, or R&D expenditures, or both of them (KC) to EBIT and net income.

The performance of these multiples is evaluated on the ICB supersector level. Firms within twelve out of the 18 ICB supersectors exhibit a broad exposure to intangible assets and/or R&D. For those twelve supersectors, which we define as science-based industries, *Table 5* presents a comparison of the performance of knowledge-related versus traditional accrual flow multiples. The first two columns show numbers for the key performance measures of our study. Based on these numbers, we compare the accuracy of individual multiples and construct rankings. First, we do this separately for each of the two multiple types (column 3 and column 4) and then combined in a single ranking of all multiples (column 5 and column 6). The separate analysis identifies the P/(E+R&D) and P/(E+KC) multiple as the best performing knowledge-related multiples. With a median error of 28.1 percent across the twelve supersectors, the P/(E+R&D) multiple ranks first followed by the P/(E+KC) multiple with a median error of 28.3 percent. The rank order changes, when the fraction of valuation errors below 15 percent is considered. In general, the variation in performance among the knowledge-related multiples is relatively small. Another observation we can make in the separate rankings for both types of multiples is that accuracy improves by using value drivers closer to bottom line number in the income statement, suggesting that sales, gross income, and EBIT(DA) do not really reflect profitability by leaving out valuable information of the detailed income statement.

The composite ranking in the last two columns of *Table 5* provides evidence for preferring knowledge-related to traditional multiples in science-based industries. With the only exception of the EV/(EBIT+AIA) multiple for the second performance indicator, knowledge-related multiples deliver better value predictions than traditional multiples. The superiority is not restricted to the ranking itself, but is also shown in the absolute numbers (first two columns of *Table 5*). Therefore, we can approve *Hypothesis 2* and conclude that knowledge-related multiples outperform traditional multiples in science-based industries.

5.4 Forward-looking versus trailing multiples

Forward-looking multiples follow the principles of value generation and appeal for their consistency. The question is if multiples constructed on consensus analyst beliefs can outperform when applied to empirical data. To find an answer, we compare the valuation accuracy of forward-looking multiples to the accuracy of the corresponding trailing accrual flow multiples. The comparison is carried out the same way as with the evaluation of equity value versus entity value multiples presented in the previous section.

The differences in the median absolute valuation error in *Table 6* show that using one-year forecasts instead of trailing numbers decreases the median error on average by

2.54 percentage points, which is equal to 8.84 percent in relative terms (first row). Moving from one-year forecasts to two-year forecasts further improves accuracy by 1.84 percentage points absolutely and 7.01 percent relatively (third row). Thus, two-year forward-looking multiples outperform trailing multiples on average by 4.38 percentage points and 15.02 percent respectively (second row). By constraining the results to the fraction of absolute valuation errors smaller than 15 percent we find similar performance improvements by substituting trailing through forward-looking value drivers. This statement is consistent with what Kim & Ritter (1999) and Liu, Nissim & Thomas (2002) find in the context of U.S. IPOs and U.S. equities.

A closer look at different multiples reveals an interesting fact: The superiority of forecast information depends crucially on the value driver. The relative performance advantage utilizing forecasts of (pre-tax) earnings lies on average above 25 percent when comparing trailing numbers and two-year forecasts. This advantage decreases significantly when choosing EBIT(DA) forecasts and eventually reverts into a disadvantage of forecasts compared to historical figures if sales are taken as the value driver. This pattern might be explained by the industry practice to determine an equity analyst's quality (and paycheck) based on her ability to accurately forecast earnings. Therefore, analysts typically devote their efforts towards the estimation of future earnings. The market also pays the highest attention to earnings forecasts and consequently market values adjust accordingly to information on earnings.

To visualize the performance of forward-looking versus trailing multiples, *Figure 2* provides a bar chart containing the number of first, second, and third ranks of multiples based on trailing numbers, one-year forecasts, and two-year forecasts for pairwise performance evaluations on the ICB sector level. Out of 300 comparisons, two-year forecasts perform best ranking first 160 times, second 108 times, and third only 32 times. One-year forecasts reach 72 first, 146 second, and 82 third ranks. Far behind, trailing numbers rank first only 68 times, second 46 times, and third 186 times.

In sum, the results presented in *Table 6* and *Figure 2* suggest the following ranking of multiples and therewith support *Hypothesis 3*: Forward-looking multiples, as a group, exhibit higher accuracy than trailing multiples. Performance increases with the forecast horizon from one year to two years.

