Impact of Climate Risk Factors on Valuations of China A-Share Market

Entela Benz-Saliasi

Abstract An increasing number of companies have embraced ESG, and an increasing number of investors have focused on the ESG impact behind their capital allocation decisions. To date, however, prior academic literature has not distinguished the useful environmental indicators in China A-share market. This study investigates the effect of environmental indicators on the valuation multiples. Using a normalized sample of 222 Chinese companies co-listed in China A-shares and MSCI China Index, it finds that most of the environmental indicators are statistically significant. Total GHG CO_2 intensity per sales and percentage of water recycled has significance in determining P/B value. This study also finds that the higher the government involvement, the higher the energy inefficiency and the GHG CO_2. These results speak to the significance of environmental factors in company valuation in China A-share market and also have implications for asset managers who have committed to the integration of environmental factors in their capital allocation decisions.

Keywords Climate risk · Climate change · Investments · Financial performance · Environmental factors · GHG · Water · Waste · Energy inefficiency

1 Introduction

Since the turn of the millennium, the world appears to have increased its commitment to sustainability and future growth. Investors have been increasingly focused on the ethical impact behind the investment while achieving outstanding returns. Meanwhile, global sustainable investment assets have expanded dramatically from $13.3 trillion in 2012 to $22.9 trillion at the start of 2016 according to Global Sustainable Investment Review, 2017 report. However, only US$500bn of US$23trn ESG asset is managed in Asia, and 90% of that is in Japan. Asia ex-Japan stands at a low level of 0.2% of the total ESG AUM, a level that clearly has room to grow.

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Closer to home, recognizing the intensity and the severe consequences of climate risk the Chinese government has laid a very ambitious plan. China's 13th Five-Year Plan targets a carbon intensity reduction of 18% and energy consumption cap of 5 billions tons of coal equivalent for 2020. By 2030, they target to have 20% renewable energy and reduce the carbon intensity by 60%. These targets are critical given the role of China. According to BP Statistical Review of World Energy, in 2017, China is the most significant contributor to GHG global emissions holding 27% of the total, followed by USA and India with 15% and 7%, respectively.[1] Currently, in China, one of the most critical restricting factors on economic development falls into the natural resource scarcity resulted from resource imbalance and industrial pollution which alarmed the government and public. Taking the water risk, in China alone, around 145 million people are exposed to flooding risk due to sea level rise. Even more acute is this issue in the Guangzhou area and surroundings due to the very high concentration of human and economic capital.[2] The societal and economic implications are unmeasurable.

With the growth of the Chinese economy and opening-up procedure in the Chinese market, domestic and foreign investors could no longer ignore environmental risk. With the inclusion of Chinese A-share[3] stocks into global equity benchmarks, asset owners must assess whether standard systematic approaches to mitigate risk and generate excess equity returns are equally valid in China. These environmental risks are underappreciated and have soon started to unfold. Significant spending on sustainable infrastructure and government incentives would be in need to meet emission reduction targets. These would present considerable investment risks and opportunities through tightening regulations, changing consumer preferences and disruptions caused by the advancement in technology.

Betting on better risk management and alpha generation, over the past decades, one of the most critical trends in portfolio management has been the incorporation of environmental, social and governance (ESG) data that integrate a measurement system to capture potential inequalities, social risk and long-term performance. ESG is more than just an ethical way of investing. ESG can enhance the portfolio by substantially reducing volatility, increasing Sharpe ratios and limiting drawdowns and have some merit as stand-alone alpha sources according to [1]. Using a comprehensive meta-study, they conclude that in 90% of the cases there is a nonnegative correlation between ESG and company financial performance. As for individual studies just to mention one or two, companies that perform high on environmental indicators achieve a cost of equity [2] and the cost of debt reduction [3]. Further, a 25% reduction on carbon emission per sales reduces the cost of equity, on average, by 0.4 basis points [4]. Oikonomou et al. [5] find a negative (positive) relation between systematic risk and a measure of aggregate strengths (concerns) for S&P 500 firms. They also find that community, employment and environmental concerns are significantly and positively related to systematic risk. And the list continues.

[1] BP Statistical Review of World Energy 2018.

[2] Deutsche Bank: Measuring Physical Climate Risk for Equity Portfolios, 2017.

[3] https://www.msci.com/china.

While there is a growing body of evidence on risk/return impact of environmental factors, the results tend to be either weak or confusing. This is because too much focus is given to the model or robustness check, with little understanding of the indicators to be used, the data collected and the method to aggregate to date from the providers. The same type of indicator is very often measured in different ways, resulting in a different meaning and conclusion (Gonenc et al. [6]. To avoid dubious results, we employ widely used and quantifiable indicators, rather than ratings (such as ESG score) that often include activities that have no financially material implication on company level.

The primary objective of this study is to answer the following questions: What works and what does not when it comes to physical climate risk, closely related to environmental factors investing in China? Is there statistical importance of specific environmental indicators toward company financial performance in China A-shares? Most of the indicators are industry-specific; hence what would happen if we normalize per sales and control for the industry as well?

We show that there is indeed a statistically significant relationship between physical climate risk capture by environmental score (*E*-score) and company financial valuations. Furthermore, the most striking result is that the most GHG polluting and most water-intensive companies are also the ones with the highest government ownership (% SOE). Last, we believe that most of these risks are currently not prices, giving rise to opportunities in certain sectors.

2 Data and Sample Description

MSCI China A-share index companies are all part of China A-share market. As such, they enjoy high market capitalization and many other intangible elements such as the accessibility to foreign markets and connections with the government among others.

