A Multifactor Model of Equity Returns and Its Application to the Chinese Stock Market

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1 Introduction

The Capital Asset Pricing Model (CAPM) was formalized in the early 1960s to create a relationship between the systematic risk of the market and the returns of an asset. Sharpe and others simplified how investors view and interact with markets and in turn, created a statistical model that linearly relates the return of an asset to the return of the market. In this sense, CAPM creates a world in which there is one source of risk: the market itself.

In the 1970s, Stephen Ross proposed an alternative, called Arbitrage Pricing Theory (APT, for short). APT simplifies the assumptions of CAPM and paved the way for many multi-factor models. Ross' model explains linearly how multiple sources of risk, known as factors, influence the return of assets. Sharpe's model is not necessary incompatible with Ross' world, however, and many investors view CAPM as a single-factor APT model.

In the decades since, academics and practitioners alike have argued over the appropriate number of factors and how to evaluate these factors. While Ross gave a solution for the latter, he did not give any insight towards the former. Even Fama and French, the inspiration for this paper, have argued for different numbers of factors at different points of time.

In this paper, we construct an eight-factor model, with the addition of ESG scores to Fama and French's Five Factor model, of the Chinese stock market. The Chinese stock market has unique characteristics that bring about some results that contradict and others that are congruent to previous research in Western markets. ESG scores are a relatively new source of information for the Chinese market, and while they are a useful tool in explaining returns, the complete effects have yet to arise. In this paper, we will give a background on Fama and French's techniques, ESG scoring, and the unique characteristics of the Chinese stock market, as well as discuss the methodology, performance, and limitations of our multi-factor model.

2 Background

2.1 Fama-French Five Factor Model

The Fama-French Five-Factor Model is an extension of the authors' original 1992 three-factor model. This earlier model was created to capture a relationship between the size and value of a company to the average return of its stock. By using market capitalization and price ratios like book-to-market, Fama and French found that small-cap stocks outperformed large-caps, and value stocks outperformed growth stocks. In the years since, practitioners and academics have argued for the addition of other factors such as momentum and volatility. In 2015, Fama and

French published a model with two additional factors: profitability and investment.

They define their five-factor model as:

$$R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + \epsilon_{it}$$

These coefficients correspond to an intercept and the factor exposures of the market, size, value, profitability, and investment, respectively. SMB (small minus big) is the difference between small-cap and large-cap stocks, HML (high minus low) is the difference between portfolios of high value and low value (i.e., growth) stocks, RMW (robust minus weak) is the difference between portfolios of high and low profitability stocks, and CMA (conservative minus aggressive) is the difference between portfolios and companies with low and high investments.

2.2 ESG

ESG is an investment philosophy and a standard for corporate evaluations that focus on corporate environmental, social, and governance performance rather than financial performance. ESG is highly compatible with China's new development concept of "Innovation, Coordination, Green, Openness and Sharing" and is also closely related to China's goal of carbon peaking and carbon neutrality.

According to data from Wind, as of the end of 2021, there are 200 ESG-themed public offerings of funds, with a total fund size of 261.222 billion yuan. 62 funds were recently established in 2021, with a total of 35.495 billion yuan. By March of 2022, the number of ESG-themed public offerings of funds was 208, with a total fund size of 255.7 billion yuan. Obviously, ESG is playing an increasingly important role in the Chinese market.

While methodology to calculate ESG scores varies wildly throughout the market, there are some common techniques to quantify a notoriously qualitative measure. Rating agencies and index providers often combine natural language processing and deep learning techniques to analyze news, financial reports, and social media to judge these factors. Inherently, there is an ability to corrupt these scores through false or misleading reporting, withholding information, and even fake "bots" on Twitter. It is the responsibility of the rating agency to meticulously comb through the noise and the responsibility of the socially- or environmentally-conscious fund manager to investigate the accuracy of ESG scores.

3 Model Formulation

3.1 Data Description

All data comes from the Wind database. The stocks we focus on make up the CSI300 Index. The data range of our research is then limited from 01/Feb/2018 to 01/Feb/2022, given that Chinese ESG data has only been made available starting from the beginning of 2018.
There are eight dimensions considered in our multi-factor model. Besides the original five dimensions Fama and French proposed in their paper, which are the market, size, value, profit, and investment, we have added three more dimensions which are environmental, social, and governance. We use the SCI800 index as a representation of market performance. We use total market capitalization, book-to-market ratio (B/M or BP), return-on-equity (ROE), and change in the total asset as measures of size, value, profit, and investment respectively. We use E, S and G scores rated by Wind as reasonable measures of Environmental, Social, and Governance, respectively.

3.2 The Playing Field

In order to examine the size, B/M, profitability, investment, E, S and G patterns in average returns, we first divide stocks into 25 (5×5) market cap weighted portfolios from independent sorts of stocks into five size groups and five book-to-market, profitability, investment, E, S, and G groups following procedures similar to Fama and French. The following tables show the results of the average monthly returns of each group of 25 portfolios.

a. Size-BP Portfolios

	Low	1	2	3	High	Average
Small	3.48	3.49	2.28	2.23	3.58	3.01
1	1.93	1.41	1.58	1.63	1.10	1.53
2	1.99	2.38	2.66	0.52	0.19	1.55
3	2.73	1.01	0.53	-0.29	0.19	0.83
Big	1.06	1.88	0.22	-0.04	-0.08	0.61
Average	2.24	2.03	1.45	0.81	0.99	1.51

Table 1: Size-BP Portfolios(%)

In the table above, we can see that the return of portfolios decreases as size increases which is

consistent with Fama-French's result. However, different from Fama-French's findings, we notice that in the Chinese market, companies with high BP ratios tend to generate lower returns than companies with low BP ratios. Below (List 1) is a sample of high-BP ratio companies. We see that most of the companies are from traditional industries such as banking, insurance, infrastructure, energy, steel, and real estate. Also, these companies are mostly government-owned, which means their primary goal is not to make profits but to serve specific social functions in China. As a matter of fact, these high BP companies tend to have relatively lower returns. On the contrary, the companies with low BP ratios are mostly high-tech companies, which are shown in List 2. These companies usually have a higher proportion of intangible assets including patents, proprietary technology, goodwill, and companies' brand names, which makes their BP ratios relatively low. However, as high-tech industries were developing rapidly in China before 2022, these low BP, but high-tech companies thus achieved relatively high returns. One thing to notice is that for companies that are small size with low BP ratio, the return of portfolios is around 3.5%. But with Fama-French's result, this value is pretty small. This conflict is due to the shell value for small listed companies that are about to go out of business in the Chinese market. In China, when a listed low BP ratio company is about to go out of the business, some other companies that are not listed will inject assets into this company which, although not intended, creates the extra shell values for those small size companies.

