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Guarantee Security for Study Abroad-the Design of a Financial Product

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Abstract: The cost is about 2.5 million for a Chinese student learning in the USA without a green card, which is not a small expenditure for most common families, serving as a burden for them. Moreover, the Sino-US currency has been fluctuating, bringing risk to these families to some extent. Considering the risk of fluctuating currency, the researchers plan to design a financial product to hedge the risk of fluctuating currency for families affording students studying in the USA, which attempts to lower the risk of Sino-Us currency under the precondition of preservation.

1. Background

The design of financial products is guided by many considerations. The list includes alleviation of manaferial entrentchment, catering to tax clienteles, and differences in preferences and endowments [1]. Financial innovation is often viewed as a by-product of regulation. The argument is that most financial innovations try to circumvent regulatory constraints [2].Recent financial liberalization in emerging economies has led to the rapid introduction of new financial products [3].The biggest characteristic of structured products is that they can be customized according to the different needs of market participants, so they have become one of the fastest growing areas in the international financial market [4]. With the continuous improvement of residents' life, the demand for going abroad is increasing, and the related financial services for going abroad have become the "new favorite" of many banks [5].

2. Reasons of Choosing the Topic

According to the data released by Ministry of Education of China, the number of students choosing to study abroad in 2008 has exceeded 0.6 million for the first time, reaching 608,400 and increasing by 11.74% compared with that in last year. Chinese students has been the largest group to study overseas.

The Open Doors Report released by The American international education association in 2020 showed that the number of international students in USA has exceeded 1 million for five years in a row. The figure of international students accepting advanced education in USA was 1,075,496 in 2019-2020 academic year, decreasing by 1.8% compared with that in 2018-2019 academic year.

And it was the first time that the number of international students in USA had declined. State-of-the-art market segmentation is becoming an important strategic tool in the continuing evolution of the financial services industry [6].

Although it showed a downward trend in the number of international students choosing to learn in the USA generally, the number of Chinese students studying in the USA has been increasing for last over 10 years. Chinese students occupied the largest part among all the international students, reaching 372,532 in 2019-2020 academic year. Additionally, only the number of Chinese showed an increase among the top 6 countries compared with that in last year, rising by 0.8% during 2018-2019 academic year, taking up 34.6% of the whole international students. It can be concluded that Chinese students prefer studying in the USA.

TOP PLACES OF ORIGIN OF INTERNATIONAL STUDENTS

		2018/19	2019/20	% of total	% change
	WORLD TOTAL	1,095,299	1,075,496	100	-1.8
1	China	369,548	372,532	34.6	0.8
2	India	202,014	193,124	18.0	-4.4
3	South Korea	52,250	49,809	4.6	-4.7
4	Saudi Arabia	37,080	30,957	2.9	-16.5
5	Canada	26,122	25,992	2.4	-0.5
6	Vietnam	24,392	23,777	2.2	-2.5

Figure 1: Top places of option of internatinal students

Generally speaking, the cost is about 2.5 million for a Chinese student learning in the USA without a green card, which is not a small expenditure for most common families, serving as a burden for them. Moreover, the Sino-US currency has been fluctuating, bringing risk to these families to some extent.

3. Design of the Product

3.1. The Main Concept

Structured products have become more and more complex [7]. The product is mainly for students studying in the USA and their families who are sensitive to the fluctuation of rate of foreign currency. The final income would rise by 0.5% annually and the part invested on options can hedge the loss caused by fluctuating rate of foreign currency under the condition of controllable risk.

3.2. Introduction of the Product

3.2.1. About the Product

Most portfolio insurance strategies are the preferred investment strategy for a prospect theory investor [8]. Due to the violent fluctuations of international politics and a series of black Swan events, the USD / RMB exchange rate often fluctuates greatly in a short period of time [9]. The product is constructive investment and provides 100% assurance for capital. Moreover, the collective principle would be invested into national debt for capital preservation. And the derivatives would be traded via options to be invested into derivatives in foreign currency market.The role of product development within personal financial service organisations is focused on, with particular emphasis on the part played by market research within the process [10].

The profit is related to the final price of product about USD/CNH currency to gain potential income and hedge risk of rising rate of foreign currency.

