The Study of Trading Based on Carry Models

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ABSTRACT
Under the leadership of Professor Eric Yeh of Columbia University, the authors use nine carry models including No arbitrage pricing model, Iron condor model, Spot holding model, Cost of carry model, Premium selling model, Classic FX carry model, Convenience yield model, Collar trade model and FX transaction decision model to evaluate the return of commodity futures, options and forex respectively. Through the trading activities under the mechanisms of nine models respectively, PNLs of each asset are drawn and listed as follows.

Keywords: *carry, commodity, option, FX, future*

1.INTRODUCTION

Carry is the return of an asset obtained from holding it. There are three basic models in carry style called no arbitrage pricing model, iron condor model and spot holding model applied to commodity, option and FX respectively. These three models can be designed to help arrange discretionary trading of different assets to get profit. The mechanism of each basic model is as follows.

1.1 Commodity

—No arbitrage pricing model

According to the theory of cost of holding, there is a linkage relationship between future price and initial price in commodity market. Convenience income can be defined as the income of holding commodity inventory. If the convenience income is introduced into equation, the difference between the current contract's price and the future contract's price can be written as

$$F(t, T) - F(0,T) = CS(t,T) - Cy(t,T)$$

F (t, T) is the price of future contract at $t(0<t<T)$; F(0,T) is the initial future contract's price; CS (t,T) is the storage cost (holding cost). Storage cost includes fixed cost and variable cost. Cy (t,T) is convenience income. Obviously, from the calculation formula, when the convenience income is lower than the holding cost, it means the price of future contract is higher at the expiration date. We choose the trading period 3/1/21–3/26/21, every Monday and Friday, and the assets used to trade are crude oil, corn, cotton, rape oil, egg, starch, cotton yarn, rapeseed, apple, palm, jujube, peanut.

1.2 Option

—Iron Condor model

An iron condor is an options strategy consisting of two puts (one long and one short) and two calls (one long and one short), and four strike prices, all with the same expiration date. The iron condor earns the maximum profit when the underlying asset closes between the middle strike prices at expiration. In other words, the goal is to profit from low volatility in the underlying asset. The maximum profit for an iron condor is the amount of premium, or credit, received for creating the four-leg options position. Maximum gain for the iron condor strategy is equal to the net credit received when entering the trade. Maximum profit is attained when the underlying stock price at expiration is between the strikes of the call and put sold. At this price, all the options expire worthless.

Max Profit = Net Premium Received - Commissions Paid

Max Profit Achieved When Price of Underlying is in between Strike Prices of the Short Put and the Short Call

We choose the trading period 3/1/21–3/26/21, every Monday and Friday, and the assets used to trade are 50ETF Call April4200, 50ETF Call April3400, 50ETF Put April3600 and 50ETF Put April3900.

1.3 FX

—Spot holding model

Borrow a certain amount of local currency A(short rate r1) at sight. Then use the spot exchange rate S to buy a certain amount of foreign currency and sells this foreign exchange future contract at price F (remaining maturity time t, short-term interest rate r2) at the same time. Thus, the financing cost in the model depends on the local short-term interest rate r1, while the return depends on the foreign short-term interest rate r2. When it becomes equilibrium, spot maturity value = futures maturity value, which can be expressed as:

$$AS(1+r_1t)=AF(1+r_2t)$$

The equation can also be expressed as:

$$F=S\frac{1+r_1t}{1+r_2t}$$

So if F/S=1+r1t/1+r2t >1, which means F>S, buy long. If not, sell short.

We choose the trading period 3/1/21–3/26/21, every Monday and Friday, and the FX futures used to trade are USDAUD, GBPAUD, CADAUD, GBPCAD, EURCAD, CHFCAD, EURHKD, USDHKD, GBPHKD, CADCHF, GBPCHF, USDCHF.

2.DISCRETIONARY TRADING

2.1 Commodity

PNL. Trading period: 3.1-3.5

The reason we choose crude oil is that the price tend to increase when it close to summer, during the months before summer the oil factories always do the maintenance and decrease the output of crude oil. So its holding cost tends to be lower than convenience income and we should buy and holding it to make profit. The reason we choose corn to short is that nowadays the holding cost of corn is becoming low because of the technical improvement, and the corn stock is high so under the influence of demand&supply, the price of corn would go down. In March 2021, the domestic cotton market, after the festival downstream production orderly recovery, lint sales continue to be active, the traditional peak season of the textile industry is coming, it is expected that the short-term domestic cotton price will continue to rise. In the international market, the growth rate of the total number of confirmed cases in the world slows down, the market's expectation of economic recovery continues to rise, and the cotton price at home and abroad is expected to continue to rise in the short term.

Crude oil（t)

Initial contract price F(0,T)/3.1. ¥415.2, Holding cost=50,C= r+s-y, r=4.35%，s=4/415.2=0.9%, c=12%, y=-6.75%,Cy=y*initial price=-¥28.026,Cs-Cy=78.026>0. Thus, F(t,T)>F(0,T), should buy long.

Corn（t)

Initial contract price/3.1. ¥2789

Holding cost=¥2200/52=42, C=r+s-y, r=4.35%, s=5/2789=0.5%, =42/2789=1.5%, y=3.35%, Cy=¥93.43, Cs-Cy=-51.43<0. Thus, F(t,T)-F(0,T)<0, sell short.

Cotton (t)

Initial contract price/3.1. ¥16685

Holding cost=¥1700, C=r+s-y, r=4.35%, s=700/16685=4%, c=1700/16685=10%, y=-1.65%, Cy=-275.3, Cs-Cy=1975.3>0. Thus, F(t,T)-F(0,T)>0, should buy long.

Learn from these absolute values, the biggest number is 1975.3 of Cotton. The higher the absolute number, the higher the possibility to get more profit. According to the comparison, the possibility of making profit of cotton is the highest. So the highest investment on cotton.1975.3/(78.026+51.43+1975.3)= 93.87% of ¥300k= ¥281.61k. Investment on corn. 2.44% of ¥300k=¥7.32k, Investment on crude oil. 3.69% of ¥300k=¥11.07k. Future price (F(t,T))/3.5: Crude oil. 428.4. PNL=(11.07k/415.2)*428.4-11.07k=351.9profit, Corn. 2819. PNL=7.32k-(7.32k/2819)*2789=77.90profit, Cotton. 15990. PNL=(281.6k/16685)*15990-281.6k=-11729.82loss, Portfolio profit=¥-11300loss.

PNL. Trading period: 3.8-3.12

We choose rape oil to long because it is estimated that its price would increase. This round of food oil price rise is affected by many factors, such as the increase of import cost and domestic soybean purchase price, the rise of agricultural products and inflation expectations, as well as the demand for goods in peak sales season. We choose egg to short because its price tendency is dropping down. After the very serious coronavirus period, see the egg market began to improve, many farmers began to raise layers. The supply of eggs began to increase significantly. After the epidemic, the economy as a whole was weak, and the consumption desire of ordinary citizens was not strong. In addition, after the epidemic ended, pork prices began to fall sharply, and the domestic demand for eggs decreased, resulting in a sharp drop in egg prices. We choose corn starch because recently its price is decreasing. In order to stabilize the market demand for corn, the Ministry of Finance suspended the purchase of VAT Deduction Policy. The Ministry of Finance issued a notice saying that in order to control the rapid development of corn deep processing, it will suspend the value-added tax deduction policy for corn deep processing enterprises.

