# The Determinants and Applications of Valuation Multiples

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**Abstract**

Practically used price multiples are disconnected from the theoretically sound discounted cash flow valuation models. In this paper, we introduce a "synthetic price multiple" that utilizes the firm's economic and accounting fundamentals, and multi-drivers of value in construction. We propose an approach to estimate simultaneously the relevant parameters. Our synthetic price multiples provide an additional tool to value stocks and identify mispricing of assets. We find that longing firms with the lowest actual price multiples relative to the synthetic price multiples and shorting firms with the highest actual multiples relative to the synthetic multiples can generate statistically and economically significant hedge returns. As an application, we provide evidence to support that firms investing in ESG align with increasing in shareholders' value.

**Keywords**: Valuation; price multiple; discounted cash flow model; simultaneous estimation; ESG

## 1. Introduction

Despite widespread use of price multiples in asset valuation among practitioners, the theoretical foundation linking certain individual multiples of selected peers to the target company's value is weak. How to connect a practical price multiple to a theoretically sound discounted cash flow (earnings) model is of vital importance in asset valuation and correcting possible mispricing. The aim of this paper is to introduce such a multiple – the synthetic price multiple.

Investment practitioners often estimate the value of a target company by a specific price multiple (*P/Z*) within the cross-section, where *Z* is a value driver such as earnings. There are three main difficulties in applying a price multiple in asset valuation in general. First, the selection of a homogeneous group of comparable peers is essentially an art form (Bhojraj and Lee 2002), and divergent accounting practices can make even very different companies appear similar (Young and Zeng 2015). Second, there is no clear support for selecting one value driver as superior to others. For example, Kim and Ritter (1999) and Liu et al. (2002) argue that multiples based on forward earnings generally perform better than cash flows, book value, and sales. Nissim (2013) finds that book value multiples generate less biased estimates than using revenue and earnings multiples in the financial sector. Third, there is no consensus on how to aggregate the peers' P/Z. Some use the harmonic mean and others use the median of comparable companies' P/Z.

A synthetic price multiple, on the other hand, is a valuation multiple that uses the firm's economic and accounting fundamentals, and multi-drivers of value in construction. The synthetic price multiples possess three distinguishing features. Firstly, a synthetic price-to-forward earnings, price-to-book and price-to-trailing earnings, all generate identical value estimates because they are grounded on the same discounted cash flow (earnings) model. The choice of value driver in forming such price multiples, therefore, becomes redundant. Secondly, a synthetic price multiple, say, the price-to-forward earnings ratio for a target company can be expressed as an adjustment to its industry "normal" price-to-forward earnings ratio. It uses corresponding industry fundamental economic and accounting characteristics including persistence of abnormal earnings, cost of equity capital, growth of future earnings and accounting conservatism as a proxy for individual firms' expected valuation parameters based on currently available information. The difference between the price multiple and its industry "normal" value effectively defines a value premium. Thirdly, the adjustment term not only reflects the fundamental characteristics, but is also a function of value drivers that drive cross-sectional variation across companies in the same industry. Specifically, it is captured by the difference between the target company's future and current return on book equity (ROE) and its industry average cost of equity capital, and the difference between the target book value growth rate and its industry average growth rate. Unlike commonly used price multiples built solely on peers' information, a synthetic price multiple for the target company directly connects to its economic fundamentals, which may reflect the target's superior products, better access to customers and economies of scale in terms of profitability and future earnings growth in the cross section. Collectively, a synthetic price multiple embeds several economic and accounting fundamentals and hence can be viewed as an enhanced price multiple.

The key to estimate a synthetic price multiple is to understand what determines a company's valuation multiples in theory. It is motivated from the parsimonious Feltham and Ohlson (1996) model, which describes the evolution of future cash flows and establishes the basic theoretical constructs of equity value. It demonstrates that future abnormal earnings can have a persistence and can be explained by nonzero NPV investments and accounting conservatism. It highlights the importance of the competitive position of companies in the business environment, the growth of future earnings, the risk of the business, and conservative accounting policy, four economic and accounting characteristics, in determining future abnormal earnings. Equity value is then determined by the future and current economic spreads, and abnormal growth in book value of the company with coefficients reflecting both short- and long-term economic and accounting properties. By economic spread, we mean the difference between a company's ROE and its cost of equity capital. By abnormal growth in book value, we mean the difference between the growth rate of book value and its long-term value. Consequently, valuation multiples must reflect these value attributes.

Since various value drivers are intrinsically linked in forecasting of future cash flows (abnormal earnings) and valuation, their weights reflecting economic characteristics must be jointly estimated (Penman, 1996). To estimate systematically the industry-year parameters embedded in a synthetic price multiple, we start from the theoretical determinants of one-period ahead abnormal earnings: current abnormal earnings, accounting goodwill and abnormal growth in book value under conservative accounting. We accordingly regress the expected one-period forward earnings on current earnings, current and lagged book values, and stock prices. In other words, the determinants of the synthetic price multiples are jointly estimated in an internally consistent manner by specifically focus on the multi-dimensional fundamental economic and accounting characteristics.  A synthetic price multiple, therefore, is more systematic and less subjective than the commonly used price multiples.

Based on 104,289 firm-year observations on US sample between 1980 and 2017, we estimate key parameters describing companies' economic and accounting characteristics for each industry year. We find that the expected long-term growth rates of future earnings are between 3.3% and 4.9%, and the cost of equity capital are between 8.4% and 11.1% across 12 industries. The persistence of abnormal earnings are between 0.08 and 0.19 for all industries, indicating that there is almost no persistence of economic profits after three years.

We apply the synthetic price multiples to value equity. While the synthetic price multiples have an upward trend over our sample period, they are in general smaller than the actual price multiples and less volatile. For example, the synthetic price-to-forward earnings ratios are in the range of 11.2 and 16.8, but the actual price-to-forward earnings ratios are between 12.9 and 22.1. We find that valuation bias and inaccuracy are substantially improved by applying our synthetic price multiples comparing to various valuation methods often used in existing literature. For example, comparing applying synthetic price multiples with the sequential procedure in estimating valuation parameters, we find the median valuation biases from the former is less than 9%, while the median biases from the latter approach is more than 36% for the representative industries. We also find that the extreme deviation between the actual price multiples and synthetic price multiples can be used to detect mispricing of assets. Longing firms with the lowest actual price multiples relative to the synthetic price multiples and shorting firms with the highest actual multiples relative to the synthetic multiples can generate statistically and economically significant hedge returns.

Disclosures in the ESG (environmental, social and governance) may shed light on companies' economic and accounting characteristics. We note the difference between the actual price multiples and synthetic price multiples decreases with the ESG scores. It implies that the disclosure of ESG-related information may help in price discovery. We find that the actual price-to-forward earnings ratios and the synthetic price-to-forward earnings ratios are very similar for the ESG stocks, but the actual price-to-forward earnings ratios are much higher than its synthetic counterpart for the non-ESG stocks. It suggests that the ESG stocks are fairly priced but non-ESG are likely overpriced relative to their intrinsic values. On the other hand, the synthetic price-to-book ratios are higher than the actual price-to-book ratios for the ESG stocks, while the actual price-to-book ratios are slightly higher than its synthetic counterpart for the non-ESG stocks. Again, this difference in price-to-book suggests that the non-ESG stocks may be slightly overpriced but the ESG stocks are undervalued. If investors understand better the intrinsic value of equity, then they can make well-informed decisions when comparing the synthetic price ratios and actual price ratios. Buying firms with high difference between the synthetic price-to-forward earnings ratios and actual price-to-forward earnings ratios implies buying firms with high ESG scores. Therefore, the disclosure of ESG-related information may help a company to attract funds from the capital markets. The evidence suggests that firms investing in ESG also behave in shareholders' interests in a sustainable and responsible manner.

We make three main contributions in the paper. First, we introduce a synthetic price multiple that builds on a theoretically sound discounted cash flow (earnings) model. The synthetic price multiple incorporates industry economic and accounting characteristics and directly connects to the target company's economic spread and investment growth. Second, we develop a systematic approach to estimate the industry-year multi-dimensional parameters embedded in a synthetic price multiple. They include the cost of capital and long-term growth of future earnings. Third, we provide an additional tool to value stocks and identify possible mispricing of shares. It can be extended to value an enterprise, a private company, and in settings of ownership transition, IPO and M&A activities.

The rest of the paper is organized as follows. Section 2 establishes the theoretical linkage between equity value and value drivers. It follows by discussing the determinants of valuation multiples and directly and systematically constructing a synthetic price multiple for a target company. Section 3 describes data. Section 4 provides empirical results in applying the synthetic price-to-forward earnings ratio and price-to-book ratio. First, we estimate parameters that describe common economic and accounting characteristics across companies in an industry. We then apply synthetic price multiples to value equity and explore potential mispricing by examining the difference between the synthetic price multiples and actual price multiples in valuation. We also discuss the implication for firms engaging with the ESG activities. Section 5 presents concluding remarks and discusses the possible implications for future research.

## 2. Equity value, value drivers and valuation multiples

In this section, we first establish the association between equity value and value drivers, then discuss the determinants of valuation multiples and introduce the concept of a synthetic price multiple.

### 2.1 The intrinsic linkage between equity value and value drivers

To establish the foundation for relative valuation, we start from making two commonly used assumptions to convert a cash flow based valuation model to a few fundamental accounting numbers based valuation model.

**Assumption 1**. Assume the no-arbitrage present value of expected dividends condition: $E_t[P_{t+1} + d_{t+1}] = RP_t$ holds, where $d_t$ is dividends at time t, $P_t$ is the market value of stock and $R-1$ is the expected constant cost of equity capital based on information at time t.

**Assumption 2**. Assume the clean surplus relation: $b_t = b_{t-1} + x_t - d_t$ holds, where $x_t$ is earnings, and $b_t$ is the book value of equity at time *t.*

The two assumptions lead to the well-known residual income valuation model (Edwards and Bell 1961; Peasnell 1982). Accordingly, forecasts of future abnormal earnings (or residual incomes) become the key input in equity valuation. The following three aspects about the nature of future (abnormal) earnings are addressed in extant literature. Firstly, abnormal earnings of a firm are expected to have a persistence in a short time period because the firm may have competitive advantage in the marketplace. Secondly, future abnormal earnings are affected by accounting policy since historical book value and earnings are governed by conservative accounting principles. Accounting defers earnings recognition under uncertainty resulting in expected future earnings. In other words, future earnings may results from "undo" accounting conservatism. Finally and most importantly, future abnormal earnings can be generated from future nonzero NPV investment activities or future growth. These three elements are summarized in the following assumption:

**Assumption 3**. Assume the following linear information dynamics (LID) holds:

$$x^a_{t+1} = \omega_1 x^a_t + \omega_2 (Rb_{t-1} - b_t) + G_t + \varepsilon_{1,t+1} \ , \tag{1}$$

$$G_{t+1} = \lambda G_t + \varepsilon_{2,t+1}, \tag{2}$$

where $x^a_t = x_t - (R-1)b_{t-1}$ is abnormal earnings at time t and $G_t$ is a variable useful in predicting future abnormal earnings. The LID parameters satisfy $0 \le \omega_1 < 1$, $\omega_2 \ge 0$ and $0 \le \lambda < R$. $\varepsilon_{1,t+1}$ and $\varepsilon_{2,t+1}$ are mean zero random error terms.

The Feltham and Ohlson (1996) cash flow information dynamics can be transformed into the above abnormal earnings dynamics.[2] It is intuitive to assume the persistence of abnormal earnings $\omega_1 < 1$ in a competitive economic market. Book value conservatism is modeled by a parsimonious conservatism-adjustment term, ($Rb_{t-1} - b_t$). Its coefficient $\omega_2 > 0$ if assets are over-depreciated in Feltham and Ohlson (1996). Pope and Wang (2005) further show that the larger the weight $\omega_2$, the higher the degree of conservatism in book value in a general linear valuation framework. We refer to $\omega_2$ as the accounting conservative policy parameter. $G_t$ captures values from future nonzero NPV investments and earnings growth generated from

[2] It can be shown that the implied abnormal earnings dynamics at equity level from (CFD) in Feltham and Ohlson (1996) are: $E_t[x^a_{t+1}] = \omega_1 x^a_t + \omega_2 (Rb_{t-1} - b_t) + G_t$, where $\omega_1 = \gamma, \omega_2 = \gamma - \delta$, and $G_t = (\kappa + \gamma - R)ci_t$, where $ci_t$ is investments and $G_t$ incorporates explicitly the firm's future growth opportunities with a persistence being greater than 1. They show that $\gamma > \delta$ induces conservative accounting (the over-depreciation case) and NPV>0 investments imply $\kappa + \gamma > R$.

conservative earnings recognition principles. This implies that conservative accounting in our model setup results from either conservative accounting principles or the firm undertakes positive NPV investments. $G_t$ can be a nonlinear function of accounting variables including historical earnings and book value or non-accounting information, e.g., corporate governance, executive compensation, corporate social responsibility. We allow for $1 \le \lambda < R$ such that abnormal earnings do not asymptotically approach to zero when the firm has positive NPV investments and practices conservative accounting.[3] The last inequality ensures convergence of the model. We interpret ($\lambda - 1$) as the expected long-term (steady state) growth rate based on information available at time t.[4] The formal theoretical relationship between equity value and accounting fundamentals and non-accounting information can be summarized in the following proposition.

**Proposition 1**. Assume Assumptions 1 and 2 and information dynamic (2). Abnormal earnings dynamic (1) holds if, and only if, the following valuation equation holds:

$$P_t = b_t + \alpha_1 x_t^a + \alpha_2 b_{t-1} + \alpha_3 G_t \,, \tag{3}$$

where $\alpha_1 = \dfrac{\omega_1}{R - \omega_1}$, $\alpha_2 = \dfrac{R\omega_2}{R - \omega_1}$ and $\alpha_3 = \dfrac{R}{(R - \omega_1)(R - \lambda)}$.

Proof: see the appendix.

[3] If $0 < \omega_1 < 1$ and $\omega_2 = 0$, then $E_t[x_{t+n}^a] = \omega_1^n x_t^a + ((\lambda^n - \omega_1^n)/(\lambda - \omega_1))G_t \to \infty$ if $1 < \lambda < R$. The assumptions allow abnormal earnings and $G_t$ to be nonstationary, which is similar to the dividend growth assumption in the Gordon dividend growth model.

[4] When we use a discounted cash flow model in equity valuation, we normally conduct short-term forecasts up to a horizon and assume a long-term steady growth rate of future abnormal earnings (cash flows) beyond the horizon. ($\lambda - 1$) here can be viewed as a smoothed average growth rate. It implicitly assumes that we pull the long-term equilibrium forward. Note that valuation involves infinite period future flows and short-term growth plays a relatively less important role. In constructing price multiples in our application of relative valuation, ($\lambda - 1$) is implied from information available at time t. It changes over time with updated information.

Proposition 1 shows that there is a one-to-one mapping between one-year ahead forecasts of (abnormal) earnings and current stock value under our model assumptions. It demonstrates that valuation of equity and forecasting of future (abnormal) earnings are interlinked. Equity value is written in terms of both current and lagged book value of equity, abnormal earnings, and nonzero NPV investment projects. The coefficient attached to abnormal earnings is the declining-perpetuity at growth of $\omega_1$. The coefficient on $G_t$ reflects a discounted compounding growth effect and the coefficient of the lagged book value represents the effect of accounting conservatism adjustment. Since conservative accounting in our model setup results from either conservative accounting principles or the firm undertakes positive NPV investments, adding the lagged book value and $G_t$ effectively "undo" accounting conservatism when using current book value and earnings numbers in valuation. Price reflecting the present value of expected all future risky cash flows anchors on the "value of assets-in-place", ($b_t + \alpha_1 x_t^a + \alpha_2 b_{t-1}$), which is measured by both book value and earnings. The two bottom line accounting numbers are presented jointly and governed by conservative principles. They are booked because uncertainty is considered to be resolved (Penman, 2021). $G_t$ then characterizes all future risky growth opportunities. However, equations (1) and (3) are not directly applicable since $G_t$ are unobservable. To overcome this problem, we develop the following proposition.