5.5 Evaluation of results

The empirical results for the European sample substantiate the economics of the comprehensive multiples valuation framework. It is worthwhile to validate the significance of the results using U.S. data. The out-of-sample test confirms our findings. In fact, even the magnitude of most results shows strong similarities.

One aspect of the results for the U.S. sample provides evidence for a phenomenon observed by Ali & Hwang (2000): Accounting information exhibit greater value relevance in U.S. equity markets than elsewhere in the world. *Table 7* shows that across the universe of equity value multiples in the study, the median absolute valuation error (fraction of valuation errors below 15 percent) is on average 10.0 percent lower (8.9 percent higher) for the U.S. sample compared to the European sample. The obvious and first explanation for the performance advantage of the U.S. sample is the heterogeneity of accounting and tax regulations across Europe. A second explanation is that the demand for published value relevant accounting information is higher in equity- and market-orientated financial systems (e.g., U.S.) than in debt- and bank-orientated systems (e.g., Germany and France). Why? Banks typically have direct access to firm information. One might also attribute the performance advantage of U.S. markets to a supposed higher degree of capital market efficiency.

Interestingly, the relative performance advantage reported in *Table 7* is based on four multiples: (1) The trailing P/E, (2) the one-year forward-looking P/E, (3) the two-year forward-looking P/E, and (4) the P/B multiple. The conclusion is two-fold: First, the popularity of the P/E and the P/B multiple among U.S. market participants has an impact on the market price levels of U.S. stocks. Second, analysts covering U.S. stocks produce earnings forecasts that better reflect intrinsic value generation than analysts covering European stocks. A closer look at the results of the cross-sectional analysis of the U.S. sample shows that entity value multiples perform slightly better in the U.S. than they do in Europe when compared to the equivalent equity value multiples. This amelioration lapses through the additional provision of equity value multiples. This can be explained by the differences in consistency. The advantages of knowledge-related and of forward-looking multiples compared to traditional and trailing multiples are stronger in the U.S. than in Europe.

5.6 Time stability and limitations

Another issue concerns the time stability of the results. To evaluate the steadiness of the accuracy pattern, we focus on eleven equity value multiples and calculate calibrated performance indicators in each year from 1996 to 2005. In an aggregated form, *Figure 3* shows the progression of the calibrated median absolute valuation errors and quartile errors for the European sample over the horizon. The absolute and relative levels of those performance indicators appear fairly consistent over time. One noticeable deviation occurs during the years of the boom and bust of the dot-com bubble. That is, after a decline of valuation accuracy in 1999 and 2000, we observe a reversion in 2001 and further slightly positive adjustments in the years thereafter. Albeit this deviation, the flat curves suggest that the overall results are robust throughout the sample period.

The dataset and sample selection impose two notable limitations on the empirical results. The first limitation concerns the selection of the Dow Jones STOXX 600 and the S&P 500 as the underlying indices of the study. Although they cover the majority of the total market capitalization in Western Europe and the U.S., the number of stocks is limited to only 600 and 500 respectively. Classifying single stocks in large cap or mid cap, the sample entirely excludes small cap stocks. Furthermore, countries in Western Europe and the U.S. represent developed equity markets as opposed to many countries in emerging markets. Therefore, it is questionable, if the results can be directly transferred to small caps and emerging markets.

Limited data availability represents the second limitation. The dataset itself is unique because the access to resources of Thomson Financial provides detailed I/B/E/S forecasts on many value drivers beyond the typically available earnings (growth) forecasts. Complete forecast material, however, is still only available for the last six years from 2000 to 2005 for the European sample and for the last three years from 2003 to 2005 for the U.S. sample respectively. Also, the dataset on R&D expenditures and amortization of intangible assets for firms in science-based industries is incomplete because of non-uniform disclosure regulations in different countries and industries. The two limitations in data availability may reduce the reliability of the results concerning forward-looking and knowledge-related multiples.

6 Conclusion

This paper examines the valuation accuracy of different types of multiples in European equity markets. We use a dataset of 600 European firms and construct a comprehensive list of multiples for the ten-year period from 1996 to 2005. The cross-sectional analysis assumes direct proportionality between market values and multiples. Comparable firms are selected from the same industry based on the ICB system. Overall, the MVM in its many variations approximate market valuations well with median absolute errors of less than thirty percent and fractions of errors below 15 percent of higher than thirty percent for the majority of the equity value multiple universe. In terms of relative performance, our results show that: (1) Equity value multiples outperform entity value multiples. (2) Knowledge-related multiples outperform traditional multiples in science-based industries. (3) Forward-looking multiples, in particular the two-year forward-looking P/E multiple, outperform trailing multiples.