Sources said that the suspension of tax deduction policy should be to calm the market demand for corn.

Rape oil（t)

Initial contract price F(0,T)/3.8 ¥11035

Holding cost=¥115, C=r+s-y, r=4.35% , s=30*52/11035=14.1%, c=115/11035=1.04%, y=17.41%, Cy=y*initial price=-3956, Cs- Cy=9956>0. Thus, F(t,T)>F(0,T), should buy long.

Egg（0.5t)

Initial contract price/3.8 ¥4380

Holding cost=¥2700/52=¥52, C=r+s-y, r=4.35%, s=25/4380=0.5%,c=52/4380=1.1%, y=3.75%, Cy=¥164.25, Cs-Cy=-112.25<0. Thus, F(t,T)-F(0,T)<0, sell short.

Starch (t)

Initial contract price/3.8. ¥3346

Holding cost=¥1100, C=r+s-y, r=4.35%, s=500/3346=14.9%, c=1100/3346=32.8%, y=-13.55%, Cy=-453.3, Cs-Cy=1553.3>0. Thus, F(t,T)-F(0,T)>0, should buy long

Learn from these absolute values, the biggest number is 284.4 of Rape oil. The higher the absolute number, the higher the possibility to get more profit. According to the comparison, the possibility of making profit of rape oil is the highest. So the highest investment on rape oil. 9956/(9956+112.25+1553.3)=85.67% of ¥300k=257k, Investment on egg 0.97%of ¥300k=¥2.90k, Investment on starch. 13.36% of ¥300k=¥40.08k, Future price (F(t,T))/3.12: Rape oil. 10724 PNL=(257k/11035)*10724-257k=-7240loss, Egg. 4519 PNL=2.90k-(2.90k/4519)*4380=90profit, Starch. 3242. PNL=(40.08k/3346)*3242-40.08k=-1246loss

Portfolio profit=¥-8396loss

PNL. Trading period: 3.15-3.19

We choose cotton yarn to long because that for the driving force conversion, from raw materials, supply and demand driven to “inventory driven”, in this way the price of cotton yarn was increased. We choose rapeseed to short because affected by African classical swine fever, the domestic rapeseed market supply is not much, and the traders generally take the goods, so the market demand for meal is weak. We choose apple to long because these years the price of apple is climbing continuously. Increasing labor costs are one of the reasons for Apple's price rise. Also there are not many apples in cold stores all over the country.

Cotton yarn（t)

Initial contract price F(0,T)/3.15. ¥22515

Holding cost=¥1000, C= r+s-y, r=4.35% , s=60/22515=0.27%, c=22.2%, y=-17.58%, Cy=y*initial price=-¥3.96, Cs-Cy=1000+3.96=1003.96>0. Thus, F(t,T)>F(0,T), should buy long.

Rapeseed（t)

Initial contract price/3.15. ¥5992

Holding cost=¥50, C=r+s-y, r=4.35%, s=30/5992=0.5%, c=50/5992=0.83%,y=4.02%, Cy=¥240.88, Cs-Cy=50-240.88=-190.88<0. Thus, F(t,T)-F(0,T)<0, sell short.

Apple (t)

Initial contract price/3.15. ¥4939

Holding cost=¥1700, C=r+s-y, r=4.35%, s=700/4939=14.2%,c=1700/4939=34.4%, y=-15.8%, Cy=-¥780.4, Cs-Cy=2480.4>0. Thus, F(t,T)-F(0,T)>0, should buy long.

Learn from these absolute values, the biggest number is 2480.4 of Apple. The higher the absolute number, the higher the possibility to get more profit. According to the comparison, the possibility of making profit of apple is the highest. So the highest investment on apple. 2480.4/(1003.96+190.88+2480.4)=67.49% of ¥300k= ¥202.47k

Investment on rapeseed. 5.19% of ¥300k=¥15.57k. Investment on cotton yarn. 27.32% of ¥300k=¥81.96k, Future price (F(t,T))/3.19:

Cotton yarn 5174. PNL=(81.96k/4939)*5174-81.96k=3900 profit

Rapeseed.

21450. PNL=(15.57k/22515)*21450-15.57k=-736loss

Apple.

5828. PNL=202.47k-(202.47k/5992)*5828=5542profit

Portfolio profit=8706profit

PNL. Trading period: 3.22-3.26

We choose palm to short because recently its price is affected by several factors, India raises tariffs, Malaysia's palm oil exports slowed and EU plans to ban palm oil. In recent years, jujube is easy to rot in large area after coloring in rainy days, which may be due to the weather. In contrast, in rainy days, the degree of decay of gray jujube is not so high, and the empty skin is less, so many farmers change the jujube tree into gray jujube. So the jujube is not that popular among people and the price decreased as a result. The price of peanut is going down affected by the purchase quantity of oil factory, export order and domestic market demand. Generally speaking, it is the problem of market demand. Thus, we choose this

commodity to sell short to get return.

Palm(t)

Initial contract price F(0,T)/3.22 ¥7802

Holding cost=620/52=11.9, C= r+s-y, r=4.35% , s=4/7802=0.05%,c=11.9/7802=0.15%, y=4.25%, Cy=y*initial price=331.5, Cs- Cy=-319.6<0. Thus, F(t,T)<F(0,T), should sell short.

Jujube(t)

Initial contract price/3.22 ¥9745

Holding cost=¥73, C=r+s-y, r=4.35%, s=165/9745=1.6%,c=73/9745=0.7%, y=3.45%, Cy=¥336.2, Cs-Cy=-263.2<0. Thus, F(t,T)-F(0,T)<0, sell short.

Peanut(t)

Initial contract price/3.22. ¥10480

Holding cost=¥6000/52=115.3, C=r+s-y, r=4.35%, s=23/10480=0.2%,c=115.3/10480=1.1%, y=3.45%, Cy=361.56, Cs-Cy=-301.9<0 Thus, F(t,T)-F(0,T)<0, should sell short.