**Proposition 2**. Assume Assumptions 1 and 2. Any two of the following three statements imply the third: (i) abnormal earnings dynamic (1) holds; (ii) equity value is given by equation (3); (iii) abnormal earnings satisfy

$$E_t[x_{t+1}^a] = \delta_1 x_t^a + \delta_2 (P_t - b_t) + \omega_2 (\lambda - b_t / b_{t-1}) b_{t-1}, \qquad (4)$$

where $\delta_1 = \dfrac{\omega_1 \lambda}{R}$ and $\delta_2 = \dfrac{(R-\omega_1)(R-\lambda)}{R}$.

Proof: see the appendix.

While Proposition 1 builds a mapping between forecasting of future earnings and stock value, equation (4) explicitly establishes a precise link between stock value and the one-period ahead forecasts of (abnormal) earnings.[5] Although abnormal earnings dynamic (4) imply neither abnormal earnings dynamic (1) without valuation equation (3) nor valuation equation (3) without abnormal earnings dynamic (1), equation (4) can be viewed as a go-between. Combining (4) with either equation (1) or (3) implies the other.

Comparing with equation (1), equation (4) suggests that the value of future earnings growth ($G_t$) can be inferred from accounting goodwill (the difference between market value and book value of equity), current abnormal earnings and abnormal growth in book value. It shows that the expected one-year ahead (abnormal) earnings can be written in terms of current (abnormal) earnings, book values and market value of stock under no-arbitrage assumption and clean surplus accounting. Unlike abnormal earnings dynamic (1) and valuation equation (3), information dynamics (4) expresses future (abnormal) earnings in terms of observables if stock price is a good proxy for its intrinsic value. The intrinsic relations in Propositions 1 and 2 are important in equity valuation since the consistency can avoid potential violation of no-arbitrage condition as argued in Myers (1999). They link a firm's financial performance in its product market to the capital market. It improves the practicability of implementation of the model and build a foundation for constructing a "synthetic price multiple".

### 2.2 Determinants of valuation multiples

Applying the clean surplus relation and noting $x_t^a = x_t - (R-1)b_{t-1}$, equation (4) demonstrates how $x_t$, $b_t$ and $x_{t+1}$ articulate in valuation in a multi-dimensional setting. Following Penman (2012, 1996), a price-to-book ratio (*P/B*) of 1.0 is referred to as a "normal" P/B ratio, a price-

[5] Note that Proposition 1 does not hold without information dynamic (2). Therefore, two statements (i) and (ii) in Proposition 2 are independent.

to-earnings ratio (trailing *P/x*) of *R/(R-1)* is referred to as a "normal" trailing *P/x*, and a price-to-forward earnings ratio ($P/x_1$) of *1/(R-1)* is referred to as a "normal" forward $P/x_1$. We can establish the relation between valuation multiples and their "normal" values below.

**Proposition 3**. Assume Assumptions 1, 2 and 3. Three valuation multiples ($P/x_1$, *P/B*, *P/x*) can be written as

$$\frac{P_t}{E_t[x_{t+1}]} = \frac{1}{(R-1)} + \frac{M_1 N^T}{E_t[x_{t+1}]}, \tag{5}$$

$$\frac{P_t}{b_t} = 1 + \frac{M_2 N^T}{b_t}, \tag{6}$$

$$\frac{P_t + d_t}{x_t} = \frac{R}{(R-1)} + \frac{M_3 N^T}{x_t}, \tag{7}$$

where

$$M_1 = \frac{1}{(R-\omega_1)(R-\lambda)}\left[\frac{R(\omega_1+\lambda-1)-\omega_1\lambda}{(R-1)}, -\omega_1\lambda, -R\omega_2\right],$$

$$M_2 = \frac{1}{(R-\omega_1)(R-\lambda)}[R, -\omega_1\lambda, -R\omega_2],$$

$$M_3 = \frac{R}{(R-\omega_1)(R-\lambda)}\left[1, \frac{-(R-\lambda+\omega_1(\lambda-1))}{(R-1)}, -\omega_2\right], \text{ and}$$

$$N = [(E_t[ROE_{t+1}]-(R-1))b_t, (ROE_t-(R-1))b_{t-1}, (\lambda - b_t/b_{t-1})b_{t-1}].$$

Proposition 3 has a number of important features. First, each of the valuation multiples $P/x_1$, P/B and *P/x* is equal to its respective "normal" value $\frac{1}{R-1}$, 1 and $\frac{R}{R-1}$ plus an adjustment term. Second, value drivers and the fundamental characteristics of a company are intrinsically embedded in valuation multiples. Vector $M_i$ $(i=1,2,3)$ in the adjustment terms is determined by a company's economic and accounting characteristics. They describe the company's short-term competitive force in the marketplace ($\omega_1$), its accounting policy ($\omega_2$), the (long-term) cost of capital (*R-1*), and future growth opportunities ($\lambda$). Third, vector N in the adjustment terms contains multi-dimensional common factors in each of the valuation multiples $P/x_1$, P/B and *P/x*. It shows that the difference between return on equity (ROE, both the current and forward) and cost of equity capital, $(ROE-(R-1))$, and the deviation of growth in book value of equity from its long-run growth rate $(\lambda - b_t / b_{t-1})$ are the key determinants of these multiples and equity value.[6]

The theoretical foundation behind these multiples can be seen from the determinants of value premiums: $(P_t - \frac{E_t[x_{t+1}]}{(R-1)})$, $(P_t - b_t)$ and $(P_t + d_t - \frac{R}{(R-1)} x_t)$ from rearranging expressions in Proposition 3. These value premiums are determined by risk inherited in (future) earnings and book value under conservative accounting principles as well as the fundamental economic characteristics. Accounting numbers indicating risk are reflected in two-period book values and earnings, which are jointly in action. Earnings are not recognized until risk is resolved and assets are not booked unless they have low risk (Penman and Zhang, 2020). It tells investors to differentiate earnings released from risk and earnings still at risk. Accounting rate of return ($ROE_t = x_t / b_{t-1}$) combines earnings and book value to convey risk and value as it is demonstrated in the Fama and French (2015, 2018) five- and six-factor pricing models, and Hou et al. (2015) and its q5 extension in Hou et al. (2021). The expensing of risky investment such as R&D reduces current earnings and book value, but increases expected higher earnings from the investments in the future. Higher expected future earnings on lower current book value (relative to cost of capital) or higher expected economic spread indicates high risk.

[6] It is not inconsistent with Nissim (2013) who demonstrates that conditioning the price-to-book ratio on ROE significantly improves the valuation accuracy.

Higher current earnings on past book value or higher current economic spread shows low risk. These are reflected in the positive and negative signs attached to the forward and current economic spreads in the value premiums respectively. While two period ROE in *N* may vary significantly over the asset's life, the economic characteristics embedded in their coefficients reflecting steady state property based on currently available information in $M$ jointly determine the value premiums. The coefficients of the forward economic spread in $M_i$ *(i=1,2,3)*: $\frac{R(\omega_1+\lambda-1)-\omega_1\lambda}{(R-1)(R-\omega_1)(R-\lambda)}$ and $\frac{R}{(R-\omega_1)(R-\lambda)}$ are all positive functions of growth ($\lambda$). Since accounting numbers are governed by conservative accounting principles, accounting conservatism can be viewed as a "noise". Therefore, $M_i$ corrects that "noise" by including the $\omega_2$ term in constructing valuation multiples. Book value conservatism explicitly convey risk in the model setup via book value growth.

### 2.3 The synthetic price multiple

A synthetic price multiple is the valuation multiple when a firm's specific ($\omega_1, \omega_2, R, \lambda$) on the right-hand side of equations (5)-(7) are replaced by its industry parameters ($\omega_{it,1}, \omega_{it,2}, R_{it}, \lambda_{it}$). The fact that many practitioners use industry multiples in relative valuation suggests that an industry portfolio is a good candidate for this purpose.[7] Companies in the same industry usually compete in input and output markets, and return on equity (ROE) tends to converge to the industry mean value (Frankel and Lee 1998; Lundholm and Sloan 2014; Penman 2012). They tend to have similar risk profiles and consequently similar costs of capital (Fama and French 1997; Bhojraj and Lee 2002). Considerable cross-industry variation in the level of accounting conservatism or financial reporting practices are also documented (Barth et al. 1999; Young

[7] Industry classification is a convenient practical way to group companies sharing similar economic and accounting characteristics, although industries can be very widely based, and a company may operate in two or more different industries.

and Zeng 2015). Differences in sector growth rates have long been studied in literature (Chenery 1960; Boatsman and Baskin 1981; Alford 1992; Kim and Ritter 1999; Liu et al. 2002). The multi-dimensionality of comparable companies suggests the usefulness and importance of industry groupings. We use industry parameters ( $\omega_{it,1}, \omega_{it,2}, R_{it}, \lambda_{it}$ ) to characterize the target company's expected economic and accounting properties that are associated with infinite period future (abnormal) earnings based on currently available information. Once we have estimated ( $\omega_{it,1}, \omega_{it,2}, R_{it}, \lambda_{it}$ ) in *M*, we can estimate: $E_t[ROE_{t+1}] - (R_{it} - 1)$, $ROE_t - (R_{it} - 1)$ and $(\lambda_{it} - b_t / b_{t-1})$ for each individual firm in industry i, and hence *N*. Since equations (5)-(7) are the same equation in different forms, we can apply any of them to value equity and generate the identical value estimate if we use common set of ( $\omega_{it,1}, \omega_{it,2}, R_{it}, \lambda_{it}$ ). It suggests that there is no need to calculate a (weighted) average of the estimates obtained using several different price multiples, such as *P/E* and *P/B* in practical relative valuation (Yee, 2004).[8]

In sharp contrast with the commonly used price multiples in relative valuation, a synthetic price multiple uses the target firm's accounting and economic fundamentals, and multi-drivers of value in construction. While the conventional relative valuation does not provide clear guidance on how to identify peer companies, synthetic multiples focus on directly estimating companies' fundamentals described by ( $\omega_1, \omega_2, R, \lambda$ ) in an industry portfolio. A possible peer's $P/x_1$ or the weighted average of few peers' $P/x_1$ is likely to be different from the target company's valuation multiple, $P/x_1$. This may be not because the prices of individual peers do not reflect their intrinsic values, but those $P/x_1$ may completely disconnect from the target company's economic and accounting fundamentals.

[8] Stock reports in Refinitiv also use a weighted average of a few price multiples, such as trailing P/E and forward P/E.

## 3. Data description

The sample includes all listed companies in NYSE, Amex and Nasdaq. Data are extracted from the CRSP monthly returns file, the Compustat industrial annual file and forecasts of earnings from the Institutional Brokers Estimate System (I/B/E/S) from 1979 to 2018.[9] The adjusted number of shares outstanding and adjusted price of equity three months after the fiscal year-end are collected from CRSP. The cumulated adjustment factors for number of shares and stock price are collected from CRSP to calculate the adjusted number of shares outstanding and the adjusted price. Stock price three months after the fiscal year-end is used to ensure that information about the prior year financials has been incorporated in the analysts' forecasts of earnings. Relevant accounting data are collected from Compustat. Firms with negative book values (CEQ) are deleted. Earnings are measured as net income before extraordinary items (IB). We use one-year ahead analysts' forecasts of earnings ($feps_{t+1}$) as a proxy of market expectation of the firm's one-year ahead earnings ( $E_t[x_{t+1}]$ ).[10] The median consensus forecasts of earnings per share at the first month after the corresponding I/B/E/S-reported prior-year earnings announcements are used. All total variables used in the estimation are divided by the adjusted number of shares outstanding to reduce heteroskedasticity and increase comparability across time. In constructing the data set, 1% at the top and bottom of stock price, (price deflated) book value, (price deflated) earnings, dividends, number of shares outstanding, and (price deflated) analysts' consensus forecasts of earnings are simultaneously deleted to avoid the influence of extreme observations.

<Insert Table 1 here>

[9] Data in 2018 is one-year ahead forecasts and data in 1979 is one-year lagged values over the sample period.
[10] To mitigate the effect of analysts' bias, we also adjust the consensus forecasts for predictable errors. The main results, not reported here, are similar.

Table 1 shows the statistics of variables of interest in our analysis. For the purpose of illustration in application of $P/x_1$, we delete firm-year observations with negative consensus forecasts of one-year ahead earnings and divide the full sample into 12 industries using the classification from Ken French's website.[11] In total, there are 104,289 firm-year observations between 1980 and 2017.

## 4. Estimation and application of synthetic price multiples

In this section, we first estimate industry-year LID parameters, cost of equity capital, and the synthetic price multiples. We then discuss the valuation accuracy and prediction of stock returns by applying the synthetic price multiples. Finally, as an example, we discuss the difference between the synthetic price multiples across the ESG stocks and other stocks, and the implication for firms engaging with the ESG activities.

### 4.1 Estimation of industry-year LID parameters and cost of equity capital

We focus on the most widely utilized multiple $P/x_1$ in the following analysis. Proposition 2 provides a foundation on how we can simultaneously estimate valuation parameters ($\omega_1, \omega_2, R, \lambda$). From equation (4), the expected one-year ahead earnings can be written in terms of current earnings, current and lagged book values, and current stock value. We use one-year ahead analysts' forecasts of earnings as a proxy for the market expected earnings and stock price as a proxy for the intrinsic value. To reduce the effects of endogeneity, we can alternatively write it in the form of the forward earnings-to-price ratio in terms of the current earnings-to-price, book value-to-price and lagged book value-to-price ratios as below:

[11] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

$$\frac{x_{t+1}}{P_t}=\frac{(R-\lambda)(R-\omega_1)}{R}+\frac{\omega_1\lambda}{R}\frac{x_t}{P_t}+[R-1-\omega_2-\frac{(R-\lambda)(R-\omega_1)}{R}]\frac{b_t}{P_t}$$
$$+\lambda[\omega_2-\frac{(R-1)\omega_1}{R}]\frac{b_{t-1}}{P_t}+\varepsilon_{t+1}. \tag{8}$$

Note that equation (8) is exactly identified since there are four "instruments" and four "parameters", ( $\omega_1,\omega_2,R,\lambda$ ). We use a jack-knifing procedure to simultaneously estimate firm-industry-year specific parameters (Easton et al. 2002, Nekrasov and Ogneva 2011, Ashton and Wang 2013). Specifically, given that the four parameters are connected in a nonlinear fashion, we can run cross-sectional nonlinear regressions using data for each firm-year in industry *i* without using the target firm's data to generate parameters, ( $\omega_{it,1},\omega_{it,2},\lambda_{it},R_{it}$ ). This allows the LID parameters to reflect variation in economic and accounting environment across industries and over years. This contrasts with most of accounting-based valuation literature that assumes a constant discount rate for all firms and all years in the model application. Since some industries only have a limited number of observations in some sample years, we run regressions on a five-year rolling window basis. It may also mitigate possible industry-wide bubble effect in estimating a specific year valuation parameters. Table 2 reports the average implied LID parameters $(\omega_1,\omega_2,\lambda-1)$ and the cost of equity capital (*R-1*) as well as their t-statistics on a year-by-year basis across 12-industry based on equation (8).[12]

<Insert Table 2 about here>

Table 2 shows that the mean and the median of the expected (nominal) long-term growth rates ( $\lambda-1$) are 3.9% and 4.0% respectively. The expected growth rates have a decline trend after the turn of the century with a minimum value of 2.4% in 2007. The cost of equity capital has a clear trend of decline from a high of 15.1% in 1981 to 7.2% in 2016. Its mean and median

[12] Since they are nonlinear regressions, we first use ( $\omega_1,\omega_2,\lambda,R-1$ ) = (0.2, 0.05, 1.0, 0.09) as a starting point. These are parameter values similar to those reported or used in prior literature.

are 9.8% and 9.3% respectively. The risk premiums of equity tend to increase over years with both mean and median being about 3.6%. They are close to those reported in Claus and Thomas (2001) and Gebhardt et al. (2001) if considering the same sample periods. The persistence of abnormal earnings ( $\omega_1$ ) is between 0.059 and 0.366 with mean of 0.132. It declines from 1980 to the middle of 1990s indicating that competitors may mimic innovations, so the persistence of abnormal profits is quickly diminishing. The persistence then stabilizes in a narrow range. The conservatism parameter ( $\omega_2$ ) is significantly positive in most sample years with mean (median) of 0.03 (0.029).