The industry group is classified under the guidance of the Global Industry Classification Standard (GICS®). Our sample constitutes 221 Chinese companies co-listed in China A-shares, and MSCI China Index deemed to be the most liquid among the China A-shares. There are eleven industry sectors: (a) communication, (b) consumer discretionary, (c) consumer staples, (d) energy, (e) financials, (f) health care, (g) industrials, (h) materials, (i) real estate, (j) technology and (k) utilities. Table 8 presents the sectors and the number of companies in each sector. The largest concentration of companies is found in financials and industrials with 55 and 41 companies, respectively. The lowest is in communication with only four companies.

2.1 Company Valuation Data Description and Analysis

The valuation multiples we choose are a price-to-earning (P/E) and price-to-book P/B ratios. P/E ratio is an equity valuation multiple (see Table 1). It is calculated by

Table 1 Sectors and companies in each sector (there are 11 sectors and 222 companies overall). P/E and P/B ratios are normalized per each sector—data as of July 2018

Industry	Number of companies	Dividend yield %	P/E	P/B	Average ownership ratio (% SOE)
Communications	4	0.59	25.00	1.28	59.2
Consumer discretionary	25	1.97	15.76	2.18	21.8
Consumer staples	12	1.72	28.89	5.14	21.0
Energy	7	3.33	14.81	1.22	54.3
Financials	55	2.85	8.87	1.12	39.6
Health care	13	0.97	28.21	3.41	23.1
Industrials	41	1.65	16.50	1.69	45.8
Information technology	25	0.77	33.80	3.00	10.8
Materials	10	1.59	16.94	1.95	36.0
Real estate	17	3.15	9.50	1.46	31.9
Utilities	12	2.14	21.37	1.49	51.0

dividing the market price per share by earnings per share (annually). It facilitates comparison between different companies within the same industry. Higher P/E ratio is often associated with growth stocks that are developing faster than average, which attracts investors. Lower P/E ratio often attracts the investors interested in investing in value stocks as low P/E ratio represents that the stock is available at a cheap cost. The other valuation multiple we use is the *P*/B ratio. The P/B multiple offers an insightful perspective on how the market evaluates a company's assets, comparing to its earnings. This makes it particularly useful for valuing firms with significant financial assets.

P/E and P/B ratios include information about other factors such as earning turnarounds, growth prospects, proportion of debt, management efficiency and investor sentiments. We improve the measurement by normalizing the P/E and P/B ratios using the MSCI China Sector Average P/E (P/B) score based on MSCI Onshore China A Index as benchmarks.

$$\text{Sector Normalized P/E Score} = ((\text{Company P/E Score})/(\text{MSCI China Sector Average P/E Score})) \times 100$$
$$\text{Sector Normalized P/B Score} = ((\text{Company P/B Score})/(\text{MSCI China Sector Average P/B Score})) \times 100$$

We also collect and analyze *the % Div. Yid* per industry (average dividend payout ratio of that industry) as a signal of investors' preference on short-term cash inflow in the form of dividends or long-term stock price appreciation due to the growth funded by retained earnings. Anecdotal evidence indicates that the state companies

in China are more inclined to operate in an environment with the absence of hard budget constraints which is replete with moral hazard.

Last but not least, our analysis takes account of average ownership ratio (percentage of state-owned % SOE) as the government ownership proportion in terms of equity in each company. Given the top-down ESG approach in China, we believe that that is an essential driver of environmental and social policies implemented on the company as well as on countrywide level. It is also a factor to be priced in company valuations given its importance in the decision-making process on the board level.

To illustrate valuation multiples across different sectors, we compare the normalized P/E ratios and P/B ratios. In particular, we see IT sector owns the highest industry average P/E while financials owns the lowest. In terms of P/B, consumer staples' sections ranked as the top while industrials is the lowest. Fifty-five companies have been included under the financials. On the contrary, only four companies have been listed under the communication sectors. Among all the companies we have compared, energy sector owns the highest average ownership ratio which aligns with our expectation. The following two graphs are based on the data we have collected (see Figs. 1 and 2).

Both figures point to an interesting result. For China A-shares included in the MSCI index, the relation of average ownership ratio is adverse to the company valuations captured by P/E and P/B ratios. Put it differently, the more independent the company, the higher the valuations. For example, information technology and consumer staples with the lowest ownership ratio (10–20%) enjoy the highest P/E valuations (~30). The opposite is true for energy, communications and industrials.

On the dividend yield ratio, from a shareholder perspective, both charts point to a positive correlation between average ownership and dividend yield. Dividends are largest in the companies with highest government ownership. One possible explanation is that these companies are beyond the growth stage. Hence, earnings are distributed rather than retained for growth.

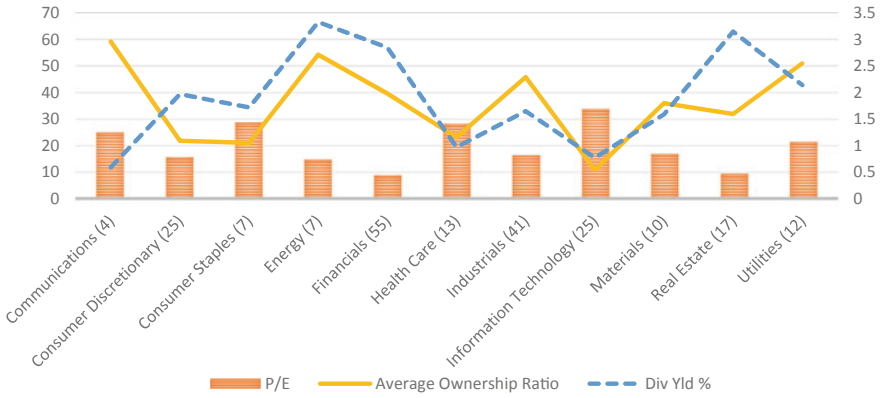

Fig. 1 Cross-industry comparison, China A-shares market, LHS: P/E, Div. Yid%; RHS: average ownership ratio. In brackets are a number of companies per sector. Normalization as of July 2018