Learn from these absolute values, the biggest number is of jujube. The higher the absolute number, the higher the possibility to get more profit. According to the comparison, the possibility of making profit of rape oil is the highest. So the highest investment on palm 319.6/(319.6+263.2+301.9)=36.13% of ¥300k= ¥108.39k, Investment on Jujube 29.75%of ¥300k=¥89.25k, Investment on Peanut 34.12% of ¥300k=¥102.36k, Future price (F(t,T))/3.26: Palm. 7524 PNL=108.39k-(108.39k/7802)*7524=3862profit, Jujube. 9740 PNL=89.25k-(89.25k/9745)*9740=45.8profit, Peanut. 10510. PNL=102.36k-(102.36k/10480)*10510=-293loss, Portfolio profit=¥3614.8profit

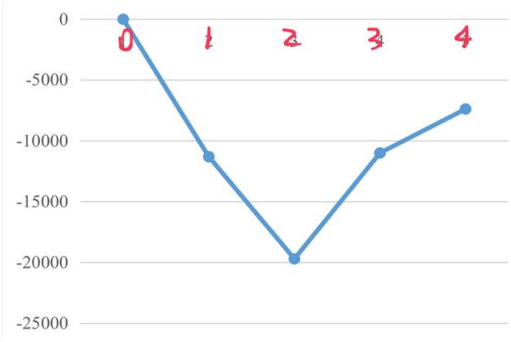

Figure 1: 4-week total return =-11300-8396+8706+3614.8=-7375.2loss

2.2 Option

Table 1: PNL trading period3.1-3.5, Total 149000 RMB

		Premium	T	Share	Price	Percentage
Long call	50ETFcallApril4200	0.263	5	10000	3.1	21%
Short call	50ETFcallApril3400	0.233	5	10000	3.3	22%
Long put	50ETFputApril3600	0.348	5	10000	4.5	30%
Short put	50ETFputApril3900	0.373	5	10000	4.0	27%

According to the four premiums, sell the put with a 3.4 strike and buy a call with a 4.2 strike, the credit on these two calls is 0.263-0.233=0.03. In addition, we sell a put with a strike 3900 and buy a put with a strike 3.6, which makes the credit 0.348-0.373=-0.025, Portfolio return(loss)=10000*(0.03-0.025)=50 RMB profit,

Table 2 PNL trading period3.8-3.12, Total 149000 RMB

		premium	T	Share	Price	Percentage
Long call	50ETFcallApril4200	0.160	5	10000	3.1	21%
Short call	50ETFcallApril3400	0.465	5	10000	3.3	22%
Long put	50ETFputApril3600	0.457	5	10000	4.5	30%
Short put	50ETFputApril3900	0.319	5	10000	4.0	27%

According to the four premiums, sell the call with a 3.4 strike and buy a call with a 4.2 strike, the credit on these two calls is 0.160-0.465=-0.305. In addition, we sell a put with a strike 3900 and buy a put with a strike 3.6, which makes the credit 0.457-0.319=0.138, Portfolio return(loss)=10000*(-0.305+0.138)= -1670 RMB loss,

Table 3: PNL trading period3.15-3.19,Total 149000 RMB

		premium	T	Share	Price	Percentage
Long call	50ETFcallApril4200	0.110	5	10000	3.1	21%
Short call	50ETFcallApril3400	0.372	5	10000	3.3	22%
Long put	50ETFputApril3600	0.428	5	10000	4.5	30%
Short put	50ETFputApril3900	0.289	5	10000	4.0	27%

According to the four premiums, sell the call with a 3.4 strike and buy a call with a 4.2 strike, the credit on these two calls is 0.110-0.372=-0.262. In addition, we sell a put with a strike 3900 and buy a put with a strike 3.6, which makes the credit 0.428-0.289=0.138, Portfolio return(loss)=10000*(-0.262+0.138)=-1240 RMB loss

Table 4: PNL trading period3.22-3.26, Total 149000 RMB

		premium	T	Share	Price	Percentage
Long call	50ETFcallApril4200	0.075	5	10000	3.1	21%
Short call	50ETFcallApril3400	0.334	5	10000	3.3	22%
Long put	50ETFputApril3600	0.455	5	10000	4.5	30%
Short put	50ETFputApril3900	0.374	5	10000	4.0	27%

According to the four premiums, sell the call with a 3.4 strike and buy a call with a 4.2 strike, the credit on these two calls is 0.075-0.334=-0.259. In addition, we sell a put with a strike 3900 and buy a put with a strike 3.6, which makes the credit 0.455-0.374=0.081, Portfolio return(loss)=10000*(-0.259+0.081)=-1780 RMB loss

4-week total return =50-1670-1240-1780=-4640 RMB

2.3 FX

Table 5: PNL trading period3.1-3.5

USDAUD.	Date 3.1.	S=1.28667	r1=1.5%.	r2=3.25%.	T=5	1+r1t/1+r2t=0.924<1.	So F<S and sell short
GBPAUD.	Date 3.1.	S=1.7912.	r1=1.5%.	r2=0.5%.	T=5	1+r1t/1+r2t=1.048>1.	So F>S andbuy long
CADAUD.	Date 3.1.	S=1.01747	r1=0.5%.	r2=0.25%.	T=5	1+r1t/1+r2t=1.11>1.	So F>S and buy long

According to the value of three 1+r1t/1+r2t, we can assign the investments on each currency. The bigger the absolute gap between 1+r1t/1+r2t and 1, the stronger the ability of the asset to make money. 0.076/(0.076+0.048+0.11)=32.48%of total 10w =32480 assigned to USDAUD. 20.51%=20510 assigned to GBPAUD. 47.01%=47010 assigned to CADAUD.Then at the expiration date 3.5, the forward's price(F) of currencies are USDAUD. 1.3017. PNL=32480-(32480/1.28667)*1.3017=-379.41loss, GBPAUD. 1.8019. PNL=(20510/1.7912)*1.8019-20510=122.52profit, CADAUD. 1.02882 PNL=(47010/1.01747)*1.02882-47010=524.4profit, Portfolio return=144.99 profit in AUD= 144.99*5.0399= 730.735 profit in CNY

Table 6: PNL trading period3.8-3.12

GBPCAD.	Date 3.8.	S=1.75185	r1=0.25%.	r2=0.5%.	T=5	1+r1t/1+r2t=0.98<1.	So F<S and sell short
EURCAD.	Date 3.8.	S=1.50145.	r1=0.25%.	r2=1.9%.	T=5	1+r1t/1+r2t=0.925<1.	So F>S and sell short
CHFCAD.	Date 3.8.	S=1.35554	r1=0.25%.	r2=2.63%.	T=5	1+r1t/1+r2t=1.116>1.	So F>S and buy long

According to the value of three 1+r1t/1+r2t, we can assign the investments on each currency. The bigger the absolute gap between 1+r1t/1+r2t and 1, the stronger the ability of the asset to make money. 0.02/(0.02+0.075+0.116)=9.48%of total 10w =9480 assigned to GBPCAD. 35.55%= 35550 assigned to EURCAD. 54.97%= 54970 assigned to CHFCAD. Then at the expiration date 3.12, the future price(F) of currencies is GBPCAD. 1.7371. PNL=9480-(9480/1.75185) *1.7371=79.82profit, EURCAD. 1.49145. PNL=35550-(35550/1.50145) *1.49145=236.77profit CHFCAD. 1.341. PNL= (54970/1.35554) *1.341-54970=-589.63loss, Portfolio return= -273.04loss in CAD= -273.04*5.2071=-1421.747loss in CNY

