Valuation of the worldwide commodities sector

The role of market-to-book and return on equity

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Abstract

Purpose – This paper aims to empirically investigate the market-to-book/return on equity valuation model.

Design/methodology/approach – The authors use a worldwide commodities sector panel of 6,323 firms from 69 countries with annual observations from 1999 to 2010 to estimate panel ordinary least squares (OLS), instrumental variables (IV) and quantile regressions. They also measure the impact of return on equity on market-to-book uncovering value versus growth and positive versus negative profitability dimensions.

Findings – The new evidence is that the impact of return on equity on market-to-book is time-varying and declining across the years in the sample. There is positive and strong persistence in the market-to-book of companies in this sector worldwide, but value stocks are more persistent than growth stocks. The coefficient of return on equity is positive at the 10th percentile of the market-to-book, but it becomes negative for growth stocks at 90th percentiles. Conditional on negative profitability, the coefficient of return on equity on market-to-book is negative for growth stocks. The effect of the S&P500 volatility index (VIX) is negative, significant and large in magnitude, but declines in absolute value, as the quantiles increase toward the upper 90th percentile.

Practical implications – The commodities sector is important for countries that depend on it for development.

Originality/value – The paper provides a rich panel data approach, and the market-to-book/return on equity valuation model is naturally applied to the commodities sector, as this sector tends to have more tangibles relative to intangibles.

Keywords Quantile regression, Valuation model, IV

Paper type Research paper

1. Introduction

Commodity or raw/primary products have always been an important part of physical economic activity and an important determinant of geopolitical structures. In addition, using the commodities sector in a balanced diversification strategy has become more prevalent in the past 10 to 15 years. That is, while investors have traded in commodities for many years, more recently, commodities have risen as an important component in a balanced diversified portfolio. Those investments offer advantages, such as hedging against inflation, and other

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critical idiosyncratic risks. The list of all of the commodity products that can be traded by professionals is very large and complex. For example, in futures contracts alone, investors have options ranging from oil and natural gas to iron ore and to butter. However, for those who look to equities to establish a commodity position in their portfolio, the firms in the worldwide commodity sector are the main object of interest.

Our study of the firms in the worldwide commodities sector uses a market-to-book valuation model. The market-to-book ratio is a measure of the relative value that the market places on a share of stock. This per share book value provides a useful index of how much value the market places on the firm as a going concern (market price of stock) as opposed to the bundle of assets (book value per share) that the managers have to work with. A market-to-book below (above) one suggests that the firm's value as a going concern is actually below (above) the value of its assets. Fama and French (1992) observed that stocks with a high book-to-market (the inverse of market-to-book) ratio, called value stocks as contrasted with growth stocks, capture substantial variation in average returns. Thus, stocks with a high market-to-book ratio, called growth stocks, indicate that the market views the company and its prospects more favorably. On the other hand, return on equity measures profitability as the return on shareholders' equity of the common stock owners. Wilcox (1984) and, subsequently, Wilcox and Philips (2004) have shown that a valuation model based upon market-to-book and return on equity is plausibly an alternative to a price-to-earnings ratio valuation model. Moreover, Ohlson (1990) describes market-to-book in terms of return on equity in an asset pricing equilibrium framework[1].

We engage in a full empirical evaluation of the relationship between market-to-book ratio and the given discount rate, the return on equity for firms in the worldwide commodities market using panel data. Our empirical strategy includes five basic extensions of the basic market-to-book/return on equity model:

(1) the potential for lag effects in both market-to-book ratio and return on equity as suggested by Beaver and Ryan (2000), but here we use the instrumental variable approach for lagged market-to-book;

(2) a measure of risk of the US S&P500 options market as a proxy for risk factors in the Wilcox (1984), Ohlson (1990) and Wilcox and Philips (2004) models;

(3) the informativeness of positive versus negative return on equity (profitability) as suggested by Leibowitz (1999) which showed the association between market-to-book and return on equity differs according to the sign of return on equity;

(4) time-varying coefficients on return on equity allow us to examine potential changes in the relationship between market-to-book and return on equity over the sample period; and

(5) the evaluation via the quantile regression method of Koenker and Bassett (1978) to understand the heterogeneity of profitability effects across alternative value quantiles of firms.

The main subject matters 3 and 5 represent the key aspect of our methodology to understand the relationship between market-to-book and return on equity at alternative states of the independent variable, say positive versus negative return on equity (profitability), and at alternative quantiles of the distribution of the dependent variable, the market-to-book valuation. In particular, the low quantiles of stocks (low market-to-book ratios) represent value stocks, whereas the high quantiles (high market-to-book ratios) represent the growth stocks. It is well known that the quantile estimates can be interpreted as Value at Risk (VaR)[2]. Fama and French (1995) claim that low market-to-book (value)

firms are riskier and this risk can be priced. In our sample, the marginal quantile is the area under the distribution of the market-to-book ratio. At the 10 per cent quantile, the market-to-book is 0.36, very low and well below unit (Table II), and firms in this quantile fall into the category that Fama and French describe as value stocks. At the market-to-book ratio of 0.36, there is a 10 per cent probability that the market-to-book can be less than the valuation, interpreted as VaR here. Thus, in this context, value firms with low market-to-book ratio are riskier and at VaR[3]. The high market-to-book or growth firms are less risky and are represented at the upper quantiles of the distribution. The subject matter 2 refers to the impact of the level of the volatility index (VIX) measure of risk on the market-to-book ratio, given return on equity and other controls. In general, we find that the VIX risk has a significant negative impact on the market-to-book ratio and thus an asset pricing impact[4].

A main motivation for market-to-book and return on equity valuation in the commodity economy is that this sector tends to have more tangibles relative to intangibles, given the nature of the physical capital and economic activities involved. The measurement of the relationship between market-to-book and return on equity (profitability) for the sector is a more accurate reflection of the facts and determinants of the value multiple[5]. In general, Zhang (2005) finds that growth firms with high market-to-book ratios should be able to deal better with a downturn by deferring investment plans, and thus should be more profitable. Hence, we would expect that firms which have high returns on equity or high profitability sell for well above book value, and firms which have low returns on equity or low profitability sell below book value. On the other hand, it is unexpected when stocks that have low market-to-book ratios (value stocks) are highly profitable and vice versa, thus providing a mismatch that could prove a profitable investment opportunity. That is, low market-to-book ratio can render an arbitrage opportunity once the company shows returns. It is thus important to understand this relationship at a sectoral level. In addition, Zhang (2005) suggests that the value firms with low market-to-book ratios on average could have a relatively greater amount of tangible capital and thus be more sensitive to investment irreversibility in economic downturns. In contrast, growth firms with high market-to-book ratios should do better in a downturn by postponing investment plans. We examine this hypothesis from the perspective of a state of negative return on equity (negative profitability) versus a state of positive return on equity (positive profitability) of the firm. We find that for the commodities sector where firms have more tangibles, bullish firms with positive return on equity respond much more to signals of profitability, whereas bearish firms tend to provide an arbitrage opportunity at the upper quantiles of market-to-book ratio.

The three main results under ordinary least squares (OLS) estimation are, first, that market-to-book values are positively and strongly autocorrelated with a lag one memory of close to 0.8, and this result is robust across all model specifications. Second, the VIX measure of risk of the USA S&P500 impacts negatively and robustly on market-to-book values with an impact effect of about minus 3 per cent on value per unit of VIX index across all specifications. Third, the effect of the return on equity on market-to-book values is time-varying and declining across the years in the sample. However, when conditioning on positive and negative returns on equity (profitability), those results are not robust across both domains.

The evidence of quantile regression estimation is another key contribution here. In general, the effect of return on equity on market-to-book is declining across quantiles. The market-to-book ratio is positively and strongly autocorrelated with a lag one memory across all quantiles, and both growth and value stocks show strong persistence. The VIX measure of risk of the USA S&P500 impacts negatively and robustly on market-to-book values across all quantiles, hence at both value and growth stocks as well. More specifically, there

is positive and strong persistence in the market-to-book of companies in this sector worldwide, but the lower quantiles (riskier value stocks at VaR) are more persistent than the upper quantiles (growth stocks), and intuitively, this potentially indicates that bearish firms can potentially take longer to revert to an upside state. For firms with positive return on equity (positive profitability), a one unit (percentage point) increase in return on equity increases market-to-book by about 1.0 per cent conditional on the return on equity being positive at the 10th percentile (riskier value stocks at VaR). It increases to 1.6, 1.8 and ultimately 2.0 per cent at the upper most 90th percentile for growth stocks. Thus, conditional on positive profitability, bullish firms are more sensitive to return on equity. For firms with negative return on equity (negative profitability), the effect of return on equity on market-to-book is positive and very small at the lower 10th percentile (riskier value stocks at VaR). Then, it is negative at all other percentiles ranging from −0.1 to −0.8 per cent at the upper most 90th percentile for growth stocks. Conditional on firms with negative return on equity (negative profitability), the effect of return on equity on market-to-book is statistically significant, and it decreases significantly over the years. It seems that bearish firms may be able to slow the speed of down-pricing providing arbitrage opportunity when short-selling in these stocks. Conditional on negative returns (negative profitability), the lags one and two of returns on equity are both statistically significant at the 50th and 75th percentiles, respectively, but vary across the tails. There is evidence of overreaction of return on equity on market-to-book for growth stocks.