List 1, with specific examples in English.
平安银行(Ping An Bank), 万科A (Vanke), 浦发银行(Shanghai Pudong Development Bank), 民生银行(China Minsheng Bank), 宝钢股份(Baoshan Iron & Steel Co.),中国石化(Sinopec), 保利发展(Poly Real Estate), 中国联通(China Unicom), 上汽集团(SAIC Motor), 中国神华(China Shenhua Energy), 兴业银行,中国铁建(China Railway Construction Corporation), 农业银行(Agricultural Bank of China), 中国平安(Ping An Insurance), 交通银行,中国中铁(China Railway Group),工商银行,中国太保,中国建筑,中国交建,光大银行,中国石油,建设银行,中国银行,中信银行, 华侨城A,徐工机械,长安汽车,中信特钢,苏宁易购,包钢股份,人福医药,国金证券,金发科技,中国船舶,江西铜业,金地集团,长电科技,豫园股份,国电电力,杭州银行,君正集团,中国铝业,上海医药,中国中冶,中国电建,成都银行,中煤能源

List 2
东方盛虹(Jiangsu Eastern Shenghong), 北方华创(NAURA Technology Group), 高德红外(Wuhan Guide Infrared), 晶澳科技(JA Solar Technology Co), 天齐锂业, 中公教育, 天赐材料, 凯莱英, 视源股份,深南电路,亿纬锂能,沃森生物,晶盛机电,贝达药业,康泰生物,华大基因,天坛生物,恒生电子,闻泰科技,中炬高新,中科曙光,浙江鼎力,安图生物,金域医学,晨光文具中兴通讯,五粮液,分众传媒,洋河股份,顺丰控股,海康威视,赣锋锂业,立讯精密,比亚迪,中公教育,牧原股份,亿纬锂能,爱尔眼科,东方财富,智飞生物,阳光电源,温氏股份,恒瑞医药,万华化学,片仔癀,通威股份,贵州茅台,闻泰科技,山西汾酒,伊利股份,隆基股份,三六零,长城汽车,合盛硅业

b. Size-Profit Portfolios

	Weak	1	2	3	Robust	Average
Small	2.75	2.03	2.31	3.60	5.67	3.27
1	1.31	1.84	1.10	1.85	1.45	1.51
2	0.86	0.63	1.94	1.61	2.80	1.57
3	-0.93	-0.13	0.41	1.58	2.05	0.60
Big	-0.25	-0.18	0.50	-0.17	1.43	0.26
Average	0.75	0.84	1.25	1.70	2.68	1.44

Table 2: Size-Profit (ROE) Portfolios(%)

In this table, we can see that the trend of return on different company sizes is similar to the result in Fama-French's illustration, which says that smaller size companies usually bring higher returns. For the other factor "profit", namely ROE here, the result we got is also similar to the one in the Fama-French paper, where higher ROE usually grants higher returns. The reasoning is quite intuitive. Since ROE is calculated by dividing net income by shareholders' equity, higher ROE should lead to high profit by its nature.

c. Size-Investment Portfolios

	Conservative	1	2	3	Aggressive	Average
Small	2.81	2.91	3.78	2.89	2.98	3.08
1	0.59	1.17	2.33	2.28	1.81	1.64
2	1.07	1.13	1.38	1.35	2.71	1.53
3	-0.20	0.54	-0.28	1.17	1.64	0.58
Big	0.26	0.01	0.26	0.29	0.91	0.35
Average	0.91	1.15	1.50	1.60	2.01	1.43

Table 3: Size-Investment Portfolios(%)

Here smaller size implies higher returns as usual, complying with the result in Fama-French's paper. However, the trend here on variable "investment", which we defined as the changes in total assets, has a different impact compared to the one in Fama-French's paper. Here, higher investment measure arises higher return. In the Fama-French paper, more aggressive investment usually brings lower return, which verified the fact that the total assets of the company are actually the expenses to be amortized in the future, which means total assets are, in some sense, costs. This effect is not found in the Chinese market. The retail investors could possibly contribute to this phenomenon as they took a large part of the Chinese stock market. In 2020 Q3, institutional investors accounted for about 20.3% of the total shares, and individual

investors accounted for 22.6%. Such individual investors might not think about the meaning of assets but are more easily guided by incitement of "public opinion" which could be influenced or operated by grouped institutional investors. Besides, the expansion of large companies in China would be a more complex process than in the U.S., which involved considerations like regional economic plan and relationships with the government, so the braided complexity of the investment and expansion process would somehow grant a more stable income brought by the expansion. Thirdly, the expansions that took place in China in recent years were mostly related to the hot industries which attracted a large number of investors so that the related income could be much higher than the normal forecast.

d. Size-Social Portfolios

	Bad	1	2	3	Good	Average
Small	4.05	2.92	2.69	2.85	2.90	3.08
1	2.01	1.75	1.28	1.71	1.07	1.56
2	2.83	-0.12	1.47	1.00	2.29	1.49
3	1.14	0.83	0.15	0.55	0.60	0.65
Big	0.14	0.74	0.75	-0.15	0.40	0.38
Average	2.03	1.22	1.27	1.19	1.45	1.43

Table 4: Size-Social Portfolios(%)

In this table, small size companies have higher return, as usual. However, contrary to our expectation, companies with bad social scores tend to have higher return than companies with good social scores. According to List 3 which includes companies with high social scores, companies in China with high social scores are normally state-owned companies. It makes sense in China as state-owned companies in China usually provide very good welfare (i.e., five social insurance and one housing fund) to their employees. However, as the primary goal of those companies is to serve specific functions to society and take more social responsibilities instead of being profit-oriented, the portfolios made up by those companies tend to generate relatively low returns.

List 3

平安银行,万科A,京东方A,招商蛇口,顺丰控股,海康威视,比亚迪,牧原股份,阳光电源,温氏股份,宝钢股份,中国石化,招商银行,中国联通,海螺水泥,海尔智家,海通证券,伊利股份,中国神华,中国国航,兴业银行,国泰君安,农业银行,中国平安,新华保险,中国太保,中国人寿,中国建筑,华泰证券,中国交建,中国石油,紫金矿业,中远海控,中国银行,洛阳钼业

e. Size-Environmental Portfolios and Size-Governance Portfolios

	Bottom	1	2	3	Top	Average
Smalll	2.90	3.48	3.16	2.39	3.89	3.16
1	1.12	0.87	1.69	2.88	2.27	1.77
2	1.82	1.19	0.95	1.53	1.41	1.38
3	0.10	0.73	1.12	0.28	0.81	0.61
Big	0.55	1.08	0.48	0.48	-0.26	0.47
Average	1.30	1.47	1.48	1.51	1.62	1.48

Table 5: Size-Environmental Portfolios(%)

	Little	1	2	3	Large	Average
Small	4.34	3.17	2.67	1.71	2.31	2.84
1	1.22	1.81	1.10	1.63	2.57	1.67
2	1.84	0.69	1.95	1.24	2.20	1.58
3	1.08	0.75	1.46	-0.20	0.23	0.66
Big	-0.85	-0.09	1.16	0.14	-0.12	0.05
Average	1.53	1.27	1.67	0.90	1.44	1.36

Table 6: Size-Governance Portfolios(%)

We can see from these two tables that there is no obvious trend. One possible explanation is that data of these two categories are not very accurate in China, even deliberately covered sometimes. So the result of that table may not reflect the true effect of environment and governance.

3.3 Factor Definition

We define eight factors: the original FF five, MKT, SMB(Small Minus Big), HML(High Minus Low), RMW(Robust minus Weak), CMA(Conservative minus Aggressive), and our additional ESG, TMB(Top Minus Bottom), GMB(Good Minus Bad), and LML(Large Minus Little). To generate these factor returns, we follow a similar methodology as Fama and French. First, we split the stocks into two size groups using the median market cap. We call these the "small" and "big" groups. We then split them into three groups at the 30th and 70th percentile for each remaining metric. This creates six portfolios whose returns we use to construct our factors.

