



Establishment and Application of Multi-Factor Pricing Model in China A-Shares Market

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Abstract: Quantified investment refers to quantitative investment model and the way of issuing orders by programming, so as to obtain stable returns. In recent years quantitative investment is increasingly valued by institutional investors and hedge funds in terms of its discipline, systematicness, timeliness and decentralization. From the perspective of the effectiveness of China's securities market and the development experience of foreign securities market, the prospect of quantified investment is worth looking forward to. However, domestic quantitative investment products still have shortcomings such as small overall size, single quantitative strategy, differentiation of strategic performance. Therefore, it is of great significance to study the new quantitative investment mode and to dig out new modeling ideas to enrich the quantitative investment products, improve the market scale and promote the development of quantitative investment. Based on the method indicated by Eugene Fama and Kenneth French and using public information from China A-share market. This paper attempts to establish a multi-factor model which is able to explain the stock price in Chinese stock market. The model is based on four fundamental factors, including liquidity, profitability, growth opportunity and earning revision. In addition, four fundamental factors are further derived to ten factors. The effectiveness of the ten-factor model is tested by using historical data. The results show that this model could beat the market standard effectively and provide relatively stable excess income.

Keywords: China A-Share Market, Multi-Factor Model, Pricing Model

1. Introduction

Capital Asset pricing model (CAPM) is the foundation of the modern finance theory. This theory is developed from the traditional pricing model starting as discount cash flow model (DCF) by John Burr Williams (1938) [1]. The model indicates that the price should be the present value of the future cash flow generated from the asset. Harry Markowitz (1952) [2] proposes the Mean-Variance model. In this model, mean of the stock return is used to measure the expected return and the variance of the stock return shows the risk of the stock. The Mean-Variance model is the symbol of the beginning of the modern investment theory. Twelve years later, William Sharpe publishes the CAPM [3] based on formal Portfolio Theories, also known as the single factor model. It suggests that the expected return of the investment portfolio is related to the systematic risk. As the research goes on, Eugene Fama and Kenneth French presents the

Fama-French three-factor model in their thesis "Common risk factors in the returns on stocks and bonds" in 1983. This paper discusses the impact of three stock market factors on the stock price and return, which are market risk ($R_m - R_f$), the outperformance of small versus big companies (SMB), and the outperformance of companies with high book/market ratio versus that with small book/market ratio (HML). In addition, Eugene Fama and Kenneth French (1993) [4] indicate that the bond market factors, term structure of interest rate and payment risk, can influence the stock price as well. In conclusion, the stock and bond market risk factors can explain the price of the stock in some extent. Compared with CAPM, Fama-French three-factor model can explain the stock price more effectively.

Based on the method indicated by Eugene Fama and Kenneth French (1993), this paper attempts to establish a multi-factor model which is able to explain the stock price in China's stock market. The model is based on four factors,

including liquidity, profitability, growth opportunity and earning revision. In addition, four factors are further derived to ten factors. Therefore, this paper extends the three-factor model to ten-factor model. The effectiveness of the ten-factor model is tested by using historical data. The experiential window of this paper is from 2010 Aug to 2017 Dec.

2. Model and Methodology

2.1. Liquidity

According to the liquidity premium theory [5], the liquidity of the asset has important influence on asset pricing. Amihud and Mendelson (1986) [6] indicate that the liquidity of the asset is negatively correlated with the return on the asset. Since trading the stock with low liquidity incurs high transaction cost, the required yield on the low liquidity stock is high, compared with the stock with high liquidity. Therefore, there is illiquidity premium in the market.

However, it is hard to measure the liquidity of the stock. In general, the stock with high market value or high trading volume has high liquidity. However, these two indicators can not quantify the influence of liquidity on the asset pricing. Amihud (2002) [7] proposes that the ILLIQ factor is able to quantify the liquidity of stock, which can be calculated by using the Equation (1).

$$ILLIQ_{iT} = \frac{1}{Days_{iT}} \sum_{t=1}^{Days_{iT}} \frac{|R_{idt}|}{Volume_{idt}} \quad (1)$$

R_{idt} is the return of the stock at time t , $Volume_{idt}$ is the trading volume at time t .

