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AN INVESTMENT PORTFOLIO FOR COLLEGE STUDENTS UNDER THE DEPENDENCY AND LOSS PSYCHOLOGY OF ENTREPRENEURSHIP

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Abstract

This paper aims to design a suitable investment portfolio for college students under the dependence and loss psychology of entrepreneurship. Considering the market distribution of their entrepreneurial assets, college students' psychological features of loss were described by the prospect theory. Then, a portfolio model was constructed for college students under the dependence and loss psychology of entrepreneurship, in the light of the adjustment cost of investment portfolio. Inspired by the duality (optimization) theory, the authors constructed a dual portfolio model under the same conditions, and transformed into a linear programming model, which is easier to solve. Finally, the asset return features and effectiveness of our model were evaluated empirically. The results show that our model can optimize the investment portfolio for college students in entrepreneurial process.

Key words: *College Students' Entrepreneurship, Loss Psychology, Investment Portfolio, Dual Optimization.*

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INTRODUCTION

As a high-quality social group, college students are an important force in entrepreneurial activities. In addition to individual factors and environmental factors, the psychological capital elements of college students are also the main factors affecting college students' entrepreneurial activities. In the process of entrepreneurship, human capital and social capital are indispensable. However, due to the uncertainty and high risk of entrepreneurship, entrepreneurs are required to have positive psychological capital for dealing with the hardships of entrepreneurship. At present, many scholars have studied the individual characteristics and environmental factors that affect college students' entrepreneurship, but there are relatively few studies in the perspective of psychological capital.

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As an effective risk dispersion tool, investment portfolio theory has received wide attention. Most of the existing dual portfolio model studies assume that investors are completely rational people, and thus ignore the role of investors' psychological behavior in investment decisions. Through behavioral experiments, Omorede, Thorgren, & Wincent (2015) discovered that there are cognitive biases in the decision-making process of college entrepreneurial investors, and then proposed the prospect theory by introducing the research results of psychology into economics. In addition, Meussling (1985) analysed the participants' risk-making behaviors and found that compared with the expected utility theory, the prospect theory can more accurately describe the decision-making behavior of college students' entrepreneurship. With the development of behavioral psychology, the investment portfolio model considering the behavioral characteristics of college entrepreneurial investors has become a new research direction. de la Cruz Sánchez-Escobedo, Díaz-Casero, Hernández-Mogollón et al. (2011) combined SP/A theory and prospect theory to

create a multi-psychological account behavior portfolio model, and incorporated the research results of behavioral psychology into the modern portfolio selection theory. Considering the loss psychological characteristics of college entrepreneurial investors, Roy, Akhtar, & Das (2017) proposed the portfolio model of loss psychology and studied the equivalence conditions of this model with the mean-variance model/the mean CVaR model. Nielsen & Gartner (2017) put forward a large loss psychological measure based on the cumulative prospect theory, and studied the influence of the large loss psychological measure on the well-posedness of the portfolio model.

A large number of empirical research on college students' entrepreneurship shows that the return and risk of assets change with market dependence, and the use of single dependence to describe the return characteristics of assets can no longer meet the actual investment needs. Hong et al. and Bernstein found that under the high-yield dependence of college students' entrepreneurship, the volatility of assets was low, and vice versa (Hong, Hong, Cui et al., 2012; Bernstein, 2012). Robinson (2014) studied the transformation characteristics of market dependence using the Markov autoregressive model of dependent vector, and found that there are obvious dynamic structural changes in Chinese college students' entrepreneurship. On this basis, the portfolio model considering the the entrepreneurial dependence and loss psychology of college students has gradually attracted the attention of scholars. Zampetakis, Lerakis, Kafetsios et al. (2016) constructed a portfolio model considering the entrepreneurial dependence and loss psychology of college students under the Bayesian framework; the results showed that the entrepreneurial dependence and loss psychology of college students have a significant impact on portfolio decision. Aziz (2014) divided college students' entrepreneurship into two kinds of dependence: high volatility and low volatility, and established a mixed normal distribution portfolio model under two-order stochastic dominance. Bukhsh, Shahzad, & Nisa (2011) constructed a portfolio model under the entrepreneurial dependence and loss psychology of college students, and studied the solution strategy of the model.