The relationship between market-to-book and return on equity has been empirically investigated previously by several authors. Most of them used Compustat data for all firms listed on the NYSE and AMEX. Penman (1991) and Bernard (1994, 1995) examined data from the 1960s to the late 1980s for all firms listed during that period. Leibowitz (1999) uses similar data for the year 1997 only. Beaver and Ryan (2000) uses the same data from 1974 to 1993. Evidence for the market-to-book ratio and return on equity for the worldwide commodities sector using WorldScope data is lacking. We pursue the issue using a sample of 6,323 firms with annual observations from 1999 to 2010, including companies with primary addresses in 69 countries and 413 primary standard industry classification (SIC) code sub-sectors.

The rest of the paper is organized as follows. In the next section, we discuss some basic theoretical models of relevance. Section 3 discusses the data, while Section 4 presents the methodology and the econometric models to be estimated. Section 5 presents the main empirical results. The last section offers a summary and concluding remarks.

2. Models

The models of the relationship between market-to-book and return on equity are basically of two types. One is the model based upon the work of Wilcox (1984) and Wilcox and Philips (2004). This is built upon the Gordon–Shapiro growth model where, under assumptions on the growth and dividend processes, the market-to-book ratio (in logarithms) is linearly related to the return on equity, thus an econometrically plausible model that can be empirically estimated. More specifically, the equation is of the form:

$$\log\left(\frac{P_{i,t}}{B_{i,t}}\right) = \mu_{01} + \mu_{02} RoE_{i,t} \tag{M1}$$

where $P_{i,t}$ is the price of equity of firm i, time t; $B_{i,t}$ is the book value per share of equity of firm i, time t, $RoE_{i,t}$ is the return on equity for firm i, time t. In this case, the coefficients

$\mu_{01,02}$ are related to the investment horizon of the investor and the shareholder expected return. The other approach is based on equilibrium asset pricing under no arbitrage and complete markets as in Ohlson (1990), Feltham and Ohlson (1995) and Penman (1991). They described market share prices in terms of return on equity in an equilibrium framework and described market-to-book in terms of current observed return on equity along with other information. First, Feltham and Ohlson (1995, based on Ohlson, 1990) reconcile price to book value in terms of future earnings as:

$$\frac{P_{i,t}}{B_{i,t}} = 1 + B_{i,t}^{-1} \sum_{j=1}^{\infty} r^{-j} E_t \left[X_{i,t+j} \right] \qquad (M2a)$$

where $P_{i,t}$ is the price of equity of firm i, time t; $B_{i,t}$ is the book value per share of equity of firm i, time t, r is a discount factor and $E_t[X_{i,t+j}]$ is a measure of expected future extraordinary earnings. Thus, the market-to-book ratio is greater (less) than one when discounted future earnings (scaled by book value) are positive (negative). Then, they further show a linear representation based upon the current return on equity and other information variables as:

$$\frac{P_{i,t}}{B_{i,t}} = 1 + \mu_{11} B_{i,t}^{-1} X_{i,t} + \mu_{12} B_{i,t}^{-1} Z_{i,t} \qquad (M2b)$$

where $Z_{i,t}$ is a vector on information relevant for market-to-book of firm i, time t; $\mu_{11,12}$ are constants that depend upon potential persistence and discount factor. Equations [M2(a)-(b)] deliver an empirical relationship between market-to-book and current return on equity where the latter is a profitability measure of the firm thus reflecting future earnings prospects. This relationship is of the same form as equation (M1), but derived from an equilibrium framework. Expressions [(M1, 2(a)-(b)] form the basis of our empirical models for the worldwide commodities sector. A company whose returns on equity exceed its cost of capital should trade above book value. Thus, the higher (lower) the return on equity, the higher (lower) the fair market-to-book ratio for a given stock[6].

3. Data

The two main variables of the study are the market-to-book ratio and the return on equity. The sample is from the WorldScope data set and spans from 1999 to 2010, or 12 years. The focus is on the commodities sector with the major SIC codes (groups) described in Table I, thus comprising a total of 413 four-digit codes in the sample.

We have an unbalanced panel with 6,323 firms whose primary addresses are located in 69 countries over the 12-year period 1999-2010 totaling 35,341 observations. The total useable number of firm-year observations was 35,341 after deleting the top and bottom

Division A: Agriculture, forestry and fishing	Division B: Mining
Group 01: Agricultural production crops	Group 10: Metal mining
Group 02: Agriculture production livestock and animal specialties	Group 12: Coal mining
Group 07: Agricultural services	Group 13: Oil and gas extraction
Group 08: Forestry	Group 14: Mining and quarrying of nonmetallic minerals, except fuels
Group 09: Fishing, hunting, and trapping	

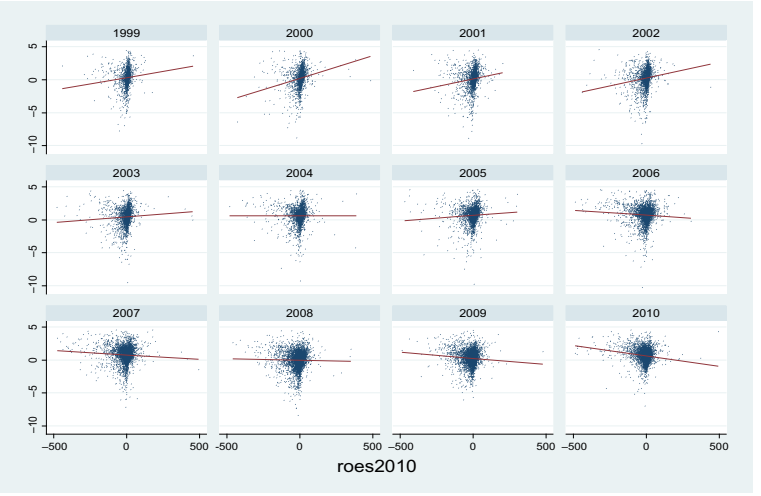
Table I. Major SIC codes for the commodities sector

1 per cent of observations on both the market-to-book and return on equity variables. The market-to-book is calculated as the market value of equity divided by book value of equity and the return on equity is net income divided by total equity as provided by WorldScope. Table II shows the descriptive statistics of the level and logarithm of market-to-book and the return on equity in the sample. The level of the market to book shows that the distribution is skewed to the right with a mean of 3.2 and median of 1.6 [Figure1(b)], both well above one showing that on average firms in the sector have positive expected future earnings. The logarithm of market-to-book is also skewed but much less so than its level [Figure 1(b)]. The return on equity is skewed to the left with a median of 0.8 per cent per year. The 69 countries in the sample are in Table III. The countries with most observations/firms are Australia with 1,085 firms; Canada with 1,898; China with 225; the UK with 374; the USA with 748 and Malaysia with 189 firms. Figure 1 shows the plots by country of the (log) market-to-book and return on equity data with the OLS fit. The slope of the market-to-book/return on equity relationship varies widely across countries in the sample. Argentina, Brazil, Chile, China, France, Germany, Greece, Hong Kong, India, Indonesia, South Korea, Malaysia, Norway, Peru, Russia, Singapore and South Africa have a clear positive slope, while Canada has a clear negative slope.

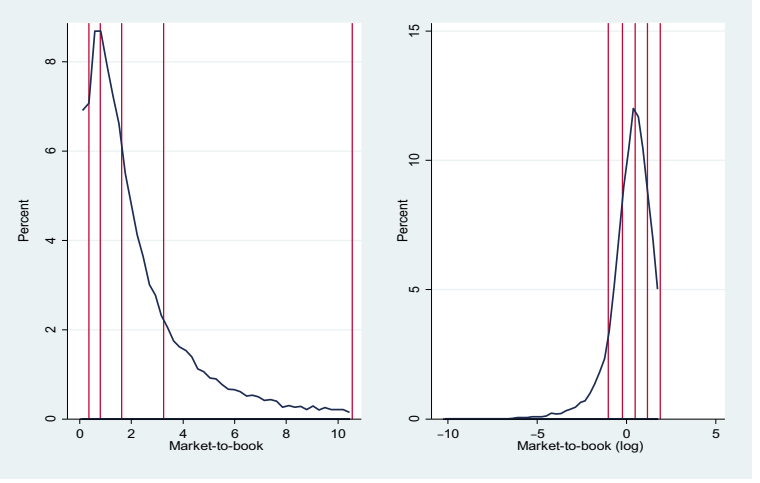
Figure 1(a) shows the relationship of market-to-book and return on equity by year for all companies in the sample. It is clear that while the relationship is positive for the great moderation period up to 2005, after 2006 the relationship becomes negative. Figure 1(b) shows histograms of the market-to-book and the logarithm of market-to-book where the vertical lines denote the percentiles reported in Table II. For the level of the market-to-book, the 10th percentile of the distribution is at a market-to-book of 0.36, well below unity thus indicating that there is a 10 per cent probability that a firm in the sample has a market-to-book value less than 0.36, or VaR at 10 per cent. Similarly, the VaR at 25, 50, 75 and 90 per cent are at 0.8, 1.6, 3.2 and 6.5 market-to-book ratios, respectively. More relevant to us in our estimations will be the logarithm of the market-to-book with distribution depicted in Figure 1(b) (left). For the logarithm of the market-to-book, the 10th percentile of the distribution is at a (log) market-to-book of −1.02, or VaR of 10 per cent. Similarly, the VaR of 25, 50, 75 and 90 per cent are at −0.22, 0.49, 1.18, and 1.87 (log) market-to-book ratios respectively. Figure 2 shows graphs by year of the relationship between market-to-book and lagged market-to-book where the persistence is positive and strong.