<Insert Table 3 about here>

Table 3 reports the average of estimates on an industry-by-industry basis over 38 years. As we would expect, Industry #10 "Healthcare, Medical Equipment, and Drugs" has the highest growth rate ( $\lambda - 1$ ) of 4.9%. Industry #3 "Manufacturing" and industry #4 "Oil, Gas, and Coal Extraction and Products" have the lowest growth rate of 3.3%. Industry #7 "Telephone and Television Transmission" has the lowest cost of capital of 8.4% and lowest risk premium of 2.1%. Industry #2 "Consumer Durables" has the highest cost of equity capital of 11.1% and risk premium of 4.9%. Industry #8 "Utilities" and Industry #5 "Chemicals and Allied Products" have the highest persistence of abnormal earnings of 0.189. Industry #6 "Computers, Software, and Electronic Equipment" has the lowest persistence of abnormal earnings of 0.085 and smallest accounting conservatism parameter of 0.019.

### 4.2 Synthetic $P/x_1$ and $P/B$ multiples

Equation (5) shows that vectors $M$ and $N$ jointly determine the synthetic price-to-forward earnings ratio and value premium over the capitalized expected one-period ahead earnings. For illustrative purpose, in the following analysis we examine four industries that have relatively large number of observations: Consumer Non-Durables (#1), Manufacturing (#3), Business Equipment (#6) and Shops (#9).[13]

We first run cross-sectional regressions using data for each firm-year in each of the four industries without using the firm's data to generate parameters ( $\omega_{it,1}, \omega_{it,2}, \lambda_{it}, R_{it}$ ), then we calculate the coefficients of forward spread, current spread and the abnormal growth in book value term in equation (5). Finally, we can estimate the synthetic price-to-forward earnings ratio:

$$P / x_1 \equiv \frac{1}{(R-1)} + \frac{M_1 N^T}{feps_{t+1}},$$

where $M_1 = [M_{11,i}, M_{12,i}, M_{13,i}]$ , $M_{11,i} = \frac{R_{it}(\omega_{it,1} + \lambda_{it} - 1) - \omega_{it,1}\lambda_{it}}{(R_{it} - \omega_{it,1})(R_{it} - \lambda_{it})(R_{it} - 1)}$ ,

$M_{12,i} = \frac{-\omega_{it,1}\lambda_{it}}{(R_{it} - \omega_{it,1})(R_{it} - \lambda_{it})}$, $M_{13,i} = \frac{-R_{it}\omega_{it,2}}{(R_{it} - \omega_{it,1})(R_{it} - \lambda_{it})}$, and $N_{i,j} = [N_{i,j1}, N_{i,j2}, N_{i,j3}]$, where $N_{i,j1} = (E_t[ROE_{j,t+1}] - (R_{it} - 1))b_{j,t}$, $N_{i,j2} = (ROE_{j,t} - (R_{it} - 1))b_{j,t-1}$, and $N_{i,j3} = (\lambda_{it} - b_{j,t} / b_{j,t-1})b_{j,t-1}$ describe the forward spread, current spread and the abnormal growth in book value for firm *j* in industry *i*. For comparison, we also report the synthetic price-to-book ratio as in (6):

$$P / B \equiv 1 + \frac{M_2 N^T}{b_t},$$

[13] Industry "Consumer Non-Durables" include food, tobacco, textiles, apparel, leather and toys. Industry "Manufacturing" includes machinery, trucks, planes, paper and printing. Industry "Business Equipment" includes computers, software, and electronic equipment. Industry "Shops" include wholesale, retail, and some services (laundries and repair shops).

where $M_2 = [M_{21,i}, M_{22,i}, M_{23,i}]$, $M_{21,i} = \dfrac{R_{it}}{(R_{it} - \omega_{it,1})(R_{it} - \lambda_{it})}$, $M_{22,i} = M_{12,i}$ and $M_{23,i} = M_{13,i}$ for firm *j* in industry *i*. To generate meaningful price multiples, we drop company observations with negative synthetic $P/x_1$ and $P/B$.[14]

<Insert Table 4 about here>

<Insert Figure 1 about here>

In Table 4 and Figure 1, we compare the synthetic price-to-forward earnings ratios with the actual price-to-forward earnings ratios for the four industries over our sample period. In general, the actual price-to-forward earnings ratios are higher than the synthetic price-to-forward earnings ratios. The medians of the actual price-to-forward earnings ratios are 15.73, 15.16, 20.66 and 15.98 for industries “Consumer Non-Durables”, “Manufacturing”, “Business Equipment” and “Shops” respectively, the corresponding medians of the synthetic price-to-forward earnings ratios are 12.97, 11.85, 15.71 and 13.44 over 1980-2017. The actual price multiples are also much more volatile as expected. Figure 1 shows that the gap between the actual and synthetic price multiples are particularly larger for Industry “Business Equipment” from 1990s to 2008. In fact, almost all actual price multiples are less than the synthetic price multiples for the four industries during 2007-2008 global financial crisis. It suggests that the synthetic price multiples are more resilient and valuation based on the multiples may better reflect stock intrinsic values particularly during financial crisis. The correlation between the synthetic price multiples and actual price multiples are between 0.8 and 0.89.

The synthetic price-to-book ratios and actual price-to-book ratios on a year-by-year basis for each of the four industries are reported in Table 5.

[14] There are about 4 percent of company observations with negative synthetic $P/x_1$ and $P/B$.

<Insert Table 5 about here>

We can observe a similar pattern that the synthetic price-to-book ratios are in general lower than the actual price-to-book ratios. A few exceptions include turbulent periods in the financial markets surrounding 1987, 2000 and 2008.

Tables 4 and 5 show that the mean and the median of the synthetic $P/x_1$ are between 11.85 and 13.44, except for industry “Business Equipment”, which is about 15.7. This industry also has the highest mean and median of synthetic P/B, which are 3.06 and 2.97 respectively. Otherwise, the mean and the median of the synthetic *P/B* are between 2.18 and 2.72, while the mean and the median of the actual *P/B* are between 2.42 and 2.85. On the contrary, industry “Manufacturing” has the lowest mean and median of the synthetic $P/x_1$ and P/B. This should be expected since industry “Business Equipment” consists of high-tech companies and “Manufacturing” is a traditional industry. There is considerable cross-industry variation in the price multiples.

<Insert Figure 2 about here>

Figure 2 plots the synthetic price-to-forward earnings ratios and price-to-book ratios over the sample period. It indicates that in general both synthetic $P/x_1$ and *P/B* have an upward trend for each of the four industries over our sample period. This upward trend is not inconsistent with empirical findings in capital market research that document fundamental accounting numbers failure to fully account some value relevant items such as intangible assets and customers’ data in the digital era.

The cross-industry variation in the price multiples for all 12-industry is detailed in Table 6 and Figure 3 below. As a robustness check, we run 5-year rolling window regressions without using a jack-knifing procedure in this exercise.

<Insert Table 6 about here>

<Insert Figure 3 about here>

They show that on average the actual price-to-forward earnings ratios are greater than the synthetic price-to-forward earnings ratios for all 12-industry. As expected, the utility industry, "Utils", has the smallest difference between the two price-to-earnings ratios. They also show that the actual price-to-book ratios are all greater than the synthetic price-to-book ratios except for the energy industry, "Enrgy".

### 4.3 Valuation bias and inaccuracy

Next, we apply the synthetic $P/x_1$ as an example to value equity shares. The value of a share equals the synthetic $P/x_1$ multiplying by its one-period ahead forecasts of earnings per share. To evaluate valuation bias and valuation inaccuracy, we follow prior studies and define valuation bias as the difference between observable stock prices and the predicted values from the synthetic $P/x_1$ multiple, scaled by price. Valuation inaccuracy is defined as the absolute value of the difference between observable stock prices and the multiple predicted values, scaled by price.

For comparison, we also report valuation bias and inaccuracy by directly estimating LID parameters and $G_t$ in (1) and (2), using the sequential approach as in Dechow et al. (1999). Specifically, we first assume a constant discount rate and use historical accounting data to run regressions to estimate LID parameters ($\omega_1, \omega_2$) in a cross section by ignoring $G_t$. We assume a discount rate of 9%, which is close to the median that we estimate.[15] Second, using one-period ahead analysts' forecasts of earnings as a proxy of $E_t[x_{t+1}]$ and unconditional LID parameters ($\omega_1, \omega_2$) from the first stage, we estimate the value of $G_t$ from equation (1):

[15] Dechow et al. (1999) assume a cost of equity capital of 12%. They also use 9% and 15% in their robustness test. Given the decline trend of risk-free rate over the last two decades, we assume a cost of equity of 9%. We also apply a 12% discount rate and find the valuation errors are much higher.

$G_t = E_t[x_{t+1}^a] - \omega_1 x_t^a - \omega_2 (Rb_{t-1} - b_t)$ and then estimate the persistence of $G_t$ from regressions on (2). Finally, equity value is given by equation (3), the discounted abnormal earnings model.

<Insert Table 7 about here>

Panel A of Table 7 reports the valuation bias. It shows that the mean valuation biases from the synthetic $P/x_1$ multiple approach are between -0.006 and -0.057 across the four industries, while the minimum mean of valuation biases from the sequential approach is 0.267. It suggests that estimates from the multiple approach slightly overstates stock prices, but those from the sequential approach severely understates stock prices. The median valuation biases from the multiple approach are between 0.07 and 0.09, while the median biases from the sequential approach are between 0.362 and 0.518. The evidence of severe underestimation from the sequential approach is consistent in magnitude with the prior literature (Dechow et al. 1999; Choi et al. 2006). Panel B of Table 7 reports the valuation inaccuracy. It shows that the estimates from the synthetic $P/x_1$ multiple approach are more accurate than those from the sequential approach. The median valuation inaccuracy from the $P/x_1$ multiple approach is between 0.278 and 0.36, while the median from the sequential approach is between 0.413 and 0.532 across the four industries. Therefore, valuation biases and valuation inaccuracy are substantially improved by applying our synthetic $P/x_1$ multiples.

### 4.4 Prediction of stock returns

If an actual price-to-forward earnings ratio is deviated from a synthetic price-to-forward earnings ratio, we should be able to create portfolios based on the difference between the two ratios and generate a hedge return based on extreme differences if the synthetic price multiple is a better tool to value equity (Sloan 2002). Note that the synthetic price multiples incorporate both a company's short- and long-term economic properties and reflect its fundamental value, while actual price multiples describe contemporaneous price relative to the one-period ahead earnings. If actual price multiples of a portfolio are much bigger (smaller) than its synthetic price multiples, then the portfolio should have low (high) risk and returns. Therefore, firms with high synthetic price multiples relative to its actual price multiples should outperform firms with low synthetic multiples relative to the actual multiples. For this purpose, we calculate the difference between the synthetic price-to-forward earnings ratios and actual price-to-forward earnings ratios for each firm each year. We group all firms into 10 deciles based on the difference each year and calculate the one-, two- and three-year-ahead realized buy-and-hold returns. Firms in decile 1 have the smallest difference between the synthetic price-to-forward earnings ratios and actual price-to-forward earnings ratios, and firms in decile 10 have the largest. Therefore, firms in decile 1 should have lower returns than firms in decile 10. In the middle deciles, it is not clear whether firms are over- or under-priced relative to the estimates based on the synthetic multiples.

< Insert Table 8 about here>

Panel A of Table 8 indeed shows that the one-, two- and three-year buy-and-hold returns for firms in decile 1 are 0.132, 0.237 and 0.368 respectively, while those are 0.203, 0.375 and 0.571 for firms in decile 10. The return differences between these two deciles are both statistically and economically significant. Portfolios formed based on the difference between the synthetic price-to-book ratios and actual price-to-book ratios have similar properties as shown in Panel B of Table 8. It suggests that it is profitable by buying portfolios with high ($P/x_1$ –actual price-to-forward earnings ratio) or ($P/B$ –actual price-to-book ratio) and shorting portfolios with low ($P/x_1$ –actual price-to-forward earnings ratio) or ($P/B$ –actual price-to-book ratio).

**4.5 The synthetic price multiples of ESG stocks**

We close this section by applying the synthetic price multiples on the environmental, social and governance (ESG) stocks. Since many investors prioritize the ESG goals in recent decades, we should be able to find the footprints that firms investing in ESG and disclosing ESG information are align with increasing in shareholders' value. The Bloomberg ESG disclosure score quantifies a company's transparency in reporting ESG information. It indicates the amount of ESG data a company reports publicly from 2005. The score ranks from 0 to 100, where 0 indicates no disclosure about any ESG issues and 100 the highest level of ESG disclosure with some identical disclosure scores for some firms in a particular year. We refer to firms with high ESG disclosure scores as the ESG firms. It is interesting to know whether the difference between the synthetic price multiples and actual price multiples differs between the ESG firms and other firms. Can we observe the ESG firms have high difference between the synthetic price-to-forward earnings (price-to-book) ratios and actual price-to-forward earnings (price-to-book) ratios? Information in accounting disclosures including the ESG disclosures is important input in equity valuation. Can the ESG disclosures reduce valuation error and improve valuation accuracy? Informational efficiency implies that the disclosures should help in price discovery. For firms with high ESG disclosure scores, we would expect an improved valuation accuracy. To answer these questions, we group all firms into 5 quintiles based on their ESG scores each year from 2005 to 2017. Firms in quintile 1 have the lowest ESG scores and firms in quintile 5 have the highest.

<Insert Table 9 about here>

<Insert Figure 4 about here>

Table 9 and Figure 4 show that the synthetic price-to-forward earnings ratios have an upward trend with the ESG scores, while the actual price-to-forward earnings ratios decrease with the ESG score. The difference between the actual price-to-forward earnings ratios and synthetic price-to-forward earnings ratios reaches its smallest value in quintile 5, from 5.2 in quintile 1 to 0.1. Not only is the difference between the two ratios largest in quintile 5, but Table 9 also shows that the absolute difference between the two ratios decreases monotonically from 5.2 to 0.1 for the ESG firms. That is, the actual price-to-forward earnings ratios are much higher than its synthetic counterpart for the non-ESG stocks, but the two ratios are very similar for the ESG stocks. It suggests that the ESG stocks are fairly priced but non-ESG are likely overpriced relative to their intrinsic values. There is little evidence of 'green bubble' if we use price-to-earnings as a benchmark. On the other hand, both synthetic price-to-book ratios and actual price-to-book ratios increase with the ESG score, but the difference between the synthetic price-to-book ratios and actual price-to-book ratios is the largest in quintile 5. While the actual price-to-book ratios are slightly higher than its synthetic counterpart for the non-ESG stocks, the synthetic price-to-book ratios are higher than the actual price-to-book ratios for the ESG stocks. Again, this difference in price-to-book suggests that the non-ESG stocks may be slightly overpriced, but the ESG stocks are likely undervalued relative to their intrinsic values.

To further address whether there exists a 'green bubble' for the ESG stocks, we use a metric independent of value drivers used in the multiples. Table 9 shows that the valuation biases decrease and the valuation accuracy improves when the ESG scores increase. For quintile 5, we observe that the valuation bias defined as the difference between observable stock prices and the predicted values scaled by price is actually negative. It suggests that the ESG stocks are likely under priced. The evidence suggests that ESG disclosures can help in price discovery when applying the synthetic price-to-forward earnings ratio. If an investor buys firms with high difference between the synthetic price-to-forward earnings ratios and actual price-to-forward earnings ratios, she would buy firms with high ESG scores. Therefore, the disclosure of ESG-related information may help a company to attract money from the capital markets in a sustainable manner and ESG activities are not a waste of corporate resources (Lys et al. 2015;

Ferrell et al. 2016). It is consistent with veteran businessman Ronnie Cohen's assessment that "you can already see a correlation in the data between greater pollution and lower stock market valuations, as ESG money has shifted the scale in favour of companies that pollute less" (Edgecliffe-Johnson et al. 2021).

## 5. Concluding remarks

Investment community apparently prefers to use price multiples in practical valuation. However, it is a challenge to verify the validity of a proxy for the target company's price multiple since there is no rigorous theoretical foundation to guide investors on how to identify comparable peers, select value drivers and aggregate the peers' price multiples. The target company's price multiples disconnect from the popular discounted cash flow (DCF) valuation models introduced in the valuation textbooks. In this paper, we aim to bridge the gap between price multiples and the DCF models by introducing a "synthetic price multiple."