With reference to the research at home and abroad, it is a question worthy of study to combine with behavioral psychology theory and duality optimization theory, and study the portfolio model of college students' entrepreurship on the basis of college students' entrepreneurial dependence and loss psychology. Firstly, considering the impact of college students' entrepreneurial dependence and loss psychology on the distribution of asset returns, it can more accurately describe the income characteristics of college students' entrepreneurial assets, and help the portfolio model to achieve investment objectives. Secondly, combining behavioral psychology theory and dual optimization theory into college students' portfolio model can help to analyse the psychological behavior characteristics of college students' entrepreneurship and also the parameters of the model, which is in line with the actual needs of college students' Entrepreneurial investment management.

In view of this, the paper starts from the relationship between college students' entrepreneurial assets income distribution and market dependence, uses prospect theory to describe the loss psychological characteristics of college students, and constructs a portfolio model of college students' entrepreneurial dependence and loss psychology considering the adjustment cost of the portfolio (Beng, 2010). Secondly, combined with the dual optimization theory, the dual portfolio model under the entrepreneurial dependence and loss psychology of college students was established, and on this basis, the portfolio model was transformed into a linear programming problem, which reduced the difficulty of solving the model. Finally, the empirical method was adopted to study the asset return characteristics and the validity of the portfolio model under the different dependence of college students' entrepreneurial dependence and loss psychology.

INVESTMENT PORTFOLIO MODEL UNDER THE LOSS PSYCHOLOGY OF COLLEGE STUDENTS' ENTREPRENEURIAL DEPENDENCE

It's assumed that there is 1 risk-free asset a_0 and n risk assets $\{a_1, \dots\dots, a_n\}$, and the investor currently holds the portfolio $X^0 = (x_0^0, x_1^0, \dots\dots, x_n^0)$, where x_0^0 and x_i^0 represent the wealth of the current risk-free assets a_0 and risk assets a_i, $i = 1, \dots\dots, n$. When the market changes, investors will adjust the current portfolio; let $\Delta X = (\Delta x_0, \Delta x_1, \dots\dots, \Delta x_n)$ be the amount of adjustment in the portfolio, it means that the wealth of the purchased asset a_i is Δx_i

at $\Delta x_i \geq 0$; at $\Delta x_i \leq 0$, the wealth of the sold asset is Δx_i. Thus, an adjusted portfolio $X = (x_0, x_i, \dots\dots, x_n)$ was obtained, in which $x_i = x_i^0 + \Delta x_i$, $i = 0,1, \dots\dots, n$.

The combined utility of college students' entrepreneurial dependence

The research on entrepreneurial dependence of college students shows that the income and risk of assets change with the state of the market, and the use of a single dependence to describe the income characteristics of assets can no longer meet the actual investment needs. Considering the return distribution of assets changes with the market, it is assumed that there are s kinds of dependencies. Also, in terms of the uncertainty, it is assumed that yield rate of the risky asset a_i for the dependence s is the interval random number, that is, $r_{i,s} \in [\overline{r_{i,s}} - \hat{r}_{i,s}, \overline{r_{i,s}} + \hat{r}_{i,s}]$, where $r_{i,s}$ is the average yields of the risk asset a_i in the dependence s, $\hat{r}_{i,s}$ is yielding perturbation term of the risky asset for the dependence s, $i = 1, \dots\dots, n$, and $s = 1, \dots\dots, S$. Suppose that the yield rate of risk-free assets a_0 are constant in dependence s, $s = 1, \dots\dots, S$. After the investment is over, the wealth of the portfolio based on the dependence s is given as:

$$W_s = \sum_{i=0}^{n} x_i (r_{i,s} + 1), \quad s = 1, \dots\dots, S \tag{1}$$

College entrepreneurial investors generally have cognitive biases, and their psychological and emotional factors play an important role in the investment decision-making process. The prospect theory proposed by Antonio et al. is the cornerstone of modern behavioral psychology theory. It believes that investors may make a mistake caused by enlightenment, and the decision characteristics in the risk situation are inconsistent with the basic principles of expected utility theory (Antonio, Lanawati, Wiriana et al., 2014). Loss psychology is an important feature of prospect theory, that is, college entrepreneurial investors are more sensitive to losses than income. Based on the theory of prospects, Harvey & Miller (2010) proposed a loss utility function which is expressed as:

$$u(W_s) = \begin{cases} W_s, & W_s \geq \hat{y} \\ (1+\lambda) W_s - \lambda \hat{y}, & W_s < \hat{y} \end{cases} = W_s - \lambda [\hat{y} - W_s]^+, \quad s = 1, \dots\dots, S \tag{2}$$

where, λ is the psychological coefficient of loss, $\hat{y}$ is the wealth reference point, and $[k]^+ = max\{0, k\}$.

