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Application of Quantitative Methods in Asset Allocation Based on the Chinese Capital Market

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Abstract: Investors' demand for asset management products is rising; however, traditional asset allocation models are facing difficulties in playing a full role due to the restrictions on the investment scope and the limitation of the accuracy of fund manager's subjective judgments. The application of traditional asset allocation model necessitates knowledge about the expected returns, future trends, or risk scopes of assets. This study holds that the quantitative method based on macroeconomic logic is one of the solutions. Beginning from the macro-cycle, this study analyzes the logical chain behind the application of the momentum effect and contrarian effect to stock index allocation and stock bond allocation, verifies their effectiveness, as well as explores relevant strategies using data from 2010 to 2021. Therefore, when the accuracy of subjective views cannot be guaranteed, it is a good idea to form a benchmark scheme with generalized quantitative methods based on financial market logic, and then make subjective adjustments.

Keywords: Asset allocation; Quantitative investment; Momentum effect; Contrarian effect

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1. Introduction

Since the implementation of new asset management laws in 2018, the majority of bank-guaranteed products have been phased out of the market. Given that the pension replacement rate is also on the decline, investors' demand for asset management products has risen significantly. Asset management products with lower access threshold and higher information transparency have often received more attention from investors. However, in order to protect the interests of investors, such products are subjected to more stringent regulations. As a result, complete asset allocation models for global asset allocation are often inapplicable. Moreover, traditional asset allocation models, such as the mean variance model proposed by Markowitz [1], are highly sensitive to the expected rate of return of assets. Although the Black-Litterman (BL) model proposed by Black and Litterman [2] modifies this point from the perspectives of investors, it will still be affected by the accuracy of subjective judgments. When it comes to the risk parity model, which was proposed by Qian [3] and applied by Dalio in his all-weather strategy on bridge water fund, the issue is on how to quantify the risk to realize the real risk parity.

It is impossible to always keep subjective judgments accurate even for the most professional fund manager as this fact provides the soil for quantitative investment development. The biggest risk of quantitative investment comes from pursuing the complexity and current accuracy of technology or model while neglecting the logic behind it. Doing so will introduce unknown risks and reduce the applicability of the model in complex and changing market environments. This study holds that the future development direction of asset allocation is to take the quantitative investment method as the benchmark to provide a

direction for decision-making, and then adjust it according to the market situation through subjective judgment.

2. Viewpoint and relevant research

In the field of asset allocation, macro models are always the mainstream. Economic phenomena result from compound effects of various exogenous and endogenous factors in the economic system. These factors form a system with a feedback mechanism that exhibits a specific economic cycle phenomenon. Merrill Lynch's investment clock model is a classic model for asset allocation according to the macroeconomic cycle. The report divides the economic stages into recovery, overheating, stagflation, and recession. However, China's economic environment is unique and not fully in line with the premise hypothesis as well as the logic of foreign models. Therefore, domestic scholars, such as Dezhi Dong [4], are working to propose new models based on China's national conditions. In any instance, a macroeconomic stage exists and will exist for a period of time, affecting the price of all types of assets until the next stage arrives. This phenomenon in the market is similar to that of the well-known momentum effect and contrarian effect in quantitative investment.

Ever since Jegadeesh and Titman [5] as well as Debondt and Thaler [6] proposed the momentum effect and contrarian effect, respectively, these concepts have attracted extensive attention. Although the causal relationship behind these effects is still controversial, there is no doubt about their guiding significance in investment. Academic research on the momentum effect and contrarian effect in European and American markets began much earlier than in the Chinese market, and opinions on their effectiveness are more uniform. Scholars who first conducted research on the A-share market include Yonghong Wang, Xuejun Zhao [7], Joseph Kang, Ming-Hua Liu, and Sophie Xiaoyan Ni [8]. Wang and Zhao analyzed the performance of all A shares listed before 1993 and suggested that the high turnover rate is caused by the overreaction of Chinese investors as well as the high proportion of systemic risk as the market risk finally made the contrarian strategy effective in the Chinese market, while the momentum strategy was slightly weak. Joseph Kang and other researchers who studied the data from the same period confirmed short-term contrarian effect and medium-term momentum effect, but the latter was only obvious in the market capitalization-weighted portfolio. The effectiveness of the two effects, especially the momentum effect in the A-share market, has not been fully agreed on. In recent studies, Kailong Fan [9] and Xianghui Dai [10] corroborated the validity of the contrarian effect but disagreed on the existence of the momentum effect. On the other hand, Zhou Ying [11], Yajie Chen [12], Chang Yan [13] suggested that the momentum effect exists in A-share markets in some cases.

