*Note: the statistical values in the table 2 are t-values using ADF model without intercept. The critical values are -2.5683, -1.9413 and -1.6164 at the confidence 99%, 95% and 90%, Lag n=2. ***, **, * denote the confidence 99%, 95% and 90% level.*

6 Options Property Test of Convenience Yields with Different Maturities

Positive convenience yields are call options, holding the nearby futures contracts can capture implied convenience yields, while negative convenience yields are put options, holding the distant futures contracts can capture implied convenience yields. Unexpected market shock has a different impact on futures prices with different maturities, market participants adjust futures assets portfolio sizes through unexpected volatility of futures prices, and then achieve excess arbitrage incomes. In the actual emissions allowances market, prices spreads of futures contracts with different maturities contain convenience yields implied from the futures markets. Based on equation (6), we can gain the following equation (8)

$$\ln F_{t,T_2} = \ln F_{t+1,T_1} + r(T_2 - T_1) - cy(T_2 - T_1) \quad (8)$$

From the equation (8), we can achieve the following equation (9)

$$\begin{aligned} IAB_t &= r(T_2 - T_1) - cy(T_2 - T_1) \\ &= \ln F_{t,T_2} - \ln F_{t+1,T_1} \end{aligned} \quad (9)$$

From the equation (9), convenience yields implied from the futures markets have significant impacts on prices spreads of futures contracts with different maturities. Prices spreads of futures contracts have enlarging trends with an decline of convenience yields, while prices spreads of futures contracts have shrinking trends with an increase of convenience yields. When unexpected market volatility of futures contracts exhibit a stationary trend, arbitrage revenues are disappeared with an adjustment of assets portfolio sizes among different futures contracts. Assumed longer-maturity futures prices discounted by constant risk-free interest rate, $f_{t,T_2} = F_{t,T_2} e^{-r(T_2 - t)/365}$. We propose the following hypothesis.

Hypothesis 1: convenience yields of emissions allowances are negatively related with prices spreads between the distant and nearby futures contracts, while they are positively related with prices spreads between the nearby and distant futures contracts.

Hypothesis 2: when convenience yields implied from emissions allowances futures markets are positive, prices spreads between the nearby and discounted distant futures contracts are positively related with convenience yields. When convenience yields implied from the futures market are negative, prices spreads between the discounted distant and nearby futures contracts are negatively related with convenience yields.

When the convenience yields implied from the futures markets are positive, we present the following equation (10) and (11)

$$\ln F_{t+1,T_1} - \ln F_{t,T_2} = A_0 + A_1 cy_t + \varepsilon_t \quad (10)$$

$$\ln F_{t+1,T_1} - \ln f_{t,T_2} = B_0 + B_1 cy_t + B_2 \varepsilon_t + \xi_t \quad (11)$$

When the convenience yields implied from the futures markets are negative, we present the following equation (12) and (13)

$$\ln F_{t,T_2} - \ln F_{t+1,T_1} = A_0 + A_1 cy_t + \varepsilon_t \quad (12)$$

$$\ln f_{t,T_2} - \ln F_{t+1,T_1} = B_0 + B_1 cy_t + B_2 \varepsilon_t + \xi_t \quad (13)$$

Where $\ln F_{t+1,T_1} - \ln F_{t,T_2}, \ln F_{t,T_2} - \ln F_{t+1,T_1}$ denote prices spreads between the nearby and distant futures contracts, and prices spreads between the distant and nearby futures contracts. $\ln F_{t+1,T_1} - \ln f_{t,T_2}, \ln f_{t,T_2} - \ln F_{t+1,T_1}$ denote prices spreads between the nearby and discounted distant futures contracts, and prices spreads between the discounted distant and nearby futures contracts. Based on the above hypothesis, we present empirical results from equation (10) to equation (13).

From the table 3, convenience yields are significantly positive related with prices spreads between the nearby and distant futures contracts. The related coefficients A_1 between convenience yields and prices spreads of futures contracts are 1.5974, 2.7935, 3.9008, 4.8601, they have an increasing trend with an increase of time-to-maturity.