Model construction

Let 0 be the transaction rate for risk-free assets, and c_i be the transaction rate for risk assets, then $i = 1, \dots\dots, n$, then

Considering self-financing constraints, it's shown as:

$$\sum_{i=0}^{n} \Delta x_i + \sum_{i=1}^{n} c_i |\Delta x_i| = 0 \tag{3}$$

Considering the psychological characteristics of college students' entrepreneurial losses, the maximization of loss psychological utility was regarded as the objective function. According to formulas (1)-(3), a portfolio model under the loss psychology of dependent considering the adjustment cost of the portfolio was constructed.

$$\begin{aligned} &\max \quad d \\ &s.t. \sum_{i=0}^{n} x_i (r_{i,s} + 1) - \lambda [\hat{y} - \sum_{i=0}^{n} x_i (r_{i,s} + 1)]^+ \geq d, \quad s = 1, \dots\dots, S \\ &\sum_{i=0}^{n} \Delta x_i + \sum_{i=1}^{n} c_i |\Delta x_i| = 0 \\ &x_i = x_i^0 + \Delta x_i, i = 0, 1, \dots\dots, n \\ &l_i \leq x_i / \sum_{i=0}^{n} x_i \leq u_i, i = 0, 1, \dots\dots, n \end{aligned} \tag{4}$$

here, u_i and l_i respectively represent the upper and lower limits of the investment weight for the asset a_i, and $i = 0,1, \dots\dots, n$.

Introducing auxiliary variables $\{y_1^-, \dots\dots, y_s^-\}$ and $\{h_1, \dots\dots, h_n\}$, model (4) can be converted to:

$$\begin{aligned} &\max \quad d \\ &s.t. \sum_{i=0}^{n} x_i (r_{i,s} + 1) - \lambda y_s^- \geq d, \quad s = 1, \dots\dots, S \\ &y_s^- \geq \hat{y} - \sum_{i=0}^{n} x_i (r_{i,s} + 1), y_s^- \geq 0, s = 1, \dots\dots, S \\ &\sum_{i=0}^{n} \Delta x_i + \sum_{i=1}^{n} c_i h_i = 0 \\ &h_i \geq \Delta x_i, h_i \geq -\Delta x_i, i = 1, \dots\dots, n \\ &x_i = x_i^0 + \Delta x_i, i = 0, 1, \dots\dots, n \\ &l_i \leq x_i / \sum_{i=0}^{n} x_i \leq u_i, i = 0, 1, \dots\dots, n \end{aligned} \tag{5}$$

DUAL PORTFOLIO MODEL UNDER THE ENTREPRENEURIAL DEPENDENCE AND LOSS PSYCHOLOGY OF COLLEGE STUDENTS

Beng proposed a new dual optimization method, which can flexibly adjust the dual control parameters of the model and avoid the over-conservative defect of the traditional dual optimization method. In model (5), the yield rate of risk assets is interval random number. In order to determine the optimal solution of the model, a

dual portfolio model based on the dual optimization theory under the entrepreneurial dependence and loss psychology of college students was constructed.

Dual optimization method

The dual control parameter Γ_s and set B_s of the depence s were defined, and $\Gamma_s \in R^+$, satisfying $s = 1, \dots\dots, S$. Further, the perturbation term $\hat{r}_{v_s,s}$ was defined, where $v_s \in J \backslash B_s$, and $s = 1, \dots\dots, S$. With reference to the dual optimization theory, the dual control parameters Γ_s were used to control the number of risk assets that are subject to disturbances of the yield rate under the dependence of s. Specifically, the yield rate of one risk asset can be changed to $\overline{r}_{v_s,s} - (\Gamma_s - [\Gamma_s])\hat{r}_{v_s,s}, v_s \in J \backslash B_s$, while the yield of $[\Gamma_s]$ risk asset can be changed to $\overline{r}_{i,s} - \hat{r}_{i,s}, i \in B_s$. Given $\hat{r}_{i,s}$, $\hat{r}_{v,s}$ and Γ_s, $i \in B_s$ and $v_s \in J \backslash B_s$, then the wealth of the portfolio under s dependence is given as:

$$\begin{aligned} W_s &= (r_{0,s}+1)x_0 + \sum_{i=1}^{n}(\overline{r}_{i,s}+1)x_i \\ &-[\sum_{i\in B}\overline{r}_{i,s}x_i + (\Gamma_s q_s - [\Gamma_s])\overline{r}_{v_s,s}x_{v_s}] \\ &s = 1, \dots\dots, S \end{aligned} \quad (6)$$