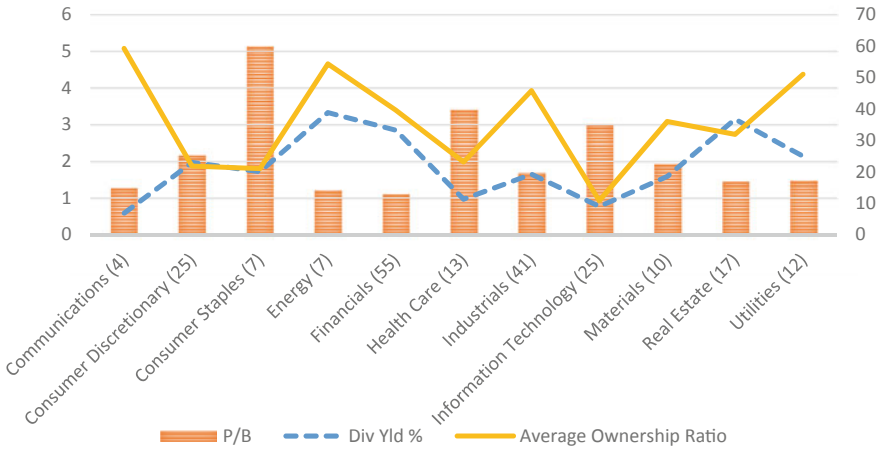

Fig. 2 Cross-industry comparison, China A-share market, LHS: P/B, Div. Yid%; RHS: average ownership ratio. In brackets are a number of companies per sector. Normalization as of July 2018

The following sections aim at analyzing the potential relationship between the environmental factors and company valuation as well as the role/influence, if any, of the government ownership ratio.

3 Company Environmental Data Description and Analysis

Bloomberg has been adopted as the data provider[4] for the environment indicators (*E*-scores). Based on BlackRock's model and the emphasis outlined by the Chinese government's Five-Year Plan, five indicators are chosen to quantify the environment risk:(i) CO_2 (total GHG CO_2 emission intensity per sales), (ii) *energy* (energy intensity per sales), (iii) *water* (water intensity per sales), (iv) *waste* (waste generated per sales) and (v) *recycled* (percentage of water recycled) (see Table 2). The first four indicators are divided by total sales which stands for a good proxy for efficiency rather than the absolute level.

Table 3 shows how these indicators behave across different sectors of MSCI China A-share companies. Sensitive industries perform a higher level climate-related risk.

i. None of the four companies in communication sectors reports the key environmental indicators.

[4]The platform is on track to provide company-reported ESG data for almost 9500 companies in 83 countries. It has been broadly used by over 700 reports and one million unique users per month, covering four ESG investment themes including 35 ESG indicators where eleven of them are E factors. The eleven indicators are aimed to measure the direct or indirect impact of a company's activity on the environment (waste management, level of carbon dioxide emissions, responsible consumption of water, development of renewable energy, degree of energy efficiency are examples).

Table 2 Environmental (climate) risk indicators used for the analysis. There are five environmental indicators (E_score_i) used, and we denote each as i

Environmental indicators (E-score$_i$)	Definition
1. CO_2	Total GHG CO_2 emission intensity per sales
2. Energy	Energy intensity per sales
3. Water	Water intensity per sales
4. Waste	Waste generated per sales
5. Recycled	Percentage of water recycled

Table 3 Cross-industry comparison of environmental indicators. CO_2, energy, water and waste are reported as total number per sales. For example, CO_2 is the total GHG emission divided by sales. The recycled indicator is in percentage only

Industry average E-scores	CO_2	Energy	Water	Waste	Recycled
Communications	-	-	-	-	-
Consumer discretionary	108.94	341.34	113.28	2.69	98.40
Consumer staples	26.59	38.19	-	5.50	-
Energy	70.71	203.19	-	212.48	-
Financials	0.32	10.64	5.23	-	-
Health care	4.12	40.56	391.15	2.23	-
Industrials	92.21	224.24	136.93	1.71	10.58
Materials	32.19	469.07	8595.39	1219.57	89.61
Real estate	-	3931.59	-	-	-
Technology	1.67	9.30	354.33	0.71	61.71
Utilities	-	4624.05	2749.91	0.04	-

ii. Consumer discretionary and industrials pollute the most in terms of CO_2 emissions. This result is consistent with the ones reported in [7]. Working on a comprehensive sample of 1600 firms, from 43 countries with data of 2008–2016, they also found that the industrials and consumer goods sectors are the highest CO_2-emitting industries.
iii. Utilities and real estate are the least efficient in terms of energy use, while materials and utilities are the least efficient in water usage. This is important in light of hefty fines and stricter regulation in China due to high water scarcity and water pollution.
iv. Materials are also the sector with the highest waste per given sales.
v. Overall, materials and utility sector have the highest environmental risk in China.

While some researchers argue that sensitive industries produce better ESG performance [8], it may not be the case in China. Since the overall disclosure is scarce, there is little incentive for the companies in sensitive industries to disclose and improve their environmental performance in order to maintain or improve reputation. This simple analysis has important consequences: Investors looking to put money in these

sectors need to quantify, price and undertake stress scenarios and proper risk analysis to understand environmental risk in their portfolios better.