All of our results are significant in magnitude, robust to the use of different statistical performance measures, and constant over time. More importantly, the study finds similar or even stronger results in an out-of-sample test using a dataset of 500 U.S. firms for the same time horizon. In sum, our results extend the knowledge of the absolute and relative valuation accuracy of different (types of) multiples and provide reasoning for the industry practice of using multiples as the standard valuation approach.

The straightforwardness of the methodology and the significance of the empirical results make these results directly relevant to practice. There is a good indication of which type of information the market processes in order to determine values. The study supports the importance of knowledge-related variables in science-based industries. It also supports the importance of earnings forecasts across all industries.

Our study opens space for further investigation in the area of corporate valuation using multiples. We suggest an extension of the dataset for the cross-sectional analysis to emerging markets and small firms.

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Figure 1: Categorization of multiples

Note: P = (stock) price / market capitalization, EV = enterprise value, SA = sales / revenues, GI = gross income, EBITDA = earnings before interest, taxes, depreciation, and amortization, EBIT = earnings before interest and taxes, EBT = earnings before taxes / pre-tax income, E = earnings / net income available to common shareholders, TA = total assets, IC = invested capital, B = book value of common equity, OCF = operating cash flow, D = (ordinary cash) dividend, R&D = research & development expenditures, AIA = amortization of intangible assets, and KC = knowledge costs = R&D + AIA. Forward-looking multiples are based on mean consensus analysts' forecasts for the next two years (1 = one year, 2 = two years) provided by I/B/E/S. The multiples shown within this two dimensional categorization framework are just a selection of the universe of possible multiples. However, any multiple can be classified within this framework.

	Traditional / trailing multiples				
	Accrual flow multiples	*Book value multiples*	*Cash flow multiples*	*Alternative multiples*	*Forward-looking multiples*
Equity value multiples	P / SA	P / TA	P / OCF	P / (EBIT+R&D)	P / SA 1
	P / GI	P / IC	P / D	P / (EBIT+AIA)	P / SA 2
	P / EBITDA	P / B		P / (EBIT+KC)	P / EBITDA 1
	P / EBIT			P / (E+R&D)	P / EBITDA 2
	P / EBT			P / (E+AIA)	P / EBIT 1
	P / E			P / (E+KC)	P / EBIT 2
					P / EBT 1
					P / EBT 2
					P / E 1
					P / E 2
Entity value multiples	EV / SA	EV / TA	EV / OCF	EV / (EBIT+R&D)	EV / SA 1
	EV / GI	EV / IC		EV / (EBIT+AIA)	EV / SA 2
	EV / EBITDA			EV / (EBIT+KC)	EV / EBITDA 1
	EV / EBIT				EV / EBITDA 2
					EV / EBIT 1
					EV / EBIT 2

Figure 2: Performance of forward-looking versus trailing multiples

Note: The three bars indicate first, second, and third ranks of multiples based on trailing numbers, one-year forecasts, and two-year forecasts for pairwise performance evaluations (n = 300) on the ICB sector level (3-digit codes).