Table II.
Descriptive statistics of key variables

Statistic	Market-to-book	Market-to-book (log)	Return on equity (%)
Mean	3.19	0.42	−10.14
StDev	6.02	1.29	50.39
Skewness	7.11	−0.86	−2.31
Kurtosis	74.00	6.57	20.68
Min	0.00	−10.28	−488.84
Max	99.09	4.60	496.08
N	35,341	35,341	35,341
Percentiles			
10th	0.36	−1.02	−58.08
25th	0.80	−0.22	−18.90
50th	1.62	0.49	0.79
75th	3.25	1.18	12.59
90th	6.51	1.87	24.91



(a)



(b)

Notes: Red lines are the 10th, 25th, 50th, 75th and 90th percentiles as reported in Table II; distribution truncated at the 90th percentile

Figure 1.
(a) Market-to-book (logs) and return on equity, by year; data and OLS fitted line; (b) histograms – market-to-book and market-to-book (logs)

4. Methodology

The core of our methodology is to understand the relationship between market-to-book ratio and return on equity at alternative states of the independent variable, say positive versus negative return on equity; and at alternative quantiles of the distribution of the dependent variable, market-to-book, indicating alternative VaR for value and growth stocks. The upper quantiles refer to growth stocks, and the

Country	Freq.	(%)	Cum.
Argentina	230	0.65	0.65
Australia	6,064	17.16	17.81
Austria	36	0.1	17.91
Bahrain	2	0.01	17.92
Belgium	87	0.25	18.16
Bermuda	76	0.22	18.38
Brazil	140	0.4	18.77
Bulgaria	46	0.13	18.9
Canada	8,937	25.29	44.19
Cayman Islands	19	0.05	44.25
Chile	455	1.29	45.53
China	1,409	3.99	49.52
Colombia	46	0.13	49.65
Cyprus	23	0.07	49.72
Czech Republic	40	0.11	49.83
Denmark	60	0.17	50
Egypt	62	0.18	50.17
Finland	126	0.36	50.53
France	497	1.41	51.94
Germany	251	0.71	52.65
Ghana	10	0.03	52.68
Greece	288	0.81	53.49
Hong Kong	587	1.66	55.15
Hungary	16	0.05	55.2
Iceland	7	0.02	55.22
India	556	1.57	56.79
Indonesia	392	1.11	57.9
Ireland	185	0.52	58.42
Israel	122	0.35	58.77
Italy	155	0.44	59.21
Japan	853	2.41	61.62
Jordan	46	0.13	61.75
Korea (South)	467	1.32	63.07
Kuwait	108	0.31	63.38
Latvia	25	0.07	63.45
Lithuania	7	0.02	63.47
Luxembourg	91	0.26	63.72
Malaysia	1,538	4.35	68.08
Malta	5	0.01	68.09
Mexico	157	0.44	68.54
Morocco	59	0.17	68.7
The Netherlands	119	0.34	69.04
New Zealand	194	0.55	69.59
Norway	474	1.34	70.93
Pakistan	75	0.21	71.14
Peru	295	0.83	71.98
Philippines	197	0.56	72.53
Poland	78	0.22	72.75
Portugal	31	0.09	72.84
Qatar	23	0.07	72.91
Russian Federation	394	1.11	74.02
Saudi Arabia	79	0.22	74.25

Table III.
Countries with companies included in the sample

(*continued*)

Country	Freq.	(%)	Cum.
Singapore	451	1.28	75.52
Slovakia	20	0.06	75.58
Slovenia	2	0.01	75.58
South Africa	737	2.09	77.67
Spain	282	0.8	78.47
Sri Lanka	151	0.43	78.89
Sweden	242	0.68	79.58
Switzerland	90	0.25	79.83
Taiwan	62	0.18	80.01
Thailand	198	0.56	80.57
Turkey	138	0.39	80.96
United Arab Emirates	23	0.07	81.02
UK	1,961	5.55	86.57
USA	4,343	12.29	98.86
Venezuela	35	0.1	98.96
Vietnam	359	1.02	99.98
Virgin Islands (BRIT)	8	0.02	100
Total	35,341	100	

Table III.

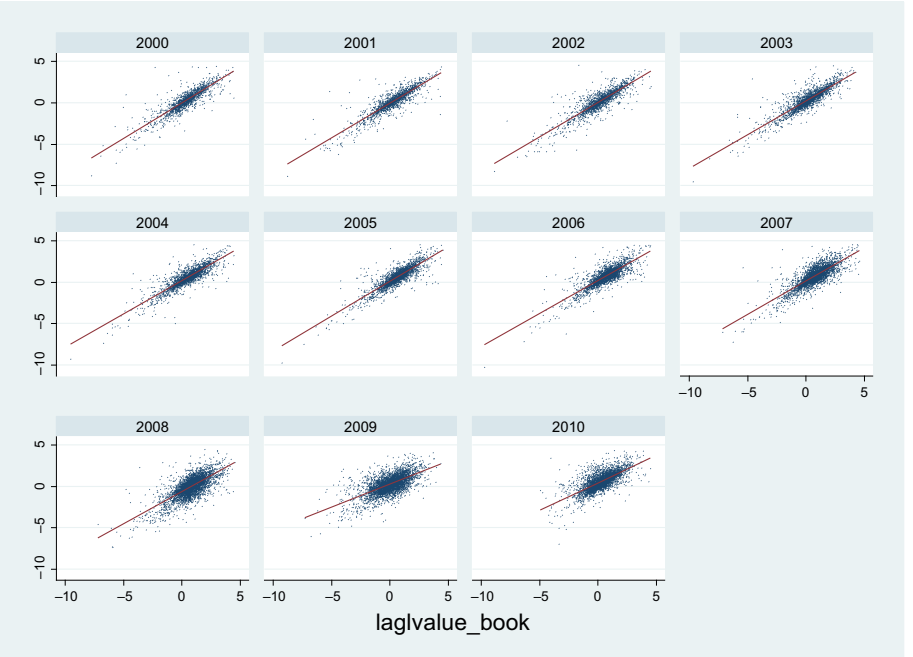


Figure 2.
Market-to-book (logs) and one lag market-to-book, by year; data and OLS fitted line

quantile regression methodology proves to be useful to highlight the segmented classes of stocks.

We estimate eight basic models of the market-to-book/return on equity relationship. First, we estimate via OLS, then via quantile regression methods of Koenker and Bassett (1978). Here, we describe the models in some detail. Model (1) is the basic benchmark model as in the equations [(M1, M2(a), (b)] where the current return on equity is projected on the valuation measure, market-to-book, or:

$$MtB_{i,t} = \beta_0 + \beta_1 RoE_{i,t} + u_{i,t} \tag{1}$$

where $MtB_{i,t}$ is the market-to-book ratio of firm i in year t, in logarithms, $RoE_{i,t}$ is the return on equity of firm i for year t, $u_{i,t}$ is the regression error term and β_1 is the sensitivity of the market-to-book ratio to changes in the return on equity. We estimate the basic model via OLS, then panel with firm fixed and year effects and panel with sector, region, country and year fixed effects. In the case of firm fixed effects, we eliminate unobserved heterogeneity across firms that are deemed to be constant across time, but include time dummies as well to capture time variation. In the case of sector fixed effects, we contemplate unobserved heterogeneity across the four-digit sectors, controlling for region, country and year fixed effects.

Next, econometric Model (2) includes the potential for time-varying effects of return on equity, instrumented lagged market-to-book according to the method of Arellano and Bond (1991), and several controls. It is a two-stage least squares case where first we estimate a panel fixed effects regression to instrument for lagged market-to-book and obtain predictions for lagged market-to-book. This prediction is then used into the main model which includes year, region, country and sector fixed effects as well as the potential time-varying sensitivity of market-to-book to return on equity captured by an interaction with the year variable. The model is:

$$MtB_{i,t} = \beta_0 + \alpha_1 E[MtB_{i,t-1}|.] + \beta_1 RoE_{i,t} + \beta_2 RoE_{i,t} \times year_t + \beta_3 Vix_t + \sum_{i=1}^{n2} \delta_{1t}\, year_t + \sum_{i=1}^{n3} \delta_{2i}\, region_i + \sum_{i=1}^{n4} \delta_{3i}\, country_i + \sum_{i=1}^{n5} \delta_{4i}\, sector_i + u_{i,t} \tag{2}$$

where $E[MtB_{i,t-1}|.]$ is the first stage predicted lagged market-to-book ratio of firm i in year t, in logarithms; $RoE_{i,t}$ is the return on equity of firm i for year t; Vix_t is the volatility measure of the USA S&P500 from the Chicago Board of Trade options market; $year_t$ is the year fixed effect 1999-2010, total of 12 years; $region_i$ is the region in the world where the company is located, a total of 20 regions in the sample; $country_i$ is the country in the world where the company has its main address, total of 69 in Table III; $sector_i$ is the four-digit SIC primary code of the company, total of 413 sectors[7]; and $u_{i,t}$ is the regression error term. The econometric Model (3) only includes the effect of contemporaneous and two year lags of return on equity following the evidence of Beaver and Ryan (2000). The model is:

$$MtB_{i,t} = \beta_0 + \beta_1 RoE_{i,t} + \beta_2 RoE_{i,t-1} + \beta_3 RoE_{i,t-2} + u_{i,t} \tag{3}$$

The next econometric Model (4) is complete including the potential for time-varying effects of the effect of return on equity, instrumented lagged market-to-book, lagged return on equity and several controls. It is a two-stage least squares extension of Model (2), thus

including year, region, country and sector fixed effects as well as the potential time-varying sensitivity of market-to-book to return on equity captured by an interaction with the year and lagged return on equity:

$$MtB_{i,t} = \beta_0 + \alpha_1 E[MtB_{i,t-1}|.] + \beta_1 RoE_{i,t} + \beta_2 RoE_{i,t} \times year_t + \beta_3 Vix_t + \beta_4 RoE_{i,t-1} + \beta_5 RoE_{i,t-2} + \sum_{i=1}^{n2} \delta_{1t} year_t + \sum_{i=1}^{n3} \delta_{2i} region_i + \sum_{i=1}^{n4} \delta_{3i} country_i + \sum_{i=1}^{n5} \delta_{4i} sector_i + u_{i,t} \quad (4)$$

where $E[MtB_{i,t-1}|.]$ is the predicted lagged market-to-book ratio of firm i in year t, in logarithms; $RoE_{i,t}$ is the return on equity of firm i for year t; Vix_t is the volatility measure of the USA S&P500 from the Chicago Board of Trade options market; $year_t$ is the year fixed effect 1999-2010; $region_i$ is the region in the world where the company is located, total of 20; $country_i$ is the country in the world where the company has its main address, total of 98 in Table III; $sector_i$ is the four-digit SIC primary code of the company, total of 413 sectors; and $u_{i,t}$ is the regression error term.