While most relevant studies focus on cross-sectional data, Moskowitz and several other researchers [14] proposed a different idea – the time series momentum effect, which solely considers the asset's yield in the previous period. According to this theory, the yield will exhibit a momentum effect over a period of time before reversing. In Moskowitz's study, 58 kinds of underlying assets were tested, and they found that the time series momentum effect can last for 12 months before reversing. Shi and Zhou [15] tested and confirmed the existence of the time series momentum effect in Chinese stocks. The performance of relevant strategies will be affected by the look-back period, the duration of holding period, and specific company characteristics.

This study holds that the economic form, determined by macroeconomic fundamentals, will last for a period of time regardless of its stage in the economic cycle. During this period, the macroeconomic fundamentals will receive feedback from all aspects and gradually change. From the accumulation of small changes, it will undergo a qualitative shift, and the economic form will eventually progress to the next stage. The feedback system indirectly lays the foundation for the price trends of assets, which will be promoted by investors in the market. However, the transmission of information is time-consuming. Some investors

may respond more quickly, whereas the majority of investors are slow to respond. When information asymmetry is high, investors tend to overreact; that is, the asset trend, which is indirectly influenced by macro fundamentals, may have changed, but investors who received information later are still immersed in the previous trend, thus preventing the market from responding in time. When the majority of market participants notice that the asset trend has shifted or deviated from the current reasonable value, the trend of assets will reverse. For individual stocks, more factors are affected, including the company's own financial characteristics and its development prospect in the industry. In contrast, the momentum effect and contrarian effect will have a purer performance on stock or debt indexes, which reflect the price trend of a basket of underlying assets. Therefore, this study believes that the application of momentum effect and contrarian effect in asset allocation is logically supported. The third section shows the data and discusses the methods as well as the investment yield of a single asset. The fourth section reveals the test results and strategy back test results, which will be summarized in the fifth section.

3. Data and methods

The daily data of all trading days from 2010 to 2021 were used. The selected stock and bond indexes included SSE 50 Index, CSI 300 Index, CSI 500 Index, CSI All Share Index, and CSI Aggregate Bond Index. Other commonly used indexes, such as CSI 800 Index and CSI 1000 Index, were not selected in the scope of this study due to high correlations with CSI 300 index and CSI 500 index, respectively. From the descriptive statistics, no index was found outstanding. Among the selected indexes, SSE 50's correlation with CSI 300 was 0.948***, while that with CSI 500 was 0. 672***. The correlation between CSI 300 and CSI 500 was 0.850*** (*** indicates a significance level at 1%).