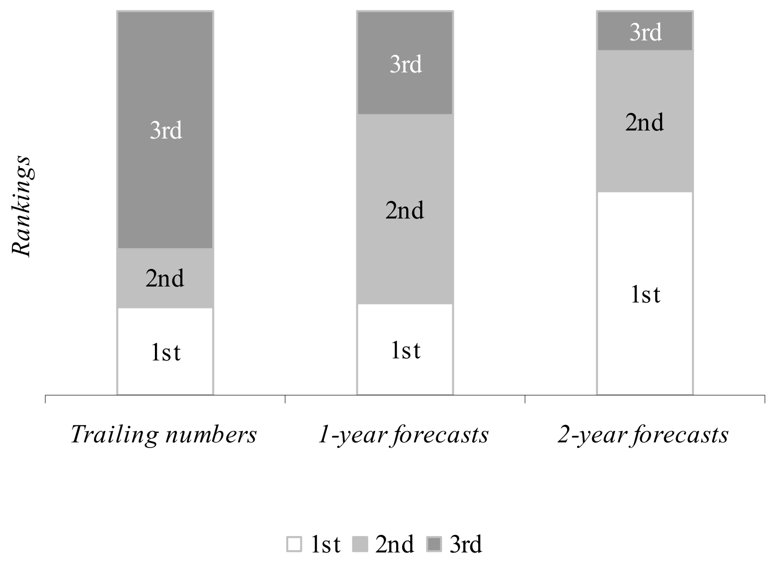

Figure 3: Time stability of calibrated absolute valuation errors in Europe

Note: To illustrate the time stability of valuation accuracy, calibrated performance indicators (median absolute valuation error, 1st and 3rd quartile) are calculated in each year from 1996 to 2005 for eleven representative equity value multiples. The arithmetic mean is used for the aggregation of performance indicators.

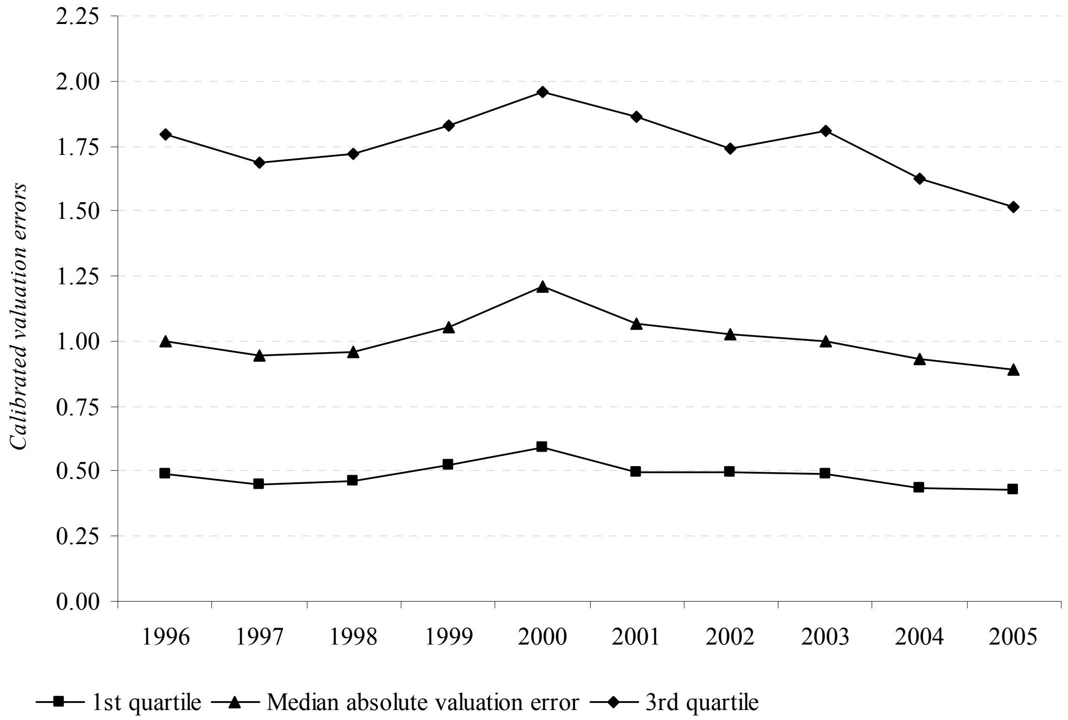

Table 1: Sample characteristics and descriptive statistics

Panel A presents the characteristics of the European sample. From the 600 stocks within the Dow Jones STOXX 600, eight stocks of four different firms (i.e., Fresenius (Medical Care), Heineken, Reed Elsevier, Unilever) are excluded because these firms are listed both as holding and as subsidiary, but only one set of accounting numbers is available for each year. Panel B presents the analysis results of the pooled sample of annual data from 1996 to 2005. Annual accounting numbers are as of the beginning of January each year. Negative numbers are excluded.