Table 3 Regression results of equation (10) and (11) ($cy > 0$)

coefficient	F_1 & F_2	F_1 & F_3	F_1 & F_4
A_0	-0.0635***	-0.1163***	-0.1660***
	(-11.39)	(-22.31)	(-50.37)
A_1	1.5974***	2.7935***	3.9008***

	(5.28)	(7.88)	(12.59)
R^2	0.169	0.312	0.436
B_0	0.1083***	0.2242***	0.3460***
	(53.15)	(63.14)	(111.64)
B_1	1.4442***	2.3265***	2.1486***
	(13.04)	(9.64)	(7.38)
B_2	0.9224***	0.8044***	0.7031***
	(29.50)	(13.80)	(8.74)
R^2	0.884	0.677	0.592
coefficients	F_1 & F_5	F_2 & F_3	F_2 & F_4
A_0	-0.2197***	-0.0596***	-0.1078***
	(-45.98)	(-13.67)	(-51.35)
A_1	4.8601***	1.6401***	2.4807***
	(12.00)	(4.19)	(9.87)
R^2	0.413	0.114	0.418
B_0	0.4541***	0.1150***	0.2368***
	(79.58)	(71.90)	(171.37)
B_1	2.8352***	1.3358***	1.3834***
	(5.87)	(9.30)	(8.37)
B_2	0.4527***	0.9256***	0.8295***
	(4.42)	(29.40)	(14.70)
R^2	0.585	0.876	0.679
coefficient	F_2 & F_5	F_3 & F_4	F_3 & F_5
A_0	-0.1627***	-0.0530***	-0.1061***
	(-47.50)	(-31.24)	(-43.37)
A_1	3.3692***	1.1272***	2.0705***
	(10.13)	(8.19)	(9.36)
R^2	0.430	0.330	0.392
B_0	0.3516***	0.1210***	0.2411***
	(104.76)	(200.20)	(133.58)
B_1	2.0725***	0.8169***	1.5430***
	(6.30)	(16.67)	(9.45)
B_2	0.6064***	0.9273***	0.7613***
	(7.15)	(30.36)	(12.03)
R^2	0.518	0.899	0.634
coefficient	F_4 & F_5		
A_0	-0.0504***		
	(-14.79)		
A_1	0.8418***		
	(4.71)		
R^2	0.140		
B_0	0.2862***		
	(106.42)		
B_1	1.2199***		
	(8.64)		
B_2	0.8311***		
	(12.29)		
R^2	0.626		

Note; 1. convenience yields implied from the futures markets are positive, $cy > 0$, data samples cover the period form April 8, 2008 to October 21,2008.

*2. *** , ** , * denote the confidence 99% , 95% and 90% level, the number in the parentheses is t statistic values.*

Table 4 Regression results of equation (12) and (13) ($cy < 0$)