ILLIQ measures how a unit of trading volume changes the price of the stock. Therefore, the stock with higher ILLIQ is more illiquid than the stock with lower ILLIQ. The suitability of ILLIQ factor in China A-share market is tested by using historical data. The experiential window is from 2010 Aug to 2017 Dec. The independent factor is the ILLIQ of each stock in A-share market in the experiential window. The dependent factor is the price of each stock on time $t+1$. For each stock, 90 set of data is obtained, and then the cross-regression is conducted. The average beta of cross-regression is 63.32, and the average P-value is 1.87%. In conclusion, ILLIQ factor has significant positive influence on the stock price. Besides, we used the factor ILLIQ as a single-factor and tested its stock selection ability. In order to get a general reflection of China's A shares market stock price, this study uses CSI300 index as indicator of portfolio behavior. As Figure 1 shows, ILLIQ can beat the market effectively.

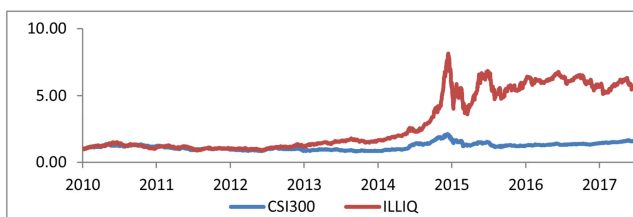


Figure 1. Back Testing of ILLIQ.

Therefore, this paper use ILLIQ as one of the factors in the stock pricing model.

2.2. Quality of Earnings

Fundamental analysis is always the most direct way to find companies with high quality no matter in bull market or bear market. The quality of earnings of a listed company decides the continuity of their future profitability. Higher quality earnings have higher chances of remaining than those of lower quality earnings. As a direct indicator of a company's Return of Investment (ROI), Return on assets (ROA) and Return on Equity (ROE) are indicators for quality of the company's earnings as well. Meanwhile, this study adds the Gross Margin Percentage in the model so as to take the appreciation of a product generated by the company's transformation into account. Calculation of the three indicators are using the Equations (2), (3), (4):

$$ROA = \frac{\text{Net Income}}{\text{Average Total Assets}} \quad (2)$$

$$ROE = \frac{\text{Net Income}}{\text{Book Value Of Equity}} \quad (3)$$

$$\text{Gross margin Percentage} = \frac{\text{Revenue} - \text{COGS}}{\text{Revenue}} * 100 \quad (4)$$

As Figure 2 shows, those three factors can also beat the market effectively.

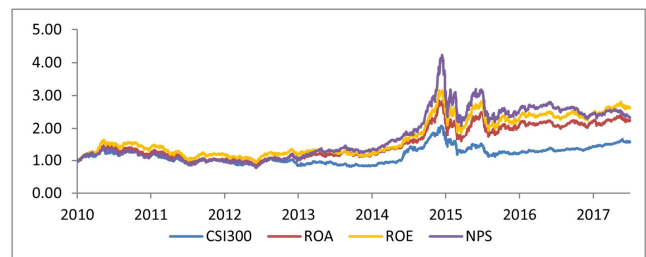


Figure 2. Back Testing of Quality of earnings Factors.

2.3. Growth Potential

Since Robert Gibrat proposed Gibrat's Law (1931) [8], more scholars started to research on elements contributing to a company's Growth Potential. There are mainly two types of theories about Growth Potential, deterministic and stochastic. Deterministic theory states that company's characteristics and the industry the company in decide the growth rate altogether. Stochastic theory believes that growth rates are independent from now or future records of the company therefore they are distributed randomly. This paper agrees with deterministic theory. Since a company's growth is a continuous process starting from being established to growing into certain state, the company's current state is related to its history records. With accumulated earnings, the company's capital accumulates and the company's size grows. Meanwhile, the structure of the company will be more organizational and mature. The strengthen in the company's different parts will reflect on its earning ability eventually. Therefore, it is very important

to conduct Fundamental analysis.