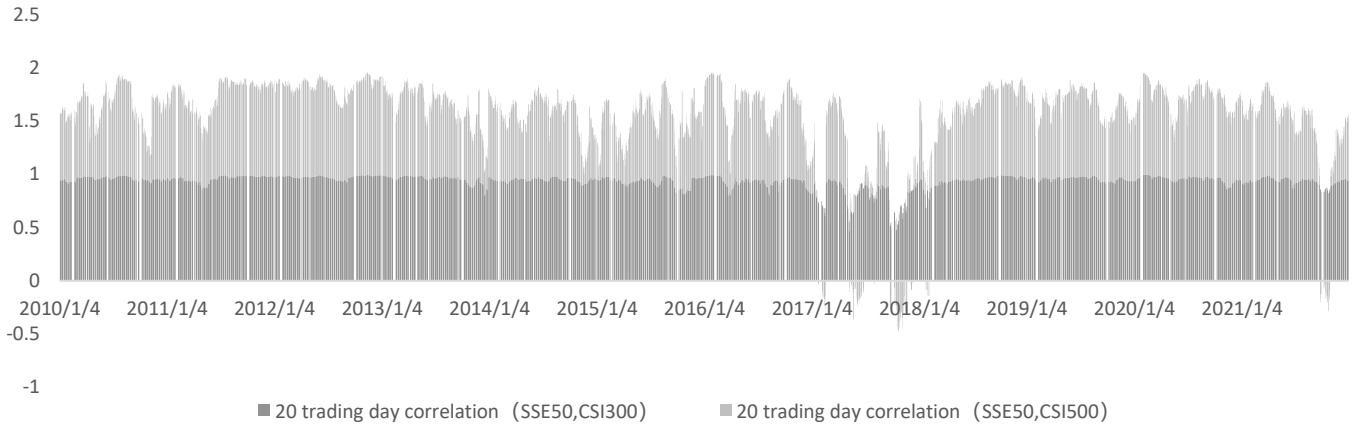

Figure 1. Correlation data of stock indexes for 20 trading days

Figure 1 shows that, while the daily return of stock indexes has a substantial high correlation under the general trend within this 12-year frame, even the strongest correlation indexes, the SSE 50 Index and the CSI 300 Index, may dip in short-term correlation during specific market periods. In some ranges, the SSE 50 Index and the CSI 500 Index even showed a reverse trend. In the long run, the overall returns of stock market indexes are closely tied to the performance of the actual economy although there may be differences over time, which is the basis for stock index allocation. As shown in **Table 1**, since the stock indexes have seen a cycle of rise and fall in the transformation of the economic cycle, the yield of holding a single index is even lower than that of holding bonds over the past 12 years. We plan to employ the momentum effect and contrarian effect in stock index allocation and stock bond allocation to identify the current asset trend, increase the position of assets in the rising period, and reduce the position of assets in the falling period, so as to increase the incomes of our portfolio.

Table 1. Investment return analysis of the selected indexes

	SSE 50	CSI 300	CSI 500	CSI All Share	CSI Aggregate Bond
Annualized rate of return	2.22%	2.83%	4.17%	3.90%	4.54%
Annualized volatility	0.23	0.23	0.26	0.23	0.01
Maximum drawdown	-44.70%	-65.20%	-46.70%	-57.85%	-4.28%
Sharp ratio	0.10	0.16	0.12	0.17	3.24
Calmar ratio	0.05	0.06	0.06	0.07	1.06

4. Tests and empirical results

4.1. Momentum effect test and empirical results of stock index allocation strategy

Similar with traditional momentum research methods, we begin by determining the winner index, which showed the best performance among the three indexes in the previous R trading days, and the loser index, which showed the worst performance among the three indexes. The winner's performance is then compared to the loser's excess annualized return over the next K trading days. **Table 2** shows the outcomes of the inspection.

Table 2. Cross-sectional momentum effect test of stock index

		Ranking days, R						
		3	**5**	**10**	**20**	**40**	**120**	**252**
Holding days, K	3	8.52%*	7.31%*	9.18%**	7.70%*	-3.70%	0.68%	-4.24%
	5	5.25%	6.61%*	8.85%**	5.89%	-3.14%	0.65%	-2.60%
	10	5.96%**	6.90%***	6.88%***	1.30%	-1.02%	1.70%	-1.89%
	20	4.31%**	4.58%**	4.01%**	-0.35%	-0.70%	0.50%	-3.12%*
	40	1.47%	1.13%	1.63%	-0.65%	-0.54%	-2.10%*	-4.25%***
	120	-0.92%	-1.19%*	-1.01%	-1.75%***	-1.75%***	-1.66%**	-1.29%**
	252	-0.66%*	-0.50%	-0.42%	-0.45%	0.04%	1.68%***	2.10%***