For example, to construct the value (HML) factor, we create two size groups and three value groups. The value groups are the stocks with the lowest 30 percent, middle 40 percent, and highest 30 percent of book-to-market ratio. We ignore the middle book-to-market then average

the return of the small-cap-high-book-market (SH) and the large-cap-high-book-market (BH) portfolios and subtract the average returns of the small-cap-low-book-market (SL) and large-cap-low-book-market portfolios (BL). A similar process is used for profitability (RMW), investment (CMA), environmental (TMB), social (GMB), and governance (LML). To summarize:

Factor	Ratio/Metric	Formula
Value	Book to Market	$HML = \frac{1}{2}[(SH + BH) - (SL + BL)]$
Profitability	ROE	$RMW = \frac{1}{2}[(SR + BR) - (SW + BW)]$
Investment	Change of Total Assets	$CMA = \frac{1}{2}[(SC + BC) - (SA + BA)]$
Environment	"E" score	$TMB = \frac{1}{2}[(STop + BTop) - (SBottom + BBottom)]$
Social	"S" score	$GMB = \frac{1}{2}[(SGood + BGood) - (SBad + BBad)]$
Governance	"G" score	$LML = \frac{1}{2}[(SLarge + BLarge) - (SLarge + BLittle)]$

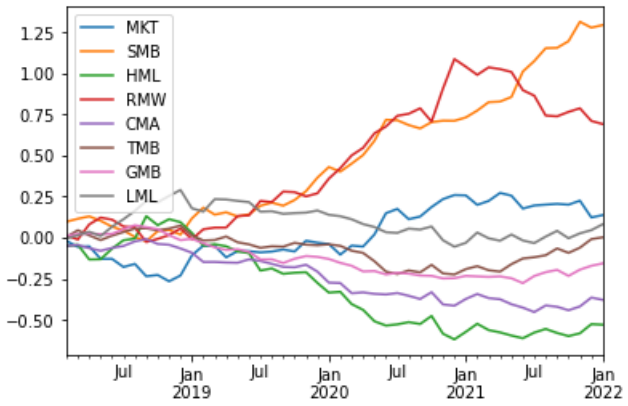
Table 7: Factor Definition

To calculate SMB, we used the 36 portfolios (6 other factors, times 6 portfolios for each factor) we already created to calculate the average return of each size group. As in, we have a small-cap-high-ROE portfolio, a small-cap-middle-ROE portfolio, a large-cap-low-ROE portfolio, and so on. For each factor excluding size, we find SMB scores as the average return of the small-cap portfolios minus the average return of the large-cap portfolios. For example, with ROE, we have: $SMB_{prof} = \frac{1}{3}[(SR + SMiddle + SW) - (BR + BM + BW)]$.
In all, SMB is the average of each of these subcategories:

$$SMB = \frac{1}{6}(SMB_V + SMB_P + SMB_I + SMB_E + SMB_S + SMB_G)$$

3.4 Summary Statistics for Factor Returns

Graph 1 and 2 show the cumulative returns of each factor. In Graph 2, the cumulative returns are normalized to have market volatility.



Graph 1: Factors' Cumulative Return

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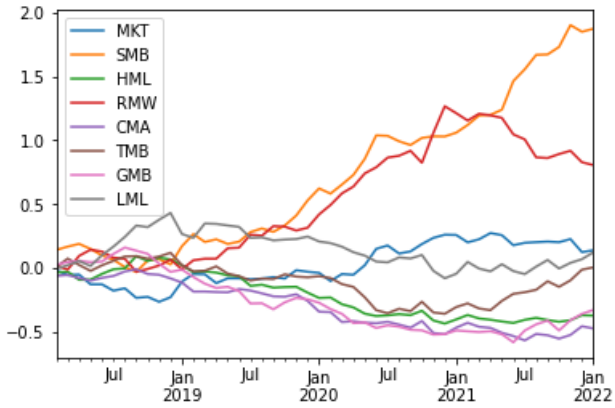

Graph 2: Factors' Cumulative Return with Normalization

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	MKT	SMB	HML	RMW	CMA	TMB	GMB	LML
Mean	0.39%	1.80%	-1.30%	1.19%	-0.90%	0.05%	-0.33%	0.22%
Std dev.	5.09%	3.52%	7.23%	4.38%	4.06%	3.17%	2.42%	3.44%
Sharpe Ratio	0.27	1.96	-0.58	1.01	-0.73	0.06	-0.46	0.23

Table 8: Factor Statistics Summary

	MKT	SMB	HML	RMW	CMA	TMB	GMB	LML
MKT	1.00	0.40	-0.42	0.21	-0.21	-0.53	0.05	-0.40
SMB	0.40	1.00	-0.36	-0.04	-0.25	-0.26	-0.03	-0.47
HML	-0.42	-0.36	1.00	-0.72	0.75	0.63	0.44	0.65
RMW	0.21	-0.04	-0.72	1.00	-0.54	-0.55	-0.37	-0.42
CMA	-0.21	-0.25	0.75	-0.54	1.00	0.46	0.37	0.52
TMB	-0.53	-0.26	0.63	-0.55	0.46	1.00	0.32	0.65
GMB	0.05	-0.03	0.44	-0.37	0.37	0.32	1.00	0.31
LML	-0.40	-0.47	0.65	-0.42	0.52	0.65	0.31	1.00

Table 9: Factor Correlation

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We found that value (HML) is highly positively correlated with investment (CMA) and ESG scores and negatively correlated with profitability (RMW). The reason for the negative correlation between RMW and HML is that, in China, stocks with a high book-to-market are often in traditional industries, like banking or insurance, or are state-owned. These essential companies' primary goal is to serve the people, not make money for their shareholders. This uniquely Chinese characteristic creates stability at the expense of growing the business. High book-to-market companies, as mentioned before, are usually state-owned and thus tend to have a large size, accounting for the high positive correlation between HML and CMA. Thus, it is quite hard for their total assets to grow rapidly.

We also found that CMA is highly negatively correlated with RMW, with a correlation of -.54. A company that is aggressive, meaning they are reinvesting in themselves, will often be profitable. For example, tech stocks globally will often not issue dividends in order to reinvest earnings into growing the business.

Environment (TMB), Social (GMB), and Governance (LML) are all positively correlated with each other. A company that is conscious of one category will most likely also be conscious of the others. ESG was also positively correlated with value and investment, and negatively correlated with profitability. Again, stable companies in China are often state-owned or there are state pressures to not be overly profitable. The government often will pressure these large businesses to meet national goals, like reducing carbon emissions and income inequality.

4 Model Performance

4.1 Model Comparison

The tables below compare the performance of different factor models to explain monthly excess returns on 25 Size-BP portfolios, 25 Size-Profit portfolios, 25 Size-Investment portfolios, 25 Size-Environment portfolios, 25 Size-Social portfolios, and 25 Size-Governance portfolios. For each table of 25 regressions, we generate 2 columns: the average of absolute value of the intercepts, $\mathbf{A}(|a_i|)$, and the average of absolute value of the intercept over the average of absolute value of the intercept of CAPM, $\mathbf{A}(|a_i|)/\mathbf{A}(|r_i|)$. The closer $\mathbf{A}(|a_i|)$ is to zero, the better the model is since it leaves less return unexplained. For $\mathbf{A}(|a_i|)/\mathbf{A}(|r_i|)$, a smaller value is better as it measures how well the model performs comparing to CAPM and a smaller value means the model keeps less return unexplained than CAPM. The highlighted parts are models that perform relatively well.

A:Size-Value Portfolios

Model Used	$\mathbf{A}(\|a_i\|)$	$\mathbf{A}(\|a_i\|)/\mathbf{A}(\|r_i\|)$
MKT	0.0121	100.0%
MKT SMB HML	0.0087	71.97%
MKT SMB HML RMW	0.0083	68.67%
MKT SMB HML CMA	0.0089	73.22%
MKT SMB CMA RMW	0.0094	77.86%
MKT SMB HML RMW CMA	0.0084	69.09%
MKT HML RMW CMA	0.012	99.33%
MKT SMB HML RMW CMA TMB GMB	0.0088	72.36%
MKT SMB HML RMW CMA GMB LML	0.0093	76.61%
MKT SMB HML RMW CMA TMB LML	0.0095	78.25%
MKT SMB HML RMW CMA TMB GMB LML	0.0093	76.98%