The deal price is the average number of buying rate and selling rate about USD/CNH released by Thomson Reuters on 15:00. Moreover, the rate would be accurately remained to four decimal places. Investors can inquire USD / CNH rate via the mentioned system while the bank is not responsible for the information accuracy.

The final price is set according to the fixing price on the final observation day.

3.2.2. Profit of the Product

The tax of profit can't be paid by bank. However, the bank is obliged to pay tax if there is national law or administrative requirement. And the cost will be subtracted from the profit.

The lowest manual rate of profit is 0.5% in customers' expectation.

The highest manual rate of profit is 4.39% in customers' expectation.

The actual profit rate of wealth management refers to USD/CNH rate A on the due date.

(1) If A ≤6.41, the annual profit rate would be 0.5%.

(2)If 6.41<A≤6.73， the annual profit rate would be [0.5%+0.78*(A-6.41)/6.41];

(3)If A >6.73, the annual profit rate would be 4.39%.

The simulation model of profit of wealth management is as follows.

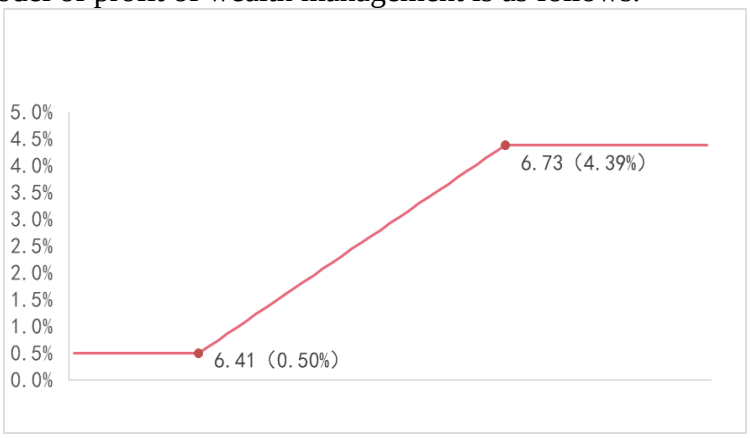

Figure 2: The line shows the profit of the product. Y-axis indicates return rate while x-axis indicates USD / CNH rate

4. Pricing of the Product

The derivatives constitutes the product is the two combination of same deadline but different exercise prices. And the related option is USD/CHN exchange rate. The exercise prices are 6.41 yuan and 6.73 yuan respectively. Clients would buy call options of 6.41 yuan and sell call options at exercise price of 6.73 yuan.

The Mertonian model and the Monte Carlo simulations are adopted to set price for the opition combination.

4.1. The Merton Model

Foreign currencies can obtain foreign risk-free interest rates, so European-style foreign exchange options apply the European-style option pricing model that pays continuous dividend rates.

The Merton model regards the continuous dividend rate paid by the underlying asset as a negative interest rate to expand the original European option pricing formula without dividends (that is, the B-S-M model). According to the Merton model, the value of the European call option with continuous dividends paid by the underlying asset is:

BSM model:

$$c_t = S_t e^{-r_f(T-t)} N(d_1) - K e^{-r(T-t)} N(d_2) \quad (1)$$

Among them:

$$d_1 = \frac{ln(S_t/K) + (r - r_f + \sigma^2/2)(T-t)}{\sigma\sqrt{T-t}} \quad (2)$$

$$d_2 = d_1 - \sigma\sqrt{T-t} \quad (3)$$

Parameter Description:

St: The initial exchange rate is 6.4103 yuan, and the average amount from November 2 to December 23, 2020 is selected.

Rf: The U.S. risk-free interest rate is 0.102%, using the one-year U.S. national bond yield announced on December 23, 2020.

N: the probability of a standard normal distribution

K: exercise rate.

r: China's risk-free interest rate is 2.6551%, using the one-year national debt yield announced on December 23.

T-t: 1 year, which is the due time of the option combination.

Σ: The volatility of exchange rate returns is 0.03562, calculated from the standard deviation of returns of exchange rates from November 1, 2019 to December 1, 2020 using the repetition method of historical volatility.

c1, c2: c1 stands for the price of a call option with a lower strike price, and c2 represents the price of a call option with a higher strike price.

It is calculated according to the Merton model (implemented through python programming, see appendix for code and results):

c1 is 0.1929 yuan.

c2 is 0.0359 yuan.

he price of option combination is 0.1570 yuan(c1－c2).