According to formula (6), the dual equivalence of portfolio wealth can be derived as:

$$\begin{aligned} W_s^R &= (r_{0,s}+1)x_0 + \sum_{i=1}^{n}(\overline{r}_{i,s}+1)x_i \\ &- \max_{\{B_s \cup \{v_s\} | B_s \subseteq J, |B_s| = [\Gamma_s], v_s \in J \backslash B_s\}} \left\{\sum_{i\in B}\overline{r}_{i,s}x_i + (\Gamma_s - [\Gamma_s])\overline{r}_{v_s,s}x_{v_s}\right\} \\ &s = 1, \dots\dots, S \end{aligned} \quad (7)$$

It can be seen from equation (7) that the dual control parameter Γ_s reflects the conservative psychology of the portfolio strategy under s: The larger the parameter Γ_s, the more conservative the portfolio strategy; conversely, the more optimistic the portfolio strategy. When Γ_s=0, the yield of all risky assets is equal to $\overline{r}_{i,s}$, and the portfolio's dual wealth W_s^R under s is the average level, $s = 1, \dots\dots, n$, $s = 1, \dots\dots, S$. At $\Gamma_s = n$, the yield of all risky assets is equal to $\overline{r}_{i,s} - \hat{r}_{i,s}$, and the dual wealth W_s^R of investment portfolio under the dependence s is the worst level, $s = 1, \dots\dots, n$, $s = 1, \dots\dots, S$.

Combined optimization model

Let

$$\beta(x, \Gamma_s) = \max_{\{B_s \cup \{v_s\} | B_s \subseteq J, |B_s| = [\Gamma_s], v_s \in J \backslash B_S\}} \{\sum i \in B\, \hat{r}_{i,s}x_i + (\Gamma_s - [\Gamma_s])\hat{r}_{v_s,s}x_{v_s}\},$$

given a portfolio $X^* = (x_1^*, \dots\dots, x_n^*)$, then $\beta(X^*, \Gamma_s)$ is equivalent to:

$$\begin{cases} \max \sum_{i=1}^{n} \hat{r}_{i,s}x_i^* z_{i,s} \\ s.t. \sum_{i=1}^{n} z_{i,s} \le \Gamma_s, 0 \le z_{i,s} \le 1, i = 1, \dots\dots, n \end{cases} \quad (8)$$

According to the dual theory, the formula (8) can be converted to:

$$\begin{cases} \min \sum_{i=1}^{n} p_{i,s} + \Gamma_s q_s \\ s.t.\, q_s + p_{i,s} \ge \hat{r}_{i,s}x_i^*, p_{i,s} \ge 0, q_s \ge 0, i = 1, \dots\dots, n \end{cases} \quad (9)$$

where, q_s and $p_{i,s}$ are the relaxation variables representing $\max \sum_{i=1}^{n} z_{i,s} \le \Gamma_s$ and $z_{i,s} \le 1$, respectively, $1, \dots\dots, n$, and $s = 1, \dots\dots, S$. Substituting formula (9) into the model (5), the dual portfolio model under the dependence and loss psychology can be derived as:

$$\begin{aligned} &\max \quad d \\ &s,t.(r_{0,s}+1)x_0 + \sum_{i=1}^{n}(\overline{r}_{i,s}+1)x_i - \sum_{i=1}^{n} p_{i,s} - \Gamma_s q_s - d - \lambda \overline{y}_s \ge 0, \\ &s = 1, \dots\dots, S \\ &(r_{0,s}+1)x_0 + \sum_{i=1}^{n}(\overline{r}_{i,s}+1)x_i - \sum_{i=1}^{n} p_{i,s} - \Gamma_s q_s - \overline{y} + \overline{y}_s \ge 0, \\ &y_s^- \ge 0, s = 1, \dots\dots, S \\ &q_s + p_{i,s} \ge r_{i,s}, p_{i,s} \ge 0, q_s \ge 0, i = 1, \dots\dots, n, s = 1, \dots\dots, S \\ &\sum_{i=0}^{n} \Delta x_i + \sum_{i=1}^{n} c_i h_i = 0 \\ &h_i \ge \Delta x_i, h_i \ge -\Delta x_i, i = 1, \dots\dots, n \\ &x_i = x_i^0 + \Delta x_i, i = 0, 1, \dots\dots, n \\ &l_i \le x_i / \sum_{i=0}^{n} x_i \le u_i, i = 0, 1, \dots\dots, n \end{aligned} \quad (10)$$