Table 10: Model Performance on Size-Value Portfolios

B:Size-Profit Portfolios

Model Used	$\mathbf{A}(\lvert a_i \rvert)$	$\mathbf{A}(\lvert a_i \rvert)/\mathbf{A}(\lvert r_i \rvert)$
MKT	0.0129	100.0%
MKT SMB HML	0.0095	73.23%
MKT SMB HML RMW	0.0084	65.03%
MKT SMB HML CMA	0.0097	75.1%
MKT SMB CMA RMW	0.0092	71.51%
MKT SMB HML RMW CMA	0.0085	65.62%
MKT HML RMW CMA	0.0123	95.18%
MKT SMB HML RMW CMA TMB GMB	0.0085	65.79%
MKT SMB HML RMW CMA GMB LML	0.0084	65.37%
MKT SMB HML RMW CMA TMB LML	0.0084	65.44%
MKT SMB HML RMW CMA TMB GMB LML	0.0084	65.44%

Table 11: Model Performance on Size-Profit Portfolios

C:Size-Investment Portfolios

Model Used	$\mathbf{A}(\lvert a_i \rvert)$	$\mathbf{A}(\lvert a_i \rvert)/\mathbf{A}(\lvert r_i \rvert)$
MKT	0.0115	100.0%
MKT SMB HML	0.0084	72.79%
MKT SMB HML RMW	0.0079	68.34%
MKT SMB HML CMA	0.0084	72.7%
MKT SMB CMA RMW	0.0083	72.44%
MKT SMB HML RMW CMA	0.0079	68.25%
MKT HML RMW CMA	0.0121	105.47%
MKT SMB HML RMW CMA TMB GMB	0.0079	68.6%
MKT SMB HML RMW CMA GMB LML	0.0078	67.48%
MKT SMB HML RMW CMA TMB LML	0.0078	68.15%
MKT SMB HML RMW CMA TMB GMB LML	0.0078	67.88%

Table 12: Model Performance on Size-Investment Portfolios

D:Size-Environment Portfolios

Model Used	$\mathbf{A}(\lvert a_i \rvert)$	$\mathbf{A}(\lvert a_i \rvert)/\mathbf{A}(\lvert r_i \rvert)$
MKT	0.0113	100.0%
MKT SMB HML	0.0085	75.09%
MKT SMB HML RMW	0.0084	73.98%
MKT SMB HML CMA	0.0086	76.16%
MKT SMB CMA RMW	0.009	78.98%
MKT SMB HML RMW CMA	0.0084	74.48%
MKT HML RMW CMA	0.0124	109.15%
MKT SMB HML RMW CMA TMB GMB	0.0081	71.78%
MKT SMB HML RMW CMA GMB LML	0.008	70.39%
MKT SMB HML RMW CMA TMB LML	0.0079	69.55%
MKT SMB HML RMW CMA TMB GMB LML	0.008	70.91%

Table 13: Model Performance on Size-Environment Portfolios

E:Size-Social Portfolios

Model Used	$\mathbf{A}(\lvert a_i \rvert)$	$\mathbf{A}(\lvert a_i \rvert)/\mathbf{A}(\lvert r_i \rvert)$
MKT	0.0113	100.0%
MKT SMB HML	0.0083	73.08%
MKT SMB HML RMW	0.0075	65.96%
MKT SMB HML CMA	0.0082	72.81%
MKT SMB CMA RMW	0.0082	72.78%
MKT SMB HML RMW CMA	0.0074	65.42%
MKT HML RMW CMA	0.0119	105.38%
MKT SMB HML RMW CMA TMB GMB	0.0074	65.1%
MKT SMB HML RMW CMA GMB LML	0.0085	75.55%
MKT SMB HML RMW CMA TMB LML	0.0085	75.41%
MKT SMB HML RMW CMA TMB GMB LML	0.0084	74.63%

Table 14: Model Performance on Size-Social Portfolios

F:Size-Governance Portfolios

Model Used	$\mathbf{A}(\lvert a_i \rvert)$	$\mathbf{A}(\lvert a_i \rvert)/\mathbf{A}(\lvert r_i \rvert)$
MKT	0.012	100.0%
MKT SMB HML	0.0092	76.17%
MKT SMB HML RMW	0.0084	70.01%
MKT SMB HML CMA	0.0093	77.69%
MKT SMB CMA RMW	0.0094	77.91%
MKT SMB HML RMW CMA	0.0086	71.55%
MKT HML RMW CMA	0.0122	101.11%
MKT SMB HML RMW CMA TMB GMB	0.0085	70.38%
MKT SMB HML RMW CMA GMB LML	0.0086	71.41%
MKT SMB HML RMW CMA TMB LML	0.0087	72.4%
MKT SMB HML RMW CMA TMB GMB LML	0.0084	69.85%

Table 15: Model Performance on Size-Governance Portfolios

It is interesting that the best model may not always be the 8-factor model but can be the model with fewer factors. Actually, the four-factor model excluding CMA, the five-factor model, and the 7-factor model excluding one of the three ESG factors perform better most of the time. Also, we notice that the four-factor model excluding CMA always performs as well as the five-factor model, which implies that CMA is a redundant factor.

Besides, comparing the regression models above, we found that SMB is a very robust and important factor, because in each of the table presented, the portfolio without SMB factor (MKT HML RMW CMA) performed much worse than the others (some of them even performs worse than CAPM), which is similar to the result in Fama-French's paper. Therefore, we conclude that SMB is an essential factor in both Chinese and U.S. stock markets.

Also, according to the six tables above, we can see that factor HML has a consistently good performance. Comparing with the four-factor-model without factor HML, the five-factor-model usually has a smaller value of $\mathbf{A}(|a_i|)$ and of $\mathbf{A}(|a_i|)/\mathbf{A}(|r_i|)$, which means that factor HML does improve the model. Moreover, for factor HML in group A, focusing on the four-factor models, except the one without factor SMB, models with factor HML perform better than the model without factor HML. Similarly, we can see that in group B, models that have factor RMW perform much better than those without factor RMW, which means the factor RMW is also a robust factor.

Considering CMA, we can see that, in group C, the four-factor model without CMA performs even better than the other two models with CMA which corresponds to our conclusion that CMA is redundant.

For the ESG factors, although in groups D, E, and F, adding ESG factors does reduce a small

amount of unexplained return so that the best models are the 7-factor model excluding GMB in group D, the 7-factor model excluding LML in group E, and the 8-factor model in group F, we can see that in the group A, B, and C, the five-factor model or the four-factor model(MKT SMB HML RMW) performs even better than the models that include ESG factors. Thus, we conclude that ESG factors do provide minor improvement to the model but the influence of ESG is relatively small comparing to other effective factors.

4.2 Collinearity

	intercept	**MKT**	**SMB**	**HML**	**RMW**	**CMA**	**TMB**	**GMB**	**LML**	**R^2**
MKT	0.001		0.280	-0.299	-0.161	0.242	-0.806	0.561	0.077	0.448
SMB	0.020	0.140		-0.242	-0.416	0.002	0.109	0.102	-0.378	0.425
HML	0.008	-0.210	-0.341		-0.665	0.625	0.024	0.356	0.244	0.808
RMW	0.014	-0.078	-0.403	-0.458		0.018	-0.313	0.033	0.018	0.640
CMA	-0.004	0.116	0.002	0.427	0.018		0.020	0.020	0.095	0.585
TMB	0.002	-0.220	0.060	0.009	-0.177	0.012		0.156	0.349	0.612
GMB	-0.003	0.163	0.059	0.147	0.020	0.012	0.165		0.047	0.292
LML	0.009	0.026	-0.260	0.120	0.013	0.069	0.439	0.055		0.584