Getting more granular, within sectors, the company environmental performance, hence indicators (*E*-score) should be evaluated at a relative horizontal level, i.e., peer comparison. This is because the central added value of E within the ESG investing comes from how well the firms managed their industry-specific environmental risk while controlling for the differences of regulations, market landscape and operational risk level across industries. Consequently, based on the ESG data provided by Bloomberg, we normalize each environmental score using the following method:

$$\text{Sector Normalized } E\_\text{score}_i = \left(\frac{\text{Company } E\_\text{score}_i}{\text{Industry Average } E\_\text{score}_i} \right) \times 100$$

Thus, environmental leaders and laggards in sectors could be identified. Except for *% recycled*, the larger the level of the score, the higher the level of the environmental indicators used and therefore the higher the climate risk the company holds.

4 Results and Interpretations

In an attempt to explain the statistical importance of the above environmental (*E*-score) indicators on P/E and P/B ratios of the firms listed in China A-shares, we firstly ranked the stocks of the entities we have chosen in descending order according to a specific *E*-score. The lower the *E*-score, the better is the company managing its environmental risk and more specifically the physical part of climate[5] risk. Two groups are established by taking out the first quartile (top 25% in the specific *E*-score) and the fourth quartile (last 25% in the specific *E*-score). We then calculate the mean and the standard deviation for each quartile. Finally, we make use of the difference in mean methods to conclude whether there is a statistically significant difference between the two groups/quartiles.

To provide readers with explicit evidence of association on an absolute level, meaning no sector normalization, we conduct the hypothesis test on the P/E and P/B levels before normalizations (Table 9 in Appendix 1). The companies are ranked in descending order in terms of market capitalization. The hypothesis is conducted within the first quartile and the last quartile of the companies by market capitalization. Interestingly while the difference in the P/E ratios is statistically significant (but not on P/B), none of the *E*-scores indicates significant differences. This means that unlike the ESG ratings, the performance on our environmental indicators is not dependent on the company's market size. This is good news as it shows that normalizing the level of environmental indicators per given sales, it is neutralizing market capitalization.

[5]The climate risk we mention here is actually the physical risk as mentioned and measured in the previous paper.

4.1 Total GHG CO_2 Emission Intensity Per Sales

We start the analysis with total GHG CO_2 emission intensity per sales (CO_2) versus the P/E and P/B ratios. Given that some companies do not report any data on this specific E_score_i, our sample shrinks to 14 companies, 7 with high CO_2 versus 7 companies with low CO_2 emissions.

Our first hypothesis is as follows:

$$H_0 : \text{Difference in normalized } E\_\text{Score}(\text{CO}_2)\text{in two groups} = 0$$
$$H_1 : \text{Difference in normalized } E\_\text{Score}(\text{CO}_2)\text{in two groups} \neq 0$$

The t-statistic is evaluated by:

$$t\text{-statistics} = \frac{(x_0 - x_1)}{\sqrt{\frac{\text{SD}_0^2}{n} + \frac{\text{SD}_1^2}{n}}}$$

where n is equal to seven in this case and the resulting t-statistics on $E\_\text{Score}(\text{CO}_2)$ is 11.26 which is higher than 2.02 (for small sample size). Thus, the null hypothesis can be rejected at 90% significance level. It can be concluded that $E\_\text{score}_{\text{CO2}}$ is statistically different among the top 25% quantile and the last 25% quantile.

Similarly, our second hypothesis tests the significance of the mean difference of P/E and P/B ratios between top versus bottom companies. When comparing the companies ranked on the top 25% and the last 25% of the $E\_\text{Score}(\text{CO}_2)$, the difference of mean t-statistic on P/E ratio and P/B ratio is -1.38 and -2.05, respectively. Hence at 90% confidence interval, only valuation captured via P/B is statistically different. From valuation perspective, it indicates that polluting companies have lower price-to-book ratios.

Table 4 presents *t*-statistics and top/last quartile stocks in China A-share market ranked based on CO_2 intensity per sales as our chosen environmental indicator. We analyzed 222 China A-share companies part of the MSCI EM Index. The data are as of July 2018. The P/E and P/B ratios are normalized per sector. Div. Yid % is the sector average dividend yield. Government ownership is reported in the third column. We ranked the companies based on CO_2 per given sales normalized per industry level as well (CO_2 industry normalized). We then calculate the difference of means to find if there is a statistically significant difference between top versus bottom quartile companies in terms of the environmental indicator and financial variables presented in the table. We find that the difference of means is significant in terms of CO_2 industry normalized usage, ownership ratio and firm performance P/B ratio. It is nonetheless not significant for the P/E ratio. The significance of the difference of means is measured via t-statistic T0 at a confidence interval of 99%, 95% and 90% and represented with (***), (**) or (*), respectively.

Furthermore, there is a statistically significant difference in the ownership ratio between top versus bottom, implying that the polluters tend to be mostly state-owned

Table 4 *T*-statistics and top/last quartile stocks in China A-share market ranked based on CO_2 intensity per sales

CO_2 intensity per sales								
Company	Industry	Ownership	Industry normalized PE	Industry normalized PB	CO_2 intensity	CO_2 industry normalized	Div. Yid %	P/E forward
COSCO Ship Dev A (HK-C)	Industrials	91.47	0.84	0.52	259.01	2.81	1.65	12.28
China Citic BK A (HK-C)	Financials	92.45	0.80	0.74	0.71	2.18	2.85	7.73
Air China A (HK-C)	Industrials	73.16	1.39	1.23	194.45	2.11	1.65	12.28
China East Air A (HK-C)	Industrials	85.67	1.13	1.32	190.33	2.06	1.65	12.28
GF Securities A (HK-C)	Financials	24.11	1.66	1.34	0.67	2.06	2.85	7.73
China Southern Airlines Co., Ltd	Consumer discretionary	82.25	1.26	1.10	197.80	1.82	1.97	12.56
China Gezhouba A (HK-C)	Industrials	84.82	0.49	0.89	156.66	1.70	1.65	12.28
	Mean	76.28	1.08	1.02	142.80	2.11	2.04	11.02
	SD	22.10	0.37	0.29	94.14	0.33	0.52	2.08
China Commu Con A (HK-C)	Industrials	5.60	0.71	0.68	13.32	0.14	1.65	12.28
China Intl Mar A (HK-C)	Industrials	16.37	1.71	1.33	12.93	0.14	1.65	12.28
Haitong Sec A (HK-C)	Financials	36.00	1.93	1.12	0.04	0.11	2.85	7.73