Panel A: Sample characteristics

Underlying index	Dow Jones STOXX 600
Regional coverage	17 developed countries in Western Europe
Industry classification used	Industry Classification Benchmark
Stocks within the sample	592
Period covered	10 years (1996-2005)

Panel B: Descriptive statistics of the sample

	Median	*Mean*	*1st quartile*	*3rd quartile*	*Number of observations*
Sales (mio $)	3558	9750	1223	9667	5367
EBITDA (mio $)	577	1653	228	1511	4675
EBIT (mio $)	410	1213	162	1065	4850
Net income (mio $)	206	1144	86	535	4917
Total assets (mio $)	5830	38766	1974	19674	5373
Invested capital (mio $)	3777	18494	1383	10814	4101
Book value of equity (mio $)	1677	4284	661	4320	5255
Operating cash flow (mio $)	393	1364	152	1079	4178
Cash dividend paid (mio $)	85	258	35	245	4662

Table 2: Equity value multiples summary statistics

Note: Multiples are calculated for each firm i in year t using accounting numbers and mean consensus analyst forecasts as of the beginning of January and market prices as of the beginning of April. Criteria for the calculation of multiples and thus inclusion into the summary statistics are: (1) firm i is part of the sample; (2) the market capitalization of firm i is above 200 million U.S. Dollar and the value of net debt is positive in an individual year t; and (3) the underlying value driver x of an individual multiple λ of firm i in year t is positive.

		Median	*Mean*	*1st quartile*	*3rd quartile*	*Number of observations*
Equity value multiples	*Accrual flow multiples*					
	P / SA	1.1	5.4	0.6	2.2	4950
	P / GI	4.4	6.9	2.5	7.8	3878
	P / EBITDA	6.4	10.2	4.1	9.5	4317
	P / EBIT	8.9	15.6	6.0	13.6	4493
	P / EBT	11.5	18.4	8.0	17.1	4615
	P / E	16.8	37.6	11.7	25.7	4566
	Book value multiples					
	P / TA	0.6	1.2	0.3	1.2	4957
	P / IC	1.0	1.6	0.6	1.9	3810
	P / B	2.1	4.1	1.3	3.6	4865
	Cash flow multiples					
	P / OCF	9.5	17.4	5.6	16.3	3909
	P / D	41.5	81.4	26.8	70.4	4449
	Knowledge-related multiples					
	P / (EBIT+R&D)	7.1	9.8	4.7	10.7	1116
	P / (EBIT+AIA)	8.4	12.3	5.7	12.4	1973
	P / (EBIT+KC)	6.5	8.7	4.3	9.6	1029
	P / (E+R&D)	11.3	15.8	7.4	16.6	1073
	P / (E+AIA)	14.1	19.6	10.0	20.2	1898
	P / (E+KC)	9.9	13.3	6.6	14.5	988
	Forward-looking multiples					
	P / SA 1	1.2	13.8	0.6	2.6	3150
	P / SA 2	1.1	14.0	0.5	2.4	3146
	P / EBITDA 1	6.5	23.0	4.3	9.8	2995
	P / EBITDA 2	5.9	17.7	3.9	8.6	2995
	P / EBIT 1	9.2	17.2	6.4	13.4	2929
	P / EBIT 2	8.1	38.6	5.8	11.3	2945
	P / EBT 1	10.5	14.8	7.7	14.9	3058
	P / EBT 2	9.3	30.7	6.9	12.6	3128
	P / E 1	15.8	31.0	11.6	22.7	3056
	P / E 2	14.1	21.6	10.7	19.1	3125

Table 3: Absolute valuation accuracy of equity value multiples

Note: Statistical measures of absolute valuation accuracy (median, mean, 1st and 3rd quartile) are based on scaled absolute valuation errors (see equation (9)). The fraction <0.15 (<0.25) measures the proportion of scaled absolute valuation errors below 15 percent (25 percent).

