Project5 Stable Coins

Group 43
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1. Introduction

Stable coins are kind of digital currencies with relatively stable prices. They ensure that the prices fluctuate slightly up and down from the target price through some model designs, so as to play the functions of capital hedging, transaction intermediary, payment and settlement in the digital currency market with violent price fluctuations.

2. Data Preparation

In our group's project, ETH is our underlying cryptocurrency. And our stable coin has a dual class split structure which, combined with Class A Coin and Class B Coin. The Class A Coin behaves like a bond and receives periodical coupon payment. The Class B Coin entitles leveraged participation of the underlying cryptocurrency. Beyond that, the ratio of A and B is 1:1, and the daily coupon rate is 0.02%. The duration between two adjacent regular reset date is 100 days, which denoted by T = 100. We also have an upward reset clause and a downward clause, denoted by $H_u = \$2$ and $H_d = \$0.25$ .Annualized ETH volatility is calculated from 1 Oct 2017 to 28 Feb 2018 and the value is 120.49%, denoted by σ. Finally, we also define the annual risk-free rate is 3%, as well as 0.0082%, denoted as r_f.

3. Implementation

3.1. Question 1

As we all know:

$$V_A^t + V_B^t = \frac{2P_t}{\beta_t P_0}$$

$$V_A^t = 1 + R \cdot v_t$$

So that we can get:

$$V_B^t = \frac{2P_t}{\beta_t P_0} - 1 - R \cdot v_t$$

We took the idea of dual-purpose funds to design the stable cryptocurrency on ETH and we defined that:

$$S_t = \frac{P_t}{P_0 \beta_t}$$

so that:

$$V_A^t + V_B^t = 2S_t$$

We used Monte Carlo simulations to simulate the S_t as Geometric Brownian Motion：

$$S_t = S_0 e^{(r-\frac{1}{2}\sigma^2)t+\sigma\sqrt{t}W_t}$$

In which P_0 and P_t represent the start price and the price at time t of ETH, and β_t is the conversion factor at time t.

When $2 > V_B^t > 0.25$, no reset clause will be trigger, and $V_A^T = 1 + R \cdot v_T$, so that $V_B^T = 2S_T - 1 - R \cdot v_T$.In this case, only Class A generates cash flow which is coupon, Class B does not generate cash flow in Figure 1：