Guided by the theoretical linkage between the synthetic price multiples and the competitive position of the target company, the cost of equity capital, long-term growth of earnings and the degree of accounting conservatism, we directly estimate parameters that describe these economic and accounting characteristics from companies in the same industry as the target company. A synthetic price multiple does not only reflect the industry common fundamental economic and accounting characteristics, but it is also determined by the future and current economic spreads, and abnormal growth in book value of the target company that drive cross-sectional variation across companies in its industry. In essence, a synthetic price multiple is built on the idea that value premium is determined by risk and accounting policy. Like conventional price multiples, the synthetic price multiples only rely on one-period ahead forecasts of earnings and current period accounting numbers, and do not assume a company's dividend policy.

We apply a synthetic price-to-forward earnings ratio in equity valuation on companies in four representative industries as an example. We construct a synthetic price-to-forward earnings ratio for each company in an industry based on simultaneously estimated parameters that describes the common economic and accounting characteristics and the company's own value drivers embedded in valuation theory. The synthetic price-to-forward earnings ratio is therefore more systematic and less subjective to the price-to-earnings ratio commonly used in relative valuation. The empirical results suggest that a synthetic price multiple is an additional tool to value assets. We find that valuation bias and inaccuracy are substantially improved by applying the synthetic price multiples comparing to those by applying the conventional procedure. We also find that the extreme deviation between the actual price multiples and synthetic price multiples can be used to identify mispricing of assets. In addition, we find that the disclosure of ESG-related information may help a company to attract funds from the capital markets, a supporting evidence that firms investing in ESG also behave in shareholders' long-term interests.

A synthetic price multiple can also be constructed at the enterprise level. In the above analysis, equity level book value, earnings and stock prices can be replaced by net operating assets (NOA), operating incomes ($OI$) and the enterprise value (V) respectively. The persistence of abnormal net operating income, the conservatism parameter, long-term growth rate and the weighted average cost of capital can be simultaneously estimated on an industry-year basis. Therefore, we can estimate the synthetic enterprise level value-to-forward earnings ratio ($V/OI_1$) for the target company. Once we estimate the company's $V/OI_1$, we can estimate its value by multiplying the ratio to the one-period ahead forecasts of operating income of the company. We can also estimate a number of variants of synthetic valuation multiples of $V/OI_1$ such as value-to-EBIT, value-to-EBITA, value-to-EBITDA and value-to-sales. They are the product of a synthetic enterprise level value-to-forward earnings ratio (value-to-NOA ratio) and a measure of profit margin (asset turnover).

As long as fundamental accounting numbers are available, the synthetic price multiples also apply to non-listed companies. Since operating earnings and operating assets are produced jointly and governed by conservative accounting principles, and private companies are not legally required to publicly disclose their financial statements in the U.S, using the synthetic value multiples that characterize both operating earnings and assets in determining private firms' values become even more important. We can follow Gompers et al. (2008) and Badertscher et al. (2019) to use industry-level valuation parameters of all publicly-traded firms in the industry as a proxy for privately-held firms since public firms and private firms share common input and output markets. As a result, the synthetic value multiples reflect the industry common fundamental economic and accounting characteristics (in *M*), and the cross-sectional variation in its industry (in *N*). Given that analysts' forecasts of earnings is not available for privately-held firms, conventional price-to-forward earnings ratio is not applicable. However, we can apply the synthetic value-to-book asset multiple and expect it to generates the identical firm value as applying the synthetic value-to-forward earnings multiple. Furthermore, the synthetic multiples could be applied in settings of ownership transition, IPO and M&A activities. We can analyze whether value is created or destroyed from public to private ownership or vice versa.

## Appendix:

**Proof of Proposition 1**:

**"Sufficiency"**. Assume equations (1) and (2). The present value of all expected future abnormal earnings is a function of current abnormal earnings, lagged book value and nonzero NPV investments. We can write it as equation (3), and then identify unique valuation parameters ( $\alpha_1, \alpha_2, \alpha_3$ ) in terms of ( $\omega_1, \omega_2, \lambda$ ,R). From equation (3) and Assumption 2: $b_{t+1} + d_{t+1} = Rb_t + x_{t+1}^a$, we have

$$P_{t+1} + d_{t+1} = b_{t+1} + d_{t+1} + \alpha_1 x_{t+1}^a + \alpha_2 b_t + \alpha_3 G_{t+1} = Rb_t + (1+\alpha_1) x_{t+1}^a + \alpha_2 b_t + \alpha_3 G_{t+1} .$$

Assumption 1: $E_t[P_{t+1} + d_{t+1}] = RP_t$ and equation (2) imply that

$$Rb_t + (1+\alpha_1) E_t[x_{t+1}^a] + \alpha_2 b_t + \alpha_3 \lambda G_t = RP_t . \qquad (*)$$

The LID further implies that

$$Rb_t + (1+\alpha_1)(\omega_1 x_t^a + \omega_2 (Rb_{t-1} - b_t) + G_t) + \alpha_2 b_t + \alpha_3 \lambda G_t = R(b_t + \alpha_1 x_t^a + \alpha_2 b_{t-1} + \alpha_3 G_t) .$$

Comparing the coefficients of $x_t^a, Rb_{t-1} - b_t$ and G$_t$, we have the following equation system:

$$\begin{aligned} &(1+\alpha_1)\omega_1 = R\alpha_1, \\ &-(1+\alpha_1)\omega_2 + \alpha_2 = 0, \\ &(1+\alpha_1) + \alpha_3 \lambda = R\alpha_3. \end{aligned}$$

Solving the above equation system, we have the valuation parameters: $\alpha_1 = \dfrac{\omega_1}{R - \omega_1}$ , $\alpha_2 = \dfrac{R\omega_2}{R - \omega_1}$ and $\alpha_3 = \dfrac{R}{(R - \omega_1)(R - \lambda)}$ .

**"Necessity"**. Assume equations (3) and (2). From equation (3), Assumptions 1 and 2, we have

$$Rb_t + (1+\alpha_1) E_t[x_{t+1}^a] + \alpha_2 b_t + \alpha_3 \lambda G_t = R(b_t + \alpha_1 x_t^a + \alpha_2 b_{t-1} + \alpha_3 G_t) .$$

Reorganizing terms and noting $\alpha_1 = \dfrac{\omega_1}{R-\omega_1}$, $\alpha_2 = \dfrac{R\omega_2}{R-\omega_1}$, $\alpha_3 = \dfrac{R}{(R-\omega_1)(R-\lambda)}$, we have

$$E_t[x_{t+1}^a] = \frac{R\alpha_1}{(1+\alpha_1)} x_t^a + \frac{\alpha_2}{(1+\alpha_1)}(Rb_{t-1} - b_t) + \frac{(R-\lambda)\alpha_3}{(1+\alpha_1)} G_t = \omega_1 x_t^a + \omega_2 (Rb_{t-1} - b_t) + G_t.$$

**Proof of Proposition 2**:

First, we show that equations (1) and (3) imply equation (4). From equations (1) and (3), we have

$$\begin{aligned}
&E_t[x_{t+1}^a] = \omega_1 x_t^a + \omega_2 (Rb_{t-1} - b_t) + G_t \\
&= \frac{\omega_1\lambda}{R} x_t^a + \frac{(R-\omega_1)(R-\lambda)}{R}\left(\frac{\omega_1}{R-\omega_1} x_t^a + \frac{R\omega_2}{R-\omega_1} b_{t-1} + \frac{R}{(R-\omega_1)(R-\lambda)} G_t\right) - \omega_2 (b_t - \lambda b_{t-1}) \\
&= \frac{\omega_1\lambda}{R} x_t^a + \frac{(R-\omega_1)(R-\lambda)}{R}(P_t - b_t) - \omega_2 (b_t - \lambda b_{t-1}).
\end{aligned}$$

Next, we show equations (4) and (1) imply equation (3) or equations (4) and (3) imply equation (1). From equation (4), we have

$$\begin{aligned}
E_t[x_{t+1}^a] &= \frac{\omega_1\lambda}{R} x_t^a + \frac{(R-\omega_1)(R-\lambda)}{R}(P_t - b_t) - \omega_2 (b_t - \lambda b_{t-1}) \\
&= \omega_1 x_t^a + \omega_2 (Rb_{t-1} - b_t) + \frac{(R-\omega_1)(R-\lambda)}{R}\left[P_t - \left(b_t + \frac{\omega_1}{(R-\omega_1)} x_t^a + \frac{R\omega_2}{R-\omega_1} b_{t-1}\right)\right].
\end{aligned} \tag{*}$$

If information dynamic (1) holds, the left-hand side of (*), $E_t[x_{t+1}^a]$ can be replaced by $\omega_1 x_t^a + \omega_2 (Rb_{t-1} - b_t) + G_t$. Reorganizing terms in (*), we have: $P_t = b_t + \alpha_1 x_t^a + \alpha_2 b_{t-1} + \alpha_3 G_t$, where $\alpha_1 = \dfrac{\omega_1}{R-\omega_1}$, $\alpha_2 = \dfrac{R\omega_2}{R-\omega_1}$, and $\alpha_3 = \dfrac{R}{(R-\omega_1)(R-\lambda)}$. That is, valuation equation (3) holds.

If valuation model (3) holds, the right-hand side of (*) $P_t-(b_t+\frac{\omega_1}{(R-\omega_1)}x_t^a+\frac{R\omega_2}{R-\omega_1}b_{t-1})=\frac{R}{(R-\lambda)(R-\omega_1)}G_t$ . Therefore, (*) implies information dynamic (1): $E_t[x_{t+1}^a]=\omega_1 x_t^a+\omega_2(Rb_{t-1}-b_t)+G_t$.

**Proof of Proposition 3**:

Since $b_{t-1}=b_t-(x_t-d_t)$, equation (4) implies that stock value can be written in terms of current earnings, book value, dividends and expected one-year ahead forecasts of earnings as:

$$P_t=\Psi\times x_t+\mathrm{B}\times b_t+\Delta\times d_t+\Phi\times E_t[x_{t+1}], \tag{9}$$

where

$$\begin{aligned}\Psi&=\frac{R(\omega_2-\omega_1)\lambda}{(R-\omega_1)(R-\lambda)}, &\mathrm{B}&=\frac{R(1-\omega_1+\omega_2)(1-\lambda)}{(R-\omega_1)(R-\lambda)}\ ,\\ \Delta&=\frac{((R-1)\omega_1-R\omega_2)\lambda}{(R-\omega_1)(R-\lambda)}, &\text{and}\quad \Phi&=\frac{R}{(R-\omega_1)(R-\lambda)}.\end{aligned} \tag{10}$$

To illustrate how each of valuation multiples, *P/x₁*, P/B and *P/x* is related to its normal benchmark, we reorganize valuation equation (9) in the following value premium forms.

$$\begin{aligned}P_t-\frac{E_t[x_{t+1}]}{(R-1)}&=\frac{R(\omega_1+\lambda-1)-\omega_1\lambda}{(R-\omega_1)(R-\lambda)(R-1)}[E_t[ROE_{t+1}]-(R-1)]b_t\\&-\frac{\omega_1\lambda}{(R-\omega_1)(R-\lambda)}[ROE_t-(R-1)]b_{t-1}-\frac{R\omega_2}{(R-\omega_1)(R-\lambda)}(\lambda-b_t/b_{t-1})b_{t-1},\end{aligned} \tag{11}$$

or

$$\begin{aligned}P_t-b_t&=\frac{R}{(R-\omega_1)(R-\lambda)}[E_t[ROE_{t+1}]-(R-1)]b_t\\&-\frac{\omega_1\lambda}{(R-\omega_1)(R-\lambda)}(ROE_t-(R-1))b_{t-1}-\frac{R\omega_2}{(R-\omega_1)(R-\lambda)}(\lambda-b_t/b_{t-1})b_{t-1},\end{aligned} \tag{12}$$

or

$$P_t + d_t - \frac{R}{(R-1)} x_t = \frac{R}{(R-\omega_1)(R-\lambda)} (E_t[ROE_{t+1}] - (R-1)) b_t$$
$$- \frac{R(R-1-(1-\omega_1)(\lambda-1))}{(R-1)(R-\omega_1)(R-\lambda)} (ROE_t - (R-1)) b_{t-1} - \frac{R\omega_2}{(R-\omega_1)(R-\lambda)} (\lambda - b_t / b_{t-1}) b_{t-1}, \tag{13}$$

where return on equity $ROE_t = x_t / b_{t-1}$ and $E_t[ROE_{t+1}] = E_t[x_{t+1}] / b_t$. Dividing equations (11)-(13) by $E_t[x_{t+1}]$, $b_t$ and $x_t$ respectively, and reorganizing terms, we have Proposition 3.

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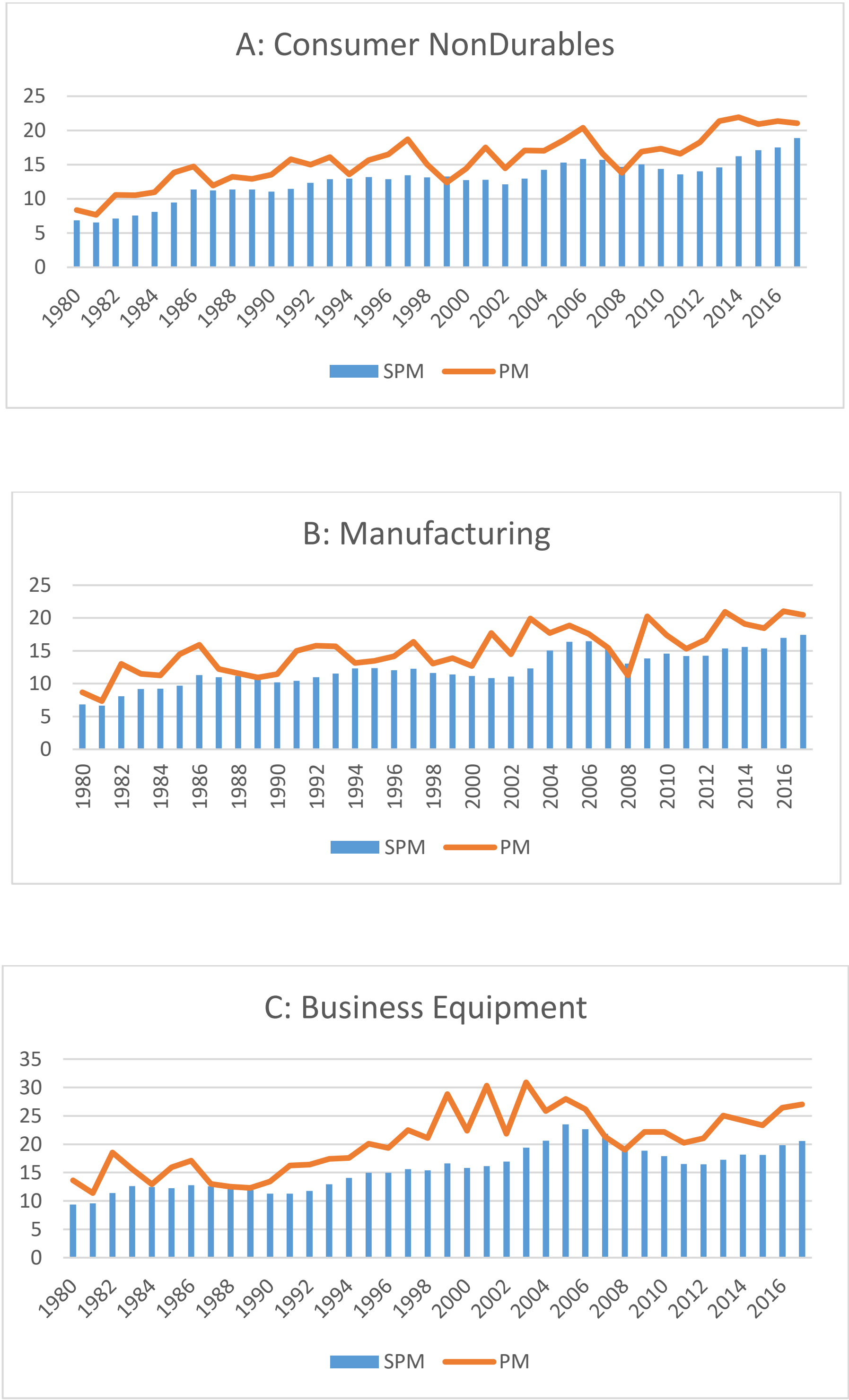
**Figure 1: Synthetic price-to-forward earnings ratio (SPM) vs. actual price-to-forward earnings ratio (PM) by year**



