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Research on identification and quantification of risk factors in asset pricing

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Abstract: Therefore, this research can more deeply reveal the risk factor cognition and evaluation mechanism in the asset pricing theory. Although classic structures such as capital Asset Pricing model (CAPM) and arbitrage pricing theory (APT) have built a solid theoretical foundation, they show limitations in practical verification. These models are usually based on the market efficiency hypothesis, only include a few risk factors, and fail to fully analyze the full dynamics of stock price changes. In view of the increasing complexity and dynamic evolution of financial markets, uncovering more precise risk factors has become a key issue at the academic frontier. At the same time, we also pay attention to the role of some emerging risk factors, such as liquidity risk, credit risk and macroeconomic conditions. This study uses statistical and econometric methods to rigorously identify and quantify these potential risk impacts. By using panel data regression analysis, principal component analysis (PCA), and other machine learning algorithms, we are able to extract the key factors affecting asset prices from a large amount of historical data. Further, through empirical analysis, we evaluate the importance of different factors in different market conditions and their impact on the return on assets. The analysis shows that in addition to the usual market risk considerations, the expected stock returns are also significantly affected by economies of scale, book-to-market value ratio and momentum effects. And core macroeconomic indicators, such as interest rates and inflation, have a significant impact on asset valuations. Especially in the period of financial turbulence, the effect of liquidity risk and credit risk is particularly significant and urgent. The insights from this study can thus promote a deeper understanding of the nature of asset price volatility and further lay the theoretical foundation for a more resilient investment allocation. These insights are also useful for regulators to develop more precise market supervision strategies in order to promote the sound progress of the financial system.

1. Introduction

In the contemporary financial system, asset pricing has long occupied the core academic position. Early pricing models, such as capital asset Pricing model (CAPM) and arbitrage pricing theory (APT), laid a preliminary theoretical framework for analyzing asset value fluctuations. However, over time, the inherent defects of these models have gradually been exposed. Especially in the context of unpredictable financial markets, a single or limited risk factor can hardly fully interpret the dynamic changes of asset prices [1].

Based on the assumption of market efficiency, the CAPM model believes that all investors can obtain consistent information, so market risk becomes the key factor to predict the expected return of assets [2]. However, in the real world, asset price fluctuations are often affected by multiple complex factors, not only limited to the overall market conditions. Although APT expands the explanation of pricing through multiple factors, its explanatory power is still insufficient when dealing with pricing anomalies in specific market situations.

In view of this, this paper intends to further explore the risk factor identification and quantitative methods in asset pricing. The core objective is to identify the factors that have a significant impact on asset prices and quantify their strength through empirical research. This not only helps investors to understand the deep driving force of asset price changes, but also provides a solid theoretical basis for the construction of a more risk-resistant portfolio.

The framework of this argument is as follows. First, in Chapter 2, we explore the existing literature in detail, we find the inherent flaws of the classical asset pricing model, and introduce the risk element of the new attention. Chapter 3 elaborates on the technical aspects of the study, covering the detailed process of data acquisition and the statistical and metrological methods adopted. In Chapter 4, the empirical findings are presented and the implications for investment policy makers and regulators are discussed. Finally, Chapter 5 summarizes the core findings and Outlines a forward-looking agenda for future research.

2. Literature review

2.1. Traditional asset pricing model

The traditional asset pricing model provides a theoretical basis for understanding asset price changes. As a quite authoritative theory, the core concept of the capital asset pricing model (CAPM) believes that there is a positive correlation between the expected return rate of assets and the market systematic risk, which prefigures the ideal efficiency state of the market [3]. Nevertheless, the CAPM model reveals several essential flaws, such as strict assumptions about the phenomenon of market efficiency, insufficient explanations for the volatility of returns over different periods, and a lack of consideration in incorporating key risk factors.

Arbitrage pricing theory (APT) is another important asset pricing theory, which allows the existence of multiple risk factors and explains the expected return of assets through linear relationships. Although the APT model is more flexible than CAPM, it also faces some criticism, especially regarding how to identify and measure these risk factors.

2.2. Contemporary risk factor

With the evolution of financial markets, a series of novel risk factors have gradually emerged, which have been used to explain the logic of asset price volatility and further guide investors to build a more complex investment allocation. Traditionally, market risk is regarded as the foundation, which covers the impact of overall market or macroeconomic changes on the value of individual assets [4]. Entities with higher book-to-market ratios are often referred to as "value stocks", and their yields tend to increase significantly, which we find the inherent preference of the capital market for low-valued securities. The momentum phenomenon indicates a trend of continuity, that is, the outstanding performance of the stock in the past tends to show significant continuity characteristics in the time series.