(continued)

Table 4 (continued)

CO_2 intensity per sales								
Company	Industry	Ownership	Industry normalized PE	Industry normalized PB	CO_2 intensity	CO_2 industry normalized	Div. Yid %	P/E forward
CRRC Corp A (HK-C)	Industrials	85.15	1.93	1.61	9.38	0.10	1.65	12.28
China Life Ins A (HK-C)	Financials	3.67	3.04	2.39	0.03	0.08	2.85	7.73
Huatai Securities Co., Ltd	Financials	13.33	1.50	1.26	0.02	0.06	2.85	7.73
CSSC Offshore and Marine Engineering Group	Industrials	90.70	32.06	2.015	5.37	0.06	1.65	12.28
	Mean	35.83	6.13	1.51	5.87	0.10	2.16	10.33
	SD	34.38	10.61	0.55	5.61	0.03	0.59	2.25
	*H*0	Ownership**	PE	PB**	CO_2^{**}	CO_2 (normalized)***	DivYId %	P/E forward
	*T*0	2.62	−1.26	−2.05	3.84	16.10	−0.42	0.60

enterprises, operating in an environment that lacks hard constraints. Thus, the best strategy is to avoid companies with large state owned as they tend to be the biggest polluters in GHG emissions and have a lower valuation in terms of P/B ratios.

4.2 Energy Intensity Per Sales

The same methodology as above is used for the next $Escore_{Energy}$ ranking that is the energy intensity per sales. The differences between the top scoring quartile and the last scoring quartile have again been tested to see if there is statistical confidence for us to acknowledge the differences.

Table 5 presents *t*-statistics and top/last quartile stocks in China A-share market ranked based on energy per sales as our chosen environmental indicator. We analyzed 222 China A-share companies part of the MSCI EM Index. The data are as of July 2018. The P/E and P/B ratios are normalized per sector. Div. Yid % is the sector average dividend yield. Government ownership is reported in the third column. We ranked the companies based on energy per given sales normalized per industry level as well (energy industry normalized). We then calculate the difference of means to find if there is a statistically significant difference between top versus bottom quartile companies in terms of the environmental indicator and financial variables presented in the table. We find that the difference of means is significant in terms of energy usage and ownership ratio, but not for financial valuation P/E and P/B ratios. The significance of the difference of means is measured via *t*-statistic $T0$ at a confidence interval of 99%, 95% and 90% and represented with (***), (**) or (*), respectively.

The table shows that energy efficiency seems not to be correlated with valuation, but once again it is negatively related to government ownership. The higher the government involvement, the higher the energy inefficiency is.

4.3 Water Intensity Per Sales

When ranked on water intensity normalized per industry, companies ranked on top quartile spend in average 25 times the water consumed from companies' position on the bottom quartile. The difference of the mean is significant at a 99% confidence interval. Despite this strong result, there is no statistical difference between the two groups in terms of financial performance or the ownership structure.

Table 6 presents *t*-statistics and top/last quartile stocks in China A-share market ranked based on water intensity per sales as our chosen environmental indicator. We analyzed 222 China A-share companies part of the MSCI EM Index. The data are as of July 2018. The P/E and P/B ratios are normalized per sector. Div. Yid % is the sector average dividend yield. Government ownership is reported in the third column. We ranked the companies based on water intensity per given sales normalized per industry level as well (water intensity industry normalized). We then calculate the

Table 5 *T*-statistics and top/last quartile stocks in China A-share market ranked based on energy per sales

Energy intensity per sales								
Company	Industry	Ownership	Industry normalized PE	Industry normalized PB	Energy	Energy industry normalized	Div. Yid%	P/E forward
Huatai Securities Co., Ltd	Financials	13.33	1.50	1.26	54.47	5.12	2.85	7.73
COSCO Ship Dev A (HK-C)	Industrials	91.47	0.84	0.52	924.67	4.12	1.65	12.28
Air China A (HK-C)	Industrials	73.16	1.39	1.23	742.60	3.31	1.65	12.28
China East Air A (HK-O)	Industrials	85.67	1.13	1.32	729.04	3.25	1.65	12.28
Haitong Sec A (HK-C)	Financials	36.00	1.93	1.12	33.77	3.17	2.85	7.73
Shanghai Fosun A (HK-C)	Health care	1.77	1.24	1.29	104.29	2.57	0.97	-
Shanxi Taigang A (HK-C)	Materials	93.64	0.36	0.54	1105.48	2.36	1.59	11.80
China Southern Airlines Co., Ltd	Consumer discretionary	82.25	1.26	1.10	759.20	2.22	1.97	12.56
Aluminium Corp of China H	Materials	77.50	23.88	1.62	1024.13	2.18	1.59	11.80
Dong E. E. Jiao A (HK-C)	Information technology	7.76	0.57	1.33	16.80	1.81	0.77	-
Hainan Airlines Holding Co., Ltd	Consumer discretionary	0.00	1.11	0.47	558.28	1.64	1.97	12.56

(continued)

Table 5 (continued)