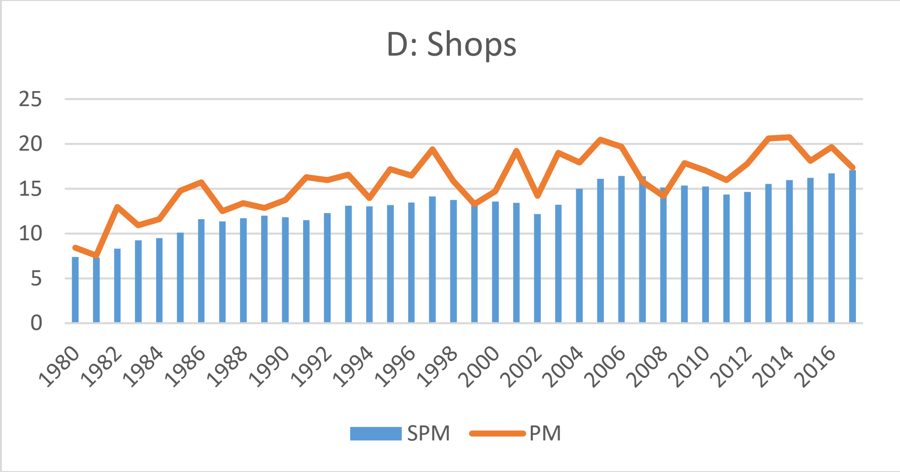
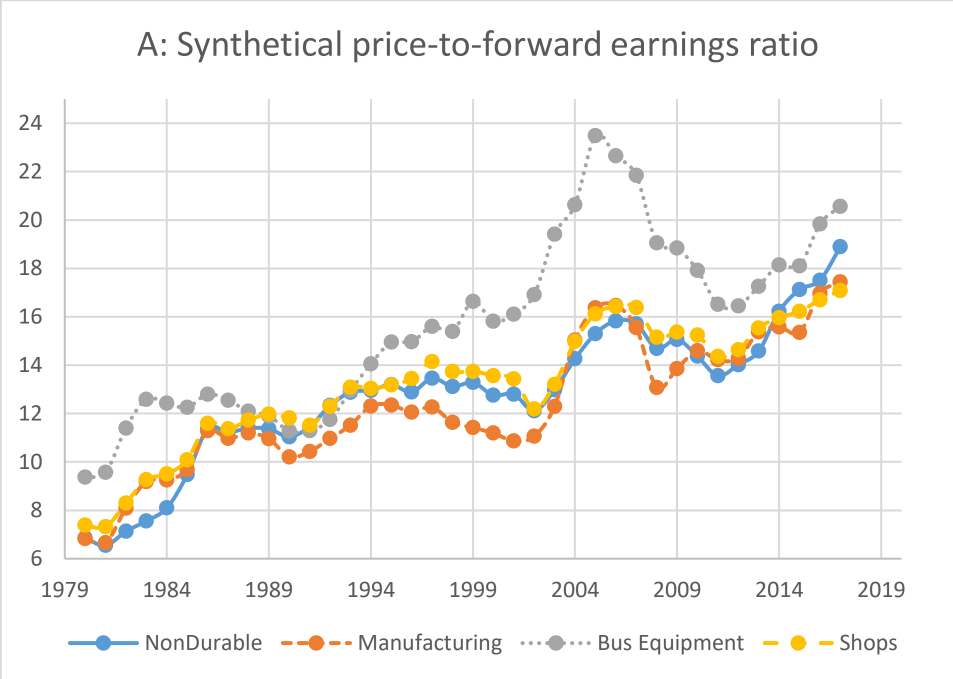



Figure 1 (A)-(D) show the trends of synthetic price-to-forward earnings ratios and actual price-to-forward earnings ratios for four industries between 1980 and 2017. The industry definitions are obtained from Kenneth French's online data library, 12-industry classification.

**Figure 2: Trends of synthetic price-to-forward earnings ratios and price-to-book ratios**



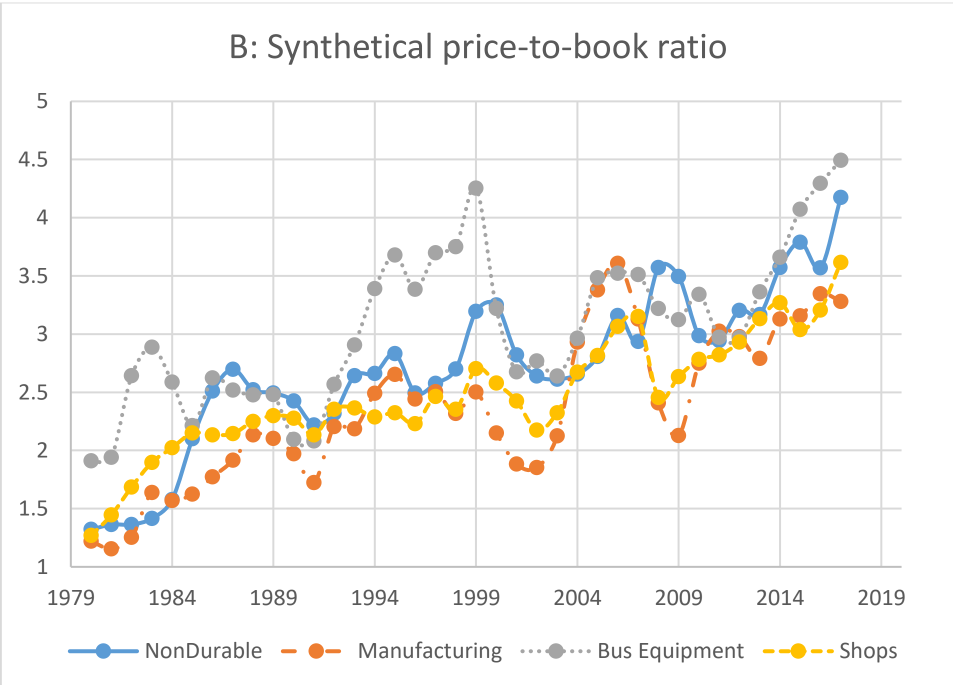
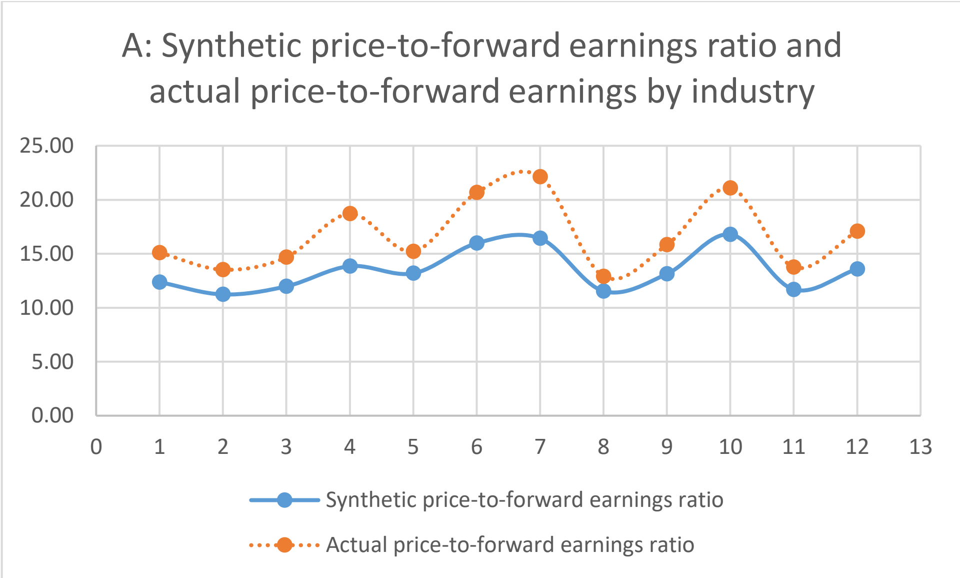




Figure 2 (A) and (B) show the trends of synthetic price-to-forward earnings ratios and synthetic price-to-book value ratios for four industries: Consumer Non-Durables, Manufacturing, Business Equipment and Shops between 1980 and 2017. The industry definitions are obtained from Kenneth French's online data library, 12-industry classification.

**Figure 3: Synthetic *$P/x_1$* vs. actual *$P/x_1$* and synthetic P/B vs. actual P/B by industry**



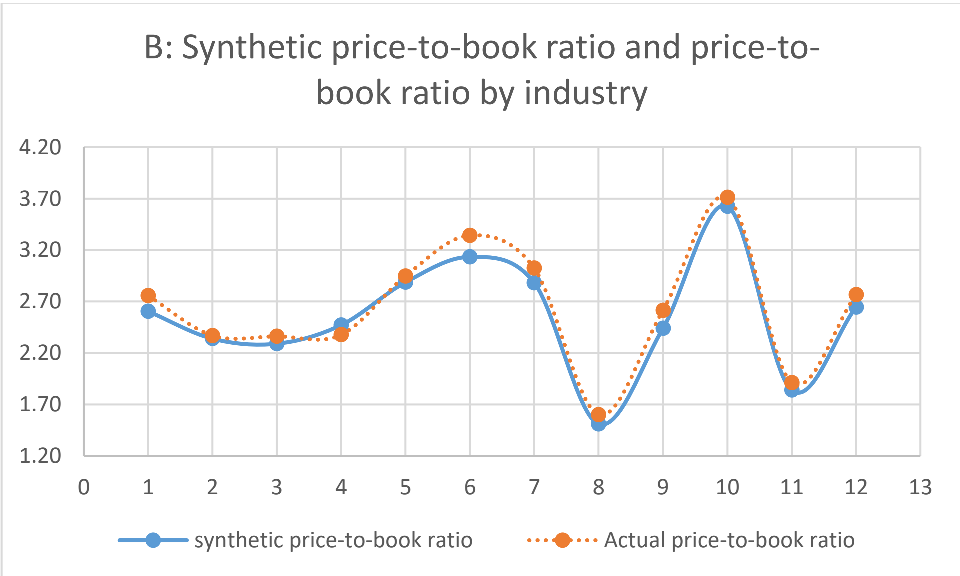
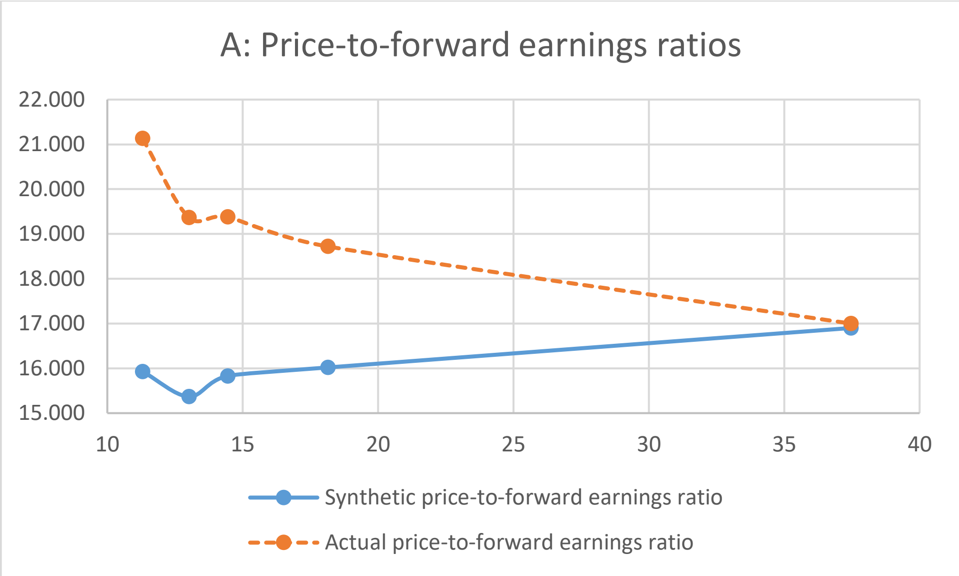




Figure 3 (A) shows the trends of synthetic price-to-forward earnings ratios and actual price-to-forward earnings ratios for 12 industries between 1980 and 2017. Figure 3 (B) shows the trends of synthetic price-to-book ratios and actual price-to-book ratios for 12 industries between 1980 and 2017. 12 industries are “#1. NoDur”, “#2. Durbl”, “#3. Manuf”, “#4. Enrgy”, “#5. Chems”, “#6. BusEq”, “#7. Telcm”, “#8. Utils”, “#9. Shops”, “#10. Hlth”, “#11. Money” and “#12. Other”. These 12-industry definitions are obtained from Kenneth French's online data library.

**Figure 4: The synthetic price-to-forward earnings (price-to-book) ratios and actual price-to-forward earnings (price-to-book) ratios from the ESG score quintile sorted portfolios**



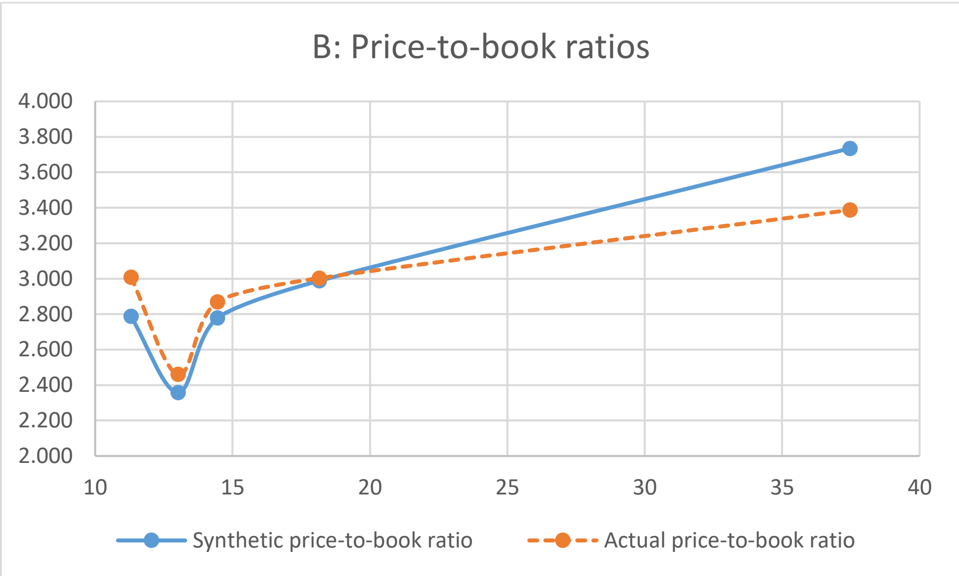




Figure 4(A) shows the mean synthetic price-to-forward earnings ratios and actual price-to-forward earnings ratios based on the ESG score quintile sorted portfolios. Figure 4(B) shows the mean synthetic price-to-book ratios and actual price-to-book ratios based on the ESG score quintile sorted portfolios. The x-axis are the ESG disclosure scores and the y-axis are the price multiples. The ESG disclosure scores are from Bloomberg.