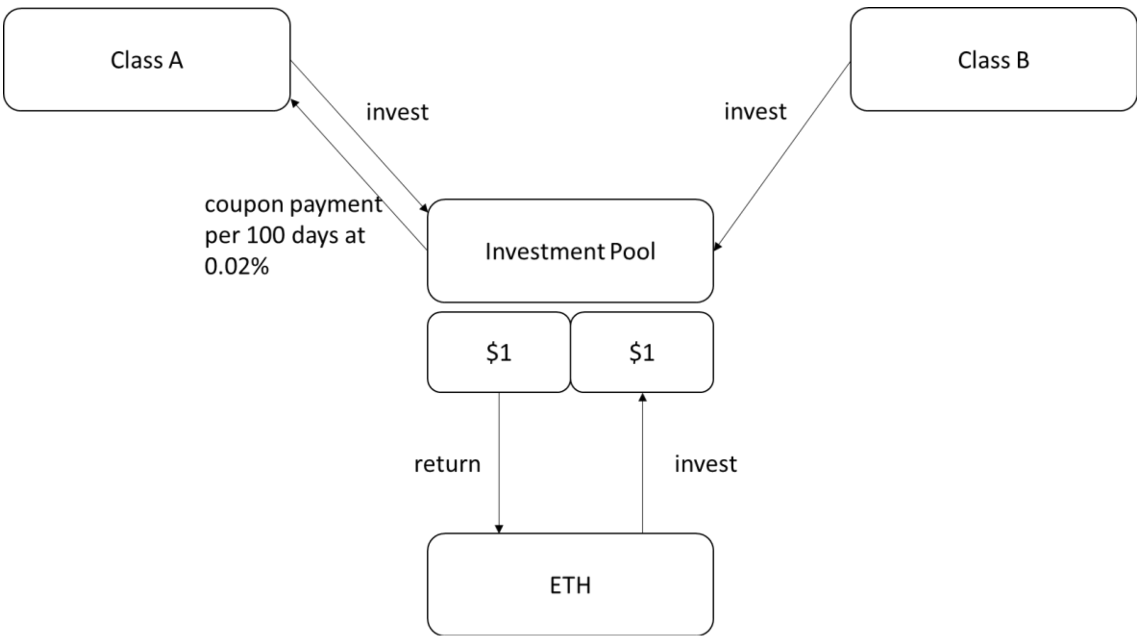

Figure 1: The cash flow of Class A and B when no clause is triggered

When $V_B^t \geq 2$, S_t will be reset to 1. Coins A and B can get dividends $rT$and $2S_t - 2 - rT$.In this case, Class A generates cash flow which is coupon, Class B generates dividend payment $1 in Figure 2:

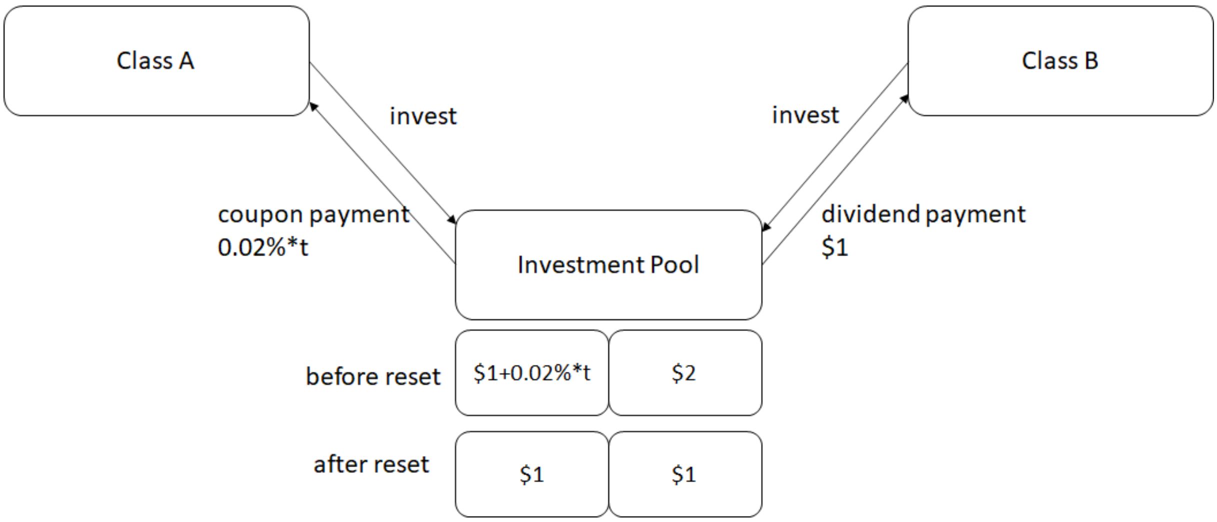

Figure 2: The cash flow of Class A and B when upward reset clause is triggered

When $V_B^t \leq 0.25$, S_t will also be reset to 1. Coin A will get $rT + 0.75$dividends and 4 coins A and 4 coins B merged into 1 coin A and 1 coin B. In this case, only Class A generates cash flow which is coupon and principal payback $0.75, Class B does not generate cash flow. Here is the figure:

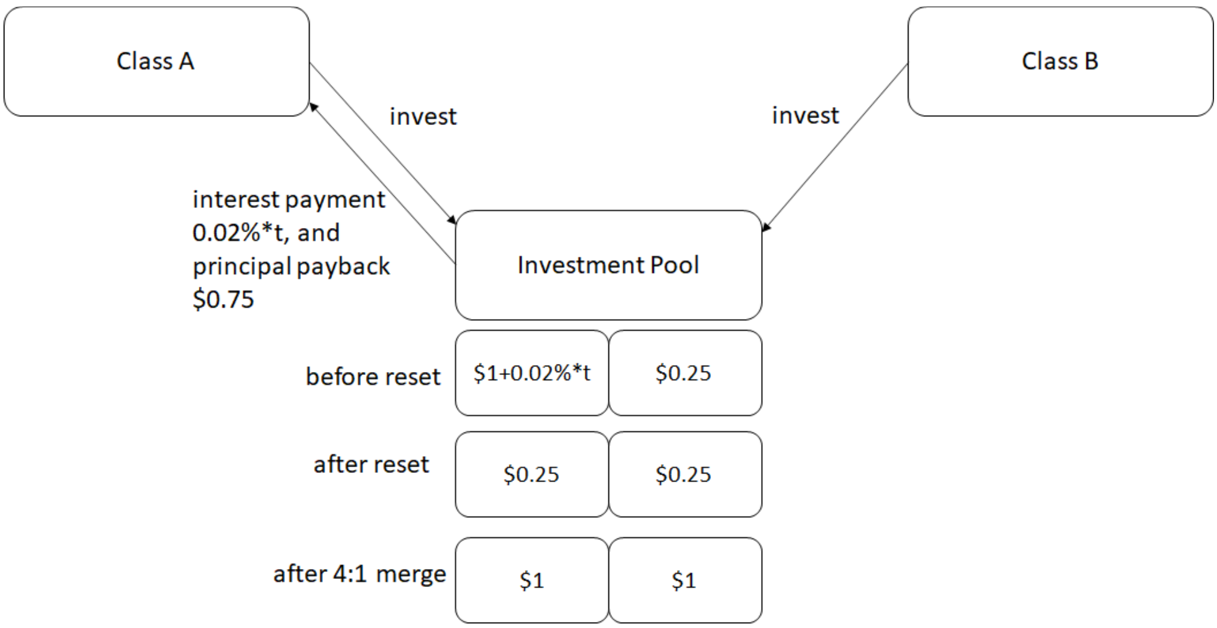

Figure 3: The cash flow of Class A and B when downward reset clause is triggered

We selected a set of random numbers to represent the price of S_t and draw a figure. In this figure, downward reset clause was triggered at t = 50 and upward reset claim was triggered at t = 75. And the figure also included the simulation results of V_A^t, V_B^t

and S_t, we marked the upward boundary and downward boundary with red dotted lines. Obviously, the value of coins A was very stable during the t from 0 to 100, it only changed slightly when upward or downward reset clause was triggered. The value of coins B changed largely and when the clauses were triggered, the value returned to 1 sharply.

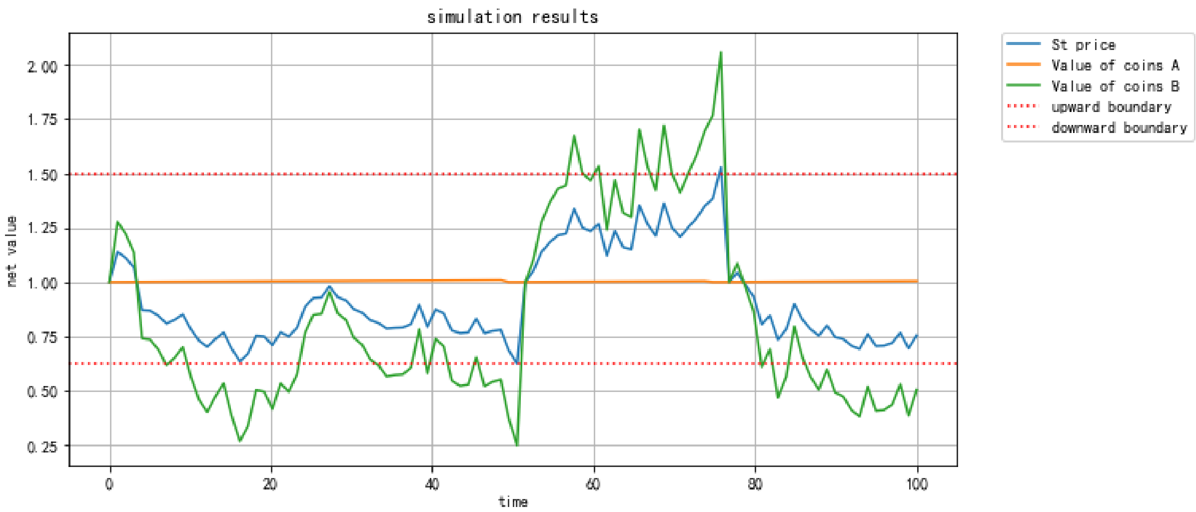

Figure 4: The simulation when downward reset clause is triggered at t=50 and upward reset clause is triggered at t=75.