The following econometric Models (5-8) explore the issue of whether the relationship between market-to-book and return on equity is influenced by firms that exhibit positive return on equity versus firms those that exhibit negative return on equity as pointed out by Leibowitz (1999). Econometric Model (5) is the basic benchmark for this case, or:

$$MtB_{i,t} = \beta_0 + \beta_1 D_{i,t} \times RoE_{i,t} + \beta_2 (1 - D_{i,t}) \times RoE_{i,t} + u_{i,t} \quad (5)$$

where $MtB_{i,t}$ is the market-to-book ratio of firm i in year t, in logarithms; $RoE_{i,t}$ is the return on equity of firm i for year t, $D_{i,t}$ a dummy variable that takes the value of 1 when $RoE_{i,t}$ is positive and 0 otherwise; and $u_{i,t}$ is the regression error term. The key issue here is whether β_1 and β_2 are qualitatively and statistically different. The econometric Model (6) includes the potential for time-varying effects of the effect of both positive and negative return on equity, instrumented lagged market-to-book and several controls. It is the two-stage least squares case which includes year, region, country and sector fixed effects as well as the potential time-varying sensitivity of market-to-book to both positive and negative return on equity captured by an interaction with the year:

$$MtB_{i,t} = \beta_0 + \alpha_1 E[MtB_{i,t-1}|.] + \beta_1 D_{i,t} \times RoE_{i,t} + \beta_2 (1 - D_{i,t}) \times RoE_{i,t} + \beta_3 D_{i,t} \times RoE_{i,t} \times year_t + \beta_4 (1 - D_{i,t}) \times RoE_{i,t} \times year_t + \beta_5 Vix_t + \sum_{i=1}^{n2} \delta_{1t} year_t + \sum_{i=1}^{n3} \delta_{2i} region_i + \sum_{i=1}^{n4} \delta_{3i} country_i + \sum_{i=1}^{n5} \delta_{4i} sector_i + u_{i,t} \quad (6)$$

where $E[MtB_{i,t-1}|.]$ is the predicted lagged market-to-book ratio of firm i in year t, in logarithms; $RoE_{i,t}$ is the return on equity of firm i for year t; $D_{i,t}$ a dummy variable that takes

the value of 1 when $RoE_{i,t}$ is positive and 0 otherwise; Vix_t is the volatility measure of the USA S&P500 from the Chicago Board of Trade options market; $year_t$ is the year fixed effect 1999-2010; $region_i$ is the region in the world where the company is located, total of 20; $country_i$ is the country in the world where the company has its main address, total of 98 in Table III; $sector_i$ is the four-digit SIC primary code of the company, total of 413 sectors; $u_{i,t}$ is the regression error term.

The Model (7) only includes the effect of contemporaneous and two year lags of both positive and negative return on equity for positive and negative return on equity:

$$MtB_{i,t} = \beta_0 + \beta_1 D_{i,t} \times RoE_{i,t} + \beta_2 D_{i,t} \times RoE_{i,t-1} + \beta_3 D_{i,t} \times RoE_{i,t-2} + \beta_4 (1 - D_{i,t}) \times RoE_{i,t} + \beta_5 (1 - D_{i,t}) \times RoE_{i,t-1} + \beta_6 (1 - D_{i,t}) \times RoE_{i,t-2} + u_{i,t} \quad (7)$$

where $RoE_{i,t}$ is the return on equity of firm i for year t; $D_{i,t}$ a dummy variable that takes the value of 1 when $RoE_{i,t}$ is positive and 0 otherwise; and $u_{i,t}$ is the regression error term. Finally, Model (8) includes the potential for time-varying effects of the effect of both positive and negative return on equity, and two year lags of both positive and negative return on equity, instrumented lagged market-to-book and several controls. It is the two-stage least squares case which includes year, region, country and sector fixed effects:

$$MtB_{i,t} = \beta_0 + \alpha_1 E[MtB_{i,t-1}|.] + \beta_1 D_{i,t} \times RoE_{i,t} + \beta_2 (1 - D_{i,t}) \times RoE_{i,t} + \beta_3 D_{i,t} \times RoE_{i,t} \times year_t + \beta_4 (1 - D_{i,t}) \times RoE_{i,t} \times year_t + \beta_5 D_{i,t} \times RoE_{i,t-1} + \beta_6 D_{i,t} \times RoE_{i,t-2} + \beta_7 (1 - D_{i,t}) \times RoE_{i,t-1} + \beta_8 (1 - D_{i,t}) \times RoE_{i,t-2} + \beta_9 Vix_t + \sum_{i=1}^{n2} \delta_{1i} year_t + \sum_{i=1}^{n3} \delta_{2i} region_i + \sum_{i=1}^{n4} \delta_{3i} country_i + \sum_{i=1}^{n5} \delta_{4i} sector_i + u_{i,t} \quad (8)$$

where $E[MtB_{i,t-1}|.]$ is the predicted lagged market-to-book ratio of firm i in year t, in logarithms; $RoE_{i,t}$ is the return on equity of firm i for year t; $D_{i,t}$ a dummy variable that takes the value of 1 when $RoE_{i,t}$ is positive and 0 otherwise; Vix_t is the volatility measure of the USA S&P500 from the Chicago Board of Trade options market; $year_t$ is the year fixed effect 1999-2010; $region_i$ is the region in the world where the company is located, total of 20; $country_i$ is the country in the world where the company has its main address, total of 98 in Table III; $sector_i$ is the four-digit SIC primary code of the company, total of 413 sectors; and $u_{i,t}$ is the regression error term[8].

5. Empirical results

We estimate the eight basic models of the market-to-book/return on equity relationship.

5.1 OLS estimates

First, we estimate the models via OLS. Table IV gives the results of the basic eight models estimated under OLS with robust standard errors. The OLS results for Model (1) are not statistically significant and the effect is well not identified. We proceed to our second model below. The results for econometric Model (2) are significantly better relative to the

OLS (log)	(1) mkt_to_book	(2) mkt_to_book	(3) mkt_to_book	(4) mkt_to_book
Lag_mkt_to_b		0.788***		0.792***
ret_o_eq	0.000154	0.997***	0.00103**	1.013***
ret_o_eq x y		−0.000498***		−0.000506***
L.ret_o_eq			0.000988**	−0.00108***
L2.ret_o_eq			0.000236	0.00135***
VIX		−0.0308***		−0.0309***
Year		Y		Y
Region		Y		Y
Country		Y		Y
Sector		Y		Y
Const	0.421***	−0.0150	0.410***	0.0187
N	35341	22543	22550	22543

Notes: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$; Y indicates control included; same for all regressions below: mkt_to_book = Market-to-book in logarithms; Lag_mkt_to_b = one lag instrumented market to book; ret_o_eq = return on equity; ret_o_eq x y = return on equity times year dummies; L.ret_o_eq = one lag return on equity; L2.ret_o_eq = two lags return on equity; VIX is the VIX index itself; Year, region, country and sector are dummies for fixed effects as explained in the text

Table IV. OLS Estimates of regression specifications (1)-(8), each column represents the numbered equation in Section 4

benchmark. First, the model shows that the autocorrelation of the market-to-book is significant and large, of the order of 0.79. This indicates that there is positive and strong persistence in the market-to-book of companies in this sector worldwide. The effect of the return on equity is now statistically significant with evidence of time-varying structure[9]. The effect is declining but positive until 2002. After 2002, the effect becomes negative. The magnitudes are relatively small but significant. In 1999, a one-unit percentage point increase in return on equity increases market-to-book by about 0.2 per cent, whereas in 2010, this effect reverses to a decrease of about 0.4 per cent. This is important because low market-to-book ratio or value stocks (high market-to-book ratio/growth stocks) and high (low) return on equity represent mismatches that provide opportunity for investor profits. The evidence is that those mismatches start to arise in 2003 and increase from then on[10]. The effect of the S&P500 VIX, which captures risk, is negative, significant and large in magnitude. One-unit increase in the VIX index decreases market-to-book by approximately 3 per cent in the year.