		Analysis of absolute valuation errors				*Fractions*	
		Median	*Mean*	*1st quartile*	*3rd quartile*	*Fraction < 0.15*	*Fraction < 0.25*
Equity value multiples	*Accrual flow multiples*						
	P / SA	0.4374	0.7478	0.1816	0.7656	0.2294	0.3395
	P / GI	0.4000	0.6979	0.1620	0.7178	0.2464	0.3611
	P / EBITDA	0.2954	0.5083	0.1224	0.5547	0.3118	0.4449
	P / EBIT	0.2872	0.4942	0.1184	0.5551	0.3213	0.4618
	P / EBT	*0.2809*	*0.4801*	*0.1140*	*0.5508*	*0.3189*	*0.4650*
	P / E	0.2925	0.4831	0.1123	0.5610	0.3094	0.4571
	Book value multiples						
	P / TA	0.3775	0.6696	0.1561	0.6715	0.2585	0.3818
	P / IC	*0.3480*	*0.6609*	*0.1364*	*0.6393*	*0.2797*	*0.4038*
	P / B	0.3729	0.5600	0.1570	0.6458	0.2566	0.3733
	Cash flow multiples						
	P / OCF	*0.3365*	*0.7256*	*0.1310*	*0.6712*	*0.3028*	*0.4209*
	P / D	0.3468	0.6255	0.1366	0.6466	0.2811	0.4005
	Knowledge-related multiples						
	P / (EBIT+R&D)	0.2735	0.4599	0.1101	0.5294	0.3362	0.4791
	P / (EBIT+AIA)	0.2714	0.4572	0.1129	0.5083	0.3310	0.4732
	P / (EBIT+KC)	0.2849	0.4732	0.1027	0.5214	0.3398	0.4756
	P / (E+R&D)	0.2736	0.4543	0.1171	0.5218	0.3261	0.4805
	P / (E+AIA)	*0.2537*	*0.4445*	*0.1003*	*0.4957*	*0.3461*	*0.4903*
	P / (E+KC)	0.2729	0.4512	0.1093	0.4989	0.3244	0.4623
	Forward-looking multiples						
	P / SA 1	0.4376	0.7069	0.1915	0.7339	0.2241	0.3304
	P / SA 2	0.4297	0.6853	0.1940	0.7107	0.2248	0.3302
	P / EBITDA 1	0.2813	0.5568	0.1186	0.5504	0.3188	0.4755
	P / EBITDA 2	0.2658	0.4798	0.1156	0.4981	0.3285	0.4893
	P / EBIT 1	0.2628	1.9712	0.1128	0.5256	0.3346	0.4924
	P / EBIT 2	0.2483	1.7225	0.0971	0.4537	0.3662	0.5222
	P / EBT 1	*0.2403*	*0.4101*	*0.0988*	*0.4675*	*0.3621*	*0.5265*
	P / EBT 2	*0.2151*	*0.3348*	*0.0854*	*0.4119*	*0.4003*	*0.5580*
	P / E 1	0.2441	0.3649	0.0909	0.4621	0.3609	0.5152
	P / E 2	0.2155	0.3168	0.0863	0.4121	0.3954	0.5635

Table 4: Performance of equity value versus entity value multiples

Note: Negative numbers for the absolute (relative) difference of median valuation errors indicate that equity value multiples outperform entity value multiples. For instance, using the P/GI multiple instead of the EV/GI multiple reduces the absolute (relative) median valuation error on average by 5.65 percentage points (14.12 percent). Positive numbers for the absolute (relative) difference of the fraction <0.15 also indicate that equity value multiples outperform entity value multiples. For instance, using the P/GI multiple instead of the EV/GI multiple increases the fraction of valuation errors below 15 percent on average by 1.05 percentage points in absolute terms and by 4.27 percent in relative terms. For the overall comparison, the average of the individual differences is taken.

			Median valuation errors		*Fraction < 0.15*	
			Absolute difference	*Relative difference (%)*	*Absolute difference*	*Relative difference (%)*
Overall comparison						
Equity value MP	vs.	Entity value MP	-0.0694	-22.51%	0.0126	1.22%
Accrual flow multiples						
P / SA	vs.	EV / SA	-0.0621	-14.20%	-0.0096	-4.17%
P / GI	vs.	EV / GI	-0.0565	-14.12%	0.0105	4.27%
P / EBITDA	vs.	EV / EBITDA	-0.0568	-19.22%	-0.0033	-1.05%
P / EBIT	vs.	EV / EBIT	-0.0705	-24.54%	0.0289	9.00%
Book value multiples						
P / TA	vs.	EV / TA	-0.0103	-2.74%	0.0018	0.71%
P / IC	vs.	EV / IC	0.0149	4.28%	-0.0166	-5.94%
Cash flow multiples						
P / CFO	vs.	EV / CFO	-0.1076	-31.99%	0.0273	-30.28%
Knowledge-related multiples						
P / (EBIT+R&D)	vs.	EV / (EBIT+R&D)	-0.0738	-26.98%	0.0414	12.30%
P / (EBIT+AIA)	vs.	EV / (EBIT+AIA)	-0.0351	-12.95%	0.0095	2.86%
P / (EBIT+KC)	vs.	EV / (EBIT+KC)	-0.0325	-11.40%	0.0266	7.84%
Forward-looking multiples						
P / SA 1	vs.	EV / SA 1	-0.0916	-20.92%	-0.0006	-0.29%
P / SA 2	vs.	EV / SA 2	-0.1032	-24.03%	-0.0070	-3.09%
P / EBITDA 1	vs.	EV / EBITDA 1	-0.1001	-35.59%	0.0162	5.07%
P / EBITDA 2	vs.	EV / EBITDA 2	-0.0899	-33.84%	0.0104	3.17%
P / EBIT 1	vs.	EV / EBIT 1	-0.1334	-50.76%	0.0323	9.65%
P / EBIT 2	vs.	EV / EBIT 2	-0.1023	-41.18%	0.0345	9.41%