Note: ***, **, and * indicate a significance level at 1%, 5%, and 10%, respectively

The test results in **Table 2** verify our conjecture. For stock indexes, the momentum effect is significant in short to medium term, while the contrarian effect is significant in medium to long term. When the period is long enough, the momentum effect becomes significant again. Among the selected indexes, the CSI 500 Index, which represents the price of small market value stocks, fluctuates more with the overall rise and fall of the market. The CSI 500 Index performs best when the market is trending upward, and it is likely to have the worst performance when the market is in decline. The SSE 50 Index may outperform the CSI 500 Index when the market declines, but as a winning index, its return during the period when the market begins to rebound in the medium term may be lower. Hence, the winner index may alternate between the index representing large market value and that representing small market value. **Table 3** examines the data from 2018 to 2021. During that period, the correlation between indexes is lower than that from 2010 to 2017. Therefore, this trend can be seen more clearly in **Table 3**.

Table 3. Cross-sectional momentum effect test of stock index (2018-2021)

		Ranking days, R						
		3	**5**	**10**	**20**	**40**	**120**	**252**
Holding days, K	3	-0.42%	-2.18%	9.39%*	12.17%*	6.59%	1.77%	0.22%
	5	-2.16%	-1.48%	10.85%**	11.99%**	6.72%	1.89%	0.50%
	10	4.28%	6.83%**	12.91%***	10.44%***	8.22%**	3.00%	-1.14%
	20	4.55%*	5.78%**	7.25%***	6.02%**	3.18%	2.36%	-3.07%
	40	3.44%**	3.00%*	5.97%***	4.41%**	1.79%	-0.96%	-6.21%***
	120	1.31%	1.53%	2.10%**	1.04%	-0.97%	-5.39%***	-7.52%***
	252	-0.91%*	-0.83%	-1.87%***	-2.30%***	-2.07%***	-1.43%***	2.61%***

Note: ***, **, and * indicate a significance level at 1%, 5%, and 10%, respectively

Based on the above analysis, the following strategy is adopted: hold the winner index within ranking period R_1, and when it becomes the loser index within ranking period R_2, the winner index is held within R_2 instead. Since it is difficult to shift positions in one trading day in real-world settings, the impact of gradually increasing and reducing positions on the strategy will be considered in the subsequent analysis.

Table 4 shows the back test results of this strategy. Compared with **Table 1**, it can be clearly seen that in 12 years, from 2010 to 2021, selecting indexes by momentum and contrarian logic has a certain improvement in both the annualized yield and the sharp ratio than simply holding a single stock index. When the ranking period is longer, the degree of improvement of the strategy decreases.

Table 4. Back test results of stock index allocation strategy

			Momentum ranking days, R_1		
			10	**20**	**40**
Contrarian ranking days, R_2	5	Annualized rate of return	10.19%	11.02%	9.22%
		Sharp ratio	0.42	0.45	0.38
	10	Annualized rate of return	/	10.71%	7.38%
		Sharp ratio	/	0.41	0.30
	20	Annualized rate of return	/	/	5.71%
		Sharp ratio	/	/	0.24

This strategy did not significantly improve returns from 2010 to 2014 when market volatility was low and the correlation between stock indexes was high. The following seven years, however, saw an increase in market volatility, an obvious distinction in the stock index trend, and a greater impact by this strategy.

4.2. Momentum effect test and empirical results of stock bond index allocation strategy

The time series momentum effect of CSI All Share Index was tested. If the CSI All Share Index has a time series momentum effect, holding it when its return is positive during the ranking period will result in a considerable excess return over holding it when its return is negative during the ranking period. The results are shown in **Table 5**.

Table 5. Time series momentum effect test of CSI All Share Index

Ranking days	10	20	40	60	120	252
Annualized excess return	-0.05%	0.05%	0.05%	0.05%	0.05%	0.05%

From **Table 5** itself, it is impossible to confirm the existence of the time series momentum effect. Although the annualized returns of two holding methods vary under different ranking periods, the annualized excess returns are small and insignificant. However, it is probable that the duration of the time series momentum effect and contrarian effect has changed during the past 12 years, resulting in the effect being neutralized in the long run in the case of a fixed ranking period. Assuming this is the case, a stock bond allocation strategy based on the time series momentum effect may still be developed although the test is insignificant.