Cliff Asness (1997) [9] is a scholar supporting Fundamental Analysis. He believes that a company's fundamentals are main factors that affect its stock price, even though other factors may have small effect on the stock price as well. In terms of stock price, good behavior of fundamentals brings more attention from more investors therefore contribute to rise of stock price. On the other hand, investor will hesitate over bad fundamentals behaviors therefore contribute to fall of stock price. The Theory was supported by other scholars. Zhang Chen (1998) [10] proves both part of Cliff Asness Theory separately. His research supported the statement that good fundamental behaviors brings more interest and contributed to the rise of stock price while bad fundamentals behavior brings skeptical for companies, therefore have negative influence over stock price. Joseph D. Piotroski (2000) [11] supported the theory and made a more detailed division based on it. He chose multiple factors from the company's finance statements as factors of the company's stock price. Then he scored companies based on those factors by setting thresholds, ranked those companies according to the scores and used only top 20% as his investment combination. He found that he could remain a smaller level of risk while withholding a relative high return, therefore he believes that Fundamental analysis based on companies' financial reports can increase return of investments. This study is going to use revenue growth rate (RevQ), profit growth rate (ProQ) and Net Profit Growth Rate (NetProQ) those three fundamental indicators to evaluate the growth potential of a company.

As Figure 3 shows, those three factors can also beat the market effectively.

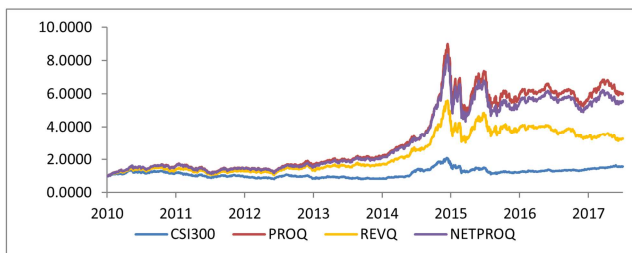


Figure 3. Back Testing of Growth Potential Factors.

2.4. Earning Revision

Profit forecast are fundamental statistics to describe corporate income level given by Financial Analysts. Financial analysts' main job function is to collect, analyze and spread information. Financial analyst plays a crucial role in improving communication between listed companies and investors by visiting the facility in real life, researching the business's financial statements and making judgement over industrial trend. Meanwhile analysts summarize their research result into formal Profit Forecast of a company and publish them to the capital market occasionally. It is fair to say that Profit Forecast contains professional study of listed companies and general judgements for quality of returns.

From the view of quantitative investments, Profit Forecast is the only fundamental data source concerning the future of a company among many data types. Historical factor is usually the main factor related to choosing stock according to traditional quantitative stock models. However, those historical factors have already been reflected on the current stock price based on Efficient Markets Hypothesis [12]. Using Profit forecast to build pricing model could avoid the effect from such phenomenon. Erica Slgter and Dick Van Dijk (2003) [13] did research on stock choosing strategy based on Jaapvan der Hart's Theory and discovered that value strategy, momentum strategy and profit forecast strategy produced the highest excess income. Therefore profit forecast produces a large portion of excess income during investment practices. By calculating analyst prediction change over the company's profit forecast, Profit forecast strategy can bring latest view of the market prediction over the company's future into the model, therefore being able to predict excess income brought by the stock.

To sum all, profit forecast strategy is analyst making adjustment over company profit forecast based on all information at hands. Because of anchoring effect, increase or cut of profit forecast will not happen in one time but rather in many steps. Certain behavior provides others with chances to arbitrage.

On the other hand, analysts who only have limited effort tend to cover companies with more chances. When analysts are not optimistic about the future of a company, they will not publish reports in order to maintain a good relationship with list companies. Therefore there are definitely selection base for analysts. Companies with good fundamentals, more future chances and higher future profit prediction will be chosen to cover by more analysts [14].

The study uses profit forecast data from Wind [15] to build such factors:

- 1). Sales change in one month (SalesChange1M)
- 2). Net profit change in one month (NetProfitChange1M)
- 3). Coverage change in one month (CoverageChange)

As Figure 4 shows, those three factors can also beat the market effectively.