Table 7: PNL trading period3.15-3.19

EURHKD.	Date 3.15.	S=9.26235	r1=2%.	r2=1.9%.	T=5	1+r1t/1+r2t=1.05>1.	So F>S and buy long
USDHKD.	Date 3.15.	S=7.7652.	r1=2%.	r2=3.25%.	T=5	1+r1t/1+r2t=0.94<1.	So F<S and sell short
GBPHKD.	Date 3.15.	S=10.79315	r1=2%.	r2=0.5%.	T=5	1+r1t/1+r2t=1.07>1.	So F>S and buy long

According to the value of three 1+r1t/1+r2t, we can assign the investments on each currency. The bigger the absolute gap between 1+r1t/1+r2t and 1, the stronger the ability of the asset to make money. 0.05/(0.05+0.06+0.07)=27.78%of total 10w = 27780assigned to EURHKD. 33.33%=33330 assigned to USDHKD . 38.89%=38890assigned to GBPHKD . Then at the expiration date 3.19, the future price(F) of currencies are EURHKD. 9.2767. PNL=(27780/9.26235)*9.2767-27780=43.04profit, USDHKD. 7.765. PNL=33330-(33330/7.7652)*7.765=0.86profit, GBPHKD. 10.7647 PNL=(38890/10.79315)*10.7647-38890=-102.51loss, Portfolio return=-58.61loss in HKD= -58.61*0.8385=-49.14loss in CNY

Table 8: PNL trading period3.22-3.26

CADCHF.	Date 3.22	S=0.73703	r1=2.9%.	r2=0.25%.	T=5	1+r1t/1+r2t=1.13>1.	So F>S and buy long
GBPCHF.	Date 3.22.	S=1.2787.	r1=2.9%.	r2=0.5%.	T=5	1+r1t/1+r2t=1.11>1.	So F>S and buy long
USDCHF.	Date 3.22.	S=0.92301	r1=2.9%.	r2=3.25%.	T=5	1+r1t/1+r2t=0.98<1.	So F<S and sell short

According to the value of three 1+r1t/1+r2t, we can assign the investments on each currency. The bigger the absolute gap between 1+r1t/1+r2t and 1, the stronger the ability of the asset to make money. 0.13/(0.13+0.11+0.02)=50%of total 10w = 50000assigned to CADCHF. 42.31%=42310assigned to GBPCHF. 7.69%=7690assigned to USDCHF. Then at the expiration date 3.26, the future price(F) of currencies are CADCHF 0.74473. PNL=(50000/0.73703)*0.74473-50000=522.3profit, GBPCHF. 1.2949. PNL=(42310/1.2787)*1.2949-42310=536.03profit, USDCHF. 0.93929. PNL=7690-(7690/0.92301)*0.93929=-135.64loss, Portfolio return= 922.69profit in CHF=6.9852*922.69= 6445.174profit in CNY

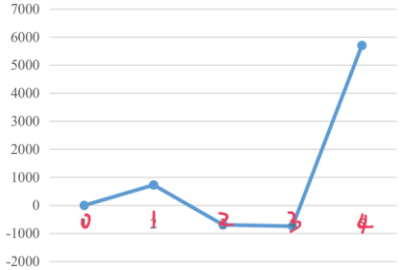

Figure 2: 4-week total return=5705.022profit in CNY, 4-week total portfolio return of three big assets is -6310.178 loss.

3. SYSTEMATIC TRADING

3.1 Commodity

—cost of carry model

In order to avoid inter-temporal arbitrage, the cost of carry model is established based on forward futures price and short-term futures price. Trading rules: On the one hand, when the price of forward futures is higher than that of short-term futures and the holding cost from short-term holding to long-term holding is eliminated, the trader will sell forward futures and buy short-term futures for arbitrage. In order to prevent arbitrage, the price of forward futures should not be greater than the sum of the price of recent futures and the corresponding holding cost.

$$Fd \leq Fn(1+C')$$

Here, Fd is the current price of further futures, Fn is the current price of closer futures, and C' is the fraction of holding cost. On the other hand, if the forward futures price is relatively lower than the recent futures price, there will be a buyer's forward futures contract and sell the recent futures contract for arbitrage. In order to prevent arbitrage, the relationship between Fn and Fd should be as follows:

Fd≥Fn(1 +C')

So: Fd = Fn (1 + C') (signal)

The assets used are cotton and sugar and the trading period 3/14/16–3/14/21. Source of data: The data used comes from CF2105 and SR2109 found in Tonghuashun. app, opening and closing prices of every quarter from 3/14/16 to 3/14/21.

Table 9: Backtest.

c=r+s-y				Cost of carry model	Cotton40 %					
R(quarterly)=1.07%										
C=5%										
72	1	2	3	4	1	2	3	4	1	2
Average price per quarter	11805	13410	15225	15642.5	15340	15510	15227.5	15037.5	16840	17742.5
Storage rate	0.0061	0.005369128	0.004729064	0.004602845	0.004693611	0.004642166	0.004728288	0.00478803	0.004275534	0.004058053
Y=R+S-C	-0.0332	-0.033930872	-0.034570936	-0.034697155	-0.034606389	-0.034657834	-0.034571712	-0.03451197	-0.035024466	-0.035241947
C'=r-y	0.0439	0.044630872	0.045270936	0.045397155	0.045306389	0.045357834	0.045271712	0.04521197	0.045724466	0.045941947
Fd=?Fn(1+C)	12895>10715*(1+0.0439)	14130>12690*1.0446	16135>14315x1.0453	15500<15785x1.0454	15425<15255x1.0453	15550<15470x1.04536	15065<15390x1.04527	15060<15015x1.04521	18680>15000x1.04573	17335<18150x1.0459
	Fd>Fn(1+C') sell forward ,buy recent future									
Amount	3.101977511	2.830856334	2.479082739	2.534051315	2.622091118	2.585649644	2.599090318	2.664002664	2.141327623	2.203856749
Total price	33237.68903	35923.56688	35488.06941	39277.79538	40445.75549	40206.85197	39155.29565	40119.88012	32119.91435	38203.85675
Return	6762.310973	4076.433121	4511.930586	722.2046246	-445.75549	-206.8519716	844.7043535	-119.8801199	7880.085653	1796.143251
	3	4	1	2	3	4	1	2	3	4
Average price per quarter	16255	15332.5	14812.5	13887.5	13430	12557.5	12095	12757.5	13905	15377.5
Storage rate	0.004429406	0.004695907	0.004860759	0.005184518	0.005361132	0.005733625	0.005952873	0.005643739	0.005177994	0.004682166

Y=R+S-C	-0.034870594	-0.034604093	-0.034439241	-0.034115482	-0.033938868	-0.033566375	-0.033347127	-0.033656261	-0.034122006	-0.034617834
C'=r-y	0.045570594	0.045304093	0.045139241	0.044815482	0.044638868	0.044266375	0.044047127	0.044356261	0.044822006	0.045317834
Fd=?Fn(1+C)	15310<17200x1.04557	15295<15370x1.0453	14385<15240x1.04514	13380<14395x1.0448	13370<13490x1.04046	11775<13340x1.04427	12755>11435x1.044	12940<12575x1.04436	14835>12975x1.0448	15725<15870x1.0453
Amount	2.325581395	2.602472349	2.624671916	2.778742619	2.965159377	2.99850075	3.136025088	3.180914513	2.696326255	2.520478891
Total price	35604.65116	39804.81457	37755.90551	37179.57624	39644.18087	35307.34633	35860.44688	41161.0338	34984.83316	39634.53056
Return	4395.348837	195.1854262	2244.094488	2820.423758	355.8191253	4692.653673	4139.553116	-1161.033797	5015.166835	365.4694392
Total Return	48884.006									