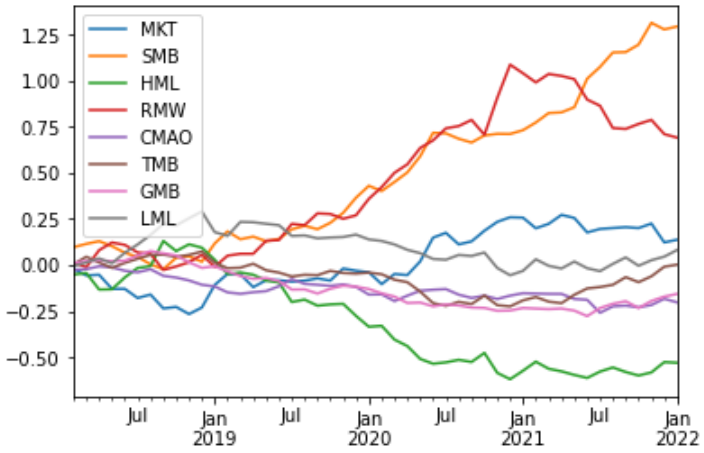
Table 16: Regression among Factors

We do regressions of each of the eight factors on the other seven, and below are some observations from the table we created above. Firstly, in the HML regression, the RMW slope is strongly negative, and in the RMW regression, the HML slope is strongly negative as well, which are in line with the fact that companies with high BP ratio usually generate low profit as discussed earlier. Secondly, the slope for HML in the CMA regression and the slope for CMA in the HML regression are highly positive. This is also in accordance with the previously analyzed fact that large companies in China are usually state-owned and thus tend to have less intention to increase their total assets aggressively. Moreover, as shown in the blue box above, when the three ESG factors are used as dependent variables in the regressions, the slopes of the five Fama-French factors are very low, implying that the original five factors cannot fully explain ESG, or in other words, ESG does add a new dimension to our model. And more interestingly, as shown in the green box, among ESG factors, each ESG factor is relatively independent of each other.

As we analyzed in section 4.1 Model Comparison, CMA is a redundant factor for describing average returns. Also, from the collinearity analysis above, CMA has a strongly positive slope in the regression of HML. So, we intend to wipe off the collinearity between CMA and other

factors by using a similar approach as what Fama French did in their paper. We removed the part that the investment factor CMA is collinear with other factors and defined a new factor CMAO as the sum of the intercept and the residual from the regression of CMA on the other seven factors. Then we use CMAO instead of CMA to create a new eight-factor model which will be the model we use in the next section:

$$R_{it} = a_i + b_i MKT_t + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMAO_t + d_i TMB_t + g_i GMBt + l_i LML_t + e_{it}$$



Graph 3: Factors' Cumulative Return

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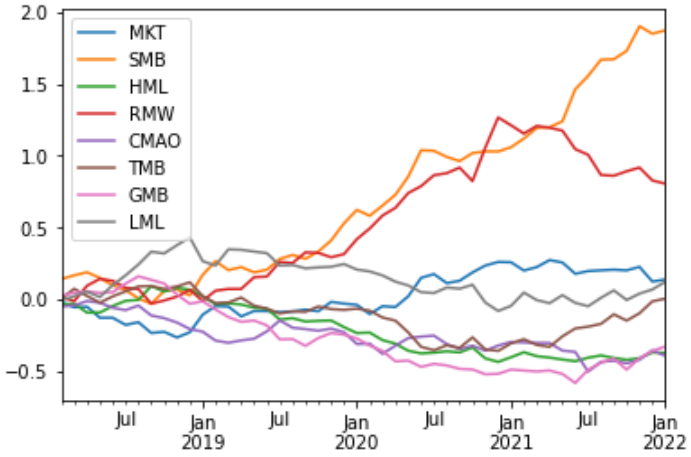

Graph 4: Factors' Cumulative Return with Normalization

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Graph 3 and 4 are similar graphs as graph 1 and 2 respectively, except that the cumulative

return of CMA is changed to that of CMAO.

4.3 Regression Detail

Table 17: Size - Value

Value	Low	2	3	4	High	Low	2	3	4	High
			Alpha					beta_MKT		
Small	0.011	0.015	0.010	0.014	0.028	0.595	1.218	1.422	1.189	1.531
2	0.004	0.003	-0.003	0.008	0.012	0.653	0.870	1.074	1.080	0.875
3	0.011	0.019	0.014	-0.001	0.004	0.942	0.784	1.219	1.069	0.897
4	0.021	-0.004	0.006	0.000	0.007	0.780	1.122	1.127	1.079	0.860
Big	0.007	0.014	0.003	0.007	0.008	1.149	1.206	1.025	1.197	0.788
			beta_SMB					beta_HML		
Small	0.782	0.706	0.533	0.720	0.760	-0.308	-0.023	0.244	0.463	0.845
2	0.257	0.285	0.627	0.629	0.392	-0.709	-0.541	0.029	0.491	0.669
3	0.072	0.013	0.464	0.410	0.163	-0.469	-0.290	0.211	0.544	0.476
4	-0.162	0.200	-0.112	-0.022	-0.100	-0.803	-0.127	0.366	0.417	0.447
Big	-0.477	-0.354	-0.187	-0.471	-0.464	-0.299	-0.086	0.263	0.379	0.299
			beta_RMW					beta_CMAO		
Small	0.782	0.706	0.533	0.720	0.760	0.126	0.202	0.082	0.092	0.437
2	0.257	0.285	0.627	0.629	0.392	0.229	-0.042	-0.141	-0.228	-0.019
3	0.072	0.013	0.464	0.410	0.163	-0.908	0.044	-0.087	0.271	0.121
4	-0.162	0.200	-0.112	-0.022	-0.100	-0.184	-0.064	-0.239	-0.258	-0.157
Big	-0.477	-0.354	-0.187	-0.471	-0.464	0.491	-0.025	0.014	0.324	0.162
			beta_TMB					beta_GMB		
Small	-0.628	-0.127	0.239	-0.752	-0.006	-0.329	-0.178	-0.428	-0.351	-0.527
2	0.008	0.615	0.099	-0.100	-0.401	-0.071	-0.113	-0.257	0.417	0.005
3	0.030	0.057	0.297	0.252	-0.229	0.765	-0.068	-0.102	0.093	-0.055
4	0.125	0.033	-0.096	-0.332	0.122	-0.469	-0.002	0.045	0.280	0.246
Big	-0.121	0.566	-0.647	0.297	0.338	-0.196	-0.004	0.069	0.394	-0.063
			beta_LML							
Small	0.032	0.180	-0.022	-0.053	-0.092					
2	0.153	-0.517	-0.076	-0.191	-0.162					
3	-0.914	0.095	-0.161	-0.055	-0.064					
4	-0.609	0.028	-0.375	-0.292	-0.305					
Big	0.184	-0.225	0.683	-0.114	0.107					