The econometric Model (3) in Table IV only includes the effect of contemporaneous and two year lags of return on equity, thus capturing the potential over (under) reaction of the effect of return on equity on market-to-book[11]. The contemporaneous effect of the return on equity is statistically significant with a one-unit (percentage point) increase in return on equity increasing market-to-book by about 0.1 per cent. The first lag of the return on equity has a positive and significant effect of about the same magnitude as the contemporaneous effect indicating similar reaction of the effect of return on equity on market-to-book; but the second lag is not significant. Econometric Model (4) is the complete model including the potential for time-varying effects of the effect of return on equity, instrumented lagged market-to-book, lagged return on equity and several controls. The estimates show that the autocorrelation of the market-to-book is significant and large, of the order of 0.79. This indicates that there is positive and strong persistence in the market-to-book of companies in this sector worldwide. The effect of the return on equity is statistically significant with evidence of time-varying

structure. The first lag of the return on equity has a negative and significant effect of about minus 0.1 per cent and the second lag has a positive effect of the approximately similar magnitude, thus indicating overreaction effects on the market-to-book ratio. The effect of the S&P500 volatility index VIX is negative, significant and large in magnitude similar to Model (2), one-unit increase in the VIX index decreases market-to-book by approximately 3 per cent in the year. Thus, the overall stock market risk (VIX) is captured by the market equity pricing.

The following econometric Models (5-8) in Table V explore the issue of whether the relationship between market-to-book and return on equity is influenced by firms that exhibit positive return on equity (positive profitability) versus firms that exhibit negative return on equity (negative profitability). Model (5) is the basic benchmark for this case, and the results are statistically significant and informative. For firms with positive return on equity or positive profitability, the effect of return on equity on market-to-book is positive and large, a one unit (percentage point) increase in return on equity increasing market-to-book by about 1.3 per cent conditional on the return on equity being positive. For firms with negative return on equity or negative profitability, the effect of return on equity on market-to-book is negative and moderate, a one unit (percentage point) increase in return on equity decreases market-to-book by about 0.3 per cent conditional on the return on equity being negative. This confirms Leibowitz's (1999) main hypothesis that the relationship between market-to-book and return on equity is positive (negative) for the domain of positive (negative) return

OLS (log)	(5) mkt_to_book	(6) mkt_to_book	(7) mkt_to_book	(8) mkt_to_book
Lag_mkt_to_b		0.773***		0.782***
d_p_tim~2010	0.0132***	−0.293	0.0137***	−0.326
d_p_times_~r		0.000149		0.000166
L.d_p_t~2010			0.00761***	0.000346
L2.d_p_~2010			0.00317***	−0.00105**
one_min~2010	−0.00338***	0.884***	−0.00284***	0.887***
one_minus_~r		−0.000443***		−0.000444***
L.one_m~2010			−0.00101*	0.00130***
L2.one_~2010			−0.000733*	0.00229***
VIX		0.0310***		−0.0310***
Year		Y		Y
Region		Y		Y
Country		Y		Y
Sector		Y		Y
Const		Y		Y
N	35341	22543	22550	22543

Table V.
OLS estimates of regression specifications (5)-(8), each column represents the numbered equation in Section 4

Notes: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$; Y indicates control included; mkt_to_book = Market-to-book in logarithms; Lag_mkt_to_b = one lag instrumented market to book; d_p_tim~2010 = positive return on equity dummy times return on equity; d_p_times_~r = positive return on equity dummy times return on equity times year; L.d_p_t~2010 = lag one of positive return on equity dummy times return on equity; L2.d_p_~2010 = lag two of positive return on equity dummy times return on equity; one_min~2010 = negative return on equity dummy times return on equity; one_minus_~r = negative return on equity dummy times return on equity times year; L.one_m~2010 = lag one negative return on equity dummy times return on equity; L2.one_~2010 = lag two negative positive return on equity dummy times return on equity; VIX is the VIX index itself; Year, region, country and sector are dummies for fixed effects as explained in the text

on equity. We corroborate this finding in a worldwide sample of the commodities sector in the more recent period 1999-2010.

Econometric Model (6) includes the potential for time-varying effects of the effect of both positive and negative return on equity, instrumented lagged market-to-book and several controls. First, the autocorrelation of the market-to-book continues to be significant and large, of the order of 0.77. Conditional on firms with positive return on equity (positive profitability), the effect of return on equity on market-to-book is not statistically significant when combined with potential variation over time; thus, we find no evidence of time-varying effects of return on equity on market-to-book conditional on positive return on equity or positive profitability. However, conditional on firms with negative return on equity (negative profitability), the effect of return on equity on market-to-book is statistically significant and time varying, decreasing significantly over the years. The time structure of the effect when return on equity is negative or negative profitability is declining and negative across all years in the sample. The magnitudes are relatively small. In 1999, a one-unit (percentage point) increase in return on equity decreased market-to-book by about minus 0.15 per cent, whereas in 2010, this effect leads to a decrease of about minus 0.65 per cent. The effect of the S&P500 volatility index VIX is negative, significant and large in magnitude. A one-unit increase in the VIX index decreases market-to-book by approximately 3 per cent in the year. Estimation of econometric Model (7) only includes the effect of contemporaneous and two year lags of both positive and negative return on equity. Conditional on positive returns on equity (positive profitability), the contemporaneous and lags one and two of returns on equity are positive and statistically significant, of an order of magnitude of 1.4, 0.8 and 0.3 per cent, respectively. Conditional on negative returns (negative profitability), the contemporaneous and lags one of returns on equity are negative and statistically significant, of an order of magnitude of minus 0.3 and 0.1 per cent, respectively[12].

Finally, Model (8) is complete and includes the potential for time-varying effects of the effect of both positive and negative return on equity, and two year lags of both positive and negative return on equity, instrumented lagged market-to-book and several controls. The autocorrelation of the market-to-book is significant and large, of the order of 0.78. Conditional on firms with positive return on equity (positive profitability), the effect of return on equity on market-to-book is not statistically significant when combined with potential variation over time; thus, we find no evidence of time-varying effects of return on equity on market-to-book conditional on positive return on equity or positive profitability. The lag one effect of the positive return on equity on market-to-book is also not statistically significant, while lag two effect is marginally negatively significant. Overall, conditional on positive return on equity (positive profitability), the time-varying structure of contemporaneous return on equity and the lagged return on equity is not statistically relevant when all controls are included. However, conditional on firms with negative return on equity (negative profitability), the effect of return on equity on market-to-book is statistically significant and time varying, decreasing significantly over the years. Conditional on negative returns, the lags one and two of returns on equity are both statistically significant, of an order of magnitude of -0.1 per cent and 0.2 per cent, respectively, thus indicating some overreaction at the negative return on equity domain when controls are included. The effect of the S&P500 volatility index VIX is negative, significant and large in magnitude. A one-unit increase in the VIX index decreases market-to-book by approximately 3 per cent in the year.

In summary, Tables IV and V show that under OLS estimation, market-to-book values are positively and strongly autocorrelated with a lag one memory of slightly under 0.8, and

this result is robust across all specifications. The VIX measure of risk of the USA S&P500 impacts negatively and robustly on market-to-book values with an impact effect of about −3 per cent on value per unit of VIX index across all specifications. In general, the effect of the return on equity is time-varying and declining across the years in the sample.

In the most general Model (8) under OLS, we find no evidence of time-varying effects of return on equity on market-to-book conditional on positive return on equity (positive profitability), and the lagged return on equity is not statistically relevant when all controls are included. Conditional on firms with negative return on equity (negative profitability), the effect of return on equity on market-to-book is negative, statistically significant and time varying, decreasing significantly over the years. Conditional on negative returns (negative profitability), the lags one and two of returns on equity are both statistically significant indicating overreaction at the negative return on equity space when controls are included.

5.2 Quantile regression estimates

Next, we present results of the quantile regression method. Tables VI to IX present each econometric model (1)-(8) estimated via the quantile regression method of Koenker and Bassett (1978) for market-to-book quantiles 10th, 25th, 50th, 75th and 90th, thus considering the riskier value stocks (low quantiles) at VaR, and less risky growth stocks at high quantiles.

Results for econometric Model (1) in the first part of Table VI refer to the basic benchmark model where the return on equity is projected on the valuation measure. The results across quantiles are statistically significant and thus radically different from the OLS results in the Column (1) Tables IV and V. The effect of return on equity is declining across quantiles starting with a positive effect of about 0.9 per cent on

Quantile (log)	10 mkt_to_book	25 mkt_to_book	50 mkt_to_book	75 mkt_to_book	90 mkt_to_book
Model (1)					
ret_o_eq	0.00856***	0.00361***	−0.000731***	−0.00210***	−0.00240***
Const	−0.944***	−0.205***	0.482***	1.161***	1.835***
N	35341	35341	35341	35341	35341
Model (2)					
lag_lvalue∼t	0.877***	0.848***	0.805***	0.738***	0.656***
ret_o_eq	1.014***	0.846***	1.176***	1.127***	0.890***
ret_o_eq_y∼r	−0.000504***	−0.000421***	−0.000587***	−0.000563***	−0.000446***
VIX	−0.0401***	−0.0349***	−0.0273***	−0.0233***	−0.0224***
Year	Y	Y	Y	Y	Y
Region	Y	Y	Y	Y	Y
Country	Y	Y	Y	Y	Y
Sector	Y	Y	Y	Y	Y
Const	1.385	1.220	−1.417	−2.313	−2.204
N	22543	22543	22543	22543	22543

Notes: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$; Y indicates control included; same for all regressions below: mkt_to_book = Market-to-book in logarithms; Lag_mkt_to_b = one lag instrumented market to book; ret_o_eq = return on equity; ret_o_eq x y = return on equity times year dummies; VIX is the VIX index itself; Year, region, country and sector are dummies for fixed effects as explained in the text