coefficients	F_1 & F_2	F_1 & F_3	F_1 & F_4
A_0	0.0208***	0.0393***	0.0440***
	(9.66)	(14.37)	(9.43)
A_1	-0.7410***	-1.6911***	-3.0572***
	(-8.05)	(-18.52)	(-26.01)
R^2	0.111	0.397	0.565
B_0	-0.0240***	-0.0550***	-0.0766***
	(-21.99)	(-22.13)	(-13.55)
B_1	-0.9510***	-2.1417***	-2.9301***
	(-20.39)	(-25.82)	(-20.59)
B_2	0.8745***	0.5900***	0.0927*
	(39.39)	(14.83)	(1.75)
R^2	0.791	0.630	0.610
coefficients	F_1 & F_5	F_2 & F_3	F_2 & F_4
A_0	0.0689***	0.0244***	0.0198***
	(12.21)	(7.68)	(3.88)
A_1	-3.8135***	-0.8022***	-2.2351***
	(-27.75)	(-10.14)	(-21.31)
R^2	0.596	0.165	0.465
B_0	-0.1256***	-0.0271***	-0.0456***
	(-17.24)	(-17.83)	(-8.86)
B_1	-4.4399***	-1.0405***	-1.8361***
	(-25.03)	(-25.24)	(-17.34)
B_2	0.3274***	0.8704***	0.4831***
	(5.79)	(38.11)	(10.92)
R^2	0.605	0.801	0.546
coefficients	F_2 & F_5	F_3 & F_4	F_3 & F_5
A_0	0.0468***	-0.0036***	0.0141**
	(7.75)	(-0.83)	(2.29)
A_1	-2.9878***	-1.3175***	-2.3197***
	(-23.50)	(-19.05)	(-20.17)
R^2	0.515	0.410	0.438
B_0	-0.0983***	-0.0191***	-0.0623***
	(-13.00)	(-7.87)	(-9.39)
B_1	-3.3515***	-0.8727***	-2.1352***
	(-21.03)	(-22.44)	(-17.22)
B_2	0.0054***	0.8713***	0.4130***
	(0.10)	(35.36)	(8.74)
R^2	0.560	0.771	0.517
coefficients	F_4 & F_5		
A_0	0.0257***		
	(5.98)		
A_1	-0.7763***		
	(-8.28)		
R^2	0.116		
B_0	-0.0522***		
	(-21.80)		

B_1	-1.5456*** (-29.62)
B_2	0.8365*** (34.31)
R^2	0.798

Note: 1. convenience yields implied from the futures markets are negative, $cy < 0$.

2. data samples cover the period form December 4, 2008 to December 20, 2010.

The related coefficients are significant at the confidence 99% level, and t-values indicate larger values, the regression results support hypothesis 1. The related coefficients B_1 between convenience yields $cy_{12} - cy_{14}$ and discounted prices spreads of futures contracts are 1.4442, 2.3265, 2.1486, 2.8352, these coefficients are all positive. The related coefficients between discounted prices spreads and the residual term are 0.9224, 0.8044, 0.7031 and 0.4527, these coefficients have a declining trend with an increase of time-to-maturity. The t-values of related coefficients B_1, B_2 indicate greater values, all R^2-values have significant increasing trends and the related coefficients are significant at the confidence 99% level, these results support hypothesis 2. Other convenience yields with different maturities are obviously positive correlation relationship with prices spreads of futures contracts, and convenience yields implied from the futures markets exhibit a significant options property, these regression results support hypothesis 1 and 2.

Seen from the table 4, when convenience yields implied from the futures markets are negative, $cy < 0$, the related coefficients A_1 between convenience yields $cy_{12} - cy_{15}$ and prices spreads of futures contracts are -0.7410, -1.6911, -3.0572 and -3.8135,which are all negative, and these coefficients exhibit a higher significance at the confidence 99% level, and t-values are greater, these results support hypothesis 1. The related coefficients B_1 between convenience yields $cy_{12} - cy_{15}$ and discounted prices spreads of futures contracts are -0.9510, -2.1417, -2.9301 and -4.4399, these coefficients are all negative. Absolute values of these coefficients A_1, B_1 show an increasing trend with an increase of time-to-maturity. The related coefficients B_2 between discounted prices spreads and convenience yields are 0.8745, 0.5900, 0.0927 and 0.3274, these coefficients exhibit a higher significance at the confidence 99% level. These empirical results support hypothesis 2. The above empirical results show the convenience yields implied from the futures contracts have a significant options property, the regression results support hypothesis 1 and 2.