Determination of dual control parameters

In model (10), the conservativeness of the portfolio under s is determined by the dual control parameter Γ_s. However, in the actual investment decision, it is a key issue facing college entrepreneurs to determine the dual control parameters. Since the return rate of the asset is subject to the random distribution of the interval, the constraint of the model (10) may be violated in the actual investment. Moskowitz & Vissing-Jørgensen (2002) combined the SP/A theory and prospect theory to create a behavioral portfolio model. This model uses chance constraints considering the investor's security psychological requirements for the portfolio. In order to meet the investor's safety psychological needs, the probability that the constraint $u_s(X^{opt}) \geq d$ is violated in the actual investment should be considered, in which X^{opt} represents the optimal solution of the model (10), and $u_s(X^{opt})$ indicates the possible utility value δ of the combination X^{opt} under the dependency of s. Let δ be the maximum probability of violation that the investor is willing to bear, then it's derived as:

$$\Pr\left\{u_s(X^{opt}) < d\right\} \leq \delta, s = 1, \ldots\ldots, S \quad (11)$$

In formula (11), the maximum probability of violation δ visually reflects the investor's security psychological requirements for the portfolio. According to Beng's research findings, formula (11) is equivalent to:

$$\Gamma_s \geq 1 + \Phi^{-1}(1-\delta) \times \sqrt{n}, \quad s = 1, \ldots\ldots, S \quad (12)$$

In equation (12), $\Phi^{-1}(\cdot)$ is the inverse function of the standard normal distribution. It can also be seen that the maximum violation probability δ can reflect the conservative psychology of the model: the higher the investor's safety psychological requirements, the smaller the value δ, and the greater the conservativeness of the model; on the contrary, the lower the value δ, the less the conservativeness of the model.

EMPIRICAL RESEARCH

Using the actual college students' entrepreneurial data in a city in Jiangsu Province, China, the author studied the income characteristics of assets under different market dependencies and the effectiveness of the portfolio model. At the beginning of the venture capital investment of college students, it's assumed that investors hold 500,000 yuan of risk-free assets. The sample interval was from January 1, 2011 to December 31, 2017. The disturbance term $\hat{r}_{i,s}$ of the return on risk assets was set to 1 unit standard deviation of the rate of return, i.e., $r_{i,s} \in [\overline{r}_{i,s} - \sigma, \overline{r}_{i,s} + \sigma_i]$. The six-month fixed term deposits in bank were used as risk-free assets, i.e., $r_{o,s} = 2.63 \times 10^{-4}$. In the parameter setting of the model, the transaction rate of the risk asset was set to $c_i = 6 \times 10^{-3}$, the lower and upper limit of the asset investment weight $l_i = 0$ and $u_i = 0.5$, and the wealth reference point $\hat{y} = W_0 \times (1 + 2.63 \times 10^{-4})$, where W_0 represents the total wealth before the combination adjustment; with reference to the literatures (Eckert, 2013), the psychological loss $\lambda = 3.02$.

Portfolio performance was calculated by means of time-scrolling: first, the yield from week 1 to week T was used to measure the mean and standard deviation of the return rate under s, and further calculate the investment portfolio from week T +1 week to week T +5 ; then, using the yields from week 6 to week T +5, re-measure the mean and standard deviation of the yields under s, and calculate the portfolio from T+6 weeks to T+10 weeks; repeat this until the end of the investment period. January 1, 2011 was set to be the timing point of the first week, and then December 31, 2015 waa the time of the T week at T=250. Since the model (10) was a linear programming problem, it could be solved using Matlab's linear programming toolbox linprog. Thus, a dual portfolio of models (10) from December 31, 2015 to December 31, 2017 was obtained.

Analysis of college students' entrepreneurial dependence

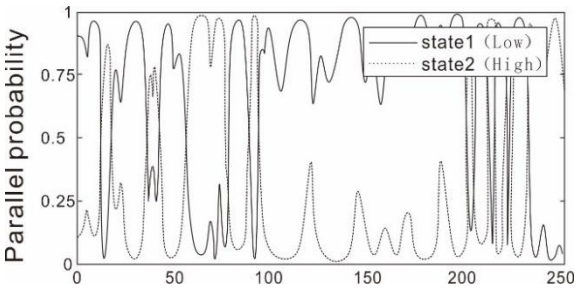
In the practical application of model (10), it is necessary to identify the different dependencies of college students' entrepreneurship and the income characteristics of assets under different dependencies. The Markov dependency model is a method for studying the structural changes of time series. The model contains multiple structural equations, which can describe the variation of time series under different dependencies. The Markov dependent vector autoregressive model was used to obtain the time points of different college students' entrepreneurial dependence, and calculate the mean and standard deviation of the

return on assets under different dependencies.