Table 18: Size - Profit

Profit	Low	2	3	4	High	Low	2	3	4	High
			Alpha					beta_MKT		
Small	0.025	0.002	0.001	0.011	0.026	1.368	1.169	1.230	1.030	0.885
2	0.012	0.001	-0.001	0.005	0.001	0.987	1.022	0.896	0.898	0.627
3	0.004	0.001	0.011	0.008	0.015	0.989	1.057	1.034	1.073	0.892
4	-0.012	0.006	0.001	0.018	0.006	1.082	1.027	0.934	1.099	1.050
Big	0.006	0.008	0.013	0.009	0.009	0.833	0.776	0.916	1.036	1.102
			beta_SMB					beta_HML		
Small	0.396	0.853	0.927	0.974	1.008	0.194	0.182	0.131	0.479	-0.149
2	0.427	0.967	0.395	0.216	0.400	0.196	0.375	-0.045	-0.360	-0.382
3	0.345	0.340	0.225	0.142	0.312	0.035	0.157	0.144	-0.217	0.132
4	0.119	-0.255	0.109	-0.313	0.062	-0.104	0.189	0.367	-0.031	0.042
Big	-0.581	-0.593	-0.527	-0.733	-0.329	-0.435	-0.133	0.254	-0.079	0.048
			beta_RMW					beta_CMAO		
Small	-0.458	-0.049	0.130	0.651	0.794	0.077	0.285	0.153	-0.205	0.475
2	-0.686	0.053	0.079	0.120	0.085	-0.112	0.039	0.142	0.063	0.107
3	-0.377	-0.342	0.273	-0.059	0.534	0.184	0.019	0.117	0.142	-0.642
4	-0.512	-0.359	0.121	-0.093	0.821	-0.186	-0.433	-0.128	-0.184	-0.031
Big	-0.790	-0.214	0.116	-0.161	0.621	-0.277	0.170	0.199	0.243	0.175
			beta_TMB					beta_GMB		
Small	0.185	-0.101	-0.011	-0.440	-0.494	-0.076	-0.651	-0.229	-0.215	0.323
2	-0.278	0.165	-0.101	0.321	0.100	-0.220	-0.051	0.125	0.097	0.235
3	0.095	-0.513	0.251	-0.169	0.204	0.160	-0.343	0.008	0.216	0.840
4	0.252	0.006	-0.205	0.058	0.184	-0.124	0.191	-0.139	-0.180	0.076
Big	0.204	0.294	0.344	0.152	-0.297	0.024	0.397	-0.139	-0.166	-0.007
			beta_LML							
Small	-0.791	0.305	0.463	0.087	0.461					
2	-0.305	-0.157	0.259	0.240	-0.266					
3	0.126	0.057	-0.442	0.274	-0.501					
4	-0.323	-0.478	-0.005	-0.540	-0.182					
Big	0.281	0.228	0.048	0.123	0.325					

Table 19: Size - Investment

Investment	Low	2	3	4	High	Low	2	3	4	High
			Alpha					beta_MKT		
Small	0.019	0.009	0.020	0.010	0.002	1.471	1.256	0.908	0.941	1.099
2	0.003	0.002	0.008	0.006	0.003	1.062	1.091	0.829	0.761	0.791
3	0.003	0.010	0.003	0.002	0.017	0.898	1.020	1.108	1.124	0.989
4	-0.007	0.009	-0.004	0.010	0.012	1.185	0.837	0.979	0.994	0.980
Big	0.006	0.005	0.011	0.013	0.002	1.065	0.904	1.095	1.001	0.962
			beta_SMB					beta_HML		
Small	0.711	0.631	0.928	0.811	1.028	0.277	0.232	0.126	0.158	0.238
2	0.193	0.631	0.600	0.643	0.368	0.008	0.427	-0.140	-0.050	-0.390
3	0.406	0.145	0.431	0.416	-0.007	0.043	0.069	0.370	0.061	-0.150
4	0.175	-0.202	-0.166	0.011	-0.068	0.180	0.056	0.174	-0.087	-0.023
Big	-0.189	-0.372	-0.527	-0.886	-0.304	0.250	0.304	0.212	-0.364	-0.180
			beta_RMW					beta_CMAO		
Small	-0.308	0.556	-0.019	0.247	0.453	0.599	0.236	0.145	0.116	-0.331
2	-0.190	0.033	-0.170	0.119	0.017	0.399	-0.158	0.164	-0.433	-0.070
3	0.057	-0.241	0.311	0.015	0.101	0.658	0.305	-0.003	-0.075	-1.251
4	-0.060	-0.361	0.219	-0.299	-0.060	0.018	-0.386	-0.271	0.084	-0.656
Big	0.288	0.260	-0.035	-0.180	0.192	1.081	0.426	0.173	-0.318	-0.618
			beta_TMB					beta_GMB		
Small	0.034	0.221	-0.464	-0.071	-0.448	-0.383	-0.353	0.007	0.018	-0.089
2	-0.051	0.112	0.211	0.162	-0.066	0.170	0.151	-0.223	0.195	0.054
3	0.081	-0.015	0.044	0.074	0.045	0.251	0.070	0.065	-0.157	0.546
4	-0.283	0.242	0.544	-0.127	-0.277	-0.084	-0.253	0.028	-0.110	-0.102
Big	0.047	0.048	-0.102	0.384	-0.289	-0.058	-0.066	-0.134	0.403	-0.281
			beta_LML							
Small	-0.387	-0.026	0.176	0.093	0.301					
2	-0.230	-0.432	0.386	-0.327	0.020					
3	0.153	0.009	-0.122	-0.102	-0.260					
4	0.090	-0.371	-0.719	0.030	-0.556					
Big	0.202	0.367	0.233	-0.220	0.303					

Table 20: Size - Environmental

Environmental	Low	2	3	4	High	Low	2	3	4	High
			Alpha					beta_MKT		
Small	0.009	0.011	0.022	0.007	0.014	1.257	1.073	1.264	1.242	1.180
2	-0.001	0.001	0.007	0.011	0.013	0.900	0.785	1.003	1.010	0.691
3	0.006	0.004	0.004	0.009	0.007	0.930	0.993	0.814	1.503	1.066
4	0.002	0.008	0.012	0.004	-0.001	1.106	1.150	0.836	1.146	0.907
Big	-0.004	0.016	0.010	0.011	0.006	1.331	1.004	1.125	0.985	0.849
			beta_SMB					beta_HML		
Small	0.895	1.121	0.750	0.587	0.750	0.538	0.307	0.442	-0.213	-0.298
2	0.484	0.420	0.297	0.671	0.542	-0.150	-0.025	-0.056	0.146	-0.241
3	0.431	0.373	0.310	0.080	0.228	-0.014	0.247	-0.004	0.135	0.077
4	-0.275	-0.179	-0.169	-0.136	0.277	0.417	0.072	-0.044	0.183	-0.133
Big	-0.174	-0.554	-0.526	-0.607	-0.524	0.187	-0.194	-0.047	-0.018	0.233
			beta_RMW					beta_CMAO		
Small	0.409	0.290	-0.069	-0.257	0.112	0.143	0.245	0.433	0.133	-0.300
2	-0.230	-0.138	0.036	0.241	-0.363	0.202	-0.235	0.194	-0.123	0.042
3	-0.008	0.252	-0.032	-0.064	0.027	-0.539	0.288	0.256	0.080	-0.008
4	0.313	0.110	-0.276	-0.141	-0.178	-0.510	0.252	-0.691	-0.311	0.107
Big	0.638	-0.040	-0.029	0.019	0.084	0.452	0.352	0.245	0.015	0.162
			beta_TMB					beta_GMB		
Small	-0.860	-0.356	0.105	0.467	0.520	-0.391	-0.383	-0.194	-0.543	0.100
2	0.169	-0.401	-0.038	0.593	-0.060	-0.578	0.537	0.047	-0.170	0.690
3	-0.221	-0.557	0.532	0.807	0.160	0.509	0.264	0.363	-0.371	0.262
4	-0.393	-0.460	-0.212	0.224	0.364	-0.011	0.238	0.175	-0.090	-0.356
Big	-0.054	-0.677	-0.195	0.479	0.399	-0.324	0.085	-0.171	-0.106	0.102
			beta_LML							
Small	0.533	0.000	-0.554	0.310	0.087					
2	-0.159	-0.399	0.170	-0.120	0.228					
3	-0.066	-0.012	-0.626	0.035	-0.104					
4	-0.433	-0.059	-0.348	-0.578	-0.011					
Big	-0.125	0.431	0.245	0.008	0.044					