The momentum ranking period is set as T_1 and the contrarian ranking period as T_2. Assuming that the yield and volatility of bonds are more stable than those of stocks, we believe that if the stock market continues to trend upward in T_1 without any reversal signal detected in T_2, we could be bullish on the stock index; otherwise, we should be bearish on the stock index. In order to make the effect more intuitive, we temporarily set the stock index to account for 80% of the positions when we are bullish on the stock index, 20% of the positions when we are bearish on the stock index, and the remaining positions are invested in the bond index. The criteria for generating reversal signals are that the stock index return rate R_{T2} within T_2 and the stock index return rate R_{T1} within T_1 are reversed and have broken through the threshold. The threshold is set to the 25% quantile value away from R_{T1} in all R_{T2} opposite to R_{T1} in the previous T_1.

Table 6. Back test result of the stock bond index allocation strategy

			Momentum ranking days, T_1			
			20	40	60	80
Contrarian ranking days, T_2	5	Annualized rate of return	7.36%	3.90%	8.41%	4.31%
		Sharp ratio	0.53	0.29	0.65	0.34
	10	Annualized rate of return	/	6.15%	8.25%	5.81%
		Sharp ratio	/	0.46	0.64	0.44
	20	Annualized rate of return	/	/	7.06%	5.01%
		Sharp ratio	/	/	0.54	0.40

Table 6 demonstrates the feasibility of stock bond allocation based on the time series momentum effect. This shows that although the effect is not significant under a fixed ranking period, the effect does exist. Therefore, it is conceivable that during a certain ranking period, there will be momentum effect at times, reversal effect at other times, and finally an offset. We have adjusted several parameters to test their impact on the effect of our strategy. The parameters include the upper and lower position limit of stock index in the total portfolio and the quantile value selected by the threshold when generating the inversion signal. The test results confirmed that the larger the adjustment range of the position of assets, the better results the portfolio can achieve. It also means there is a trade-off between the strategy's flexibility and realistic operability. Although the selection of quantile value will affect the result, it is not essential.

Figure 2 shows the result from the combination of the aforementioned two allocation strategies based on momentum idea. In the stock index allocation, we assume that $R_1 = 20$ and $R_2 = 10$. In the allocation of stock and bonds, we assume that $T_1 = 60$ and $T_2 = 10$. The bullish stock index position proportion is set to be 80%, while the bearish stock index position proportion is set to be 20%. The threshold quantile value is

set as 0.75. According to the back test result, the annualized rate of return is 13.34%, and the sharp ratio is 0.95.