It's assumed that there are two kinds of dependence on college entrepreneurship, and the lag order of the regression model is set to 1. Using Matlab's MS Regress toolbox, the smoothing probability of two college students' entrepreneurial dependence was obtained. In addition, according to the fluctuation level obtained by the regression model, state 1 was determined to be low fluctuation, and state 2 was high fluctuation. Figure 1 shows the smoothing probability from January 1, 2011 to December 31, 2015.

From January 2011 to December 2017, 28 sets of observation sequences were obtained by means of time rolling, and the smoothing probability corresponding to each group of sequences was calculated separately. If the smoothing probability of the observation point in the high fluctuation is over 0.5, the observation point is in high fluctuation, otherwise in low fluctuation. The observation points of each group of observation sequences were divided into two sub-samples: high fluctuation and low fluctuation, and the mean and standard deviation of the return rates under two kinds of dependence were calculated respectively.

Figure 1. **Smoothing concept of two dependence of college students' entrepreneurship**



The t test was conducted to test whether there is a significant difference in the income characteristics of the two dependencies. The results showed that at the 5% confidence level, the 28 groups of observation sequences were significantly different in the mean and standard deviation of the high and low fluctuations. Therefore, the income distribution of assets changes with the entrepreneurial dependence of college students, and the income characteristics using single dependency description are inconsistent with the actual investment decisions.

Analysis of the impact of college students' entrepreneurial dependence on investment portfolio

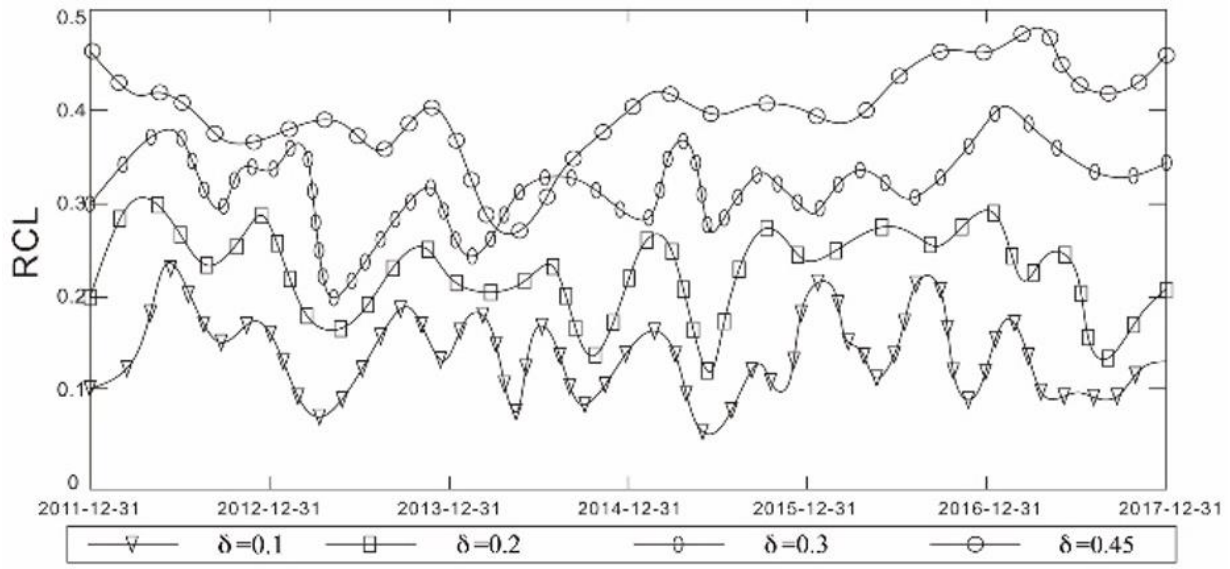
Due to the obvious structural change characteristics of the income distribution, the portfolio model constructed using a single dependency leads to the loss of the combined utility. The relative certainty-equivalent loss (RCL) (Goebel, Koch, & Macdonald, 2010) was adopted to study the potential impact of ignoring the college entrepreneurial dependence on the portfolio. Let w_1 and w_2 be the optimal solution of model (10) when the number of market dependence is $S=1$ and $S=2$. Let $S=2$ be the number of college students' entrreprenuerial dependency, and $u(w_1)$ and $u(w_2)$ be the dual utitily value of w_1 and w_2 portfolio respectively, then the RCL is expressed as:

$$RCL=\frac{u(w_2)-u(w_1)}{u(w_1)} \tag{13}$$

In formula (13) above, $u(w_2)-u(w_1)$ indicates the utility loss of the college entrepreneurial investor when they're forced to accept the portfolia w_1 at $S=2$. The greater value of RCL means a greater loss of utility that investors are exposed to, and more signigicant impact of college entrepreneurship on the portfolio. Setting the maximum violation probability to 0.45, 0.30, 0.20, and 0.10, the valueRCL corresponding to the different values δ were calculated using formula (13), and the results were obtained as shown in Figure 2.

Figure 2 shows that: (1) College students' entrepreneurial dependence and loss psychology have an important impact on portfolio decision-making. Under different maximum violation probability δ, RCL was all higher than 5%, even up to 31.3%. The results indicated that neglecting the conversion of college students' entrepreneurial dependence will lead to serious losses of the investors' utility value, and the impact of dependence on portfolio decision-making should be taken into consideration. (2) The more conservative the investment strategy, the greater the RCL. The maximum probability of violation δ reflects the conservative level of the investment strategy, and both are in a linear correlationship. It can also be seen from Figure 2, as the value of the maximum violation probability decreased, the

Figure 2. **Relative certainty-equivalent loss under different values δ of college students' entrepreneurial dependence and loss psychology**



RCL value increases. Therefore, with the increase of the conservative attitude of investment strategy, the impact of college students' entrepreneurial dependence and loss psychology on the investment portfolio becomes more obvious.

Model duality analysis

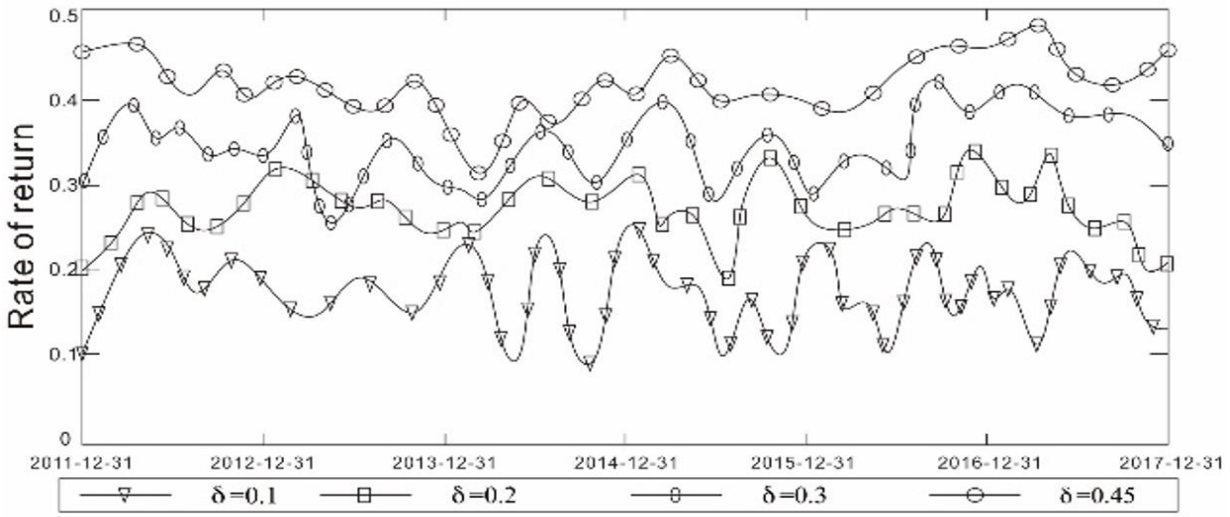
The duality of the model is an important feature of the dual optimization method. Increasing the duality of the portfolio model can help to protect the model from being influenced by the parameter changes. The degree of duality of the model (10) was tested at different maximum violation probabilities. Specifically, let $X^{opt} = (x_0^{opt}, x_1^{opt}, \dots, x_{103}^{opt})$ be the optimal investment portfolio of the model (10), d^{opt} be the optimal value of the model (10), and $\overline{r}_{i,s} \pm \sigma_{i,s}$ be the the yield $r_{i,s}$ of the risky asset at a probability of 0.5 ($i = 1,2, \dots \dots, n$, and $s = 1,2$) respectively, then 10^5 groups of income sequence of the risk assets were randomly generated under the two market dependences, to study the probability that the actual utility value of the portfolio X^{opt} is lower than d^{opt}, i.e., the constraint violation probability of the model (10). In order to study the effectiveness of the dual optimization theory on investment decision, the constraint violation probability of the nominal portfolio model (5) was calculated according to the constraint violation probability method of model (10). There were 28 adjustment periods from December 31, 2011 to December 31, 2017. For each period, this study calculated the constraint violation probability of the portfolio model, and used its mean value to reflect the overall duality level of the model during the investment period. The results are shown in Table 1.