Table VI.
Quantile regression estimates for regression specifications (1)-(2), Model (1)-(2) represent the numbered equation in Section 4

Quantile (log)	10 mkt_to_book	25 mkt_to_book	50 mkt_to_book	75 mkt_to_book	90 mkt_to_book
Model (3)					
ret_o_eq	0.00846***	0.00462***	0.00162***	−0.000546	−0.00195***
L1ret_o_eq	0.00487***	0.00279***	0.000620*	−0.000441	−0.000142
L2ret_o_eq	0.00286***	0.000956***	−0.000414	−0.000587*	0.000293
Const	−0.880***	−0.209***	0.454***	1.112***	1.769***
N	22550	22550	22550	22550	22550
Model (4)					
lag_mkt_to_book	0.879***	0.852***	0.811***	0.745***	0.666***
ret_o_eq	0.917***	0.956***	1.169***	1.096***	0.749***
ret_o_eq_y∼r	−0.000456***	−0.000476***	−0.000583***	−0.000547***	−0.000375***
L1ret_o_eq	0.000795*	−0.0000213	−0.00105***	−0.00200***	−0.00258***
L2ret_o_eq	0.00197***	0.00172***	0.000824***	0.000418*	0.000438
VIX	−0.0405***	−0.0353***	−0.0274***	−0.0233***	−0.0226***
Year	Y	Y	Y	Y	Y
Region	Y	Y	Y	Y	Y
Country	Y	Y	Y	Y	Y
Sector	Y	Y	Y	Y	Y
Const	−3.018	−3.463*	−0.768	0.0975	−0.161
N	22543	22543	22543	22543	22543

Notes: *$p < 0.05$, ** $p < 0.01$, ***$p < 0.001$; Y indicates control included; mkt_to_book = Market-to-book in logarithms; Lag_mkt_to_b = one lag instrumented market to book; L.ret_o_eq = one lag return on equity; L2.ret_o_eq = two lags return on equity; VIX is the VIX index itself; Year, region, country and sector are dummies for fixed effects as explained in the text

Table VII. Quantile regression estimates for regression specifications (3)-(4), Model (3)-(4) represent the numbered equation in Section 4

market-to-book per unit of return on equity at the 10th percentile of the market-to-book (that is for riskier value stocks at VaR), then declining to about 0.4 per cent at the 25th percentile and turning negative after the 50 per cent (median) percentile, with −0.01 per cent, 0.02 and 0.02 per cent for the 50th, 75th, and 90th percentiles, respectively, that is for less risky growth stocks. Results for econometric Model (2), which includes the instrumented lagged market-to-book ratio, time-varying return on equity effects, the measure of risk and controls are in the second part of Table VI. The results across quantiles are statistically significant. The persistence of market-to-book is positive and slightly declines across quantiles ranging from 0.88 to 0.65 at the 10th and 90th percentiles, respectively. This indicates that there is positive and strong persistence in the market-to-book of companies in this sector worldwide, but the lower quantiles (riskier value stocks at VaR) are more persistent than the upper quantiles (growth stocks). Intuitively, this potentially indicates that bearish firms can potentially take longer to revert to an upside state. The overall time-varying effect of return on equity declines across quantiles and across time. The effect of the VIX is significantly negative and declines (in absolute value) across quantiles ranging from −4 per cent at the 10th percentile (riskier value stocks at VaR) to −2 per cent at the 90th percentile for less risky growth stocks[13].

Model (3) only includes the effect of contemporaneous and two year lags of return on equity and are in the first part of Table VII. The effect of return on equity is declining across quantiles starting with a positive effect of about 0.8 per cent on market-to-book per unit of return on equity at the 10th percentile of the market-to-book (value stocks at VaR), then declining to about 0.5 per cent at the 25th percentile and about 0.2 per cent at the 50 per cent

Quantile (log)	10 mkt_to_book	25 mkt_to_book	50 mkt_to_book	75 mkt_to_book	90 mkt_to_book
Model (5)					
d_p_tim~2010	0.0104***	0.0162***	0.0181***	0.0181***	0.0200***
one_min~2010	0.00700***	−0.00135***	−0.00555***	−0.00763***	−0.00829***
Const	−0.979***	−0.358***	0.241***	0.854***	1.458***
N	35341	35341	35341	35341	35341
Model (6)					
lag_mkt_to_book	0.875***	0.828***	0.775***	0.696***	0.614***
d_p_tim~2010	−1.325*	−0.890*	0.551*	1.431***	1.571***
d_p_times_~r	0.000664*	0.000448*	−0.000270	−0.000708***	−0.000778***
one_min~2010	1.684***	1.054***	0.898***	0.513***	0.336
one_minus_~r	−0.000839***	−0.000526***	−0.000450***	−0.000259***	−0.000172
VIX	0.0416***	−0.0355***	−0.0267***	−0.0214***	−0.0203***
year	Y	Y	Y	Y	Y
region	Y	Y	Y	Y	Y
country	Y	Y	Y	Y	Y
sector	Y	Y	Y	Y	Y
Const	−3.001	−4.028**	−1.237	−0.463	−1.231
N	22543	22543	22543	22543	22543

Table VIII. Quantile regression estimates for regression specifications (5)-(6), Model (5)-(6) represent the numbered equation in Section 4

Notes: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$; Y indicates control included; mkt_to_book = Market-to-book in logarithms; Lag_mkt_to_b = one lag instrumented market to book; ret_o_eq = return on equity; ret_o_eq x y = return on equity times year dummies; d_p_tim~2010 = positive return on equity dummy times return on equity; d_p_times_~r = positive return on equity dummy times return on equity times year; one_min~2010 = negative return on equity dummy times return on equity; one_minus_~r = negative return on equity dummy times return on equity times year; VIX is the VIX index itself; Year, region, country and sector are dummies for fixed effects as explained in the text

Quantile (log)	10 mkt_to_book	25 mkt_to_book	50 mkt_to_book	75 mkt_to_book	90 mkt_to_book
Model (7)					
d_p_tim~2010	0.0128***	0.0156***	0.0184***	0.0192***	0.0205***
L1d_p_t~2010	0.00828***	0.00825***	0.00693***	0.00523***	0.00540***
L2d_p_t~2010	0.00301***	0.00198**	0.00181***	0.000553	0.000534
one_min~2010	0.00552***	−0.000315	−0.00434***	−0.00607***	−0.00736***
L1o_min~2010	0.00324***	−0.000346	−0.00229***	−0.00287***	−0.00316***
L2o_min~2010	0.00279***	−0.000138	−0.00173***	−0.00174***	−0.000728
_cons	−0.985***	−0.442***	0.0960***	0.700***	1.293***
N	22550	22550	22550	22550	22550

Table IX. Quantile regression estimates for regression specifications (7), Model (7) represent the numbered equation in Section 4

Notes: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$; Y indicates control included; mkt_to_book = Market-to-book in logarithms; d_p_tim~2010 = positive return on equity dummy times return on equity; L.d_p_t~2010 = lag one of positive return on equity dummy times return on equity; L2.d_p_~2010 = lag two of positive return on equity dummy times return on equity; one_min~2010 = negative return on equity dummy times return on equity; L.one_m~2010 = lag one negative return on equity dummy times return on equity; L2. one_~2010 = lag two negative positive return on equity dummy times return on equity; VIX is the VIX index itself; Year, region, country and sector are dummies for fixed effects as explained in the text

(median) percentile, with −0.02 per cent at the 90th percentile for less risky growth stocks. The first and second lags of return on equity have a positive and significant effect on market-to-book at the 10th and 25th percentiles only. Model (4) is in the lower part of Table VII. It is the complete model including the potential for time-varying effects of the effect of return on equity, instrumented lagged market-to-book, lagged return on equity and several controls. The model continues to show that the autocorrelation of the market-to-book is significant and large across all quantiles, ranging from 0.88 to 0.67 at the lower most quantiles (riskier value stocks at VaR) and upper most quantiles (less risky growth stocks). The overall time-varying effect of return on equity declines across quantiles and across time as illustrated in Figure 3. At the 10th percentile (riskier value stocks at low VaR), lag one and two are positive and significant as in Model (3); however, at the other quantiles, the effects vary. The first lag is negative and significant at the median and upper quantiles. Thus, there is evidence of overreaction effects on the market-to-book ratio in the upper quantiles of less risky growth stocks. The second lag is positive and statistically significant in all quantiles, except the upper 90th percentile. The effect of the S&P500 volatility index VIX is negative, significant and large in magnitude but declining (in absolute value) across quantiles as before.