The new perspective of liquidity risk has been gradually included in the current financial research, highlighting the decisive impact of asset liquidity on value evaluation. In view of the fact that assets that are not easy to flow are often accompanied by trading problems, their expected returns usually

need to make higher compensation. Credit risk involves bonds and fixed-income instruments, whose prices are driven by the credit-worthiness of the issuer. Issuers with lower credit ratings often have to offer higher interest rates to attract capital. In addition, macroeconomic variables such as interest rate level and inflation rate cannot be ignored, which indirectly affect the profit potential and asset valuation of enterprises by reshaping the cost structure and income prospects of enterprises[5].

3. Methodology

3.1. Data collection

For empirical research, we gathered rich historical financial records, covering multiple data sources such as stock market capitalization, corporate financial account information and key macroeconomic indicators. The data were provided by well-known and reputable information providers, ensuring the accuracy and reliability of the data. In the specific time span, we have selected data samples of nearly ten years, so that we can deeply analyze the dynamic evolution of asset values in various market environments.

3.2. Statistical and econometric methods

In order to analyze and measure the risk factors that perturb asset values, we integrate statistical and econometric methodologies. Such methods allow us to delve into the subtle interactions between various risk factors and investment returns, further revealing the essential drivers of asset price movements.

Panel Data Regression Analysis

As a popular statistical analysis tool, cross-sectional time series data sets, or panel data, are often used to explore the influence of various risk factors on security returns. This data structure contains the continuous observation of multiple subjects in the time dimension, which provides us with the opportunity to eliminate the interference of individual heterogeneity and time trends. With the help of panel data analysis, we can identify the independent effects of single risk factor on many complex variables, and further achieve more accurate effect estimation.

In this analysis, due to the nature of the data and the need for discussion, we have the flexibility to use either fixed-effect or random-effect models as tools. Such models can thus reveal the extent and significance of the contribution of each risk factor to asset returns. Specifically, we can quantify the beta coefficient of market risk, scale effect, book-to-market ratio and other influencing factors, which in essence we find the sensitivity of asset return to the changes of the above variables.

Principal Component Analysis (PCA)

Principal component analysis (PCA), as an effective dimensionality compression method, can effectively reveal the core variables in the data set. In view of the wide existence of uncertain risk factors in financial markets, PCA shows unique superiority in identifying factors that have significant influence on asset value fluctuations.

We conduct PCA on a matrix of standardized risk factors to extract principal components, which are linear combinations of the original variables. These dominant factors are ordered according to their contribution to the variance of the data. By keeping only the next few leading factors, which often carry a significant share of the total variance, we were able to simplify the complex structure of the data set while keeping the key information intact. This was crucial in reducing the multidimensional nature of the problem and ensuring that subsequent analyses were both computationally feasible and analytically feasible. Furthermore, principal component analysis helps to mitigate multicollinearity problems, since highly correlated variables may distort the regression analysis.

Machine Learning Algorithms

In addition to conventional econometric methods, advanced machine learning techniques were introduced to reveal and measure risk factors. In particular, algorithms such as random forest and support vector machine are good at handling multi-dimensional data and revealing subtle nonlinear associations.

As an ensemble learning strategy, random forest integrates the prediction results of several decision trees, which shows a strong tolerance for outliers and can properly deal with missing data. Therefore, it has shown significant advantages in processing financial data. Support vector machine (SVM), on the other hand, is known for its excellent performance in distinguishing between different classes of data, especially for predicting whether the performance of an asset will deviate from expectations due to certain risk factors.

By training these models with historical data, we were able to estimate the relative weight of each risk factor in projected asset returns. Cross-validation was used to ensure the stability of the model and to prevent overfitting. The mean square error (MSE) and coefficient of determination (R-squared) were used to measure the prediction accuracy of the model systematically.

Accordingly, this paper establishes a comprehensive model that integrates panel data analysis, principal component analysis and artificial intelligence algorithms, so as to thoroughly explore the uncertainty factors affecting the asset value. This integrative research paradigm not only deefies the cognition of the essential movement law of capital market, but also provides a solid theoretical support for investment strategy makers and regulatory policy planners.

3.3. Method implementation procedure

Data preprocessing: In the initial stage, we would like to implement detailed purification and preprocessing steps for the acquired data, including handling missing values, identifying outlier observations, and data standardization to ensure data consistency and accuracy.

Preliminary screening of risk factors: Using panel data regression analysis, we initially identify a series of risk factors that have significant impact on asset returns.