Table 21: Size - Social

Social	Low	2	3	4	High	Low	2	3	4	High
			Alpha					beta_MKT		
Small	0.023	0.006	0.008	0.012	0.012	1.370	1.040	1.120	1.278	1.099
2	0.002	0.008	0.002	0.009	-0.001	0.523	0.927	1.079	0.978	1.042
3	0.008	-0.008	0.010	-0.001	0.018	1.304	0.806	1.016	1.020	0.850
4	0.010	0.009	-0.004	0.006	0.003	0.964	1.008	1.017	1.045	1.070
Big	0.012	0.012	0.010	-0.002	0.015	0.940	0.911	1.068	1.033	0.930
			beta_SMB					beta_HML		
Small	0.853	0.975	0.615	0.851	0.753	0.490	0.072	-0.011	0.360	0.184
2	0.625	0.467	0.550	0.420	0.335	-0.446	0.022	0.127	0.140	-0.117
3	0.710	0.138	0.159	0.527	0.235	0.322	0.035	0.155	0.123	0.080
4	-0.292	-0.111	0.248	-0.233	0.121	-0.077	0.231	0.172	0.014	0.158
Big	-0.824	-0.389	-0.348	-0.328	-0.647	-0.049	0.188	0.172	0.013	0.060
			beta_RMW					beta_CMAO		
Small	0.198	0.178	0.141	0.180	0.169	0.090	0.039	0.306	0.351	-0.065
2	-0.271	-0.209	0.083	0.085	0.005	-0.161	0.063	0.204	0.020	-0.269
3	0.324	-0.027	0.233	0.099	-0.054	-0.557	-0.087	0.042	0.302	-0.197
4	0.219	-0.007	-0.265	-0.038	-0.140	-0.291	-0.300	-0.279	-0.197	-0.062
Big	0.000	0.134	0.151	0.158	0.000	0.418	0.245	0.164	-0.065	0.120
			beta_TMB					beta_GMB		
Small	-0.111	-0.187	0.166	0.044	-0.481	-0.503	-0.135	-0.608	-0.193	0.218
2	0.461	0.085	0.155	-0.077	0.184	-0.612	-0.276	0.322	0.661	0.508
3	-0.260	-0.373	0.299	0.558	-0.296	-0.131	-0.460	0.485	0.278	0.482
4	0.278	-0.687	-0.679	0.272	0.219	0.064	0.122	-0.412	0.109	-0.154
Big	-0.162	0.552	0.040	0.011	0.138	-0.323	-0.591	-0.056	0.059	0.455
			beta_LML							
Small	-0.238	0.170	0.458	-0.094	0.104					
2	-0.141	-0.244	-0.316	-0.023	0.135					
3	0.004	0.330	-0.484	-0.129	-0.110					
4	-0.821	-0.132	0.246	-0.369	-0.231					
Big	0.253	-0.473	0.052	0.397	0.035					

Table 22: Size - Governance

Governance	Low	2	3	4	High	Low	2	3	4	High
			Alpha					beta_MKT		
Small	0.026	0.011	0.005	0.002	0.022	1.398	1.027	1.256	1.070	1.217
2	0.000	0.012	0.000	0.000	0.009	0.892	0.885	0.938	0.690	1.174
3	0.023	-0.005	0.000	0.007	0.006	1.079	0.673	0.910	1.281	1.100
4	0.009	0.011	0.013	-0.001	-0.002	1.194	0.908	0.996	1.154	0.922
Big	-0.012	0.005	0.011	0.010	0.007	0.867	1.170	1.120	0.922	0.910
			beta_SMB					beta_HML		
Small	0.659	0.911	1.008	0.692	0.254	0.325	0.256	0.263	0.270	0.256
2	0.411	0.295	0.525	0.487	0.756	-0.080	-0.150	0.158	-0.297	0.191
3	-0.084	0.629	0.706	0.085	0.527	0.085	0.248	0.045	0.210	0.058
4	-0.155	-0.318	-0.011	-0.229	0.125	0.145	0.074	0.327	-0.067	0.068
Big	-0.232	-0.337	-0.557	-0.529	-0.577	-0.136	0.387	-0.099	0.148	0.019
			beta_RMW					beta_CMAO		
Small	0.307	0.191	0.150	0.204	-0.253	0.030	0.034	0.141	0.531	0.228
2	-0.024	-0.271	0.132	-0.184	0.214	-0.352	0.186	0.212	-0.373	0.353
3	-0.356	0.166	0.280	0.056	0.220	-0.014	-0.476	-0.255	0.000	0.249
4	0.393	-0.038	0.019	-0.256	-0.219	0.078	-0.242	-0.526	-0.242	-0.267
Big	0.002	0.204	0.401	-0.009	-0.060	0.743	0.430	-0.002	0.206	0.042
			beta_TMB					beta_GMB		
Small	0.485	-0.470	-0.019	-0.113	-0.920	0.008	-0.022	0.116	-0.270	0.582
2	0.061	0.323	0.221	-0.419	-0.228	-0.013	0.443	0.550	-0.279	0.045
3	-0.148	-0.050	-0.052	0.244	0.209	0.081	0.154	-0.397	0.010	-0.047
4	0.373	-0.434	0.444	-0.061	-0.213	0.056	-0.388	0.004	-0.106	0.251
Big	-0.322	0.773	-0.017	0.183	0.133					
			beta_LML							
Small	-0.643	0.279	0.186	0.342	-0.055					
2	-0.281	-0.381	-0.260	0.506	0.746					
3	-0.757	-0.515	0.301	-0.140	0.471					
4	-1.030	-0.170	-0.789	-0.236	0.126					
Big	-0.136	-0.772	0.090	0.074	0.309					

Above are the regression details of six sets of portfolios using the corrected multi-factor model we introduced in the previous section. As we can see, the market factor is always the most important and dominant factor and always highly correlated with the dependent variables as the betas of the market factor are all around 1.

As for the SMB factor, we found that the coefficient of SMB is decreasing vertically as the sizes of the companies in the portfolios get bigger and bigger. In addition, we notice that betas of SMB of portfolios made by stocks of small size companies are usually numbers which are positive and

large and betas of SMB of portfolios made by stocks of big size companies are numbers which are negative and relatively small. Thus, we conclude that although being consistently robust, the SMB factor is more good at explaining the returns of small cap stocks.

Other than MKT and SMB, we notice that the coefficients of other factors do not possess a clear trend except when they are used to explain the portfolios constructed by size and the corresponding dimension of that factor. For example, in table 17:Size-Value where portfolios are constructed by dividing stocks according to their size and BP ratios, we found that the betas of HML increase horizontally from negative to positive as BP ratios get higher and higher which meets the intuition that the returns of stocks of high BP ratio companies are positively correlated with HML.

However, we notice that one particular factor jumps out of the pattern discussed above. In table 17:Size-Value, although the portfolios are constructed by size and value instead of size and profit, we still find the betas of RMW possess a clear trend. As shown in table 17:Size-Value, the betas of RMW decrease from positive to negative as the size of the companies in the portfolios get bigger and bigger. This phenomenon lines up with the fact that the profitability of small cap companies tends to be better than that of big cap companies in the Chinese market and thus, tends to have a positive correlation with the RMW factor.

5 Limitations

The data about ESG in the Chinese market is still not enough. The ESG rating system in China has just started to be built in 2018 which makes the data range available for now too short. Besides, due to political reasons in China, some data may be intentionally concealed or not fully accurate, especially for ESG data.

6 Future Work

While doing the calculation, we were also aware of the special influence of Shell Value in the Chinese stock market, especially on small-cap companies. In the paper "Reverse Mergers, Shell Value, and Regulation Risk in Chinese Equity Markets", Lee et al. consider this special characteristic of the Chinese market and construct a factor called ESVM (Expected Shell Value to Market) trying to explain the shell value effect. According to Lee et al., the core of calculating this factor is finding the probability of a listed company becoming a shell company; And, intuitively, a listed company with a high probability of becoming a shell would have a higher exposure to the shell value factor than a company with a low probability. According to Lee et al. (2017), the probability of becoming a shell company should be closely related to 8 specific

indicators. Here are four important examples:

(1) Market capitalization: companies with small market capitalization are more likely to become shell companies;

(2) Profit: Companies with low profits and poor fundamentals are more likely to become shell companies, Lee et al. (2017) use Operating profit to Assets as its proxy indicator;

(3) Delisting Risk (ST): Companies marked by ST are more likely to become eligible companies due to delisting risk;

(4) Ownership Concentration: For publicly traded companies with dispersed ownership, it is easier for unlisted companies to gain control, so these companies are more likely to become shell companies. Lee et al. (2017) use the proportion of the top ten shareholders as a proxy variable for this indicator.