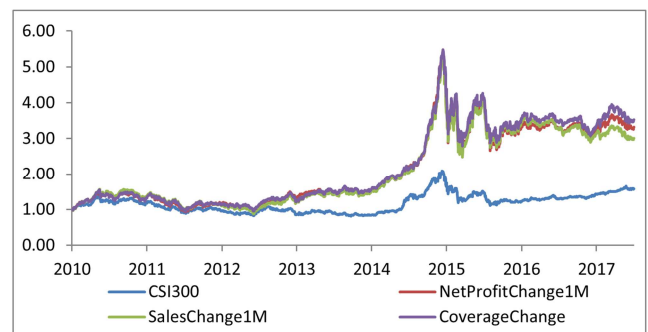


Figure 4. Back Testing of Earning Revision.

2.5. Pricing Model

In conclusion, mobility, profitability, growth and profit forecast which including ten factors, can reflect the real value

of a company. Historical data from Stock Market will be used to verify this. The study uses T day Closing Price as the dependent variable and the above ten factors as independent variables to build the following regression mode which is Equation (5):

$$P_{i,T} = \sum_{j=1}^{10} \beta_{ij} X_{i,j,T-1} + \varepsilon_{i,T} \quad (5)$$

In the formula (5), X means the factor, subscript means the T-1 value of stock i under factor j. All factors are listed in Table 1:

Table 1. List of Factors.

Variable	Factor Name
X1	ILLIQ
X2	ROA
X3	ROE
X4	Gross Margin
X5	RevQ
X6	ProQ
X7	Net ProQ
X8	Sales Change 1M
X9	Net Profit Change 1M
X10	Coverage Change

This study do not really think stock price can reflect real value of a company since there is stock discount or premium to some extent. In the regression, residual term $\varepsilon_{i,T}$ means the real price of stock i on T minus real price. According to Benjamin Graham [16], only when a stock's price is far more than its market price (margin of safety), it is worthy to invest in it. In this paper, based on the regression result, margin of safety can be defined as

$$\text{Margin of Safety} = \frac{P_{i,T}}{P_{i,T} - \varepsilon_{i,T}} \quad (6)$$

$P_{i,T} - \varepsilon_{i,T}$ represents the real value of a company. In a word, the lower margin of safety is, the more discount the company is; vice versa, the more promising the company is.

3. Empirical Study

This study does the regression on a monthly base. At the end of the month, we calculate the factors of all stocks. But before using them, normalization - data indexation has to be done to all data and analysis after. By doing normalization can avoids abnormal value, making data being dimensionless and adjust factor distribution characteristics. Abnormal value can distort the factors' statistical results and also obstruct factors' presentation in the model. By making data dimensionless, comparability problem is resolved. Numbers or indexes of different units or orders are able to compare with each other or weighting. In other words, factor normalization is the process of seeking common points and reserve differences while remodeling them. All factors are changed to similar order and

distribution characteristics, however, at the same time keep the special new stock information factor. There are tons of methods to do normalization, such as 'Min-max Normalization', 'Z-Scores Normalization' and 'Decimal Scaling'. This study uses Z-Scores Normalization [17]. The details are: First, divide the stocks based on the 29 I-grade industries from CITIC; Second, in each cross-section from all industries, using the factor value of each stock minus average cross-section value and then divided by cross-section standard deviation. After normalization, average cross-section value of factors is 0, cross-section standard deviation is 1.

Using data from last trading day of last month This study calculate all ten factors listed above and normalized them based on industry and used value of normalized factors as independent variables. Using closing price of first trading day as dependent variables and taking it into regression equation and calculating residual error, Based on the marginal safety equation above, This study calculates the safety margin of every stock correspond to, Here set the safety margin threshold value to 0.67 which means only choose stock with safety margin value smaller 0.67. Finally, a weighted market share method is used to calculate the weight distribution of the selected stocks, thus constructing the investment portfolio. This study use the opening price of the second trading day as the sales price of prior-period stock and purchase price of period stock. In order to get a general reflection of Chinese A shares market stock price, This study use CSI300 index as indicator of portfolio behavior.