**Table 1: Sample Descriptive Statistics**

Panel A: Sample Statistics

| | P | x | b | d | feps | feps/P | x/P | b/P | ROE1 | ROE |
|---|---|---|---|---|---|---|---|---|---|---|
| N | 104289 | 104289 | 104289 | 104289 | 104289 | 104289 | 104289 | 104289 | 104289 | 104289 |
| Mean | 20.120 | 0.987 | 10.560 | 0.329 | 1.394 | 0.081 | 0.043 | 0.653 | 0.163 | 0.122 |
| StDev. | 20.550 | 1.626 | 10.330 | 0.518 | 1.363 | 0.049 | 0.122 | 0.453 | 0.140 | 0.206 |
| p1 | 0.971 | -3.599 | 0.404 | 0.000 | 0.030 | 0.004 | -0.451 | 0.081 | 0.006 | -0.466 |
| p25 | 7.273 | 0.241 | 3.840 | 0.000 | 0.490 | 0.050 | 0.028 | 0.340 | 0.093 | 0.058 |
| Median | 14.250 | 0.758 | 7.643 | 0.083 | 1.000 | 0.071 | 0.055 | 0.552 | 0.140 | 0.126 |
| p75 | 25.560 | 1.572 | 13.810 | 0.462 | 1.830 | 0.100 | 0.085 | 0.839 | 0.196 | 0.189 |
| p99 | 104.400 | 6.302 | 50.960 | 2.362 | 6.800 | 0.250 | 0.225 | 2.309 | 0.630 | 0.666 |

Panel B: Pearson Correlation Matrix

| pwcorr | P | x | b | d | feps | feps/P | x/P | b/P | ROE1 | ROE |
|---|---|---|---|---|---|---|---|---|---|---|
| P | 1 | | | | | | | | | |
| x | 0.530 | 1 | | | | | | | | |
| b | 0.642 | 0.506 | 1 | | | | | | | |
| d | 0.389 | 0.450 | 0.497 | 1 | | | | | | |
| feps | 0.769 | 0.692 | 0.709 | 0.521 | 1 | | | | | |
| feps/P | -0.228 | 0.151 | 0.044 | 0.118 | 0.223 | 1 | | | | |
| x/P | 0.049 | 0.564 | 0.112 | 0.158 | 0.192 | 0.266 | 1 | | | |
| b/P | -0.277 | -0.068 | 0.283 | 0.085 | -0.059 | 0.449 | -0.016 | 1 | | |
| ROE1 | 0.085 | 0.094 | -0.223 | -0.001 | 0.194 | 0.256 | 0.061 | -0.402 | 1 | |
| ROE | 0.126 | 0.459 | -0.044 | 0.073 | 0.187 | 0.116 | 0.543 | -0.232 | 0.328 | 1 |

Panel A shows descriptive statistics for 104,289 firm-year between 1980 and 2017. Firms in the extreme percentiles are deleted. The mean, standard deviation (stdev), median, and the first percentile, first and third quartiles and last percentile are reported. Price (P) is the adjusted price per share. x, b and d are respectively earnings per share, book value per share and dividends per share based on adjusted number of shares. Earnings are net income per share before extraordinary items. feps is the one-year ahead analysts' forecasts of earnings. Observations with negative feps are deleted. feps/P, x/P and b/P are price scaled forecasts of earnings, earnings and book value respectively. Forward return on equity (ROE1) is feps scaled by book value. Return on equity (ROE) is net income before extraordinary items scaled by lagged book value.

Panel B shows the annual cross-sectional Pearson correlations for 104,289 firm-year observations.

**Table 2: Simultaneous estimation of LID parameters and the cost of equity capital**

| | $\omega_1$ | t-stat | $\omega_2$ | t-stat | $\lambda$-1(%) | t-stat | R-1(%) | t-stat | RP(%) |
|---|---|---|---|---|---|---|---|---|---|
| 1980 | 0.366 | 10.17 | 0.07 | 3.36 | 0.047 | 9.38 | 0.15 | 40.89 | 0.036 |
| 1981 | 0.345 | 11.07 | 0.059 | 3.51 | 0.05 | 10.22 | 0.151 | 47.71 | 0.012 |
| 1982 | 0.336 | 11.96 | 0.059 | 4.24 | 0.055 | 11.81 | 0.145 | 49.83 | 0.015 |
| 1983 | 0.311 | 11.21 | 0.053 | 4.15 | 0.056 | 12.32 | 0.14 | 51.65 | 0.029 |
| 1984 | 0.233 | 9.92 | 0.037 | 3.08 | 0.056 | 13.00 | 0.131 | 56.52 | 0.007 |
| 1985 | 0.216 | 10.08 | 0.039 | 3.41 | 0.056 | 13.46 | 0.125 | 55.86 | 0.019 |
| 1986 | 0.173 | 9.03 | 0.036 | 3.24 | 0.051 | 11.83 | 0.113 | 52.91 | 0.037 |
| 1987 | 0.141 | 7.77 | 0.031 | 2.43 | 0.049 | 11.59 | 0.112 | 52.33 | 0.028 |
| 1988 | 0.137 | 7.78 | 0.032 | 2.64 | 0.044 | 10.33 | 0.108 | 50.66 | 0.02 |
| 1989 | 0.111 | 6.81 | 0.028 | 2.56 | 0.041 | 9.77 | 0.104 | 49.58 | 0.02 |
| 1990 | 0.112 | 6.56 | 0.024 | 2.01 | 0.041 | 10.52 | 0.105 | 51.01 | 0.019 |
| 1991 | 0.105 | 6.27 | 0.023 | 2.00 | 0.039 | 10.51 | 0.104 | 51.94 | 0.025 |
| 1992 | 0.099 | 6.41 | 0.019 | 1.95 | 0.041 | 11.66 | 0.101 | 51.68 | 0.031 |
| 1993 | 0.077 | 5.36 | 0.019 | 2.03 | 0.04 | 12.33 | 0.097 | 53.36 | 0.038 |
| 1994 | 0.092 | 5.88 | 0.017 | 1.82 | 0.04 | 13.12 | 0.096 | 56.04 | 0.025 |
| 1995 | 0.081 | 5.54 | 0.018 | 1.94 | 0.038 | 12.60 | 0.093 | 55.35 | 0.028 |
| 1996 | 0.069 | 4.56 | 0.02 | 1.89 | 0.037 | 12.30 | 0.092 | 55.05 | 0.028 |
| 1997 | 0.065 | 4.49 | 0.02 | 2.03 | 0.037 | 12.80 | 0.09 | 54.12 | 0.026 |
| 1998 | 0.059 | 4.65 | 0.015 | 2.01 | 0.038 | 14.24 | 0.09 | 56.14 | 0.038 |
| 1999 | 0.078 | 5.62 | 0.021 | 2.54 | 0.042 | 16.01 | 0.093 | 56.69 | 0.037 |
| 2000 | 0.068 | 4.98 | 0.021 | 2.75 | 0.043 | 16.32 | 0.094 | 56.07 | 0.034 |
| 2001 | 0.077 | 5.93 | 0.022 | 2.86 | 0.044 | 16.42 | 0.093 | 53.19 | 0.043 |
| 2002 | 0.084 | 5.89 | 0.024 | 2.90 | 0.042 | 15.28 | 0.094 | 53.14 | 0.048 |
| 2003 | 0.101 | 6.79 | 0.029 | 3.10 | 0.044 | 15.31 | 0.092 | 50.68 | 0.052 |
| 2004 | 0.091 | 5.91 | 0.028 | 2.75 | 0.038 | 13.30 | 0.085 | 47.62 | 0.043 |
| 2005 | 0.098 | 7.28 | 0.025 | 2.85 | 0.033 | 11.29 | 0.079 | 45.33 | 0.036 |
| 2006 | 0.115 | 7.90 | 0.024 | 2.74 | 0.034 | 10.85 | 0.08 | 44.16 | 0.032 |
| 2007 | 0.111 | 8.03 | 0.013 | 1.68 | 0.024 | 8.30 | 0.074 | 41.21 | 0.027 |
| 2008 | 0.092 | 6.93 | 0.034 | 4.12 | 0.032 | 11.10 | 0.081 | 47.67 | 0.044 |
| 2009 | 0.084 | 6.42 | 0.029 | 3.43 | 0.029 | 10.24 | 0.08 | 47.09 | 0.047 |
| 2010 | 0.092 | 6.63 | 0.032 | 3.35 | 0.03 | 10.10 | 0.081 | 46.84 | 0.049 |
| 2011 | 0.092 | 6.27 | 0.034 | 3.22 | 0.03 | 9.76 | 0.084 | 47.75 | 0.056 |
| 2012 | 0.087 | 5.85 | 0.034 | 3.22 | 0.031 | 9.88 | 0.083 | 47.24 | 0.065 |
| 2013 | 0.118 | 6.61 | 0.021 | 1.75 | 0.027 | 8.63 | 0.079 | 43.23 | 0.055 |
| 2014 | 0.145 | 7.95 | 0.033 | 2.90 | 0.03 | 9.59 | 0.079 | 43.65 | 0.054 |
| 2015 | 0.126 | 7.13 | 0.034 | 3.16 | 0.028 | 9.43 | 0.078 | 43.87 | 0.056 |
| 2016 | 0.116 | 7.11 | 0.039 | 3.81 | 0.025 | 8.13 | 0.072 | 40.76 | 0.053 |
| 2017 | 0.12 | 6.07 | 0.037 | 3.12 | 0.026 | 7.87 | 0.072 | 37.35 | 0.049 |
| Mean | 0.132 | | 0.030 | | 0.039 | | 0.098 | | 0.036 |
| Stdev. | 0.080 | | 0.013 | | 0.009 | | 0.021 | | 0.014 |
| Median | 0.103 | | 0.029 | | 0.040 | | 0.093 | | 0.036 |
| Min | 0.059 | | 0.013 | | 0.024 | | 0.072 | | 0.007 |
| Max | 0.366 | | 0.070 | | 0.056 | | 0.151 | | 0.065 |

Table 2 reports the annual average parameters in the linear information dynamic and their t-statistics on a year-by-year basis between 1980 and 2017:

$$\begin{aligned} x_{t+1}^{a} &= \omega_1 x_t^{a} + \omega_2 (Rb_{t-1} - b_t) + G_t + \varepsilon_{1,t+1} \\ G_{t+1} &= \lambda G_t + \varepsilon_{2,t+1} \end{aligned}$$

It shows the average values across 12-industry on a yearly basis. We use a nonlinear least squares procedure from 5-year rolling window regressions to simultaneously estimate four parameters, $\omega_1, \omega_2, (\lambda - 1)$ and the cost of equity capital (*R-1*) for each year from the following regression:

$$\begin{aligned} \frac{feps_{t+1}}{P_t} &= \frac{(R-\lambda)(R-\omega_1)}{R} + \frac{\omega_1 \lambda}{R}\frac{x_t}{P_t} + [R - 1 - \omega_2 - \frac{(R-\lambda)(R-\omega_1)}{R}]\frac{b_t}{P_t} \\ &\quad + \lambda[\omega_2 - \frac{(R-1)\omega_1}{R}]\frac{b_{t-1}}{P_t} + \varepsilon_{t+1}, \end{aligned}$$

where $feps_{t+1}$ is one-year ahead analysts' forecasts of earnings. $x_t$, $b_t$ and $P_t$ are earnings, book value and price at time t respectively. The last column shows the average annual risk premium (RP), which is calculated relative to the yield on a ten-year US government bond. The summary statistics of the parameters are also reported. They are mean, standard deviation, median, minimum and maximum.

**Table 3: Simultaneous estimation of LID parameters and the cost of equity capital by industry**

| | $\omega_1$ | t-stat | $\omega_2$ | t-stat | $\lambda$ -1(%) | t-stat | R-1(%) | t-stat | RP(%) |
|---|---|---|---|---|---|---|---|---|---|
| NoDur | 0.099 | 5.87 | 0.023 | 1.82 | 0.039 | 12.500 | 0.101 | 49.295 | 0.039 |
| Durbl | 0.133 | 4.40 | 0.021 | 0.89 | 0.041 | 7.559 | 0.111 | 32.302 | 0.049 |
| Manuf | 0.131 | 9.63 | 0.022 | 2.40 | 0.033 | 12.696 | 0.101 | 62.812 | 0.038 |
| Enrgy | 0.13 | 4.84 | 0.027 | 1.48 | 0.033 | 5.092 | 0.092 | 25.282 | 0.030 |
| Chems | 0.189 | 7.12 | 0.03 | 2.08 | 0.044 | 8.176 | 0.103 | 31.864 | 0.041 |
| BusEq | 0.085 | 6.94 | 0.019 | 2.07 | 0.041 | 15.695 | 0.090 | 53.283 | 0.028 |
| Telcm | 0.132 | 3.16 | 0.054 | 3.08 | 0.035 | 5.298 | 0.084 | 22.129 | 0.021 |
| Utils | 0.189 | 8.43 | 0.041 | 4.60 | 0.040 | 11.584 | 0.099 | 69.456 | 0.037 |
| Shops | 0.118 | 7.80 | 0.029 | 2.67 | 0.035 | 15.152 | 0.096 | 62.325 | 0.034 |
| Hlth | 0.135 | 6.09 | 0.039 | 3.43 | 0.049 | 12.029 | 0.097 | 32.712 | 0.035 |
| Money | 0.143 | 13.46 | 0.038 | 6.64 | 0.044 | 20.353 | 0.107 | 97.458 | 0.045 |
| Other | 0.104 | 7.78 | 0.021 | 2.49 | 0.033 | 13.315 | 0.094 | 56.709 | 0.032 |

Table 3 reports the annual average parameters in the linear information dynamic and their t-statistics on an industry-by-industry basis over 38-year:

$$x^a_{t+1} = \omega_1 x^a_t + \omega_2 (Rb_{t-1} - b_t) + G_t + \varepsilon_{1,t+1}, \quad \mathrm{G}_{t+1} = \lambda G_t + \varepsilon_{2,t+1}.$$

We use a nonlinear least squares procedure from 5-year rolling window regressions to simultaneously estimate four parameters, $\omega_1, \omega_2, (\lambda - 1)$ and the cost of equity capital (*R-1*) for each year from the following regression:

$$\frac{feps_{t+1}}{P_t} = \frac{(R-\lambda)(R-\omega_1)}{R} + \frac{\omega_1 \lambda}{R}\frac{x_t}{P_t} + [R - 1 - \omega_2 - \frac{(R-\lambda)(R-\omega_1)}{R}]\frac{b_t}{P_t} + \lambda[\omega_2 - \frac{(R-1)\omega_1}{R}]\frac{b_{t-1}}{P_t} + \varepsilon_{t+1}$$

where $feps_{t+1}$ is one-year ahead analysts' forecasts of earnings. $x_t$, $b_t$ and $P_t$ are earnings, book value and price at time t respectively. The last column shows the average annual risk premium (RP), which is calculated relative to the yield on a ten-year US government bond.

Industry “NoDur” includes food, tobacco, textiles, apparel, leather and toys. Industry “Durbl” includes cars, TV's, furniture, household appliances. Industry “Manuf” include machinery, trucks, planes, off furniture, paper and printing. Industry “Enrgy” includes oil, gas, and coal extraction and products. Industry “Chems” includes chemicals and allied products. Industry “BusEq” include computers, software, and electronic equipment. Industry “Telcm” includes telephone and television transmission. Industry “Utils” is utilities. Industry “Shops” includes wholesale, retail, and some services. Industry “Hlth” includes healthcare, medical equipment, and drugs. Industry “Money” is financial industry. “Other” includes mines, construction, building materials, transportation, hotels, bus service and entertainment. These 12-industry definitions are obtained from Kenneth French's online data library.