Tables VIII to IX show the econometric Models (5-8) which explore the issue of whether the relationship between market-to-book and return on equity is influenced by firms that exhibit positive return on equity (positive profitability) versus firms that exhibit negative return on equity (negative profitability). The upper part of Table VIII shows the quantile regressions for Model (5), the benchmark model. For firms with positive return on equity (positive profitability), the effect of return on equity on market-to-book is positive, large and increasing with the quantiles. A one unit (percentage point) increase in return on equity increases market-to-book by about 1.0 per cent conditional on the return on equity being positive at the 10th percentile (riskier value stocks at VaR). It increases to 1.6, 1.8 and ultimately 2.0 per cent at the upper most 90th percentile for growth stocks. Thus, conditional on positive profitability, bullish firms are more sensitive to return on equity. For firms with negative return on equity (negative profitability), the effect of return on equity on market-to-

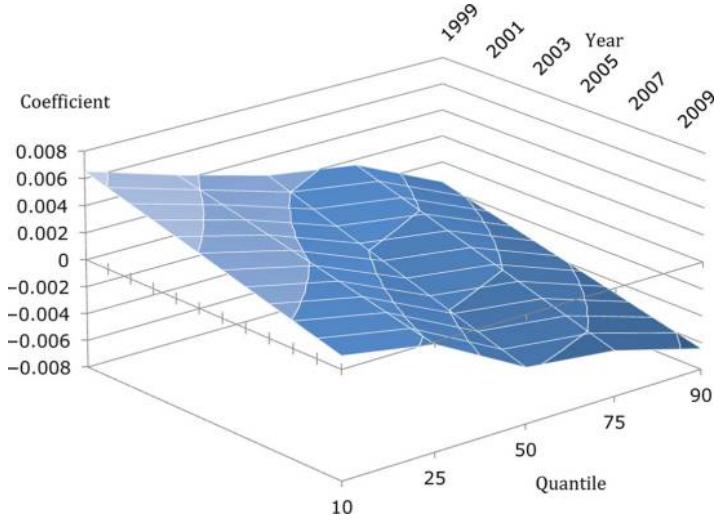


Figure 3.
Time-varying coefficients of return on equity on market-to-book (logs) across quantiles and years

book is positive and very small at the lower 10th percentile (riskier value stocks at VaR). Then, it is negative at all other percentiles ranging from −0.1 to −0.8 per cent at the upper most 90th percentile for growth stocks.

The lower part of Table VIII shows quantile regressions for Model (6) which includes the potential for time-varying effects of the effect of both positive and negative return on equity, instrumented lagged market-to-book and several controls. First, the autocorrelation of the market-to-book is significant and large, but declining across quantiles. This indicates that there is positive and strong persistence in the market-to-book of companies in this sector worldwide, but the lower quantiles (riskier value stocks at VaR) are more persistent than the upper quantiles (growth stock) confirming the results of Model (3) above. Conditional on firms with positive return on equity (positive profitability), the effect of return on equity on market-to-book is statistically significant when combined with potential variation over time; however, the time structure of the effect varies across quantiles. At the 10th and 25th quantiles (value stocks at VaR), the effect of return on equity on market-to-book increases over time; but for the 50th, 75th, and 90th percentiles (growth stock), the effect is decreasing over time. The mean effect from Table I Model (6) is moderately decreasing over time. Conditional on firms with negative return on equity (negative profitability), the effect of return on equity on market-to-book is statistically significant, and it decreases significantly over the years. The effect when return on equity is negative or negative profitability is declining and negative across all years. The magnitudes are much larger for the lower quantiles (riskier value stock at VaR), while they become smaller and eventually not significant in the upper 90th percentile (growth stocks). The mean pattern is similar to the median pattern in this case. It seems that bearish firms may be able to slow the speed of down-pricing providing arbitrage opportunity when short-selling in these stocks. The effect of the S&P500 volatility index VIX is negative, significant and also declines (in absolute value) across quantiles.

Table IX shows the estimates for Models (7) and (8). The upper part of the table shows Model (7) which only includes the effect of contemporaneous and two year lags of both positive and negative return on equity. Conditional on positive returns on equity (positive profitability), the contemporaneous and lags one and two of returns on equity are positive and statistically significant, and their magnitudes decrease as the quantiles increase. Conditional on negative returns, the contemporaneous and lags one and two of returns on equity are first positive and significant at the lower 10th percentile (riskier value stocks at VaR). At the subsequent 25th, 50th, 75th and 90th percentiles (growth stock), the effects are negative and mostly significant. Finally, the lower part of Table X shows Model (8) which includes the potential for time-varying effects of the effect of both positive and negative return on equity, and two year lags of both positive and negative return on equity, instrumented lagged market-to-book and several controls. The autocorrelation of the market-to-book is significant and large, but declines across the upper quantiles (growth stocks). Conditional on firms with positive return on equity (positive profitability), the effect of return on equity on market-to-book is statistically significant in the 25th, 75th and 90th percentiles only. The lag one effect of the positive return on equity on market-to-book is also not statistically significant, while lag two is negatively significant across all quantiles. Conditional on firms with negative return on equity (negative profitability), the effect of return on equity on market-to-book is statistically significant and time varying, decreasing significantly over the years. Conditional on negative returns (negative profitability), the lags one and two of returns on equity are both statistically significant at the 50th and 75th percentiles, but vary across the tails. There is evidence of overreaction at the 50th, 75th

Quantile (log)	10 mkt_to_book	25 mkt_to_book	50 mkt_to_book	75 mkt_to_book	90 mkt_to_book
Model (8)					
Lag_mkt_to_book	0.892***	0.840***	0.787***	0.713***	0.632***
d_p_tim~2010	−1.228*	−0.942**	0.280	1.199***	1.668***
d_p_times_~r	0.000615*	0.000474**	−0.000134	−0.000592***	−0.000825***
L1d_p_t~2010	0.000679	0.0000969	0.0000157	−0.000631	−0.000579
L2d_p_t~2010	−0.00231***	−0.00125**	−0.00141***	−0.00154***	−0.00128*
One_min~2010	1.377***	1.106***	0.939***	0.498***	0.208
one_minus_~r	−0.000686***	−0.000552***	−0.000470***	−0.000251***	−0.000108
L1o_min~2010	0.000629	−0.000239	−0.00144***	−0.00265***	−0.00329***
L2o_min~2010	0.00447***	0.00340***	0.00224***	0.00127***	0.000386
VIX	−0.0416***	−0.0357***	−0.0265***	−0.0216***	−0.0199***
Year	Y	Y	Y	Y	Y
Region	Y	Y	Y	Y	Y
Country	Y	Y	Y	Y	Y
Sector	Y	Y	Y	Y	Y
Const	−3.061	−3.367*	−0.808	−0.268	−0.431
N	22543	22543	22543	22543	22543

Notes: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$; Y indicates control included; mkt_to_book = Market-to-book in logarithms; Lag_mkt_to_b = one lag instrumented market to book; d_p_tim~2010 = positive return on equity dummy times return on equity; d_p_times_~r = positive return on equity dummy times return on equity times year; L.d_p_t~2010 = lag one of positive return on equity dummy times return on equity; L2. d_p_~2010 = lag two of positive return on equity dummy times return on equity; one_min~2010 = negative return on equity dummy times return on equity; one_minus_~r = negative return on equity dummy times return on equity times year; L.one_m~2010 = lag one negative return on equity dummy times return on equity; L2.one_~2010 = lag two negative positive return on equity dummy times return on equity; VIX is the VIX index itself; Year, region, country and sector are dummies for fixed effects as explained in the text

Table X. Quantile regression estimates for regression specifications (8), Model (8) represent the numbered equation in Section 4

and 90th percentiles (growth stocks). The effect of the S&P500 volatility index VIX is negative, significant and large in magnitude, but declines (in absolute value) as the quantiles increase toward the upper 90th percentile (growth stocks).

6. Summary and conclusions

We pursue the evidence on the valuation relationship of book-to-market and return on equity for the worldwide commodities sector using WorldScope data and a sample of 6,323 firms with annual observations from 1999 to 2010. The key aspect of our methodology is to understand the relationship between market-to-book and return on equity at alternative states of the independent variable, say positive versus negative return on equity (positive versus negative profitability); and at alternative quantiles of the distribution of the dependent variable, the market-to-book valuation, where low quantiles represent riskier value stocks at VaR, while high quantiles represent less risky growth stocks.

We find under OLS estimation that market-to-book values are positively and strongly autocorrelated with a lag one memory of slightly under 0.8. The VIX measure of risk of the USA S&P500 impacts negatively and robustly on market-to-book values with an impact effect of about −3 per cent on value per unit of VIX index. In general, the effect of the return on equity on market-to-book is time-varying and declining across the years in the sample. In

the most general Model (8) under OLS, we find no evidence of time-varying effects of return on equity on market-to-book conditional on positive return on equity (positive profitability), and the lagged return on equity is not statistically relevant when all controls are included. Conditional on firms with negative return on equity (negative profitability), the effect of return on equity on market-to-book is negative, statistically significant and time varying, decreasing significantly over the years. Conditional on negative returns (negative profitability), the lags one and two of returns on equity are both statistically significant indicating some overreaction at the negative return on equity space when controls are included.

Under quantile regression, the story is much more interesting. First, there is positive and strong persistence in the market-to-book of companies in this sector worldwide, but the lower quantiles (riskier value stocks at VaR) are more persistent than the upper quantiles (growth stocks). The effect of the return on equity is positive of about 0.9 per cent on market-to-book per unit of return on equity at the 10th percentile of the market-to-book (riskier value stocks at VaR), then declining to about 0.4 per cent at the 25th percentile and turning negative after the 50 per cent (median) percentile, with −0.01, 0.02 and 0.02 per cent for the 50th, 75th, and 90th percentiles, respectively (growth stocks). But, the one and two lagged return on equity has a mixed effect across the quantiles. There is evidence of overreaction effects on the market-to-book ratio in the upper quantiles only for growth stocks with high VaR.