The net worth of portfolio shown as Figure 5:

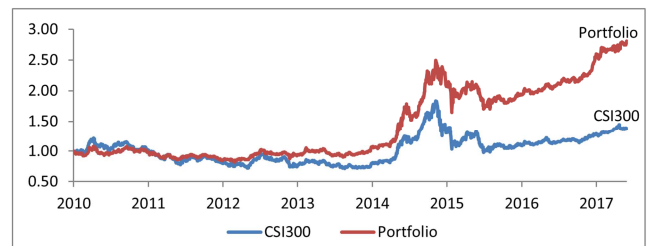


Figure 5. Portfolio Performance.

The active return shows as Figure 6

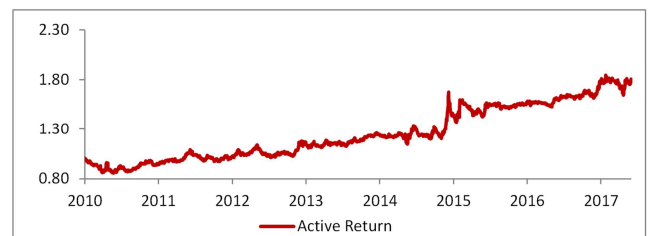


Figure 6. Active Return.

The holding examples shows in the Table 2:

Table 2. Holdings.

StockName	Weight	StockName	Weight
QUMEI HOME	0.06%	NISCO	0.75%
2345 NETWORK HOLDING	0.69%	KIBING	0.54%
AYIS	0.44%	SHCI	3.01%
SHIMGE PUMP	0.10%	LIUSTEELCO	0.73%
LONCIN	0.50%	LING STEEL	0.36%
CHENGDELOLO	0.33%	SOUYUTE	0.42%
CCYS	0.17%	ZDDC	0.63%
XINHU ZHONGBAO	1.58%	YANGGU HUATAI	0.14%
AOTO ELECTRONICS	0.09%	NanJi E-Commerce	0.41%
LEO	0.34%	HEILAN HOME	1.43%
DMG	0.78%	QCMC	0.12%
SEMIR	0.49%	YECHIU RECYCLING	0.30%
MIHF	0.29%	JSGT	0.23%
CHUY AGRO-PASTORAL	0.31%	CBM	0.12%
CNNCTD	0.23%	YIWU CCC	1.19%
SITI	0.46%	HDXY	0.53%
Sino Great Wall	0.19%	DEZHAN HEALTHCARE	0.33%
HY PROPERTY	0.32%	AOTECAR	0.26%
SPC	1.65%	JHEC	0.44%
NANSHAN ALUMINIUM	0.93%	CRE	0.18%
GPED	0.13%	QIANHONG BIO-PHARMA	0.17%
GRGBANKING	0.48%	SF DIAMOND	0.07%
XINTIAN TECHNOLOGY	0.11%	UDC	0.37%
AXXT	1.22%	LXDQ	0.16%
SHANYING PAPER	0.73%	TSPGC	0.67%
AGRICULTURAL BANK OF CHINA	39.13%	CHASE SUN PHARM.	0.37%
DEHUA TB	0.28%	FOCUS MEDIA	2.67%
SDHS	1.06%	HXPP	0.16%
BEFAR	0.33%	BANK OF CHINA	29.40%
GUANGZHOU RESTAURANT	0.04%	DTCI	0.37%

Based on George O. Aragon; Wayne E. Ferson (2006) [18] and Richard C. Grinold and Ronald N. Kahn [19], This study uses these KPIs to measure the behavior the portfolio combination in Table 3

Table 3. Performance Evaluation Indicators.