7 Arbitrage Revenues of Convenience Yields for Futures Contracts with Different Maturities

Based on Brenna (1986) [38], Molonas and Thomadakis (1997) [16] estimation, convenience yields of futures contracts with different maturities are equal to the prices difference between the nearby futures and distant futures discounted by constant interest rate.

$$CY_t = F_{t,T_1} - F_{t,T_2} e^{-r(T_2 - T_1)} \tag{14}$$

Here CY_t denotes convenience yields implied from the futures markets. Market participants can optimize assets portfolio policies of futures contracts with different maturities using the options property of convenience yields. Assumed the futures prices follow a geometric Brownian process.

$$\begin{aligned} dF_{t,T_1} &= \mu_n F_{t,T_1} dt + \sigma_n F_{t,T_1} dz_n \\ dF_{t,T_2} &= \mu_d F_{t,T_2} dt + \sigma_d F_{t,T_1} dz_d \end{aligned} \tag{15}$$

Here μ_n, μ_d denote the instantaneous returns in price for the nearby and distant futures contracts, σ_n, σ_d denote the volatility in price for the nearby and distant futures contracts, dz_n, dz_d denote the increment of a standard Wiener process for the nearby and distant futures contracts, and $dz_n dz_d = \rho_{nd} dt$, where ρ_{nd} denotes the related coefficient between the nearby and distant futures contracts. When the convenience yields implied from the futures markets are positive, convenience yields are call options, market participants buy nearby futures contracts while selling distant futures contracts.

$$OCY = MAX(F_{t,T_1} - F_{t,T_2} e^{-r(T_2 - T_1)}, 0) \tag{16}$$

In the emissions allowances markets, market participants can hold different futures assets and optimize assets portfolio policies of futures contracts with different maturities using the changes both futures prices spread and convenience yields. Assumed exchange costs of futures assets are equal to zero, and then options values of convenience yields are equal to exchange options value between the nearby and discounted distant futures contracts. Based on Poitras (1998) [39], Lin and Duan (2007) [18], we propose a new extending exchange options pricing model, options values of convenience yields are equal to

$$V_{CY} = F_{t,T_1} N(d_1) - F_{t,T_2} e^{-r(T_2-T_1)} N(d_2)$$

$$d_1 = \frac{\dfrac{E(\ln F_{t,T_1})}{E(\ln F_{t,T_2} e^{-r(T_2-T_1)})} + \dfrac{\sigma_F^2 \tau}{2}}{\sigma_F \sqrt{\tau}} \qquad (17)$$

$$d_2 = d_1 - \sigma_F \sqrt{\tau}$$

$$\sigma_F = \sigma_n^2 + \sigma_d^2 - 2\rho_{nd}\sigma_n\sigma_d$$

Here $E(\ln F_{t,T_1}), E(\ln F_{t,T_2} e^{-r(T_2-T_1)})$ denote the mean of the logarithm of the nearby futures prices and discounted distant futures prices, $N(.)$ denotes the cumulative probability function, τ denotes the exchange period between the nearby and distant futures contracts. The price volatility σ_n^2, σ_d^2 both the nearby and distant futures contracts, their related coefficient ρ_{nd} are all constant in the assets exchange period. When the convenience yields implied from the futures markets are negative, market participants buy the distant futures contracts while selling the nearby futures contracts, and then convenience yields are put options, market participant can attain excess options value through optimizing different futures assets policies.

Table 5 options value of convenience yields through exchanging futures contracts with different maturities (F_1 and F_2, F_3, F_4, F_5)