We simulated S_t using Monte Carlo simulation and discounted the cash flows of coin A and coin B respectively to calculate the price of coin A and B. The prices we calculated are: 1.0108 and 1.0291.

3.2. Question 2

3.2.1 jump risk

For jump risk, we used compound Poisson process with constant 0.2 and set risk value is -0.8. So, the PDE of S_t is

$$dS_t = rdt + \sigma dW_t + dJ_t$$

So S_t is

$$S_t = e^{(r-\frac{1}{2}\sigma^2)t+\sigma\sqrt{t}W_t+J_t}$$

Then we simulated S_t and used pricing methods in question 1 to calculate the price of coin A and B. Under the same inputs, we calculated the price of coin A and B is 0.9731 and 0.8604. Compare to vanilla methods, the price of coin A and coin B will decrease when considered jump risk. the price of coin A fluctuated less and the price of coin B fluctuated more.

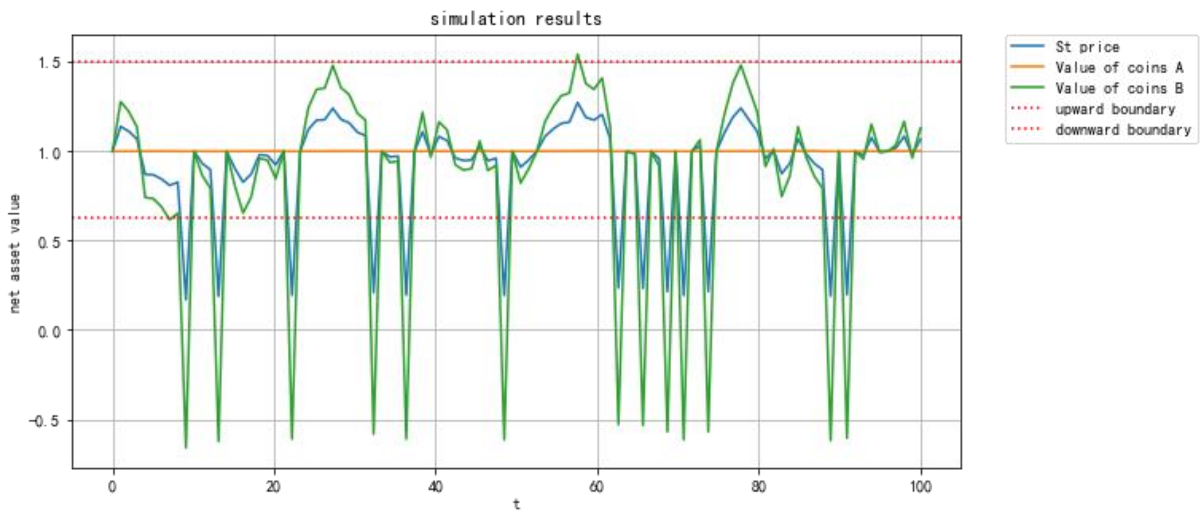

Figure 5: the simulation with jump risk

Above figure is a set of random numbers to represent the price of S_t. In this figure, because of jump risk downward reset clause was triggered at many days. And the figure also included the simulation results of V_A^t, V_B^t and S_t, we marked the upward boundary and downward boundary with red dotted lines. Obviously, the value of coins A was relative stable during the t from 0 to 100, it changed when downward reset clause was triggered. The value of coins B changed largely. And sometimes value of B changed to -0.5 at some points.

3.2.2 A/B ratio

We changed A/B ratio from 1:1 to 1:2 and 2:1. When A/B ratio became to 1:2

$$V_A^t + 2V_B^t = 3S_t$$

And the reset condition for S_t change to

upward boundary condition: $5/3 + rT/3$

downward boundary condition: $0.5 + rT/3$

Then we simulated S_t and used pricing methods in question 1 to calculate the price of coin A and B. Under the same inputs, we calculated the price of coin A and B is 1.0116 and 1.0241. When A/B ratio decrease, the price of A will increase and the price of B will decrease.