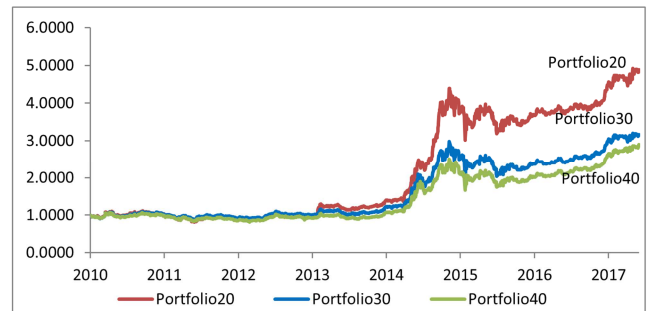
Portfolio Return	181.20%
CSI300 Return	37.90%
Active Return	143.30%
Annualized Portfolio Return	14.97%
Annualized Active Return	12.74%
Standard Deviation	20.28%
Sharpe Ratio	0.74
Information Ratio	0.92

The KPIs clearly shows that the investment portfolio model beat the market standards easily. The Portfolio return keeps growing as time goes and could still reach 181.2% of total return after the stock crisis in 2015.

Number of stocks inside a portfolio always has effect on the portfolio risk level. Based on research from Evans and Archer (1968) [20], fall of portfolio risk level has direct connection with increasing the number of stocks inside the portfolio while choosing asset completely randomly. Soon after, Statman (1987) [21] did similar research to further study diversity's effect on the portfolio. He indicates set holding at least 30 stocks will reach the purpose of spreading the risk. To find the effect of number of stocks on the portfolio, This research added one step in the testing process. Ranking the stocks descending based their safety margin and

make an inner join with stocks had safety margin higher than the threshold value, This research took first Nth stocks and build our portfolio. The N's numbers are 20, 30 and 40.

The net worth of portfolios are shows in Figure 7:

**Figure 7.** Portfolios Performance.

Portfolio risk level and sharp ratio are shown at Table 4:

Table 4. Standard Deviation and Sharpe Ratio.

N	Standard Deviation	Sharpe Ratio
20	22.51%	1.05
30	21.46%	0.79
40	20.64%	0.75

With number of stocks N increases, the portfolio risk level reduces. When you are holding 20 stocks, you can have 1.05 units of excess income while bearing 1 unit of risk. At the same time, if you are holding 40 stocks, you can have only

0.75 units of excess income when bearing 1 unit of risk. Therefore, increasing the stock number will decrease the portfolio risk but will decrease the portfolio return as well. This research shows that the best strategy is to hold 20 stocks fulfilling the requirements of safety margin. The KPIs are shown in Table 5:

Table 5. Portfolio 20 Performance Evaluation Indicators.

Portfolio Return	388.30%
CSI300 Return	37.90%
Active Return	350.40%
Annualized Portfolio Return	23.85%
Annualized Active Return	22.85%
Standard Deviation	22.51%
Sharpe Ratio	1.05
Information Ratio	1.45

This study compared the return rate of the model with 752 listed mutual fund return rate to see if such model can beat professional mutual fund manager. As Table 6 shows the highest return insides 752 mutual fund is 340.37%, but our model produce 388.88% which is a lot higher than the highest.

Table 6. Top 10 Mutual Fund.

Mutual Fund Name	Return
Xing Quan Ho Run Fund	340.37%
China Universal Private Enterprise Vitality Fund	300.57%
GuoTai Small and medium Growth Mix Fund	261.89%
Xing Quan Ho Run Structured Fund	256.22%
Xing Quan Growth Opportunity Fund	250.89%
China Universal Selective Hybrid Fund	240.84%
BOCOM Advantage Industry Mix Fund	227.33%
China Universal Focused Growth Fund	218.39%
HSBC Jin Xin Large-Cap Fund	214.99%
Lombarda China Value Discovery Mix Fund	214.17%

4. Conclusion

This paper proposes a pricing model suitable to China A-share market based on liquidity, earning ability, potential to grow and earning revision. The model uses ten factors to quantify such characteristics of such four dimensions. It uses safety margin to define stock prices' discount level and build portfolio, meanwhile using historical data to validate the model. The test result indicates that the investment portfolio could beat the market standard effectively and provide relatively stable excess income. Furthermore, This research discover that this quantitative investment model could increase the portfolio return by reducing the number of stocks. The optimized portfolio with the model has 20 stocks. With such choice, the investment portfolio built under the model could beat the market standard extensively and even surpass professional portfolio manager's KPI.

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