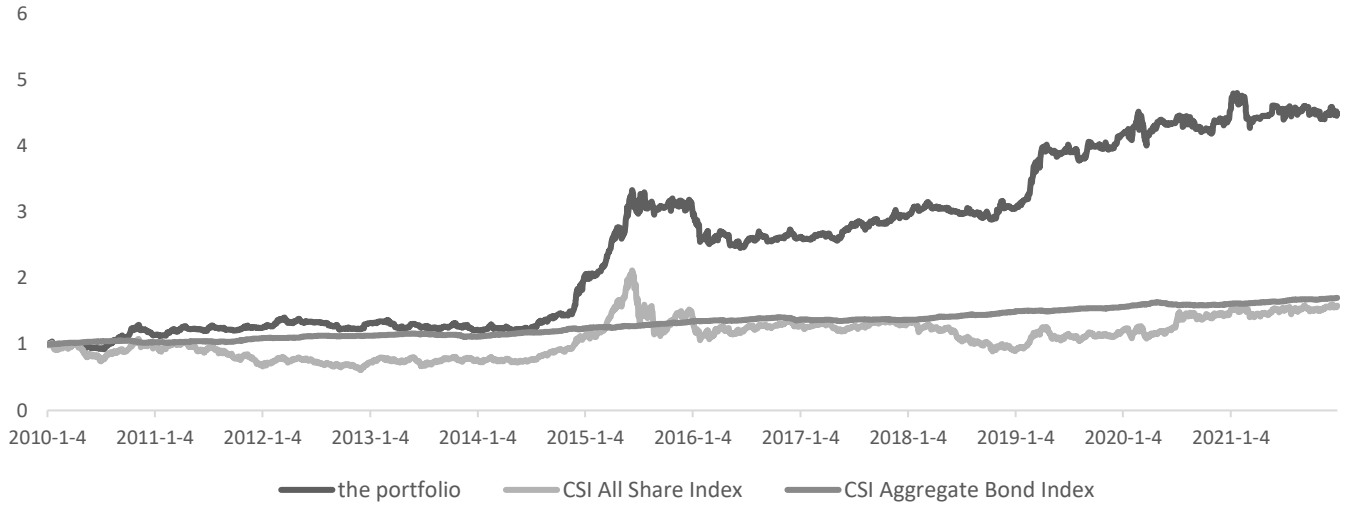

Figure 2. Back test result of the combined strategy

4.3. Position adjustment test

Compared with macro asset allocation, the turnover rate of quantitative asset allocation will be higher, which also means that there will be an increase in the transaction cost. The effectiveness of quantitative asset allocation is influenced by the transaction cost. This section examines the impact of the position adjustment ratio limit on the strategy. **Table 7** shows the performance of the stock index allocation strategy and the stock bond allocation strategy under the restricted position adjustment ratio.

Table 7. Stock index allocation under restricted position adjustment ratio

	Position adjustment ratio per day					
	100%	**50%**	**30%**	**25%**	**20%**	**10%**
Annualized rate of return	10.64%	10.14%	9.62%	9.53%	8.87%	5.98%
Sharp ratio	0.44	0.42	0.40	0.39	0.37	0.25

Based on **Table 7**, the quantitative asset allocation strategy can still work under a restricted position adjustment ratio, albeit the lower the position adjustment ratio limit, the better the effect. Furthermore, the test demonstrated that even if the annualized rate of return declines, the greater the upper limit on bond proportion, the better the overall sharp ratio.

4.4. Overall back test result under the quantitative asset allocation strategy

Based on the discussion above, a complete strategy is formed. The upper limit of equity positions is changed to 40%, and the speed of position adjustment is changed to 10%. Other parameter settings are the same as those in **4.2.** Bond positions can be exchanged for any other assets or asset portfolios as long as the alternative has a stable return. The final performance is depicted in **Figure 3**. The annualized yield of our portfolio is 7.30%, and its sharp value is 1.10.