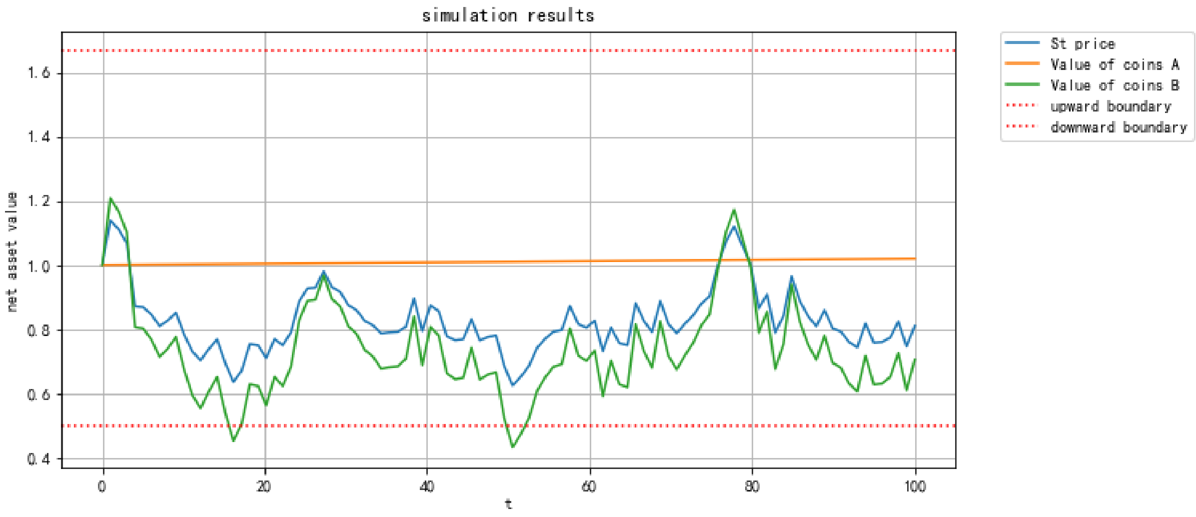

Figure 6: the simulation with A/B=1:2

Above figure is a set of random numbers to represent the price of S_t . In this figure, downward reset clause and upward reset claim did not trigger. And the figure also included the simulation results of V_A^t, V_B^t and S_t, we marked the upward boundary and downward boundary with red dotted lines. Obviously, the value of coins A was very increase stably during the t from 0 to 100.The value of coins B changed largely and when the clauses were triggered, the value returned to 1 sharply.

When A/B ratio become to 2:1

$$2V_A^t + V_B^t = 3S_t$$

And the reset condition for S_t change to

upward boundary condition:$4/3 + 2rT/3$

downward boundary condition:$2.25/3 + 2rT/3$

Then we simulated S_t and used pricing methods in question 1 to calculate the price of coin A and B. Under the same inputs, we calculated the price of coin A and B is 0.9840 and 1.0918. When A/B ratio increase, the price of A will decrease and the price of B will increase.