Energy intensity per sales								
Company	Industry	Ownership	Industry normalized PE	Industry normalized PB	Energy	Energy industry normalized	Div. Yid%	P/E forward
PetroChina Co A (HK-C)	Energy	99.09	4.55	1.02	326.81	1.61	3.33	11.20
Datang International Power Generation Co., Ltd	Utilities	74.79	1.49	0.89	7360.77	1.59	2.14	-
	Mean	56.65	3.17	1.06	1056.95	2.69	1.92	11.22
	SD	37.03	6.06	0.34	1857.98	1.03	0.70	1.79
AECC Aviation A (HK-C)	Industrials	43.21	3.47	1.39	30.91	0.14	1.65	12.28
GF Securities A (HK-C)	Financials	24.11	1.66	1.34	1.25	0.12	2.85	7.73
Weichai Power A (HK-C)	Industrials	12.18	0.59	1.12	26.02	0.12	1.65	12.28
Huadong Medicine A (HK–C)	Health care	1.63	1.04	1.83	4.55	0.11	0.97	-
BYD Co A (HK-C)	Consumer discretionary	0.00	2.77	1.59	36.39	0.11	1.97	12.56
Zhongjin Gold A (HK-C)	Materials	93.14	7.30	1.30	37.81	0.08	1.59	11.80
Orient Sec Co A (HK-C)	Financials	56.14	0.00	0.00	0.81	0.08	2.85	7.73

(continued)

Table 5 (continued)

Energy intensity per sales								
Company	Industry	Ownership	Industry normalized PE	Industry normalized PB	Energy	Energy industry normalized	Div. Yid%	P/E forward
Jiangxi Copper A (HK-C)	Materials	1.99	2.48	0.75	23.05	0.005	1.59	11.80
SAIC Motor Corp A (HK-C)	Consumer discretionary	84.89	0.69	0.76	11.51	0.03	1.97	12.56
China Pacific A (HK-C)	Financials	34.92	2.88	2.44	0.19	0.02	2.85	7.73
Ping An Ins A (HK-C)	Financials	27.45	1.58	2.41	0.16	0.01	2.85	7.73
China Everbright A (HK-C)	Financials	44.73	0.71	0.69	0.05	0.00	2.85	7.73
China Life Ins A (HK-C)	Financials	3.67	3.04	2.39	0.05	0.00	2.85	7.73
	Mean	32.93	2.17	1.39	13.29	0.07	2.19	9.97
	SD	29.78	1.82	0.72	14.62	0.05	0.65	2.25
	*H*0	Ownership*	PE	PB	Energy**	Energy	Div. Yid %	P/E forward
	*T*0	1.80	0.57	−1.50	2.03	9.18	−1.02	1.57

Table 6 *T*-statistics and top/last quartile stocks in China A-share market ranked based on water intensity per sales

Water intensity per sales								
	Industry	Ownership	Industry normalized PE	Industry normalized PB	Water intensity per sales	Water intensity industry normalized	Div. Yid %	P/E forward
Top quartile companies								
China Const BK A (HK-C)	Financials	68.4	0.9	1.0	25.4	4.9	2.9	7.7
Aluminium Corp of China	Materials	77.5	23.9	1.6	36135.9	4.2	1.6	11.8
AECC Aviation A (HK-C)	Industrials	43.2	3.5	1.4	416.7	3.0	1.7	12.3
BYD Co A (HK-C)	Consumer discretionary	0.0	2.8	1.6	266.2	2.4	2.0	12.6
Shanghai Pharma A (HK-C)	Health care	31.2	0.7	0.6	763.1	2.0	1.0	-
Metallurgical A (HK-C)	Industrials	94.0	1.1	0.9	234.1	1.7	1.7	12.3
Daqin Railway A (HK-C)	Industrials	86.1	0.6	0.8	229.3	1.7	1.7	12.3
China CITIC BK A (HK-C)	Financials	92.5	0.8	0.7	8.2	1.6	2.9	7.7
ShanghaI Fosun A (HK-C)	Health care	1.8	1.2	1.3	605.8	1.5	1.0	-
	Mean	55.0	3.9	1.1	4298.3	2.5	1.8	11.0
	SD	35.2	7.1	0.4	11258.7	1.2	0.6	2.0

(continued)

Table 6 (continued)

Water intensity per sales								
	Industry	Ownership	Industry normalized PE	Industry normalized PB	Water intensity per sales	Water intensity industry normalized	Div. Yid %	P/E forward
Bottom quartile companies								
Maanshan Iron A (HK-C)	Materials	93.5	0.5	0.7	1118.0	0.1	1.6	11.8
Hainan Airlines Holding Co., Ltd	Consumer discretionary	0.0	1.1	0.5	13.5	0.1	2.0	12.6
COSCO Ship Dev A (HK-C)	Industrials	91.5	0.8	0.5	15.1	0.1	1.7	12.3
Huadong Medicine A(HK-C)	Health care	1.6	1.0	1.8	41.3	0.1	1.0	-
China Pacific A (HK-C)	Financials	34.9	2.9	2.4	0.4	0.1	2.9	7.7
China Everbright A (HK-C)	Financials	44.7	0.7	0.7	0.3	0.1	2.9	7.7
Zijin Mining A (HK-C)	Materials	12.1	1.7	1.5	434.1	0.1	1.6	11.8
Weichai Power A (HK-C)	Industrials	12.2	0.6	1.1	6.5	0.0	1.7	12.3
BBMG Corp A (HK-C)	Materials	16.4	1.2	0.7	214.0	0.0	1.6	11.8

(continued)

Table 6 (continued)

Water intensity per sales								
	Industry	Ownership	Industry normalized PE	Industry normalized PB	Water intensity per sales	Water intensity industry normalized	Div. Yid %	P/E forward
	Mean	34.1	1.2	1.1	204.8	0.1	1.9	11.0
	SD	34.0	0.7	0.6	351.0	0.0	0.6	1.9
	$H0$	Ownership	PE	PB	Water	Water (normalized)***	Div. Yid %	P/E forward
	$T0$	1.3	1.2	0.0	1.1	6.4	−0.2	0.0

difference of means to find if there is a statistically significant difference between top versus bottom quartile companies in terms of the environmental indicator and financial variables presented in the table. We find that the difference of means is significant in terms of water usage, but none of the financial valuation P/E and P/B ratios including the ownership ratio. The significance of the difference of means is measured via t-statistic T0 at the confidence interval of 99%, 95% and 90% and represented with (***), (**) and (*), respectively.