The quantile regressions for Model (5), the benchmark model, show that for firms with positive return on equity, the effect of return on equity on market-to-book is positive and large and increasing with the quantiles. A one-unit (percentage point) increase in return on equity increasing market-to-book by about 1.0 per cent conditional on the return on equity being positive (positive profitability) at the 10th percentile (riskier value stocks at VaR). It increases to 1.6, 1.8 and ultimately 2.0 per cent at the upper most 90th percentile (growth stock). For firms with negative return on equity (negative profitability), the effect of return on equity on market-to-book is positive and very small at the lower 10th percentile (riskier value stocks at VaR). Then, it is negative at all other percentiles ranging from −0.1 to −0.8 per cent at the upper most 90th percentile (growth stocks). Hence, we find that for the commodities sector where firms have more tangibles, bullish firms respond much more to signals of profitability, whereas bearish firms tend to provide an arbitrage opportunity at the upper quantiles of market-to-book. The effect of the S&P500 volatility index VIX is negative, significant and large in magnitude, but declines as the quantiles increase toward the upper 90th for growth stocks. Our main message is that the P/B-ROE valuation model is empirically plausible and informative and together with the panel data-quantile regression methodology provides useful empirical evidence on valuation in general and, in particular, on valuation of growth versus value stocks and on valuation conditional on profitability. We expect to apply this methodology to other sectors in the worldwide publicly traded firm sphere.

Notes

1. Wilcox (1984), Ohlson (1990) and Wilcox and Philips (2004) emphasize the practical applications of this model focusing on valuation without significant bias, potential future predictability of returns and applicability in cross-section and time-series dimensions for corporate officers (the model should guide them on how best to increase firm value), fundamental analysts (can help them better evaluate a firm and its management), investment bankers and buyers and sellers of companies (unbiased valuation) and investors in general. In addition, we use a rich panel data approach.

2. Quantile regressions provide a nonparametric approach to value at risk (VaR), see Adrian and Brunnermeier (2011), Chernozhukov and Umantsev (2001) and Engle and Manganelli (1999). Considering the probability density function of the market-to-book ratio, the area to the left of each estimated quantile represents the probability that the market-to-book will be less than the estimated market-to-book at the quantile. In general, the VaR is a measure which tells us the probability of an amount of loss/gain given a period. Our interpretation here is that the 10th percentile of the market-to-book ratio indicates that the probability is 10 per cent that the market-to-book does not exceed the 10th percentile.
3. Note that value firms at VaR can represent arbitrage opportunities when the respective return on equity is positive and large, and this is important practical aspect of our study.
4. See, for example, the recent paper by Aboura and Wagner (2016) who study the relationship between extreme changes in risk-neutral volatility expectations via the VIX and aggregate asset prices via the S&P500 daily returns.
5. More generally, see Stoll and Whalley (2010) for analysis of commodities sector investing strategies and Hong and Yogo (2009) who recently investigate the determinants of aggregate commodity returns. The financial size of the global commodities market is commonly larger than the physical size, but both are relatively substantially large; see Dwyer *et al.* (2011). McSweeney and Worthington (2008) is an example of the importance of commodity prices for firm's asset prices.
6. Beaver and Ryan (2000) examine sources of variation in book value on the relationship between book-to-market ratios and return on equity. As in Fama and French (1995) and Bernard (1994, 1995), they show a negative relationship between book-to-market (the inverse of market-to-book) components and return on equity; see also the discussion of Campbell and Vuolteenaho (2004) more recently. Ryan (1995) showed that the book-to-market ratios are better suited than market values to explore patterns in valuation. In addition, a great deal of interest has been shown in the market-to-book ratio and its apparent ability to anticipate growth (Brief and Lawson, 1992) as well as future profitability (Edwards and Bell, 1961; Feltham and Ohlson, 1995) as well as its apparent ability to proxy for risk of distress (Fama and French, 1992; Chan, Hamao, and Lakonishok, 1991).
7. We have used sector fixed effects to recognize time-invariant unobserved heterogeneity across subsectors of the commodities world. We have results with alternative firm fixed effects available upon request.
8. We ran the Fisher tests for (unbalanced) panel unit roots of the key variables market-to-book and ROE. In both cases, we reject the null that all panels contain unit roots, and this is robust to alternative lags and trend/drift specifications. The VIX for the 12-yearly time dimension is also stationary.
9. The time varying coefficients are calculated as $\beta_1 + \beta_2 \times y_t$ where y_t takes the year values 1999, 2000, . . ., 2010 and the β'*s* are the coefficients of the respective regression. All other figures use similar calculation for the specific model.
10. The implication is that riskier value stocks with signals of positive profitability become a recommended "buy" after 2003 and increasingly toward 2010 due to arbitrage opportunities.
11. See De Bondt and Thaler (1985) for the issue of overreaction in stock markets. We emphasize that by using lagged variables, we can potentially identify under-overreaction effects in our framework.
12. One possible explanation is that momentum for bullish firms occurs in the former case, but reversals occur in the latter case at a lower rate.
13. This effect is robust across all models.

References

Aboura, S. and Wagner, N. (2016), "Extreme asymmetric volatility: stress and aggregate asset prices", *Journal of International Financial Markets, Institutions and Money*, Vol. 41, pp. 47-59.

Adrian, T. and Brunnermeier, M.K. (2011), "Covar", Department of Economics, Princeton University Working Paper, American Economic Review, Vol. 106, 7, July 2016, pp. 1705-1741.

Arellano, M. and Bond, S. (1991), "Some tests of specification for panel data: monte carlo evidence and an application to employment equations", *Review of Economic Studies*, Vol. 58 No. 2, pp. 277-297.

Beaver, W.H. and Ryan, S.G. (2000), "Biases and lags in book value and their effects on the ability of the book-to-market ratio to predict book return on equity", *Journal of Accounting Research*, Vol. 38 No. 1, pp. 127-148.

Bernard, V.L. (1994) "Accounting-based valuation methods, determinants of market-to-book ratios, and implications for financial statement analysis", Working Paper, University of Michigan.

Bernard, V.L. (1995), "Feltham-ohlson framework: implications for empiricists", *Contemporary Accounting Research*, Vol. 11 No. 2.

Brief, R.P. and Lawson, R.A. (1992), "The role of the accounting rate of return in financial statement analysis", *The Accounting Review*, Vol. 67 No. 2, pp. 411-426.

Campbell, J.Y. and Vuolteenaho, T. (2004), "Bad beta, good beta", *American Economic Review*, Vol. 94 No. 5, pp. 1249-1275.

Chan, H., Hamao, Y. and Lakonishok, J. (1991), "Fundamentals and stock returns in japan", *Journal of Finance*, Vol. 46 No. 5, pp. 1739-1764.

Chernozhukov, V. and Umantsev, L. (2001), "Conditional value-at-risk: aspects of modeling and estimation", *Empirical Economics*, Vol. 26 No. 1, pp. 271-292.

De Bondt, W.F.M. and Thaler, R. (1985), "Does the stock market overreact?", *Journal of Finance, American Finance Association*, Vol. 40 No. 3, pp. 793-805.

Dwyer, A., Gardner, G. and Williams, T. (2011), *Global Commodity Markets – Price Volatility and Financialisation*, Bulletin, Federal Reserve Bank of Australia.

Engle, R.F. and Manganelli, S. (1999), "CAViaR: conditional value at risk by quantile regression", NBER Working Papers 7341, National Bureau of Economic Research.

Edwards, E. and Bell, P. (1961), *Theory and Measurement of Business Income*, University of California Press, Berkeley.

Fama, E. and French, K. (1992), "The cross-section of expected stock returns", *Journal of Finance*, Vol. 47 No. 2, pp. 427-465.

Fama, E. and French, K. (1995), "Size and book-to-market factors in earnings and returns", *Journal of Finance*, Vol. 50 No. 1, pp. 131-155.

Feltham, G. and Ohlson, J. (1995), "Valuation and clean surplus accounting for operating and financial activities", *Contemporary Accounting Research*, Vol. 11 No. 2, pp. 689-731.

Hong, H. and Yogo, M. (2009), "Digging into commodities", Working paper, Department of Economics, Princeton University.

Koenker, R. and Bassett, G. (1978), "Regression quantiles", *Econometrica*, Vol. 46 No. 1, pp. 33-50.

Leibowitz, M.A. (1999), "Market-to-book ratios and positive and negative returns on equity", *Journal of Financial Statement Analysis*, Vol. 4 No. 2, pp. 21-31.

McSweeney, E. and Worthington, A. (2008), "A comparative analysis of oil as a risk factor in australian industry stock returns, 1980-2006", *Studies in Economics and Finance*, Vol. 25 No. 2, pp. 131-145.

Ohlson, J.A. (1990), "Synthesis of security valuation theory and the role of dividends, cash flows, and earnings", *Contemporary Accounting Research*, Vol. 6 No. 2, pp. 648-676.

Penman, S.H. (1991), "An evaluation of accounting rate-of-return", *Journal of Accounting, Auditing and Finance*, Vol. 6 No. 2, pp. 233-255.

Ryan, S.J. (1995), "A model of accrual measurement with implications for the evolution of the book-to-market ratio", *Journal of Accounting Research*, Vol. 33 No. 1, pp. 95-112.

Stoll, H.R. and Whalley, R.E. (2010), "Commodity index investing: speculation or diversification?", Working paper, The Owen Graduate School of Management, Vanderbilt University.

Wilcox, J.W. (1984), "The P/B-roe valuation model", *Financial Analysts Journal*, Vol. 40 No. 1, pp. 58-66.

Wilcox, J.W. and Philips, T.K. (2004), "The P/B-ROE model revisited", SSRN: available at: http://ssrn.com/abstract=534442 or http://dx.doi.org/10.2139/ssrn.534442

Zhang, L. (2005), "The value premium", *The Journal of Finance*, Vol. 60 No. 1, pp. 67-103.

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