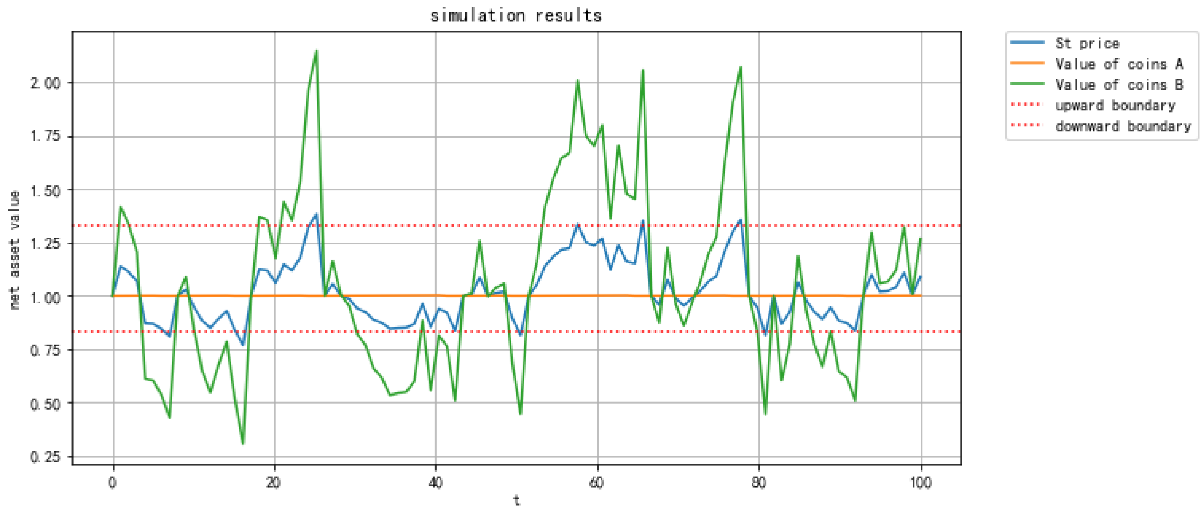

Figure 7: the simulation with A/B=2:1

Above figure is a set of random numbers to represent the price of S_t . In this figure, downward reset clause was triggered at t=7, 16, 42, 50,80, 91and upward reset was triggered at t=25, 65, 77. And the figure also included the simulation results of V_A^t, V_B^t and S_t, we marked the upward boundary and downward boundary with red dotted lines. Obviously, the value of coins A was relative stable during the t from 0 to 100, it changed when downward reset clause was triggered. The value of coins B changed largely and when the clauses were triggered, the value returned to 1 sharply.

3.2.3 reset condition

We changed the reset condition from $0.25 \leq V_B^t \leq 2$ to $0.25 \leq V_B^t \leq 2.5$and $0.1 \leq V_B^t \leq 2$.

When reset condition is $0.25 \leq V_B^t \leq 2.5$, reset condition for S_t is

upward boundary condition:$7/4 + rT/2$

downward boundary condition:$0.625 + rT/2$

Then we simulated S_t and used pricing methods in question 1 to calculate the price of coin A and B. Under the same inputs, we calculated the price of coin A and B is 1.0147 and 1.0252. When upper boundary increases, the price of coin A will increase and the price of coin B will decrease.

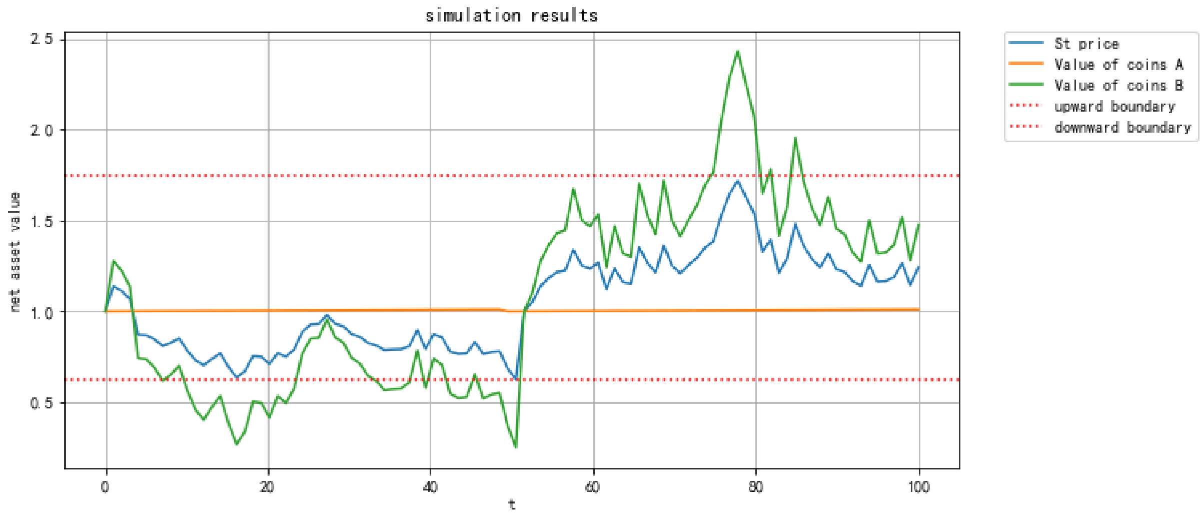

Figure 8: The simulation with upper boundary increases

Above figure is a set of random numbers to represent the price of S_t . In this figure, downward reset clause was triggered at t=50 and upward reset did not trigger. And the figure also included the simulation results of V_A^t, V_B^t and S_t, we marked the upward boundary and downward boundary with red dotted lines. Obviously, the value of coins A was relative stable during the t from 0 to 100, it changed when downward reset clause was triggered. The value of coins B changed largely and when the clauses were triggered, the value returned to 1 sharply.