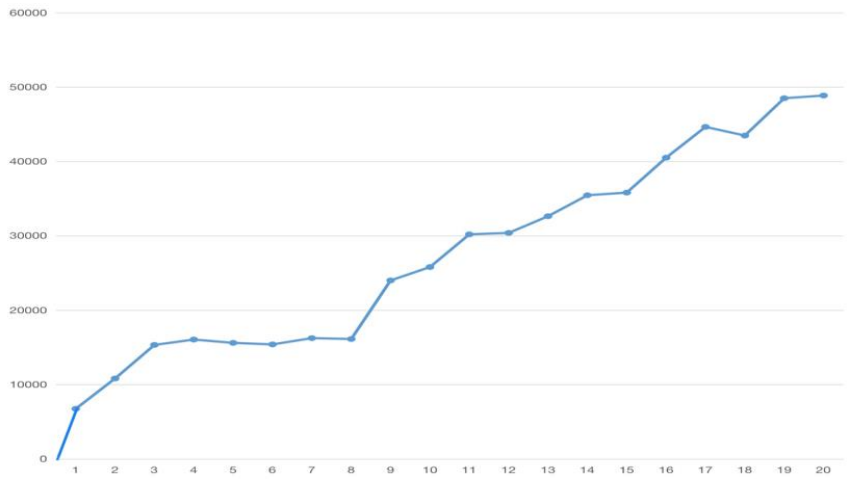

Figure 3: According to the graph, in most cases the quarterly return of cotton is positive so the line generally keeps climbing, though the data is not very stable, the overall performance of investment activities is financially favorable. And we can get profit in the end.

Table 10 : sugar 60%

c=r+s-y	Sugar60%									
R(quarterly)=1.07%	0.0107									
C=6%	0.06									
36	1	2	3	4	1	2	3	4	1	2

Average price per quarter	5871.5	6231	6800	7033	6873.5	6362.5	5960.5	5718	5444.5	5116
Storage rate	0.006131312	0.005777564	0.005294118	0.005118726	0.005237506	0.005658153	0.006039762	0.00629590 8	0.006612177	0.007036747
Y=R+S-C	-0.043168688	-0.043522436	-0.044005882	-0.044181274	-0.044062494	-0.043641847	-0.043260238	-0.04300409 2	-0.042687823	-0.042263253
C’=r-y	0.053868688	0.054222436	0.054705882	0.054881274	0.054762494	0.054341847	0.053960238	0.05370409 2	0.053387823	0.052963253
	1	2	3	4	1	2	3	4	1	2
Fd=?Fn(1+C’)	6115>5628x1.05387	6359<6103x1.0542	7240>6360x1.0547	7034<7032x1.05488	6710<7037x1.05476	6019<6706x1.05434	5878<6043x1.05396	5593<5843x1.0537	5311<5578x1.0534	4905<5327x1.05296
Amount	9.811937858	9.831230542	8.287292818	8.532423208	8.526360665	8.947211452	9.928843 29	10.26869759	10.75654356	11.26337526
Total price	55221.58626	62516.79502	52707.18232	60017.06485	57211.88006	53853.26573	58361.740 86	57432.8256	57128.00287	55246.85564
Return	4778.413737	-2516.795019	7292.81768	-17.06484642	2788.119937	6146.734268	1638.2591 43	2567.174 397	2871.997132	4753.144359
	3	4	1	2	3	4	1	2	3	4
	4914	5035	5078.5	5206	5464	5480.5	5212	4985	5115.5	5233.5
	0.007326007	0.00714995	0.007088707	0.006915098	0.0065885 8	0.006568744	0.006907137	0.007221 665	0.007037435	0.006878762
	-0.041973993	-0.04215005	-0.042211293	-0.04238490 2	-0.04271142	-0.04273125 6	-0.04239286 3	-0.04207833 5	-0.04226256 5	-0.04242123 8
	0.052673993	0.05285005	0.052911293	0.05308490 2	0.05341142	0.05343125 6	0.05309286 3	0.05277833 5	0.05296256 5	0.05312123 8
	3	4	1	2	3	4	1	2	3	4
	4926<4902x1.05267	5103<4967x1.053	5035<5122x1.0529	5408>5004x1.0531	5471<5457x1.0534	5553<5408x1.0534	4908<5516x1.0531	5100<4870x1.0528	5077<5154x1.05296	5428>5039x1.053

	12.23990208	12.07972619	11.71417415	11.09467456	10.99505223	11.09467456	10.87744743	12.32032854	11.64144354	11.05379514
	60293.75765	61642.84276	58980.86685	55517.75148	60153.93073	61608.72781	53386.51197	62833.67556	59103.60885	55700.07369
	-293.7576499	-1642.842762	1019.133151	4482.248521	-153.9307312	-1608.727811	6613.488035	-2833.675565	896.3911525	4299.926308
Total return	30302.80079									

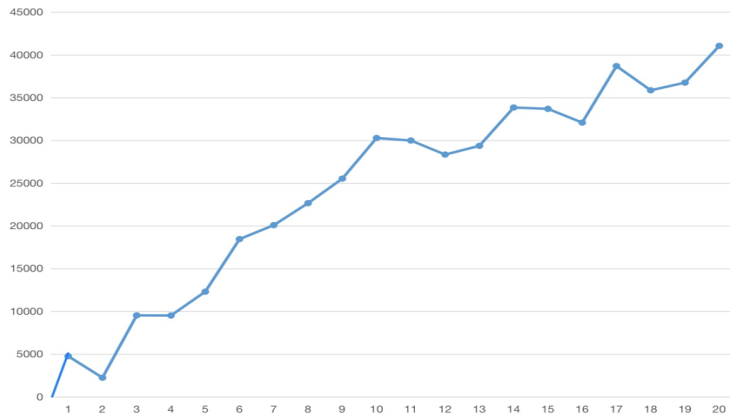

Figure 4 : According to the graph, the general trend is climbing. Some little fluctuation exists under the influence of weather but the total return is positive and the performance is favorable.

3.2 Option

—Premium selling model

Trading rules: Buy a put option and sell it when the underlying assets' price is lower than the exercise price, and in this way we can get return through premium selling. If have a right judgement about the market condition, we're supposed to close a position and get infinite profit. However, if has a wrong judgement about the market, the biggest loss is the payment for the option. Source of data: The data used comes from 50ETF in wind, opening and closing prices of every quarter from 3/14/16 to 3/12/21. The assets used to trade are 10 options in 50ETF and trading period 3/14/16–3/12/21.