coefficients	$cy_{12} > 0$	$cy_{12} < 0$
Period interval	2008.4.8-2008.12.3	2008.12.4-2010.12.20
τ	0.6548	2.0438
ρ	0.9990	0.9931
σ_F^2	0.0349	0.0265
Ex policy	$F_2 ex F_1$	$F_1 ex F_2$
$N(d_1)$	0.5712	0.5805
$N(d_2)$	0.5113	0.4881
V_{CY}	1.7353	1.7337
Ex policy	$F_1 ex F_2$	$F_2 ex F_1$
$N(d_1)$	0.4887	0.5119
$N(d_2)$	0.4288	0.4195
V_{CY}	1.2574	1.3114
ΔV_{CY}	0.4779	0.4223
coefficients	$cy_{13} > 0$	$cy_{13} < 0$
Period interval	2008.4.8-2008-11.6	2008.11.7-2010.12.20
τ	0.5808	2.1178
ρ	0.9931	0.9739
σ_F^2	0.1088	0.1302
Ex policy	$F_3 ex F_1$	$F_1 ex F_3$
$N(d_1)$	0.5913	0.6418
$N(d_2)$	0.4918	0.4357
V_{CY}	2.8324	4.1705
Ex policy	$F_1 ex F_3$	$F_3 ex F_1$
$N(d_1)$	0.5082	0.5642
$N(d_2)$	0.4087	0.3582
V_{CY}	2.1039	4.0195
ΔV_{CY}	0.7286	0.1610
coefficients	$cy_{14} > 0$	$cy_{14} < 0$
Period interval	2008.4.8-2008.10.21	2008.10.22-2010.12.20
τ	0.5370	2.1616
ρ	0.9590	0.9621
σ_F^2	0.4217	0.2857
Ex policy	$F_4 ex F_1$	$F_1 ex F_4$
$N(d_1)$	0.6159	0.7034
$N(d_2)$	0.4282	0.4007
V_{CY}	4.9237	6.6084
Ex policy	$F_1 ex F_4$	$F_4 ex F_1$
$N(d_1)$	0.5718	0.5993
$N(d_2)$	0.3841	0.2966
V_{CY}	4.3313	6.3590
ΔV_{CY}	0.5924	0.2494
coefficients	$cy_{15} > 0$	$cy_{15} < 0$
Period interval	2008.4.8-2008.10.23	2008.10.24-2010.12.20
τ	0.5425	2.1562
ρ	0.9607	0.9461
σ_F^2	0.5406	0.3798
Ex policy	$F_5 ex F_1$	$F_1 ex F_5$
$N(d_1)$	0.6370	0.7332
$N(d_2)$	0.4243	0.3888
V_{CY}	5.6702	7.0831
Ex policy	$F_1 ex F_5$	$F_5 ex F_1$
$N(d_1)$	0.5757	0.6112
$N(d_2)$	0.3630	0.2668
V_{CY}	4.7772	6.9480
ΔV_{CY}	0.8930	0.1351

Table 6 options value of convenience yields through exchanging futures contracts with different maturities (F_2 and F_3, F_4, F_5)

coefficients	$cy_{23} > 0$	$cy_{23} < 0$
Period interval	2008.4.8-2008.10.21	2008.10.30-2010.12.20
τ	0.5370	2.1397
ρ	0.9967	0.9929
σ_F^2	0.0264	0.0430
Ex policy	$F_3 ex F_2$	$F_2 ex F_3$

$N(d_1)$	0.5578	0.6030
$N(d_2)$	0.5105	0.4832
V_{CY}	1.3439	2.4268
Ex policy	F_2exF_3	F_3exF_2
$N(d_1)$	0.4895	0.5168
$N(d_2)$	0.4422	0.3970
V_{CY}	1.0810	2.3289
ΔV_{CY}	0.2629	0.0979
coefficients	$cy_{24}>0$	$cy_{24}<0$
Period interval	2008.4.8-2008.7.2	2008.10.22-2010.12.20
τ	0.2329	2.1616
ρ	0.9834	0.9806
σ_F^2	0.3302	0.1597
Ex policy	F_4exF_2	F_2exF_4
$N(d_1)$	0.5770	0.6741
$N(d_2)$	0.4669	0.4457
V_{CY}	2.8726	5.3587
Ex policy	F_2exF_4	F_4exF_2
$N(d_1)$	0.5331	0.5543
$N(d_2)$	0.4230	0.3259
V_{CY}	2.7525	4.9255
ΔV_{CY}	0.1201	0.4332
coefficients	$cy_{25}>0$	$cy_{25}<0$
Period interval	2008.4.8-2008.10.21	2008.10.22-2010.12.20
τ	0.5370	2.1616
ρ	0.9730	0.9723
σ_F^2	0.4235	0.2271
Ex policy	F_5exF_2	F_2exF_5
$N(d_1)$	0.6154	0.7063
$N(d_2)$	0.4273	0.4372
V_{CY}	4.9997	6.0894
Ex policy	F_2exF_5	F_5exF_2
$N(d_1)$	0.5727	0.5628
$N(d_2)$	0.3846	0.2937
V_{CY}	4.5644	5.9218
ΔV_{CY}	0.4353	0.1676