4.4 Waste Generated Per Sales

No significant result is produced when we rank on waste generated per sales. We believe that lack of results here is a clear outcome related to the tiny number of companies under analysis.

Table 7 presents *t*-statistics and top/last quartile stocks in China A-share market ranked based on waste generated per sales. We analyzed 221 China A-share companies part of the MSCI EM Index. The data are as of July 2018. The P/E and P/B ratios are normalized per sector. Div. Yid % is the sector average dividend yield. Government ownership is reported in the third column. We ranked the companies based on waste generated per given sales normalized per industry level as well (waste generated industry normalized). We then calculate the difference of means to find if there is a statistically significant difference between top versus bottom quartile companies in terms of the environmental indicator and financial variables presented in the table. We find that the difference of means is significant in terms of water usage, but none of the financial valuation P/E and P/B ratios including the ownership ratio. The significance of the difference of means is measured via *t*-statistic $T0$ at the confidence interval of 99%, 95% and 90% and represented with (***), (**) and (*), respectively.

4.5 Percentage of Water Recycled

Despite only a handful of companies on each quartile, there seems to be a significant relationship between recycling and P/B valuation only. There is no association with ownership, dividend yield or P/E ratios. However, the sample is too small to make further comments on this variable (Table 8).

Overall, CO_2 pollution and energy efficiency enjoy the most robust results. The least performing companies on energy and CO_2 emission (top quartile) are also the ones characterized by high government ownership and from low financial valuation.

We see no clear relationship between P/E ratios and percentage dividend payout with any of the five E indicators we selected. Our interpretation is that, as an emerging economy, China share market shows anomalies. Strict constraints, common

Table 7 *T*-statistics and top/last quartile stocks in China A-share market ranked based on waste generated per sales

Waste intensity per sales								
		Ownership	Industry normalized PE	Industry normalized PB	Waste generated per sales	Waste generated industry normalized	Div. Yid %	P/E forward
China Molybdenum A (HK-C)	Materials	37.17	2.90	2.00	4511.36	3.70	1.59	11.80
Shanghai Fosun A (HK-C)	Health care	1.77	1.24	1.296	5.58	2.50	0.97	-
BOE Tech Group A (HK-C)	Information technology	31.23	0.79	0.79	1.40	1.99	0.77	-
China Intl Mar A (HK-C)	Industrials	16.37	1.71	1.33	2.98	1.70	1.65	12.28
CSSC Offshore and Marine Engineering Group	Industrials	90.70	32.06	2.15	2.48	1.41	1.65	12.28
	Mean	35.45	7.74	1.51	904.76	2.26	1.33	12.12
	SD	30.24	12.18	0.50	1803.30	0.81	0.38	0.23
Maanshan Iron A (HK-C)	Materials	93.50	0.45	0.68	179.34	0.15	1.59	11.80
Zijin Mining A (HK-C)	Materials	12.06	1.69	1.55	178.81	0.15	1.59	11.80
Shanghai Pharma A (HK-C)	Health care	31.23	0.65	0.56	0.22	0.10	0.97	-

(continued)

Table 7 (continued)

Waste intensity per sales								
		Ownership	Industry normalized PE	Industry normalized PB	Waste generated per sales	Waste generated industry normalized	Div. Yid %	P/E forward
ZTE Corp A (HK-C)	Information technology	2.77	0.99	1.61	0.01	0.01	0.77	-
Sinopec Shanghai A (HK-C)	Materials	96.24	0.66	1.24	8.78	0.01	1.59	11.80
	Mean	47.16	0.89	1.13	73.43	0.08	1.30	11.80
	SD	40.03	0.44	0.43	86.32	0.06	0.36	0.00
	$H0$	Ownership	PE	PB	Waste	Waste (normalized)***	Div. Yid %	P/E forward
	$T0$	−0.52	1.26	1.29	1.03	6.03	0.10	3.16

Table 8 *T*-statistics and top/last quartile stocks in China A-share market ranked based on percentage water recycled

Company	Industry	Ownership	Industry normalized PE	Industry normalized PB	Recycled	Recycled industry normalized	Div. Yid %	P/E forward
Heilan Home A (HK-C)	Consumer discretionary	2.77	1.46	0.41	98.40	1.00	1.97	12.56
Metallurgical A (HK-C)	Industrials	93.97	1.13	0.92	18.77	1.77	1.65	12.28
Aluminium Corp of China H	Materials	77.50	23.88	1.62	96.28	1.07	1.59	11.80
	Mean	58.08	8.82	0.98	71.15	1.28	1.74	12.21
	SD	39.68	10.65	0.49	37.05	0.35	0.17	0.31
Zijin Mining A (HK-C)	Materials	12.06	1.69	1.55	87.44	0.98	1.59	11.80
China Molybdenum a (HK-C)	Materials	37.17	2.90	2.00	77.72	0.87	1.59	11.80
CSSC Offshore and Marine Engineering Group	Industrials	90.70	32.06	2.15	2.39	0.23	1.65	12.28
	Mean	46.64	12.22	1.90	55.85	0.69	1.61	11.96
	SD	32.80	14.04	0.26	38.01	0.33	0.03	0.23
	*H*0	Ownership	PE	PB***	Recycled	Recycled (normalized)***	Div. Yid %	P/E forward
	*T*0	0.38	−0.33	−2.85	0.50	2.14	1.30	1.13