Table 11: Backtest. selling model

Premium selling model										
P=I-(I/F)*Ft										
I=investment=10k										
F=current price of option										
Ft=option price at expiration day										
P=return										
Date	16.3.14	16.6.08	16.6.14	16.9.13	16.9.14	16.12.13	16.12.14	17.3.13	17.3.14	17.6.13

code	10002014		10002037		10001058		10002274		10002366	
F;Ft	0.132	0.002	0.1021	0.0309	0.2687	0.0927	0.248	0.0072	0.01	0.0006
P		9848.484848		6973.555338		6550.055824		9709.677419		9400
Date	17.6.14	17.9.13	17.9.14	17.12.13	17.12.14	18.3.13	18.3.14	18.6.13	18.6.14	18.9.13
code	10001099		10002322		10002106		10002795		10002561	
F;Ft	0.1293	0.1204	0.1423	0.0125	0.3486	0.3381	0.2189	0.3566	0.1551	0.31
P		688.3217324		9121.574139		301.2048193		-6290.543627		-9987.105093
Date	18.9.14	18.12.13	18.12.14	19.3.13	19.3.14	19.6.13	19.6.14	19.9.11	19.9.16	19.12.12
code	10001051		10002647		10001638		10001686		10001928	
F;Ft	0.0776	0.031	0.2183	0.1125	0.0148	0.0005	0.0036	0.0005	0.4145	0.3874
P		6005.154639		4846.541457		9662.162162		8611.111111		653.7997587
Date	19.12.16	20.3.13	20.3.16	20.6.12	20.6.14	20.9.11	20.9.14	20.12.13	20.12.14	21.3.12
code	10001918		10002003		10002424		10002408		10002734	
F;Ft	0.0081	0.007	0.3204	0.2095	0.0133	0.0004	0.0003	0.0002	0.0104	0.0005
P		1358.024691		3461.298377		9699.24812		3333.333333		9519.230769
Portfolio return										
93465.12982										

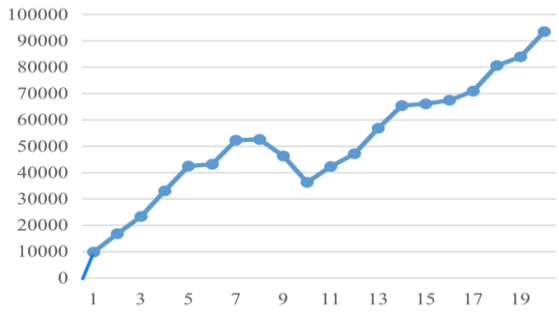

Figure 5: According to the graph, the quarterly returns are always positive, settling in the range (0,10000) with quarterly investment ¥10000 apart from the period June- September in 2018. Therefore, with the outcome of calculation, we can know we successfully get return during the trading period.

3.3 FX

—Classic FX carry model

C=return of carry, S is the price of FX contract, F is the future's price. r' is the foreign short-term interest rate and r is local interest rate. Trading rules:

$$C_t = \frac{S_t - F_t}{F_t} = \left(r_t^{f*} - r_t^f\right) \frac{1}{1 + r_t^f}.$$

First of all, there are two ways to calculate the carry value of foreign exchange at each trading time point. One is to directly use the nominal interest rate of the bank of the country to calculate the interest rate difference. The other is to calculate the difference of the prices between spot and future. After the calculation of the rightmost value, we can know the direction of S-F, and if it is positive, S>F, we're supposed to sell short. Source of data: The data of these assets is found from the futures market, the opening and closing data of every quarter among the period 3/14/16—3/15/21.

Table 12: Classic FX carry model

S-F/F=?(r'-r)/(1+r)			Classic FX carry model							
r' is foreign interest rate										
r is local interest rate										
S is initial price of contract										
F is expiration price										
Calculate F with the known value of S,r',r										
	16.3.14	16.6.14	16.9.14	16.12.14	17.3.14	17.6.14	17.9.14	17.12.14	18.3.14	18.6.14
	USDAUD	USDAUD	CADAUD	CADAUD	EURCAD	EURCAD	EURHKD	EURHKD	GBPHKD	GBPHKD
r'	3.25%	3.25%	0.25%	0.25%	1.90%	1.90%	1.90%	1.90%	0.50%	0.50%
r	1.50%	1.50%	1.50%	1.50%	0.25%	0.25%	2%	2%	2%	2%
F>/<S	F<S	F<S	F>S	F>S	F<S	F<S	F>S	F>S	F>S	F>S
If F>S, then buy long	Sell short	Sell short	Buy long	Buy long	Sell short	Sell short	Buy long	Buy long	Buy long	Buy long
S	1.3299	1.3598	1.0125	1.0099	1.429	1.4844	9.3126	9.1941	10.9516	10.4021
Expiration day on every quarter	16.6.13	16.9.13	16.12.13	17.3.13	17.6.13	17.9.13	17.12.13	18.3.13	18.6.13	18.9.13
F	1.3544	1.339	1.0156	0.9821	1.484	1.4462	9.237	9.7157	10.499	10.74145
Amount=investment/S	7519.362358	7354.02265	9876.54321	9901.970492	6997.90063	6736.728645	1073.813972	1087.654039	913.1085869	961.3443439
Return	-184.2243778	-31.26070664	-0.643422569	-275.9182022	-660.8027369	-403.4597027	-484.640039	82.68030776	-330.5926387	-4.360435547

	18.9.14	18.12.14	19.3.14	19.6.14	19.9.16	19.12.16	20.3.16	20.6.16	20.9.14	20.12.15
	GBPCHF	GBPCHF	USDJPY	USDJPY	GBPJPY	GBPJPY	CHFJPY	CHFJPY	AUDJPY	AUDJPY
r’	0.50%	0.50%	3.25%	3.25%	0.50%	0.50%	2.90%	2.90%	1.50%	1.50%
r	2.90%	2.90%	1%	1%	1%	1%	1%	1%	1%	1%
F>/<S	F>S	F>S	F<S	F<S	F>S	F>S	F<S	F<S	F<S	F<S
If F>S, then buy long	Buy long	Buy long	Sell short	Sell short	Buy long	Buy long	Sell short	Sell short	Sell short	Sell short
S	1.2639	1.2554	111.74	108.56	134.405	146.08	112.044	112.814	77.06	78.335
Expiration day on every quarter	18.12.13	19.3.13	19.6.13	19.9.13	19.12.13	20.3.13	20.6.15	20.9.14	20.12.14	21.3.15
F	1.2572	1.30315	108.4	108.1	145.765	132.445	113.097	116.382	78.375	84.645
Amount=investment/S	7912.018356	7965.588657	89.49346698	92.11495947	74.40199397	68.45564074	89.25065153	88.64148067	129.7690112	127.6568584
Return	-57.37043555	322.9864228	621.8946025	664.2674839	1509.474135	576.0814739	482.1005378	165.8277348	-4.818514891	-810.3332912
Portfolio return										
889.76935										