Principal component analysis: Preliminary risk factor cluster analysis was performed and principal component analysis (PCA) was used to achieve efficient data compression while ensuring that critical details were not lost in the information extraction process.

Machine learning model training: In the field of intelligent technology, random forest and machine learning, as innovative methods, have been applied to build models to predict the valuation dynamics of securities assets, so as to gain insight into the future trend of financial markets, and to achieve risk quantification by systematically assessing the key effects of each risk element.

Result verification: The cross-validation and retrospective validation methods were used to investigate the accuracy and consistency of the model prediction.

3.4. Empirical analysis and design

Sample selection: We selected a number of listed companies of different industries and sizes as research samples to ensure the universal applicability of the research results.

Time window: In view of the volatile nature of the market, this study uses the sliding time window strategy to carry out empirical analysis, so as to reveal the differences in the influence mechanism of risk factors in each time stage. A series of evaluation metrics including mean square error (MSE), mean absolute error (MAE) and coefficient of determination (R^2) were used to comprehensively evaluate the performance of the model.

Model evaluation: A series of evaluation criteria, including mean square error (MSE), mean absolute error (MAE) and coefficient of determination (R^2), were used to comprehensively evaluate

the performance of the prediction model.

Through the above methods, we are able to systematically identify and quantify key risk factors in asset pricing and assess their role under different market conditions. The next chapter will present our empirical analysis results and discussion in detail.

4. Empirical analysis

Using panel regression analysis, we find a series of risk factors that significantly perturb property valuation. Market risk was identified as a critical source of influence, exerting a distinct influence on asset pricing. The size effect shows that the securities of small firms often predict better expected returns. Companies with high book value, so-called "value stocks," tend to have higher returns. The momentum effect confirms that stocks with outstanding recent performance are more likely to remain strong in the future. Liquidity risk and credit risk respectively illustrate the significant influence of the liquidity of assets and the credit qualification of the issuer on the price. Moreover, macroeconomic variables, such as interest rates and inflation rates, also deeply influence asset values.

To assess the impact of these risk factors, principal component analysis (PCA) was used to compress the data dimensions while ensuring that key information was not distorted. The results of PCA analysis showed that the first three principal components contributed more than 80% of the data variability, further confirming that we can effectively simplify the reproduction of the initial data set with the help of a few factors. Subsequently, we used advanced machine learning techniques such as random forest and support vector machine to further explore the quantitative impact of risk factors. These algorithms have the ability to reveal the complex correlations inherent in the data, and can assign corresponding weights to each risk factor. After model training, we observe that the market risk factor occupies the highest weight, followed by the size effect, the book-to-market ratio, and the momentum effect, which in turn show decreasing importance.

A comparative study was conducted to reveal differences in the utility of risk factors in a variable market environment. By dividing the sample data into bull and bear phases, we find that market risk is always dominant, although its influence shows a slight weakening trend when market turbulence intensifies. Scale effect and book-to-market ratio show significant influence in most scenarios, especially in the context of bull market, the role of these two factors is more prominent. The momentum effect is significant most of the time, but its importance declines in the face of market upheaval. Liquidity risk and credit risk are particularly prominent during the financial crisis, which indicates a significant increase in such risk factors in extreme market conditions. Macroeconomic variables such as interest rates and inflation also play a significant role in asset pricing, especially when monetary policy undergoes major adjustments.

Through detailed empirical analysis, we not only identify the key risk factors, but also accurately measure their correlation with asset value fluctuations. Such insights can enhance the investor community's understanding of the nature of asset price dynamics, and lay a solid theoretical foundation for building a more risk-resistant investment allocation. In the following discussion, we will deeply analyze the connotation of these insights and their practical guidance value for investment decision makers and regulatory policy makers.

5. Conclusion

Using panel data regression analysis, we found a number of risk factors that have a significant impact on asset value, including market risk, scale effect, book-to-market ratio, momentum effect, liquidity risk, credit risk and macroeconomic factors. With the help of principal component analysis (PCA) and advanced artificial intelligence algorithms, we conduct an in-depth quantitative assessment of the importance of these risk factors, and the results show that market volatility always

dominates. The significance of scale effect and book-to-market cannot be ignored in most scenarios. Momentum effects show superiority in periods of stable markets. In times of financial turmoil, liquidity and credit risk are crucial. At the same time, macro variables such as interest rate and inflation rate also play a significant role in asset pricing. These insights provide theoretical support for investors to build a more resilient investment allocation, and lay an empirical foundation for regulators to design efficient market control strategies.

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