Table 7 options value of convenience yields through exchanging futures contracts with different maturities (F_3 and F_4, F_5, F_4 and F_5)

coefficients	$cy_{34}>0$	$cy_{34}<0$
Period interval	08.5.6-08.6.3	08.10.22-10.12.20
τ	0.0767	2.1616
ρ	0.9478	0.9902
σ_F^2	0.0417	0.0787
Ex policy	F_4exF_3	F_3exF_4
$N(d_1)$	0.6098	0.6371
$N(d_2)$	0.5879	0.4754
V_{CY}	0.6406	4.0437
Ex policy	F_3exF_4	F_4exF_3
$N(d_1)$	0.4121	0.5246
$N(d_2)$	0.3902	0.3629
V_{CY}	0.6088	3.6380
ΔV_{CY}	0.0318	0.4057
coefficients	$cy_{35}>0$	$cy_{35}<0$
Period interval	08.4.8-08.7.7	08.10.22-10.12.20
τ	0.2466	2.1616
ρ	0.9912	0.9874
σ_F^2	0.2892	0.1051
Ex policy	F_5exF_3	F_3exF_5
$N(d_1)$	0.5722	0.6744
$N(d_2)$	0.4661	0.4902
V_{CY}	2.9012	4.3945
Ex policy	F_3exF_5	F_5exF_3
$N(d_1)$	0.5339	0.5098
$N(d_2)$	0.4278	0.3256
V_{CY}	2.7204	4.2682
ΔV_{CY}	0.1808	0.1263
coefficients	$cy_{45}>0$	$cy_{45}<0$
Period interval	08.4.8-08.11.10	08.11.13-10.12.20
τ	0.5918	2.1014
ρ	0.9965	0.9964
σ_F^2	0.0741	0.0198
Ex policy	F_5exF_4	F_4exF_5
$N(d_1)$	0.5714	0.6240
$N(d_2)$	0.4883	0.5446
V_{CY}	2.4976	1.7978
Ex policy	F_4exF_5	F_5exF_4
$N(d_1)$	0.5117	0.4554
$N(d_2)$	0.4286	0.3760
V_{CY}	2.1509	1.7739
ΔV_{CY}	0.3467	0.0239

Note: 1.In the table 5, 6, 7 F_2exF_1 *denotes that the distant* F_2 *futures contract exchange the nearby* F_1 *futures contract,* F_1exF_2 *the nearby* F_1 *futures contract exchange the distant* F_2 *futures contract, the others variables are defined similarly.*
2. ΔV_{CY} *denote that market participants gain excess investment incomes using the options property of convenience yields.*