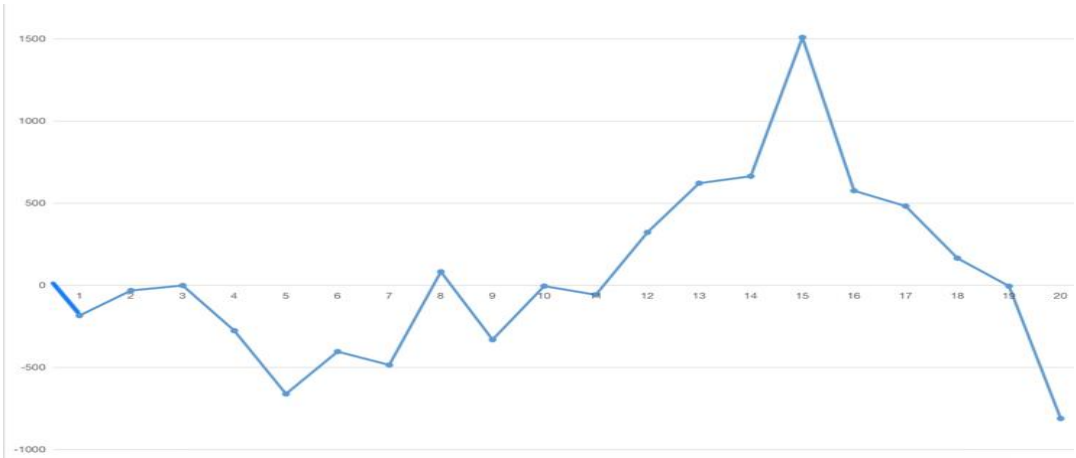

Figure 6: According to the graph, the quarterly return always settles in the range (-400,800), but the performance is not ideal in 2020—2021. However, in most cases during trading period the returns are positive and the total return is good.

4.ADVANCED MODEL

4.1 Commodity

CYM-Convenience yield model

$$F_{t,T} = e^{[r+m](T-t)} S_t^A = e^{[r+m](T-t)} \frac{S_t^C}{e^{cy(T-t)}} = e^{[r+m-cy](T-t)} S_t^C \quad (5)$$

F is the price of forward contract, S is spot price, r is risk-free rate, m is rate of storage cost, Cy is convenience yield and t is one day between the beginning and the expiration date. Define the leftmost side of the formula to be A and rightmost side B. When A=B, the signal exists, then do trading activities to get return. Trading rules: If A>B, we're supposed to buy forward with price F and borrow spot commodities then carry them for a period, during the period, S turns to B under the influence of storage costs, convenience yield and interest rate. Finally, at the expiration date we can sell the commodity through which get a net profit A-B>0. If A<B, we're supposed to buy long-forward with price F and sell spot commodities with S, then use the money earned to do risk-free investments, in this way during the trading period the revenue is B and get the net profit B-A>0 in the end. We choose the trading period 1/1/21—3/1/21 and the assets used to trade are crude oil, gold, soybean.

4.2 Option

Collar Trade Model

This trading strategy consists of the following three parts:

(1). Buy stocks

(2). long ATM or OTM put

(3). short OTM call

We can understand it easily by an example. The stock ABC, let's say it's now trading at $45.

(1). Buy 100 shares of ABC

(2). Buy a PUT with a strike price of 45 for $5.00

(3). Sell 1 strike with a call price of 60 at $3.00

Let's look at the likelihood on the upside first:

Trading rules: When the stock goes up over 47 and below 60, your stock is making money. You've got back the money you sold the Call. The Call is also making money.

When the stock goes up more than 60 years, the stock is making money, but because you sold the Call, it doesn't matter how much it goes up. The Call you sell is prepaid for you.

When the stock goes down, because you bought a Put of 45, you can sell your stock for 45 even if the stock goes down to 20. Stocks are break-even. And because the stock goes down, you make the money you made selling the Call. You only lose the difference between the price you paid to buy the Put and the price you sold the Call, which is $2. Per share you spend = $45 + $5 - $3 = $47, Your maximum risk per share = $47 - $45 = $2

Your maximum profit per share = $60 - $47 = $13. This approach is a good one for stocks that are in doubt.

Collar Carry Trade:

$$S + P_{x1} - C_{x2}, x1 \leq x2$$

Expiration date profit formula:

$$P_L = S_T - S_0 + \mathrm{Max}(0,\ X_1 - S_T) - P_1 - \mathrm{Max}(0, S_T - X_2) + C_2$$

When

$$S_T \leq X_1 \leq X_2, P_L = X_1 - S_0 - P_1 + C_2$$

$$X_1 < S_T \leq X_2, P_L = S_T - S_0 - P_1 + C_2$$

$$X_1 \leq X_2 < S_T, P_L = X_2 - S_0 - P_1 + C_2$$

The stockholder became concerned about the possibility of a decline in the stock and decided to buy put options on his stock as protection. But he was frustrated by the cost of putting options, so he also considered selling calls. If he buys an undervalued put, he is likely to sell a call, and his earnings will more than cover the cost of the put, so he can set up a week of protective collar arbitrage at no cost. At least no debt. His "cost" is forgoing the stock's potential gain on the exercised value of the sold call option. As shown in figure 1, the collar option model, which is a way of managing the cost overrun caused by change orders, consists of the insurance buyer's section of striking a call option according to the increase in cost overrun and the insurance seller's section of striking a put option according to the decrease in cost overrun. If S0is the current expected loss due to the cost overrun at present (t = 0), S0 is within the range of the strike price (Xp) of the put option and the strike price (Xc) of the call option.

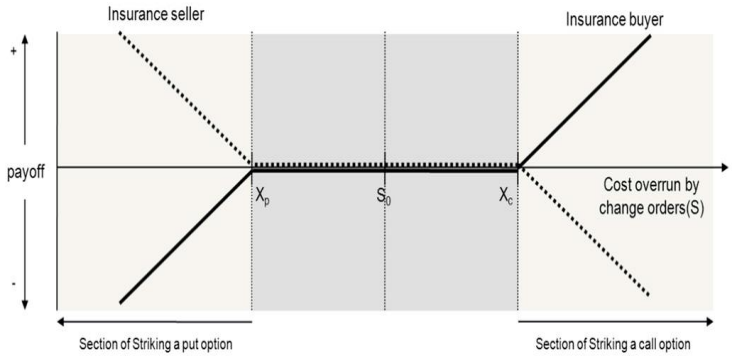

Figure 7: Concept of material contract model based on collar option.

When the actual cost overrun caused by change orders exceeds the estimate, and S exceeds Xc, the insurance buyer exercises the call option, realizing the call option value shown in. Therefore, Xc of the call option indicates the maximum permissible limit of the cost overrun caused by change orders in the corresponding project. In other words, the insurance becomes meaningless when the cost overrun is lower than Xc; i.e., the value of the insurance becomes zero. However, when the cost overrun exceeds Xc, the insurance creates value because a hedge on the cost overrun can be placed through the insurance. In this case, the insurance seller's side incurs a loss that is proportionate to the avoidance of the cost overrun caused by change orders placed through the insurance by the insurance buyer.