**Table 4. Synthetic price-to-forward earnings ratio ($P/x_1$) vs. actual price-to-forward earnings ratio ($AP/x_1$)**

| | Consumer NonDurables | | Manufacturing | | Business Equipment | | Shops | |
|---|---|---|---|---|---|---|---|---|
| | $P/x_1$ | $AP/x_1$ | $P/x_1$ | $AP/x_1$ | $P/x_1$ | $AP/x_1$ | $P/x_1$ | $AP/x_1$ |
| 1980 | 6.854 | 8.35 | 6.824 | 8.695 | 9.373 | 13.65 | 7.384 | 8.408 |
| 1981 | 6.546 | 7.664 | 6.655 | 7.35 | 9.563 | 11.38 | 7.314 | 7.545 |
| 1982 | 7.133 | 10.58 | 8.085 | 13.03 | 11.4 | 18.53 | 8.298 | 12.95 |
| 1983 | 7.559 | 10.52 | 9.189 | 11.51 | 12.59 | 15.62 | 9.262 | 10.94 |
| 1984 | 8.097 | 10.96 | 9.248 | 11.27 | 12.43 | 12.91 | 9.499 | 11.61 |
| 1985 | 9.472 | 13.83 | 9.694 | 14.48 | 12.25 | 15.91 | 10.09 | 14.79 |
| 1986 | 11.37 | 14.74 | 11.29 | 15.9 | 12.8 | 17.11 | 11.59 | 15.71 |
| 1987 | 11.23 | 11.94 | 10.97 | 12.25 | 12.55 | 13.01 | 11.37 | 12.51 |
| 1988 | 11.39 | 13.22 | 11.19 | 11.58 | 12.09 | 12.5 | 11.72 | 13.39 |
| 1989 | 11.37 | 12.9 | 10.96 | 10.94 | 11.9 | 12.28 | 11.98 | 12.86 |
| 1990 | 11.04 | 13.53 | 10.21 | 11.45 | 11.28 | 13.4 | 11.82 | 13.75 |
| 1991 | 11.46 | 15.78 | 10.43 | 14.98 | 11.29 | 16.23 | 11.51 | 16.27 |
| 1992 | 12.33 | 14.98 | 10.97 | 15.78 | 11.75 | 16.42 | 12.29 | 15.98 |
| 1993 | 12.88 | 16.11 | 11.52 | 15.68 | 12.95 | 17.44 | 13.09 | 16.57 |
| 1994 | 12.96 | 13.6 | 12.31 | 13.14 | 14.05 | 17.58 | 13.04 | 13.95 |
| 1995 | 13.19 | 15.67 | 12.35 | 13.46 | 14.95 | 20.1 | 13.18 | 17.19 |
| 1996 | 12.89 | 16.5 | 12.06 | 14.16 | 14.96 | 19.31 | 13.45 | 16.47 |
| 1997 | 13.46 | 18.72 | 12.27 | 16.36 | 15.6 | 22.46 | 14.14 | 19.39 |
| 1998 | 13.12 | 15.04 | 11.63 | 13.08 | 15.39 | 21.07 | 13.73 | 15.86 |
| 1999 | 13.28 | 12.37 | 11.42 | 13.91 | 16.64 | 28.84 | 13.74 | 13.29 |
| 2000 | 12.76 | 14.42 | 11.19 | 12.67 | 15.81 | 22.35 | 13.57 | 14.72 |
| 2001 | 12.8 | 17.53 | 10.87 | 17.73 | 16.11 | 30.3 | 13.43 | 19.22 |
| 2002 | 12.11 | 14.46 | 11.06 | 14.49 | 16.91 | 21.86 | 12.19 | 14.2 |
| 2003 | 12.98 | 17.06 | 12.3 | 19.93 | 19.41 | 30.9 | 13.21 | 19.01 |
| 2004 | 14.26 | 17.04 | 15.03 | 17.71 | 20.63 | 25.83 | 14.98 | 17.94 |
| 2005 | 15.3 | 18.58 | 16.37 | 18.85 | 23.48 | 27.99 | 16.12 | 20.46 |
| 2006 | 15.83 | 20.39 | 16.46 | 17.57 | 22.65 | 26.17 | 16.42 | 19.69 |
| 2007 | 15.71 | 16.65 | 15.55 | 15.44 | 21.85 | 21.32 | 16.38 | 15.79 |
| 2008 | 14.69 | 13.78 | 13.08 | 11.27 | 19.05 | 19.02 | 15.15 | 14.16 |
| 2009 | 15.06 | 16.89 | 13.86 | 20.26 | 18.84 | 22.14 | 15.37 | 17.87 |
| 2010 | 14.37 | 17.36 | 14.59 | 17.38 | 17.92 | 22.15 | 15.24 | 17.02 |
| 2011 | 13.56 | 16.6 | 14.22 | 15.34 | 16.51 | 20.26 | 14.36 | 15.97 |
| 2012 | 14.02 | 18.28 | 14.28 | 16.72 | 16.45 | 21.05 | 14.63 | 17.77 |
| 2013 | 14.58 | 21.38 | 15.38 | 20.95 | 17.26 | 25.03 | 15.54 | 20.62 |
| 2014 | 16.22 | 21.93 | 15.58 | 19.12 | 18.14 | 24.18 | 15.96 | 20.74 |
| 2015 | 17.12 | 20.91 | 15.35 | 18.45 | 18.1 | 23.35 | 16.22 | 18.09 |
| 2016 | 17.51 | 21.34 | 16.97 | 21.04 | 19.83 | 26.44 | 16.7 | 19.64 |
| 2017 | 18.89 | 21.06 | 17.44 | 20.5 | 20.56 | 27.02 | 17.08 | 17.35 |
| Mean | 12.77 | 15.60 | 12.34 | 15.12 | 15.67 | 20.35 | 13.19 | 15.78 |
| StDev | 2.88 | 3.53 | 2.68 | 3.40 | 3.66 | 5.30 | 2.55 | 3.15 |
| Median | 12.97 | 15.73 | 11.85 | 15.16 | 15.71 | 20.66 | 13.44 | 15.98 |
| Correlation | 0.89 | | 0.80 | | 0.82 | | 0.82 | |

Table 4 reports the annual average synthetic price-to-forward earnings ratios ($P/x_1$) and actual price-to-forward earnings ratio ($AP/x_1$) for the four industries over our sample period. For firm j in industry i, the synthetic $P/x_1$ is

$$P/x_1 \equiv \frac{1}{(R_{it}-1)} + \frac{M_{i,1}N_{i,j}^T}{feps_{j,t+1}}$$, where

$$M_{i,1} = \frac{1}{(R_{it}-\omega_{it,1})(R_{it}-\lambda_{it})}\left[\frac{R_{it}(\omega_{it,1}+\lambda_{it}-1)-\omega_{it,1}\lambda_{it}}{(R_{it}-1)}, -\omega_{it,1}\lambda_{it}, -R_{it}\omega_{it,2}\right]$$, and

$$N_{i,j} = [(E_t[ROE_{j,t+1}]-(R_{it}-1))b_{j,t}, (ROE_{j,t}-(R_{it}-1))b_{j,t-1}, (\lambda_{it}b_{j,t-1}-b_{j,t})].$$

$E_t[ROE_{j,t+1}] = feps_{j,t+1}/b_{j,t}$, $ROE_{j,t} = x_{j,t}/b_{j,t-1}$, $feps_{t+1}$ is one-year ahead analysts' forecasts of earnings. $x_t$,and $b_t$ are earnings and book value at time t respectively. Industry i's parameters $(\omega_1, \omega_2, \lambda, R)$ for each year are estimated from the following 5-year rolling window regression in a jack-knifing procedure:

$$\frac{feps_{t+1}}{P_t} = \frac{(R-\lambda)(R-\omega_1)}{R} + \frac{\omega_1\lambda}{R}\frac{x_t}{P_t} + [R-1-\omega_2-\frac{(R-\lambda)(R-\omega_1)}{R}]\frac{b_t}{P_t} + \lambda[\omega_2-\frac{(R-1)\omega_1}{R}]\frac{b_{t-1}}{P_t} + \varepsilon_{t+1}$$

where $P_t$ is price. The actual price-to-forward earnings ratio is estimated by price ($P_t$ ) divided by $feps_{t+1}$. The industry definitions are obtained from Kenneth French's online data library, 12-industry classification.

**Table 5: Synthetic price-to-book ratio (*P/B*) vs. actual price-to-book ratio (*AP/B*)**

| | Consumer NonDurables | | Manufacturing | | Business Equipment | | Shops | |
|---|---|---|---|---|---|---|---|---|
| | *P/B* | *AP/B* | *P/B* | *AP/B* | *P/B* | *AP/B* | *P/B* | *AP/B* |
| 1980 | 1.322 | 1.437 | 1.221 | 1.474 | 1.913 | 2.74 | 1.268 | 1.444 |
| 1981 | 1.363 | 1.292 | 1.154 | 1.159 | 1.94 | 2.064 | 1.445 | 1.404 |
| 1982 | 1.367 | 1.868 | 1.252 | 1.702 | 2.634 | 3.496 | 1.643 | 2.262 |
| 1983 | 1.423 | 1.768 | 1.64 | 1.725 | 2.877 | 2.88 | 1.931 | 2.045 |
| 1984 | 1.582 | 1.941 | 1.57 | 1.703 | 2.586 | 2.362 | 2.022 | 2.193 |
| 1985 | 2.106 | 2.691 | 1.624 | 1.972 | 2.229 | 2.395 | 2.158 | 2.499 |
| 1986 | 2.508 | 2.897 | 1.771 | 2.101 | 2.624 | 2.61 | 2.131 | 2.562 |
| 1987 | 2.697 | 2.401 | 1.917 | 1.841 | 2.52 | 2.095 | 2.146 | 2.076 |
| 1988 | 2.517 | 2.527 | 2.139 | 1.926 | 2.487 | 2.07 | 2.248 | 2.255 |
| 1989 | 2.496 | 2.524 | 2.098 | 1.856 | 2.479 | 2.095 | 2.295 | 2.186 |
| 1990 | 2.448 | 2.544 | 1.972 | 1.797 | 2.098 | 2.203 | 2.28 | 2.461 |
| 1991 | 2.217 | 2.797 | 1.723 | 2.089 | 2.078 | 2.694 | 2.134 | 2.725 |
| 1992 | 2.315 | 2.639 | 2.205 | 2.521 | 2.569 | 2.852 | 2.353 | 2.697 |
| 1993 | 2.621 | 2.808 | 2.191 | 2.454 | 2.91 | 3.157 | 2.366 | 2.7 |
| 1994 | 2.661 | 2.567 | 2.493 | 2.405 | 3.391 | 3.514 | 2.288 | 2.196 |
| 1995 | 2.841 | 2.936 | 2.651 | 2.462 | 3.681 | 4.163 | 2.324 | 2.627 |
| 1996 | 2.478 | 2.798 | 2.442 | 2.498 | 3.392 | 3.707 | 2.224 | 2.46 |
| 1997 | 2.581 | 3.196 | 2.504 | 2.97 | 3.698 | 4.346 | 2.463 | 3.044 |
| 1998 | 2.702 | 2.838 | 2.321 | 2.243 | 3.759 | 4.027 | 2.351 | 2.533 |
| 1999 | 3.197 | 2.635 | 2.499 | 2.445 | 4.248 | 5.712 | 2.695 | 2.393 |
| 2000 | 3.247 | 3.112 | 2.154 | 2.103 | 3.219 | 3.546 | 2.575 | 2.643 |
| 2001 | 2.821 | 3.252 | 1.889 | 2.435 | 2.678 | 4.003 | 2.425 | 2.968 |
| 2002 | 2.621 | 2.793 | 1.861 | 2.014 | 2.768 | 2.85 | 2.176 | 2.213 |
| 2003 | 2.604 | 3.002 | 2.124 | 2.759 | 2.639 | 3.537 | 2.323 | 2.85 |
| 2004 | 2.649 | 2.906 | 2.928 | 2.913 | 2.97 | 3.157 | 2.672 | 2.837 |
| 2005 | 2.821 | 3.124 | 3.385 | 3.325 | 3.486 | 3.638 | 2.814 | 3.173 |
| 2006 | 3.162 | 3.486 | 3.601 | 3.373 | 3.519 | 3.445 | 3.056 | 3.134 |
| 2007 | 2.936 | 2.739 | 3.131 | 2.726 | 3.513 | 2.84 | 3.148 | 2.662 |
| 2008 | 3.561 | 2.584 | 2.411 | 1.652 | 3.221 | 2.358 | 2.455 | 2.038 |
| 2009 | 3.5 | 3.098 | 2.14 | 2.311 | 3.125 | 2.915 | 2.637 | 2.534 |
| 2010 | 2.978 | 2.961 | 2.734 | 2.8 | 3.342 | 3.482 | 2.784 | 2.75 |
| 2011 | 2.95 | 3.033 | 3.023 | 2.75 | 2.967 | 3.189 | 2.819 | 2.963 |
| 2012 | 3.193 | 3.466 | 2.978 | 2.927 | 2.967 | 3.245 | 2.935 | 3.161 |
| 2013 | 3.164 | 3.568 | 2.794 | 3.164 | 3.366 | 3.701 | 3.126 | 3.695 |
| 2014 | 3.583 | 4.275 | 3.124 | 3.278 | 3.661 | 4.024 | 3.269 | 3.96 |
| 2015 | 3.784 | 4.167 | 3.156 | 3.181 | 4.074 | 3.768 | 3 | 3.181 |
| 2016 | 3.64 | 3.701 | 3.338 | 3.544 | 4.3 | 4.63 | 3.208 | 3.374 |
| 2017 | 4.185 | 3.801 | 3.275 | 3.336 | 4.503 | 4.779 | 3.596 | 3.072 |
| Mean | 2.71 | 2.85 | 2.35 | 2.42 | 3.06 | 3.27 | 2.47 | 2.63 |
| StDev | 0.67 | 0.64 | 0.64 | 0.60 | 0.65 | 0.83 | 0.49 | 0.52 |
| Median | 2.68 | 2.82 | 2.26 | 2.44 | 2.97 | 3.22 | 2.36 | 2.64 |
| Correlation | 0.86 | | 0.90 | | 0.82 | | 0.83 | |

Table 5 reports the annual average synthetic price-to-book ratio (*P/B*) and actual price-to-book ratio (*AP/B*) for four industries year-by-year. For firm j in industry i, the synthetic *P/B* is

$$P/B \equiv 1 + \frac{M_{i,2} N_{i,j}^{T}}{b_{j,t}},$$

$$M_{i,2} = \frac{1}{(R_{it} - \omega_{it,1})(R_{it} - \lambda_{it})}[R_{it}, -\omega_{it,1}\lambda_{it}, -R_{it}\omega_{it,2}], \text{ and}$$

$$N_{i,j} = [(E_t[ROE_{j,t+1}] - (R_{it} - 1))b_{j,t}, (ROE_{j,t} - (R_{it} - 1))b_{j,t-1}, (\lambda_{it} b_{j,t-1} - b_{j,t})].$$

$E_t[ROE_{j,t+1}] = feps_{j,t+1} / b_{j,t}$, $ROE_{j,t} = x_{j,t} / b_{j,t-1}$, $feps_{t+1}$ is one-year ahead analysts' forecasts of earnings, $x_t$,and $b_t$ are earnings and book value at time t respectively. Industry i's parameters $(\omega_1, \omega_2, \lambda, R)$ for each year are estimated from the following 5-year rolling window regression in a jack-knifing procedure:

$$\frac{feps_{t+1}}{P_t} = \frac{(R-\lambda)(R-\omega_1)}{R} + \frac{\omega_1\lambda}{R}\frac{x_t}{P_t} + [R - 1 - \omega_2 - \frac{(R-\lambda)(R-\omega_1)}{R}]\frac{b_t}{P_t} + \lambda[\omega_2 - \frac{(R-1)\omega_1}{R}]\frac{b_{t-1}}{P_t} + \varepsilon_{t+1}$$

where $P_t$ is price. The industry definitions are obtained from Kenneth French's online data library, 12-industry classification.

**Table 6. Industry synthetic price-to-forward earnings ratio vs. actual price-to-forward earnings ratio and synthetic price-to-book ratio vs. actual price-to-book ratio**

| | Synthetic $P/x_1$ | $AP/x_1$ | Synthetic $P/B$ | $AP/B$ |
|---|---|---|---|---|
| NoDur | 12.37 | 15.10 | 2.61 | 2.76 |
| Durbl | 11.23 | 13.52 | 2.34 | 2.37 |
| Manuf | 11.98 | 14.67 | 2.29 | 2.36 |
| Enrgy | 13.85 | 18.70 | 2.47 | 2.38 |
| Chems | 13.18 | 15.21 | 2.89 | 2.95 |
| BusEq | 15.97 | 20.66 | 3.13 | 3.34 |
| Telcm | 16.42 | 22.13 | 2.88 | 3.02 |
| Utils | 11.54 | 12.90 | 1.51 | 1.60 |
| Shops | 13.13 | 15.82 | 2.44 | 2.61 |
| Hlth | 16.79 | 21.08 | 3.63 | 3.71 |
| Money | 11.69 | 13.76 | 1.84 | 1.91 |
| Other | 13.59 | 17.07 | 2.65 | 2.77 |
| mean | 13.48 | 16.72 | 2.56 | 2.65 |
| median | 13.16 | 15.52 | 2.54 | 2.69 |

Table 6 reports the industry average synthetic price-to-forward earnings ratio $P/x_1$ (synthetic price-to-book ratio $P/B$) against actual price-to-forward earnings ratio $AP/x_1$ (actual price-to-book ratio $AP/B$) from 1980-2017 for 12-industry. For firm j in industry i, the synthetic price-to-forward earnings ratio ($P/x_1$ ) and synthetic price-to-book ratio ($P/B$) are

$$P/x_1 \equiv \frac{1}{(R_{it}-1)} + \frac{M_{i,1}N_{i,j}^T}{feps_{j,t+1}} \text{ and } P/B \equiv 1 + \frac{M_{i,2}N_{i,j}^T}{b_{j,t}},$$

$$M_{i,1} = \frac{1}{(R_{it}-\omega_{it,1})(R_{it}-\lambda_{it})}\left[\frac{R_{it}(\omega_{it,1}+\lambda_{it}-1)-\omega_{it,1}\lambda_{it}}{(R_{it}-1)}, -\omega_{it,1}\lambda_{it}, -R_{it}\omega_{it,2}\right],$$

$$M_{i,2} = \frac{1}{(R_{it}-\omega_{it,1})(R_{it}-\lambda_{it})}[R_{it}, -\omega_{it,1}\lambda_{it}, -R_{it}\omega_{it,2}], \text{ and}$$

$$N_{i,j} = [(E_t[ROE_{j,t+1}]-(R_{it}-1))b_{j,t}, (ROE_{j,t}-(R_{it}-1))b_{j,t-1}, (\lambda_{it}b_{j,t-1}-b_{j,t})].$$

$E_t[ROE_{j,t+1}] = feps_{j,t+1}/b_{j,t}$, $ROE_{j,t} = x_{j,t}/b_{j,t-1}$, $feps_{t+1}$ is one-year ahead analysts' forecasts of earnings, $x_t$,and $b_t$ are earnings and book value at time t respectively. Industry i's parameters $(\omega_1, \omega_2, \lambda, R)$ for each year are estimated from the following 5-year rolling window regression:

$$\frac{feps_{t+1}}{P_t} = \frac{(R-\lambda)(R-\omega_1)}{R} + \frac{\omega_1\lambda}{R}\frac{x_t}{P_t} + [R-1-\omega_2 - \frac{(R-\lambda)(R-\omega_1)}{R}]\frac{b_t}{P_t} + \lambda[\omega_2 - \frac{(R-1)\omega_1}{R}]\frac{b_{t-1}}{P_t} + \varepsilon_{t+1}$$

where $P_t$ is price. These 12-industry definitions are obtained from Kenneth French's online data library.