Table 5 show options value of exchanging assets between the nearby futures contract F_1 and distant futures contract F_2, F_3, F_4, F_5 using the convenience yields. Take the nearby futures F_1 and distant futures F_2 for an example. In the exchange period from April 8, 2008 to December 3, 2008, the convenience yields implied from the futures markets are positive, $cy_{12} > 0$, the convenience yields are call options. Market participants buy the distant F_2 futures contract while selling the nearby F_1 futures contract, and then they can gain 1.2574 € options value per ton through exchanging futures assets. Market participants find that convenience yields exhibit significant options property, they make the contrary decision to buy the nearby F_1 futures contract while selling the distant F_2 futures contract, and then they can attain 1.7353€ options value per ton using the options property of convenience yields. Thereby market participants optimize assets portfolio policies of futures contracts with different maturities through using the convenience yields implied from the futures markets, they can achieve excess 0.4779€ investment revenue per ton. In the exchange period from December 4, 2008 to December 20, 2010, the convenience yields implied from the futures markets are negative, $cy_{12} < 0$, convenience yields are put options. Market participants buy the nearby F_1 futures contract while selling the distant F_2 futures contract, and then they can attain 1.3114€ options value per ton through exchanging futures assets. Market participants make the contrary investment policy to buy the distant F_2 futures contract while selling the nearby F_1 futures contract, and then they can gain 1.7337€ options value per ton through using the options property of convenience yields. Accordingly, when convenience yields implied from the futures markets are negative, market participants can optimize assets portfolio policies through using the convenience yields implied from the futures markets, and then they can achieve additional 0.4223€ investment revenue per ton. Based on similar assets exchange policies, when the convenience yields implied from the futures markets are positive, market participants hold the nearby F_1 futures contact substituting the distant F_3, F_4, F_5 futures contracts, and then they can gain 0.7286€, 0.5924€, 0.8930€ investment revenues per ton using the convenience yields. When the convenience yields implied from the futures markets are negative, market participants hold the distant F_3, F_4, F_5 futures contracts substituting the nearby F_1 futures contact, and then they can gain 0.1610€, 0.2494€, 0.1351€ investment revenues per ton using the convenience yields.

Seen from the table 6, when the convenience yields are positive, market participants hold the nearby F_2 futures contracts substituting the distant F_3, F_4, F_5 futures contracts, and they can capture excess 0.2629€, 0.1201€ and 0.4353€ investment revenues per ton through using the options property of convenience yields. When the convenience yields are negative, market participants hold the distant F_3, F_4, F_5 futures contracts substituting the nearby F_2 futures contracts, and they can gain excess 0.0979€, 0.4332€ and 0.1676€ investment revenues per ton through using the options property of convenience yields. Seen from the table 7, based on similar exchange assets policies, market participants adjust assets portfolio policies between the nearby and distant futures contracts through using the options property of convenience yields, and then they can achieve additional investment incomes. In brief, when the convenience yields implied from the futures markets are positive, convenience yields are call options, market participants buy the nearby futures contracts while selling the distant futures contracts. When the convenience yields implied from the futures markets are negative, convenience yields are put options, market participants buy the distant futures contracts while selling the nearby futures contracts, these assets portfolio policies can gain excess investment revenues through exchanging futures assets with different maturities.

8 Conclusion

The convenience yields implied from the futures markets are equal to prices difference between the nearby and distant futures contracts. We propose the empirical results on the options property of convenience yields and options value of exchanging futures assets using the options property of convenience yields.

Our empirical results show that the nearby and distant futures contracts exhibit a significant cointegration relationship using two-step EG model, and similar market information have a convergent impact on market prices for different futures markets. Convenience yields implied from the futures markets show time-varying trends and significantly clustering effects. Convenience yields implied from the futures markets exhibit a significant correlation with prices spreads between the nearby and distant futures contracts, and convenience yields have a significant options property. Based on extending exchange options pricing model, our empirical results show that when convenience yields implied from the futures markets are positive, convenience yields are call options. Based on the options property of convenience yields for emissions allowances, market participants make an effective policies to buy the nearby futures contracts while selling the distant futures contracts. When the convenience yields implied from the futures markets are negative, convenience yields are put options. Market participants make an effective policies to buy the distant futures contracts while selling the nearby futures contracts. Market participants optimize assets portfolio policies of futures contracts through using the convenience yields implied from the futures markets, and then they can achieve excess investment revenues.

In the actual emissions allowances markets, convenience yields implied from the futures markets exhibit time-varying trends. Firstly our empirical results show that futures prices with different maturities exhibit similar convergent trends, and they have significant cointegration relationship. Secondly we confirm the options property of convenience yields from the theoretical and empirical analysis. Thirdly, based on extending exchange options pricing model, we compare different assets portfolio policies through exchanging futures assets between the nearby and distant futures contracts discounted by risk-free interest rate, our empirical results verify that market participants can make more scientific assets portfolio policies using the options property of convenience yields, and then achieve excess market arbitrage revenues through exchanging futures assets.

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