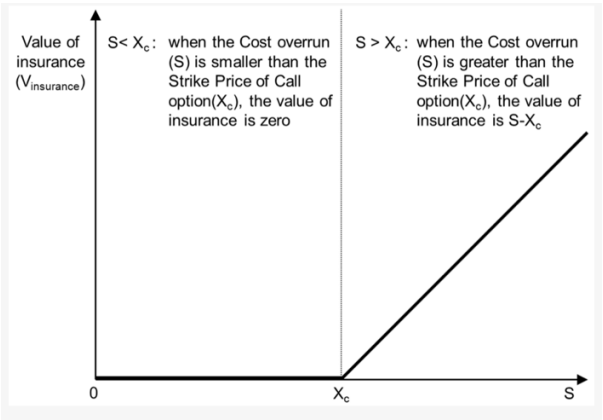

Figure 8: Value of insurance depending on the increase in the cost overrun

If the actual cost overrun caused by change orders is lower than expected, and S is below Xp, the insurance seller exercises the put option, realizing the put option value shown in figure 3. Therefore, Xp of the put option indicates the starting point from which the insurance seller can secure a fee for providing insurance without baseline cost. In other words, when the cost overrun is lower than Xp, the potential net profit margin of the insurance buyer is restored to the insurance seller.

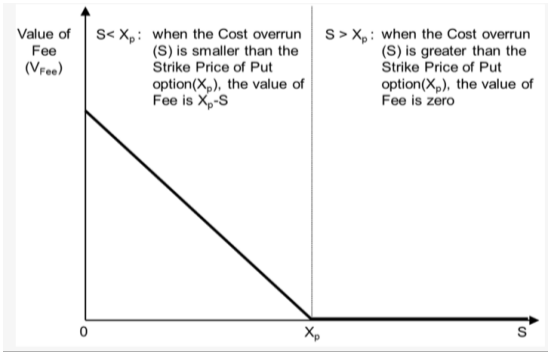

Figure 9: value of fee depending on the decrease in cost overrun

In summary, the insurance premium is not fixed. When the cost overrun caused by change orders is lower than Xp, the insurance buyer pays the difference between the Xp value and the cost overrun as the insurance premium to the insurance seller. Therefore, the insurance premium varies according to changes in the cost overrun caused by change orders. We choose the trading period 1/1/21—3/1/21 and the assets used to trade are index.

4.3 FX

Foreign exchange transaction decision model

In general, as the demand for a particular foreign currency increases, the amount of that foreign currency that can be exchanged per unit of currency gradually decreases. Our basic assumption is that foreign exchange transactions are allowed within a sufficiently large quantitative range, but that exchange rates are set at different constants for different quantitative ranges within this range. For instance, assume M is a sufficiently large number and xi,j is the amount of currency i used to exchange currency j, Ri,j(xi,j) is the number of currency j gained. When the trading quantity xi,j between 0 and a, the exchange rate equals to r(1). When the trading quantity xi,j between a and M, the amount no large than a can be exchanged by r(1), the exceeded part can be exchanged by the rate r(2). In general, assume the trading range of any two kinds of currencies is from 0 to M. And assume the amount of exchange rate changing range of every two FX is q. The exchange

rate is a constant r(t) when xi,j among C(t-1)—C(t), t=1,2.....,q.

Trading rules:

In the following formula, ak means the given amount of currency k. And in the trading network, there exists n vertexes. The vertexes create totally n(n-1) arcs, every arc has the restriction 0 and M. xi,j is the amount of currency i used to exchange currency j. Ri,j(xi,j) is set on the range from 0 to M, M is a sufficiently large number. We can use the formula to calculate the maximum cash flow at vertex I in this network.

$$R_{i,j}(x_{i,j}) = \begin{cases} r_{i,j}^{(1)} x_{i,j} & 0 \leqslant x_{i,j} \leqslant a \\ r_{i,j}^{(1)} a + r_{i,j}^{(2)} (x_{i,j} - a), & a \leqslant x_{i,j} \leqslant M \end{cases}$$

$$(P_0) \quad \text{Max } v$$

$$\text{s.t.} \quad \sum_{j=1,j\neq i}^{n} x_{i,j} - \sum_{j=1,j\neq i}^{n} R_{j,i}(x_{j,i}) = \begin{cases} \alpha_k, & i = k \\ 0, & 1 \leqslant i \leqslant n \\ -v, & i = l \end{cases}$$

$$0 \leqslant x_{i,j} \leqslant M \quad (1 \leqslant i,j \leqslant n, i \neq j)$$

$$R_{i,j}(x_{i,j}) = \sum_{s=1}^{t-1} r_{i,j}^{(s)} [C_{i,j}^{(s)} - C_{i,j}^{(s-1)}] + r_{i,j}^{(t)} [x_{i,j} - C_{i,j}^{(t-1)}]$$

We choose the trading period 1/1/21—3/1/21 and the assets used to trade are G10.

5.CONCLUSION

5.1 Summary

Some typical profitable trading model for different assets are listed as follows. Spot holding model is a model applied to FX, forecasting the price from the ratio of interest rates of currencies. We use the gap between the financing cost and interest return from two different currencies' interest rates to get profit. Through the analysis of trading results, we can know that portfolio return is positive using the formula from trading model. So we can use this to trade. Cost of carry model is a model applied to commodity, we should focus on the value of forward futures and short-term futures with holding cost, when there exist a signal(the value of two sides becomes equal). Then do short or long depending on the direction of the formula in the model to get profit. Through the application of carry model, some kinds of commodities reach high return. For example, the trading of cotton has good performance using this model. Classic FX carry model is a model applied to FX, from the comparison of normal interest rates difference and the difference of prices between spot and future, we can make the decision to buy long or sell short to get profit. From the backtest, it's obvious that using this trading model can give us portfolio return during the trading period. Therefore, classic FX model is useful in arbitrage.

5.2 Recommendation

Because the definition of carry style is getting return of assets obtained from holding, trading activities in carry style require little about analysis of price tendency using programming. In this way, carry is not as complex as momentum or value analysis, and under this style, the trading activities ask for less time so we think it would be popular in Chinese market. Firstly, we recommend spot holding model to be applied to Chinese market because the mechanism of operating is easy to understand and the data used for calculation in the formula can be easily found. The trading activities under the guidance of spot holding model do not require high funds and the risk in short term is always low, so the model is suitable for new hands or undergraduates. Secondly, about convenience yield model, we do not recommend it to Chinese market because in this model, some factors are highly changeable. For instance, rate of storage cost for commodities is uncertain among different seasons and at the same time, according to the formula C=r+s-y, y is changeable too, so the model is too basic and hard for people to evaluate the future price accurately. Maybe we're supposed to improve the model by turn the factors inside to relatively stable factors rather than directly using it in markets. Thirdly, the collar option model can be used in the Chinese market, for

example, PetroChina makes use of the international financial market to hedge the risk of raw material and product price fluctuations through hedging transactions. But on the other hand, we should fully understand the importance of risk management and respect market rules. You can't just regulate the price of oil going up, there's no hedge against the price going down.

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