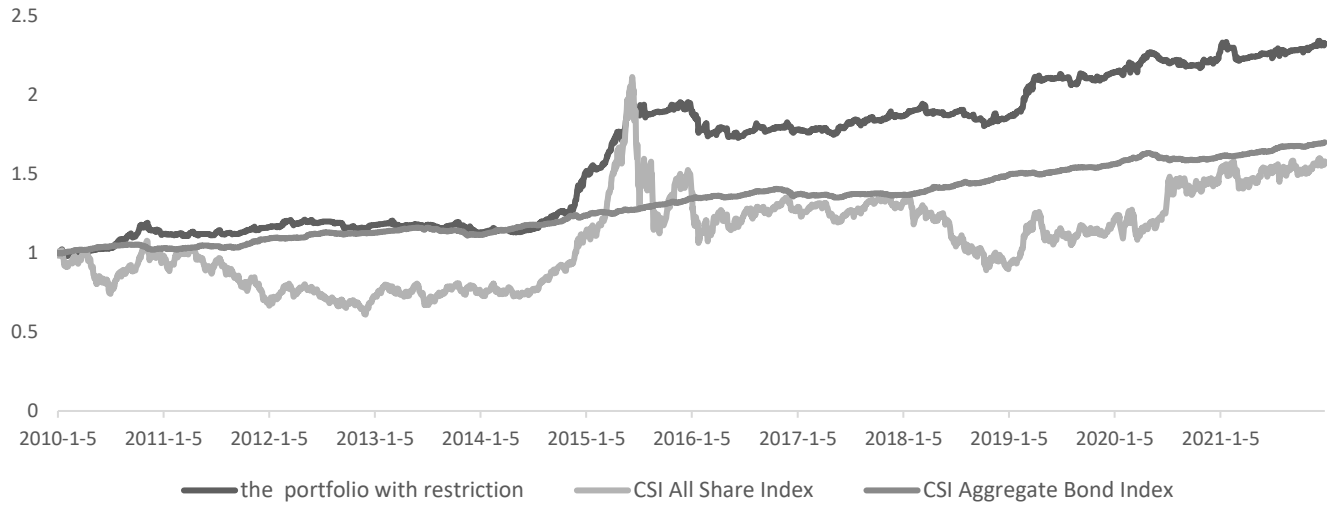

Figure 3. Back test result of the combined strategy under restricted position adjustment ratio

5. Conclusion

The implementation of new asset management legislation in 2018 broke the rigid repayment pattern, and at the same time, the pension substitution rate showed a downward trend, resulting in a significant increase in investors' demand for asset management products. Asset management products with lower access threshold and more transparent information will draw more attention from investors, and as a result, regulatory authorities will place more restrictions on their consideration in order to protect the interests of investors. The limitation of investment scope will greatly affect the traditional asset allocation models' effect. Additionally, the effect of these models such as the mean variance model, the Black-Litterman model [2], the risk parity model [3], and so on also depend on the accuracy of subjective judgments from different aspects. However, nobody can guarantee an accurate prediction of the future.

In order to solve the aforementioned issues, the quantization method is introduced as the middle layer. Based on traditional macro logic, economic is caused by macro fundamentals, and the phased trend of assets is determined by the stage in the economic cycle. When the feedback from the economic cycle to the macro fundamentals reaches a particular threshold, it will result in a qualitative shift, pushing the economic cycle into the next stage and changing the price trend of assets. This market chain reaction will result in the price trend of assets continuing for a period of time before reversing at a specific point in time. In this study, a quantitative model is established by using cross-sectional momentum and time series momentum methods, and relevant strategies have been explored, so as to lay a foundation for the benchmark scheme of asset allocation that is not affected by subjective views.

The cross-sectional momentum effect and contrarian effect were found to be significant in the stock index allocation test, whereas the time series momentum effect failed in the stock index. This may be attributable to the fixed length ranking period. In fact, the duration of the time series momentum effect may be related to the stock index's volatility and the net displacement distance trend; that is, in the period when the stock index changes rapidly in one direction, the period of the momentum effect will be shorter, and the contrarian effect will appear earlier. Therefore, in the event of a fixed ranking period, it may have entered the reversal stage in some periods while remaining in the momentum stage in others, which then offsets. If this is a fact, the benchmark strategy can still be configured even if the time series momentum effect is not significant in the test. It has been confirmed that stock index allocation and stock bond allocation strategies are both effective and greatly improve the return.

The advantage of establishing an asset allocation benchmark scheme with quantitative method is to avoid subjective error, while its disadvantage is that a quantitative method with no subjective points or

complex structure to avoid the loss of generalization can only be used to discover existing trends without predicting the future. In the logic behind the strategies, the transmission of information is time-consuming. Therefore, investors who are late to receive information may have missed the opportunity to respond, resulting in overreaction and deviation of asset prices. It is difficult to describe such complex and changeable market situations by generalized quantitative methods. In conclusion, a perfect asset allocation scheme is built based on a quantitative model supported by macro logic, and then adjusted based on the fund managers' judgements on real time market conditions as well as their own experiences. We believe that this is the future development direction of a whole asset allocation strategy.

Disclosure statement

The author declares no conflict of interest.

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