Table 5: Performance of knowledge-related versus traditional multiples

Note: Science based industries are identified on the ICB supersector level (2-digit codes) and include oil & gas (0500), chemicals (1300), basic resources (1700), construction & materials (2300), industrial goods & services (2700), automobiles & parts (3300), food & beverage (3500), personal & household goods (3700), health care (4500), telecommunications (6500), utilities (7500), and technology (9500). The calculation of absolute performance numbers is limited to these twelve industries.

	Absolute performance		*Rankings within the same multiple type*		*Composite ranking of both multiple types*	
	Median error	*Fraction < 0.15*	*Median error*	*Fraction < 0.15*	*Median error*	*Fraction < 0.15*
Traditional accrual flow multiples						
P / SA	0.4603	0.1995	6	6	12	12
P / GI	0.4406	0.2111	5	5	11	11
P / EBITDA	0.3280	0.2668	4	4	10	10
P / EBIT	0.3100	0.2962	1	2	7	7
P / EBT	0.3138	0.2989	3	1	9	6
P / E	0.3129	0.2928	2	3	8	8
Knowledge-related multiples						
P / (EBIT+R&D)	0.2980	0.3114	5	4	5	4
P / (EBIT+AIA)	0.3018	0.2819	6	6	6	9
P / (EBIT+KC)	0.2962	0.3135	3	3	3	3
P / (E+R&D)	0.2807	0.3153	1	2	1	2
P / (E+AIA)	0.2974	0.3077	4	5	4	5
P / (E+KC)	0.2828	0.3252	2	1	2	1

Table 6: Performance of forward-looking versus trailing multiples

Note: Negative numbers for the absolute (relative) difference of median valuation errors indicate that forward-looking multiples outperform trailing multiples. For instance, using the P/E1 multiple instead of the P/E multiple reduces the absolute (relative) median valuation error on average by 4.84 percentage points (16.53 percent). Positive numbers for the absolute (relative) difference of the fraction <0.15 also indicate that forward-looking multiples outperform trailing multiples. For instance, using the P/E1 multiple instead of the P/E multiple increases the fraction of valuation errors below 15 percent on average by 5.15 percentage points in absolute terms and by 16.63 percent in relative terms. For the overall comparison, the average of the individual differences is taken.

			Median valuation error		*Fraction < 0.15*	
			Absolute difference	*Relative difference (%)*	*Absolute difference*	*Relative difference (%)*
Overall comparison						
1-year forecasts	vs.	Trailing numbers	-0.0254	-8.84%	0.0219	6.85%
2-year forecasts	vs.	Trailing numbers	-0.0438	-15.02%	0.0449	14.13%
2-year forecasts	vs.	1-year forecasts	-0.0184	-7.01%	0.0229	6.58%
Sales						
P / SA 1	vs.	P / SA	0.0002	0.04%	-0.0053	-2.31%
P / SA 2	vs.	P / SA	-0.0077	-1.77%	-0.0046	-2.01%
P / SA 2	vs.	P / SA 1	-0.0079	-1.81%	0.0007	0.30%
EBITDA						
P / EBITDA 1	vs.	P / EBITDA	-0.0141	-4.76%	0.0070	2.26%
P / EBITDA 2	vs.	P / EBITDA	-0.0296	-10.02%	0.0167	5.36%
P / EBITDA 2	vs.	P / EBITDA 1	-0.0155	-5.52%	0.0097	3.03%
EBIT						
P / EBIT 1	vs.	P / EBIT	-0.0244	-8.49%	0.0133	4.14%
P / EBIT 2	vs.	P / EBIT	-0.0389	-13.54%	0.0449	13.96%
P / EBIT 2	vs.	P / EBIT 1	-0.0145	-5.52%	0.0316	9.43%
EBT						
P / EBT 1	vs.	P / EBT	-0.0406	-14.45%	0.0432	13.54%
P / EBT 2	vs.	P / EBT	-0.0658	-23.42%	0.0814	25.53%
P / EBT 2	vs.	P / EBT 1	-0.0252	-10.49%	0.0382	10.56%
Earnings						
P / E 1	vs.	P / E	-0.0484	-16.53%	0.0515	16.63%
P / E 2	vs.	P / E	-0.0770	-26.32%	0.0860	27.78%
P / E 2	vs.	P / E 1	-0.0286	-11.73%	0.0345	9.56%