So one unit of RMB is worth 0.1570 yuan

4.2. The Monte Carlo simulation

4.2.1. The Basic Principle

Monte Carlo simulation in option pricing is a method of simulating the random movement path of the underlying asset price under a risk-neutral measure, then calculating the expected return of the option according to the terms of the option contract, and then discounting it at the risk-free interest rate to obtain the current numerical methods for option pricing.

4.2.2. Pricing Steps

(1) From the price of the underlying asset at the initial moment to the expiration, take a random path for St under the risk-neutral measure.Since European options have nothing to do with the path, we only need to calculate once to get the underlying asset price at T.

(2) Many sample results can be obtained after repeating the first and second steps 100,000 times.

(3) The average of these sample returns would be calculated to get the expected option return under the risk-neutral measure.

The risk-free rate would be discounted to get the current valuation of this option.

4.2.3. Numerical Derivation

It is assumed that the exchange rate obeys geometric Brownian motion, under the risk-neutral measure, and the stochastic process followed by an exchange rate that obeys geometric Brownian motion and has a continuous rate of return rf can be written as：

Monte Carlo model

$$dlnS_t = (r - r_f - \frac{\sigma^2}{2})dt + \sigma dz_t \tag{4}$$

After change, it would be written as:

$$S_T = S_t e^{[(r - r_f - \frac{\sigma^2}{2})\Delta t + \sigma\epsilon_t\sqrt{\Delta t}]} \tag{5}$$

The function in python would be adopted to generate 100,000 normal random numbers, and then the data would be substituted into the above formula. 100,000 ST and 100,000 option returns would be found according to the formula payoff=max[ST-K,0], and findThe average of these returns is discounted at the risk-free rate.(it can be seen in appendix for python code and results)

The option price would be obtained:

c1 would be 0.1922 yuan.

c2 would be 0.0354 yuan.

The price of option combination would be 0.1568 yuan

They are very close to the result according to the formula.

5. Appendix

(1) Pricing codes are as follows:

```
S=6.4103                #spot exchange rate, average exchange rate for the last month
rf=0.00102              #U.S. one-year Treasury bond yield
r=0.026551              #One-year yield on Chinese government bonds
t=1                     #option expiry time
sigma=0.03562           #exchange rate volatility

d1=(math.log(S/K1)+(r-rf+sigma**2*0.5)*t)/(sigma*math.sqrt(t))

d2=d1-sigma*math.sqrt(t)

def Taylor(t,n=50): #The probability of a function of the standard normal distribution
    sum_t = 0
    for i in range(n+1):
        s = (-1)**i*t**(2*i+1)/(math.factorial(i)*2**i*(2*i+1))
        sum_t += s

    return 0.5+1/math.sqrt(2*math.pi)*sum_t


c1=S*e**(-rf*t)*Taylor(d1)-K1*e**(-r*t)*Taylor(d2) #A call option with a lower strike price

d3=(math.log(S/K2)+(r-rf+sigma**2*0.5)*t)/(sigma*t)
d4=d3-sigma*math.sqrt(t)
c2=S*e**(-rf*t)*Taylor(d3)-K2*e**(-r*t)*Taylor(d4) #A call option with a higher strike price

portfolio1=c1-c2
print('c1',c1)
print('c2',c2)
print('Merton model:',portfolio1)

#Monte Carlo Simulation

#Monte Carlo simulation without calculating paths
I=100000
z=np.random.standard_normal(I) #Generate a random number that follows a standard normal distribution
ST=S*np.exp((r-rf-0.5*sigma**2)*t+sigma*np.sqrt(t)*z)
payoff1=np.maximum(ST-K1,0)
payoff2=np.maximum(ST-K2,0)
c3=np.exp(-r*t)*np.sum(payoff1)/I  #A call option with a lower strike price
c4=np.exp(-r*t)*np.sum(payoff2)/I  #A call option with a higher strike price
portfolio2=c3-c4
print('c3',c3)
print('c4',c4)
print ('Monte Carlo simulation: ',portfolio2)
```

(2) The calculation result of the pricing code is as follows:

```
c1 0.19291789410702798
c2 0.03587496662510281
Merton model: 0.15704292748192517
c3 0.1923123197971735
c4 0.03563255569418906
Monte Carlo simulation:  0.15667976410298445
```

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