When reset condition is $0.1 \leq V_B^t \leq 2$, reset condition for S_t is

upward boundary condition: $1.5 + rT/2$

downward boundary condition: $0.55 + rT/2$

Then we simulated S_t and used pricing methods in question 1 to calculate the price of coin A and B. Under the same inputs, we calculated the price of coin A and B is 1.0116 and 1.0283. When downward boundary decreases, the price of A will increase and the price of B will decrease.

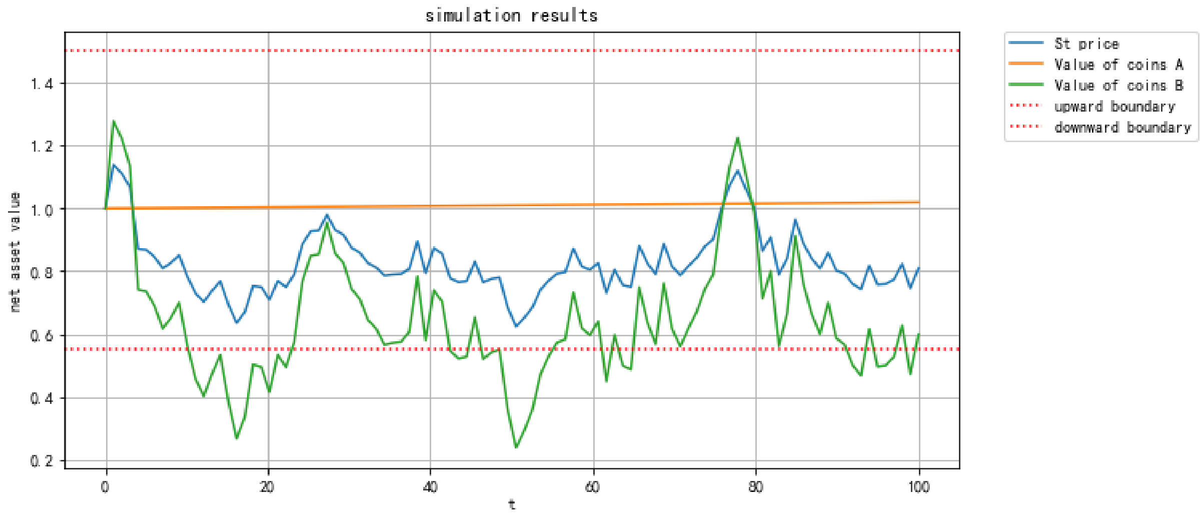

Figure 9: The simulation with downward boundary decreases

Above figure is a set of random numbers to represent the price of S_t . In this figure, downward reset clause and upward reset claim did not trigger. And the figure also included the simulation results of V_A^t, V_B^t and S_t, we marked the upward boundary and downward boundary with red dotted lines. Obviously, the value of coins A was very increase stably during the t from 0 to 100.The value of coins B changed largely and when the clauses were triggered, the value returned to 1 sharply.

3.3. Question 3

We designed another stable coin A' and coin B'. Both of them invest two shares of coin A in question 1. coin B' borrows money from coin A' at the rate R' to invest in coin A. When coin A reset because upward condition, coin A' and B' can get dividends $R'v_t$ and $(2R-R')v_t$. When coin A reset because downward condition, coin A' and B' get can get dividends $R'v_t+0.75$ and $(2R-R')v_t+0.75$. After pay out, 4 shares of coin A' and B' merge to 1 share of coin A' and B'.

4. Conclusion

Question1	the price of coin A is 1.0108 the price of coin B is 1.0291
Question2	jump risk: lower the prices A/B ratio: When A/B ratio decrease, the

	price of coin A will increase and the price of coin B will decrease. When A/B ratio increase, the price of coin A will decrease and the price of coin B will increase. reset condition: When upper boundary increases, the price of A will increase and the price of B will decrease. When downward boundary decreases, the price of A will increase and the price of B will decrease.
Question3	We designed another stable coin A' and coin B', both of them invest two shares of coin A in question 1.

5. Contribution

Li Yi(A0235958M)	Q1 and Q2 code implementation, Data collection and sorting, Report writing
Zhu Tianhang(A0236011Y)	Q1 and Q2 code implementation, Data collection and sorting, Report writing