***Statistically significant at 95% confidence interval

trading suspensions and segmented share classes negatively impact pricing formation and market liquidity. Additionally, preferential differences of Chinese investors, valuation and investing process shape the unique Chinese market. The concerns on environmental issues and sustainable development are still at the very early stage comparing to the growth prospects. Furthermore, limited dissemination of companies' information does not attract the attention of investors and financial analysts. Hence, the effect of environmental performance may have not substantially integrated into the firm value and may be unable to be reflected on certain valuation multiples.

5 Concluding Remarks

With the development of ESG investing across the globe and the rising heated discussion on sustainable development led by the Chinese government, the environmental factors are closely watched both domestically and internationally. At the same time, the opening up of China A-share market has created a new dimension of complexity for those who seek to understand the behavior of these factors in the Chinese market.

This paper analyzed 222 companies that are part of MSCI China A-share index. In light of increased market awareness on climate risk, we studied the relationship between specific environmental factors and company valuations. For the environmental factors, we use the following indicators: CO_2 (total GHG CO_2 emission intensity per sales), *energy* (energy intensity per sales), *water* (water intensity per sales), *waste* (waste generated per sales) and *recycled* (percentage of water recycled). To avoid sector biases and the noise in the data, we normalize the score using the industry average. Similarly, we also normalize the two financial valuation ratios under consideration, P/E and P/B ratios.

The first-level results show that certain sectors such as consumer discretionary and industrials are the most polluting in terms of CO_2 emissions (utilities not reporting on this indicator), while real estate and utilities are the least efficient in energy usage. Utilities top the rank again along materials in terms of substantial water usage. The figures in waste and recycling are more difficult to compare due to a large number of companies not reporting on these indicators.

The second-level analysis ranked the companies on our four environmental indicators, the difference between top quartile companies (the most air, water polluting and energy inefficient) to the bottom quartile companies (less air, water polluting and more energy efficient); it is always statistically significant despite the narrow sample size of 222 companies. More importantly, this difference is not driven by market capitalization (see Table 9) as one would expect and prove for ESG score in general, but a lot correlated with % government ownership in these companies.

We see a significant difference in the % government ownership and normalized financial valuation P/B ratio between high quartile of CO_2 and low quartile of CO_2. The same holds true for the energy intensity per sales.

Intuitively, SOEs incline to operate in an environment in which there are no hard budget constraints. However, on the policy front, we expect environmental law reforms will set a price on pollution and CO_2 emissions. It will introduce more costs for polluters, which is a particular concern for SOEs that historically shows 3 times higher average value of penalties, and 4% lower average net margins, than private sector peers according to the [9] report[6]. Thus, the energy efficiency cannot be ignored by SOEs anymore. Taken together with regulatory oversight over pollution across China at this time, these indicators represent a red flag. If the companies stay unchanged and operate with low efficiency, they are not likely to afford the increasing costs and would be most impacted by the environmental reforms, which should arouse investors' attention.

Our third-level analysis ranks companies according to environmental performance. It reveals significant differences between the top tier companies and bottom tier companies. In particular, when controlling per total GHG CO_2 intensity per sales and percentage water recycled, the difference in valuation as captured by P/B becomes significant. These results speak to the significance of environmental factors in company valuation in China A-share market and have implications for asset managers who have committed to the integration of environmental factors in their investment decisions. Interpretation has been offered and focused on the current market landscape of China and the investors' appetite.

On a final note, for China A-share market, the ESG and climate risk literature are scarce, and the knowledge between financial performance and ESG factors remains fragmented, on which further analysis could be conducted. Picking up on our analysis and upon the availability of more data, it would be interesting to find the impact of each of these indicators on the firm cost of equity, cost of debt and risk and finally explain any related mispricing or just the lack of pricing.

[6] https://www.msci.com/documents/10199/8b447f98-50bc-4d3d-b3f3-d4000a7084e7.

Besides data, the role of environmental indicators on company's financials strongly relates to country effect and industry characteristics. While we try to control for the later one, by normalizing it, the country effect is relevant given significantly different regulatory and market environments. For example, our expectations are that high CO_2-emitting and water-intensive companies in China should be associated with a higher cost of capital and lower valuations than otherwise. Firmly believing that as these risk factors are not priced in yet, from the asset managers and owner's perspective there is ample room for market opportunities and portfolio enhancements. This aligns well and should be the base for a smarter and more efficient funding mechanism toward a low-carbon economy.

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Appendix 1

See Table 9.

Table 9 Cross-industry comparison, China A-share market, pre-normalized valuation multiples

Market cap			PE	PB	CO_2 energy		Water	Waste	Recycled
Top tier[a]	Average	374782.41	19.49	2.87	24.02	290.04	78.60	2.40	61.71
	SD	409536.78	13.81	3.02	52.70	874.31	116.82	2.34	-
Bottom tier[a]	Average	22620.78	71.75	2.67	132.19	1585.16	1235.24	60.97	2.39
	SD	5400.02	111.27	2.32	179.35	2870.07	1645.90	102.51	-
	Ho	Market cap[b]	PE[b]	PB	CO_2 energy		Water	Waste	Recycled
	T-score	6.08	−3.30	0.36	−0.85	−1.09	−1.40	−0.99	-

[a]In terms of weightings with respect to MSCI EM Index
[b]Statistically significant at 95% confidence interval

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