With the indicators, Lee et al. (2017) construct ESVM as the ratio of expected shell value to market capitalization in which expected Shell Value is the probability of becoming a shell multiplied by Shell Value which could be calculated by another equation in that paper.

To test the effectiveness of the factor, they divided stocks into 10 tiers according to Size (the first tier is with the smallest market cap), and then used the Fama-French five-factor model with the new ESVM factor to perform regression analysis on these 10 portfolios. The results are as follows:

	Panel A: Under 5 factors							Panel B: Under 6 factors						
group	Ex ret	alpha	MKT	SMB	HML	RMW	CMA	alpha	MKT	SMB	HML	RMW	CMA	SV
1	2.929**	0.722***	0.862***	0.956***	-0.233***	-0.084	0.636***	0.359*	0.942***	0.067	0.157**	0.124	0.072	0.815***
	[2.13]	[2.68]	[22.22]	[8.65]	[-2.94]	[-0.42]	[6.66]	[2.00]	[46.87]	[0.67]	[2.26]	[1.29]	[0.57]	[12.35]
2	2.275*	0.126	0.923***	0.936***	-0.112	-0.145	0.285***	-0.021	0.956***	0.577***	0.045	-0.061	0.056	0.330***
	[1.85]	[0.94]	[24.73]	[16.00]	[-1.40]	[-1.25]	[3.20]	[-0.16]	[39.49]	[7.28]	[0.59]	[-0.62]	[0.70]	[7.18]
3	1.942*	-0.044	0.979***	0.829***	-0.126**	-0.153	0.204***	-0.135	0.999***	0.606***	-0.028	-0.101	0.063	0.204**
	[1.67]	[-0.35]	[21.79]	[12.33]	[-2.00]	[-1.52]	[2.72]	[-0.93]	[22.18]	[6.94]	[-0.37]	[-0.84]	[0.53]	[2.52]
4	1.544	-0.261**	0.961***	0.705***	-0.153*	-0.174	0.289***	-0.363***	0.983***	0.454***	-0.043	-0.116	0.129	0.230***
	[1.33]	[-2.49]	[22.25]	[9.46]	[-2.00]	[-1.33]	[3.54]	[-3.61]	[30.36]	[3.16]	[-0.47]	[-0.94]	[1.06]	[2.97]
5	1.305	-0.314**	0.960***	0.581***	-0.153*	-0.328*	0.072	-0.357**	0.969***	0.477***	-0.107	-0.304	0.005	0.096
	[1.21]	[-2.56]	[17.28]	[4.50]	[-1.98]	[-1.71]	[0.87]	[-2.53]	[18.57]	[3.00]	[-1.43]	[-1.50]	[0.05]	[1.37]
6	1.177	-0.403***	0.944***	0.565***	-0.227***	-0.332	0.057	-0.421***	0.948***	0.520***	-0.207**	-0.322	0.028	0.041
	[1.03]	[-3.20]	[15.80]	[3.48]	[-3.98]	[-1.23]	[0.51]	[-2.87]	[14.62]	[4.69]	[-2.04]	[-1.09]	[0.29]	[0.36]
7	0.954	-0.343**	0.955***	0.382**	-0.193*	-0.462	-0.147	-0.507***	0.991***	-0.020	-0.016	-0.368	-0.402***	0.368***
	[0.86]	[-2.60]	[13.28]	[2.43]	[-1.94]	[-1.59]	[-1.14]	[-3.82]	[17.13]	[-0.09]	[-0.12]	[-1.21]	[-2.66]	[3.30]
8	0.788	-0.426***	0.976***	0.386**	-0.180*	-0.269	-0.183	-0.493***	0.990***	0.223*	-0.109	-0.231	-0.287**	0.150
	[0.76]	[-3.11]	[13.89]	[2.60]	[-1.91]	[-0.96]	[-1.46]	[-2.97]	[13.65]	[1.80]	[-1.08]	[-0.75]	[-2.27]	[1.40]
9	0.740	0.020	0.966***	0.025	-0.245***	-0.425*	-0.075	-0.159	1.005***	-0.414*	-0.052	-0.322	-0.354***	0.402***
	[0.69]	[0.10]	[12.91]	[0.17]	[-3.52]	[-1.78]	[-0.58]	[-1.03]	[17.09]	[-1.75]	[-0.59]	[-1.28]	[-2.82]	[3.15]
10	0.355	0.223*	0.957***	-0.182**	0.182**	0.296**	0.212***	0.201*	0.962***	-0.236**	0.206**	0.309***	0.177**	0.050
	[0.38]	[1.93]	[77.37]	[-2.47]	[2.15]	[2.49]	[2.97]	[1.89]	[64.95]	[-2.13]	[2.66]	[2.67]	[2.40]	[0.88]
1-10	2.575***	0.500**	-0.095***	1.138***	-0.415***	-0.380**	0.425***	0.158	-0.020	0.303***	-0.049	-0.185**	-0.105	0.765***
	[2.84]	[2.62]	[-2.71]	[13.84]	[-3.67]	[-2.59]	[3.89]	[1.56]	[-0.97]	[3.74]	[-0.42]	[-2.13]	[-0.69]	[14.31]

Panel A considers the traditional five factors, and Panel B additionally considers a new shell value factor (SV). Adding up the shell value, as Lee et al. find out, the SMB factor was weakened severely in explaining the returns of the 10 portfolios constructed according to the Size factor, and the α of the portfolios (1-10) constructed through the Size factor was also significantly weakened after adding in the shell value factor, indicating that the shell value factor largely supports the Size factor, and the higher returns on small-cap companies could possibly due to their higher exposure to the shell value factor (Chuan Shi 2019).

Given the interesting results of Lee et al. (2017), we believe our discussion would be more complete involving the shell value factor. However, due to the lack of required data and time, we do not detailly implement it but simply make a proposal here.

7 Conclusion

By applying Fama and French's methodology, we reconstructed the Fama-French five factors for the Chinese market. Although some results go against the conclusions of previous research, these contradictions can be explained by the unique business environment and market conditions in China. The investment factor, CMA, is likely redundant, as it's highly correlated with many of the others and contributes little to the model performance when added. To contrast, Fama and French find that HML is redundant and a four-factor model that excludes HML generates nearly identical returns to the five-factor model.

Fama and French find that small companies have much lower returns than the rest of the market. This result is not replicated in our analysis. A possible explanation is the prevalence of injecting assets into poor performing, nearly defunct companies to facilitate a "reverse merger". In a similar fashion to SPACs in America, Chinese companies use companies that are going out of business to bypass IPO regulations. This creates an unintended shell value that in turn boosts stock performance.

The addition of ESG scores helps explain some gaps in the original five factors but does not create robust factors on their own. Data for these factors is relatively new, with scores we used only becoming available in 2018. The effects of these scores have yet to be fully seen, and they can be expected to have a larger impact as the Chinese government expands its carbon-reduction and corporate social responsibility initiatives. The addition of ESG scores creates a more holistic understanding of stock performance in China but has little impact on driving price.

References

[1] Charles M.C.Lee, Tao Shen, Yuanyu Qu, 2017. Reverse Mergers, Shell Value, and Regulation Risk in Chinese Equity Markets.

[2] Chuan Shi, 2019. The Work of Quantifying Shell Value in Lee et al.'s Paper.

[3] Eugene F. Fama, Kenneth R. French, 2014. A five-factor asset pricing model. Journal of Financial Economics 116 (2015) 1-22.

[4] Xiaoming Lin, 2017. 五因子模型A 股实证研究. Huatai Securities Research.