It can be seen from Table 1 that: (1) The duality of the dual portfolio model is superior to the nominal portfolio model, and its constraint violation probability increases with the increase of the maximum probability of violation δ. Duality reflects the ability of the model to be protected from parametric changes. Compared with the nominal portfolio model, this model can effectively control the impact of model parameter changes. (2) The constraint violation probability of the dual portfolio model is less than the maximum probability value of violation δ. The maximum probability of violation δ indicates the degree of maximum risk that investors are willing to bear, reflecting the safety psychological preference of college entrepreneurs; the probability of constraint violation is less than δ, indicating that the dual portfolio model can meet the security psychological requirements of investors.

Table 1. **Constraint Violation Probability of Portfolio Model**

Portfolio model	Dual portfolio model				Nominal portfolio model
	$\delta = 0.10$	$\delta = 0.20$	$\delta = 0.15$	$\delta = 0.45$	
Constraint violation	0.041	0.052	0.135	0.188	0.691

Figure 3. **Cumulative rate of return under different values δ of college entrepreneurship**



Portfolio return analysis

The actual portfolio income is an important indicator for the effectiveness of the portfolio model. Using the actual rate of return on assets, the portfolio return rate from December 31, 2011 to December 31, 2017 was caculated, for studying the effectiveness of the portfolio model in actual investment. According to the model (10), the yield of the model under different values δ was calculated, and the results are shown in Figure 3.

Figure 3 shows that: (1) The return on investment portfolio model is better than index investment. Under different maximum violation probability values δ, the portfolio model not only satisfies the investor's safety psychological requirements, but also obtains better investment returns, which is feasible in actual investment decisions; (2) The portfolio model is robust. At different maximum probability of violations, the returns on the portfolio have similar trajectories with small differences. The research shows that the portfolio model has better robustness to the parameter value δ, meeting the actual investment needs of college entrepreneurs.

CONCLUSIONS

This paper studies the dual portfolio optimization problem under the entrepreneurial dependence and loss psychology of college students. For this, from the perspective of asset income distribution dependence, it's assumed that assets have different income characteristics under different entrepreneurial entrepreneurial dependence. Considering the adjustment cost of the portfolio, the prospect theory was applied to describe the psychological characteristics of the investor's loss psychology, and construct a dependent loss psychological portfolio model, aiming at maximizing the loss psychological utility. Then, in view of the uncertainty of the model parameters, assuming that the return on assets obeys the random distribution of the interval, the dual portfolio model based on the dual optimization theory under the entrepreneurial dependence and loss psychology of college students was constructed. Using dual theory and auxiliary variables, the model was transformed into a linear programming problem, which reduces the difficulty of solving the model. The maximum probability of violation was introduced in the

model, intuitively reflecting the conservative psychology of investment strategy and the safety psychological needs of investors.

Finally, using the empirical method, it also studies the return characteristics of assets and the validity of the portfolio model under different entrepreneurial entrepreneurial dependence based on the Markov dependent vector autoregressive model. The results show that: (1) Under different entrepreureural dependence of college students, there is a significant difference in the mean and standard deviation of the rate of return; (2) Dependence has an important impact on portfolio decision-making, and with the increase of conservative strategies of investment strategies, college students entrepreneurial dependence and loss psychology have a more significant on the investment portfolio; (3) compared with the nominal portfolio model, the dual portfolio model can effectively control the influence of model parameter changes, and the model's constraint violation probability is less than the maximum violation probability value, indicating that the dual portfolio model can meet the investor's safety psychological requirements; (4) Under the premise of satisfying the investor's safety psychological requirements, the investment return of the portfolio model is better than the index investment, and the investment income of the model has good robustness to the value δ, indicating that the model has certain feasibility in actual investment decision.

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