Table 7: Comparison of valuation accuracy in European and U.S. equity markets

Note: Negative numbers for the absolute (relative) difference of median valuation errors indicate that U.S. data yields more accurate valuations than European data. For instance, using U.S. data instead of European data for the P/SA multiple reduces the absolute (relative) median valuation error on average by 3.87 percentage points (9.72 percent). Positive numbers for the absolute (relative) difference of the fraction <0.15 also indicate that U.S. data yields more accurate valuations than European data. For instance, using U.S. data instead of European data for the P/SA multiple increases the fraction of valuation errors below 15 percent on average by 2.62 percentage points in absolute terms and by 10.24 percent in relative terms. For the overall comparison, the average of the individual differences is taken.

				Median valuation error		*Fraction < 0.15*	
				Absolute difference	*Relative difference (%)*	*Absolute difference*	*Relative difference (%)*
Overall comparison							
	U.S.	vs.	Europe	-0.0233	-10.01%	0.0345	8.87%
Accrual flow multiples							
P / SA	U.S.	vs.	Europe	-0.0387	-9.72%	0.0262	10.24%
P / GI	U.S.	vs.	Europe	-0.0498	-14.23%	0.0257	9.45%
P / EBITDA	U.S.	vs.	Europe	-0.0022	-0.75%	0.0060	1.89%
P / EBIT	U.S.	vs.	Europe	-0.0113	-4.09%	0.0143	4.25%
P / EBT	U.S.	vs.	Europe	-0.0172	-6.52%	0.0324	9.23%
P / E	U.S.	vs.	Europe	-0.0442	-17.78%	0.0490	13.66%
Book value multiples							
P / TA	U.S.	vs.	Europe	0.0174	4.40%	0.0009	0.36%
P / IC	U.S.	vs.	Europe	0.0303	8.01%	-0.0089	-3.29%
P / B	U.S.	vs.	Europe	-0.0593	-18.92%	0.0605	19.08%
Cash flow multiples							
P / OCF	U.S.	vs.	Europe	-0.0139	-4.32%	-0.0041	-1.38%
P / D	U.S.	vs.	Europe	0.0422	10.85%	0.0095	3.27%
Knowledge-related multiples							
P / (EBIT+R&D)	U.S.	vs.	Europe	0.0025	0.91%	-0.0029	-0.88%
P / (EBIT+AIA)	U.S.	vs.	Europe	-0.0077	-2.92%	0.0065	1.94%
P / (EBIT+KC)	U.S.	vs.	Europe	-0.0116	-4.23%	0.0044	1.27%
P / (E+R&D)	U.S.	vs.	Europe	-0.0111	-4.22%	0.0034	1.04%
P / (E+AIA)	U.S.	vs.	Europe	-0.0162	-6.84%	0.0334	8.80%
P / (E+KC)	U.S.	vs.	Europe	-0.0087	-3.30%	-0.0026	-0.80%
Forward-looking multiples							
P / SA 1	U.S.	vs.	Europe	-0.0766	-21.21%	0.0501	18.28%
P / SA 2	U.S.	vs.	Europe	-0.0676	-18.68%	0.0401	15.12%
P / EBITDA 1	U.S.	vs.	Europe	-0.0274	-10.79%	0.0470	12.85%
P / EBITDA 2	U.S.	vs.	Europe	-0.0265	-11.09%	0.0726	18.10%
P / EBIT 1	U.S.	vs.	Europe	-0.0160	-6.47%	0.0538	13.85%
P / EBIT 2	U.S.	vs.	Europe	-0.0278	-12.58%	0.0520	12.44%
P / EBT 1	U.S.	vs.	Europe	-0.0134	-5.91%	0.0162	4.27%
P / EBT 2	U.S.	vs.	Europe	-0.0270	-14.34%	0.0391	8.90%
P / E 1	U.S.	vs.	Europe	-0.0732	-42.79%	0.1408	28.06%
P / E 2	U.S.	vs.	Europe	-0.0743	-52.64%	0.1665	29.64%