**Table 7: Valuation bias and inaccuracy: using synthetic *P/x₁* and using the sequential approach to estimate the LID**

Panel A: Valuation bias

| | Consumer Non-Durables | | Manufacturing | | Business Equipment | | Shops | |
|---|---|---|---|---|---|---|---|---|
| | *$P/x_1$* | *SEQ* | *$P/x_1$* | *SEQ* | *$P/x_1$* | *SEQ* | *$P/x_1$* | *SEQ* |
| N | 5429 | 5429 | 10811 | 10811 | 14854 | 14854 | 9856 | 9856 |
| Mean | -0.006 | 0.275 | -0.016 | 0.267 | -0.057 | 0.439 | -0.025 | 0.286 |
| Stdev | 0.603 | 0.513 | 0.597 | 0.427 | 0.758 | 0.353 | 0.609 | 0.461 |
| Q1 | -0.196 | 0.118 | -0.215 | 0.107 | -0.316 | 0.290 | -0.218 | 0.112 |
| Median | 0.090 | 0.398 | 0.076 | 0.362 | 0.071 | 0.518 | 0.075 | 0.400 |
| Q3 | 0.332 | 0.590 | 0.317 | 0.549 | 0.390 | 0.677 | 0.318 | 0.594 |

Panel B: Valuation inaccuracy

| | Consumer Non-Durables | | Manufacturing | | Business Equipment | | Shops | |
|---|---|---|---|---|---|---|---|---|
| | *$P/x_1$* | *SEQ* | *$P/x_1$* | *SEQ* | *$P/x_1$* | *SEQ* | *$P/x_1$* | *SEQ* |
| N | 5429 | 5429 | 10811 | 10811 | 14854 | 14854 | 9856 | 9856 |
| Mean | 0.390 | 0.464 | 0.390 | 0.421 | 0.484 | 0.506 | 0.390 | 0.455 |
| Stdev | 0.460 | 0.352 | 0.453 | 0.276 | 0.586 | 0.247 | 0.468 | 0.297 |
| Q1 | 0.132 | 0.255 | 0.127 | 0.230 | 0.169 | 0.333 | 0.129 | 0.248 |
| Median | 0.278 | 0.454 | 0.279 | 0.413 | 0.360 | 0.532 | 0.279 | 0.451 |
| Q3 | 0.501 | 0.623 | 0.505 | 0.579 | 0.622 | 0.686 | 0.501 | 0.625 |

Table 7 shows the valuation bias and inaccuracy for the four industries between 1981 and 2017. Valuation bias is the mean difference between observable stock prices and the predicted values scaled by price. Valuation inaccuracy is the mean of absolute value of valuation bias. Two predicted values are generated from the synthetic price-to-forward earnings ratio $P/x_1$ ratio and implementing the linear information dynamic in a sequential approach (SEQ) as in Dechow et al. (1999) respectively. The number of observations, mean, standard deviation, the first quantile (Q1), median and the third quantile (Q3) are reported. Panel A reports the valuation bias and Panel B reports the inaccuracy.

For firm j in industry i, the synthetic $P/x_1$ is $P/x_1 \equiv \frac{1}{(R_{it}-1)} + \frac{M_{i,1}N_{i,j}^T}{feps_{j,t+1}}$, the predicted value for firm j equals $(P/x_1)\times feps_{j,t+1}$, where

$$M_{i,1} = \frac{1}{(R_{it}-\omega_{it,1})(R_{it}-\lambda_{it})}\left[\frac{R_{it}(\omega_{it,1}+\lambda_{it}-1)-\omega_{it,1}\lambda_{it}}{(R_{it}-1)}, -\omega_{it,1}\lambda_{it}, -R_{it}\omega_{it,2}\right], \text{ and}$$

$$N_{i,j} = [(E_t[ROE_{j,t+1}]-(R_{it}-1))b_{j,t}, (ROE_{j,t}-(R_{it}-1))b_{j,t-1}, (\lambda_{it}b_{j,t-1}-b_{j,t})].$$

$E_t[ROE_{j,t+1}] = feps_{j,t+1}/b_{j,t}$, $ROE_{j,t} = x_{j,t}/b_{j,t-1}$, $feps_{t+1}$ is one-year ahead analysts' forecasts of earnings. $x_t$,and $b_t$ are earnings and book value at time t respectively. Industry i's parameters

$(\omega_1, \omega_2, \lambda, R)$ for each year are estimated from the following 5-year rolling window regression in a jack-knifing procedure:

$$\frac{feps_{t+1}}{P_t} = \frac{(R-\lambda)(R-\omega_1)}{R} + \frac{\omega_1\lambda}{R}\frac{x_t}{P_t} + [R-1-\omega_2 - \frac{(R-\lambda)(R-\omega_1)}{R}]\frac{b_t}{P_t} + \lambda[\omega_2 - \frac{(R-1)\omega_1}{R}]\frac{b_{t-1}}{P_t} + \varepsilon_{t+1}$$

where $P_t$ is price.

When applying LID in a sequential procedure, we follow the convention and assume R-1=9% for each firm and each year. The persistence of abnormal earnings and nonzero NPV investments for industry i in year t are the regression coefficients from 5-year rolling window regressions: $\frac{x^a_{t+1}}{P_t} = \omega_0 + \omega_1 \frac{x^a_t}{P_t} + \omega_2 \frac{Rb_{t-1} - b_t}{P_t} + \varepsilon_{1,t+1}$, where $x^a_{t+1} = x_{t+1} - (R-1)b_t$ is calculated by using realized earnings. $\omega_0$ is the intercept term. The persistence of $G_t$ ($\lambda$) for industry i in year t is estimated from 5-year rolling window regressions: $\frac{G_{t+1}}{P_t} = \lambda_0 + \lambda \frac{G_t}{P_t} + \varepsilon_{2,t+1}$, where nonzero NPV investments: $G_{j,t} = feps_{j,t+1} - (R-1)b_{j,t} - \omega_1 x^a_{j,t} - \omega_2 (Rb_{j,t-1} - b_{j,t})$, and $feps_{t+1}$ is one-year ahead analysts' forecasts of earnings. $\lambda_0$ is the intercept term. The predicted value for firm j is given by valuation model (14): $P_{j,t} = b_{j,t} + \frac{\omega_1}{R-\omega_1} x^a_{j,t} + \frac{R\omega_2}{R-\omega_1} b_{j,t-1} + \frac{R}{(R-\omega_1)(R-\lambda)} G_{j,t}$. These 12-industry definitions are obtained from Kenneth French's online data library.

**Table 8: 12-, 24- and 36-month ahead realized returns from differences between the synthetic price multiples and actual price multiples decile sorted portfolios**

| | Panel A: Price-to-forward earnings | | | | Panel B: Price-to-book value | | | |
|---|---|---|---|---|---|---|---|---|
| | Diff_PE | bhr12 | bhr24 | bhr36 | Diff_PB | bhr12 | bhr24 | bhr36 |
| 1 | -27.130 | 0.132 | 0.237 | 0.368 | -3.229 | 0.131 | 0.235 | 0.357 |
| 2 | -10.240 | 0.136 | 0.267 | 0.435 | -1.135 | 0.137 | 0.262 | 0.408 |
| 3 | -5.815 | 0.159 | 0.303 | 0.460 | -0.665 | 0.147 | 0.282 | 0.446 |
| 4 | -3.303 | 0.153 | 0.308 | 0.471 | -0.403 | 0.159 | 0.316 | 0.496 |
| 5 | -1.621 | 0.150 | 0.306 | 0.473 | -0.210 | 0.150 | 0.321 | 0.494 |
| 6 | -0.220 | 0.156 | 0.316 | 0.486 | -0.030 | 0.161 | 0.328 | 0.501 |
| 7 | 1.095 | 0.169 | 0.329 | 0.512 | 0.161 | 0.173 | 0.344 | 0.534 |
| 8 | 2.559 | 0.169 | 0.353 | 0.520 | 0.413 | 0.169 | 0.344 | 0.537 |
| 9 | 4.550 | 0.169 | 0.346 | 0.562 | 0.841 | 0.174 | 0.358 | 0.536 |
| 10 | 8.830 | 0.203 | 0.375 | 0.571 | 3.144 | 0.194 | 0.350 | 0.551 |
| D1-D10 | | 0.071 | 0.138 | 0.203 | | 0.063 | 0.116 | 0.194 |

Panel A of Table 8 reports the mean of 12-, 24- and 36-month ahead realized returns from difference (Diff_PE) between the synthetic price-to-forward earnings ratio ($P/x_1$) and actual price-to-forward earnings ratio decile sorted portfolios each year and the average return spread between decile 1 and decile 10 between 1980 and 2017 across all 12-industry. Panel B of Table 8 reports the mean of 12-, 24- and 36-month ahead realized returns from difference (Diff_PB) between the synthetic price-to-book ratio (P/B) and actual price-to-book ratio decile sorted portfolios each year and the average return spread between decile 1 and decile 10 between 1980 and 2017 across 12-industry. For firm j in industry i, the synthetic $P/x_1$ and $P/B$ are

$$P/x_1 \equiv \frac{1}{(R_{it}-1)} + \frac{M_{i,1}N_{i,j}^T}{feps_{j,t+1}} \text{ and } P/B \equiv 1 + \frac{M_{i,2}N_{i,j}^T}{b_{j,t}},$$

$$M_{i,1} = \frac{1}{(R_{it}-\omega_{it,1})(R_{it}-\lambda_{it})}\left[\frac{R_{it}(\omega_{it,1}+\lambda_{it}-1)-\omega_{it,1}\lambda_{it}}{(R_{it}-1)}, -\omega_{it,1}\lambda_{it}, -R_{it}\omega_{it,2}\right],$$

$$M_{i,2} = \frac{1}{(R_{it}-\omega_{it,1})(R_{it}-\lambda_{it})}[R_{it}, -\omega_{it,1}\lambda_{it}, -R_{it}\omega_{it,2}], \text{ and}$$

$$N_{i,j} = [(E_t[ROE_{j,t+1}]-(R_{it}-1))b_{j,t}, (ROE_{j,t}-(R_{it}-1))b_{j,t-1}, (\lambda_{it}b_{j,t-1}-b_{j,t})].$$

$E_t[ROE_{j,t+1}] = feps_{j,t+1}/b_{j,t}$, $ROE_{j,t} = x_{j,t}/b_{j,t-1}$, $feps_{t+1}$ is one-year ahead analysts' forecasts of earnings, $x_t$,and $b_t$ are earnings and book value at time t respectively. Industry i's parameters

$(\omega_1, \omega_2, \lambda, R)$ for each year are estimated from the following 5-year rolling window regression in a jack-knifing procedure:

$$\frac{feps_{t+1}}{P_t} = \frac{(R-\lambda)(R-\omega_1)}{R} + \frac{\omega_1\lambda}{R}\frac{x_t}{P_t} + [R-1-\omega_2 - \frac{(R-\lambda)(R-\omega_1)}{R}]\frac{b_t}{P_t} + \lambda[\omega_2 - \frac{(R-1)\omega_1}{R}]\frac{b_{t-1}}{P_t} + \varepsilon_{t+1}$$

where $P_t$ is price. The 12-industry definitions are obtained from Kenneth French's online data library.

**Table 9: Price multiples, valuation errors and valuation inaccuracy from ESG disclosure score quintile sorted portfolios**

| Quintile | ESG scores | Synthetic *P/x₁* | *AP/x₁* | Synthetic *P/B* | *AP/B* | Valuation bias | Valuation inaccuracy |
|---|---|---|---|---|---|---|---|
| 1 | 11.30 | 15.930 | 21.130 | 2.788 | 3.009 | 0.081 | 0.328 |
| 2 | 13.01 | 15.370 | 19.370 | 2.358 | 2.460 | 0.039 | 0.280 |
| 3 | 14.45 | 15.830 | 19.380 | 2.778 | 2.870 | 0.053 | 0.277 |
| 4 | 18.15 | 16.020 | 18.720 | 2.988 | 3.003 | 0.034 | 0.245 |
| 5 | 37.46 | 16.900 | 17.000 | 3.735 | 3.387 | -0.074 | 0.239 |

Table 9 shows the mean of ESG scores, the synthetic price-to-forward earnings ratios ($P/x_1$), actual price-to-forward earnings ratios ($AP/x_1$), the synthetic price-to-book ratios (P/B), actual price-to-book ratios ($AP/B$) for each ESG score quintile over 2005-2017 on 17,279 observations. The Bloomberg ESG disclosure data is available from 2005. The median of valuation bias and inaccuracy are also reported. Valuation bias is the difference between observable stock prices and the predicted values scaled by price. Valuation inaccuracy is the absolute value of valuation bias.

For firm j in industry i, the synthetic $P/x_1$ is $P/x_1 \equiv \frac{1}{(R_{it}-1)} + \frac{M_{i,1}N_{i,j}^T}{feps_{j,t+1}}$, the predicted value for firm j equals $(P/x_1)\times feps_{j,t+1}$, and the synthetic $P/B \equiv 1 + \frac{M_{i,2}N_{i,j}^T}{b_{j,t}}$, the predicted value for firm j equals $(P/B)\times B$, where

$$M_{i,1} = \frac{1}{(R_{it}-\omega_{it,1})(R_{it}-\lambda_{it})}\left[\frac{R_{it}(\omega_{it,1}+\lambda_{it}-1)-\omega_{it,1}\lambda_{it}}{(R_{it}-1)}, -\omega_{it,1}\lambda_{it}, -R_{it}\omega_{it,2}\right],$$

$$M_{i,2} = \frac{1}{(R_{it}-\omega_{it,1})(R_{it}-\lambda_{it})}[R_{it}, -\omega_{it,1}\lambda_{it}, -R_{it}\omega_{it,2}] \text{ and}$$

$$N_{i,j} = [(E_t[ROE_{j,t+1}]-(R_{it}-1))b_{j,t}, (ROE_{j,t}-(R_{it}-1))b_{j,t-1}, (\lambda_{it}b_{j,t-1}-b_{j,t})].$$

$E_t[ROE_{j,t+1}] = feps_{j,t+1}/b_{j,t}$, $ROE_{j,t} = x_{j,t}/b_{j,t-1}$, $feps_{t+1}$ is one-year ahead analysts' forecasts of earnings. $x_t$, and $b_t$ are earnings and book value at time t respectively. Industry i's parameters $(\omega_1, \omega_2, \lambda, R)$ for each year are estimated from the following 5-year rolling window regression:

$$\frac{feps_{t+1}}{P_t} = \frac{(R-\lambda)(R-\omega_1)}{R} + \frac{\omega_1\lambda}{R}\frac{x_t}{P_t} + \left[R-1-\omega_2-\frac{(R-\lambda)(R-\omega_1)}{R}\right]\frac{b_t}{P_t} + \lambda\left[\omega_2 - \frac{(R-1)\omega_1}{R}\right]\frac{b_{t-1}}{P_t} + \varepsilon_{t+1}$$

where $P_t$ is price.