Commodity Futures Pricing when Exposed to International Risk Factors

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***Abstract*—we proposed an expectation-oriented approach to deals with the uncertainty on futures pricing in emerging markets. The expectation model can be considered as a kind of consistent expectation based on widely accepted futures pricing model. Furthermore, we show that the expected pricing function can be verified directly from the observed data. The proposed approach can be considered as an extension of those existing no-arbitrage approaches.**

Keywords- Commodity Futures, Pricing Bias, Emerging Markets ,Unknown Parameters, Expectation Formation.

I. INTRODUCTION

No-arbitrage pricing models dominate modern futures pricing literature of international futures markets. The underlying factors inside the model are usually specified as known. To construct the risk free portfolio, the drift and volatility of the state variables are usually specified as known functions for simplicity and tractability.

However, in reality, neither the model, nor the parameter functions are known. These problems are even more complex in emerging markets. There is neither evidence nor consensus regarding which factors are best for explaining the behaviors of the futures contracts in developing countries such as China.

This immediately led to the question whether these no-arbitrage based models, built on international developed markets, can be used in emerging markets without necessary modification.

On the other hand, neglecting the existing pricing models in the price formation was indeed in common in majority papers about artificial markets.

A potential solution to these problems is to incorporate the no-arbitrage approach into trader's price expectation. This can also be considered as an economic foundation of agent-based research.

The paper is organized as follows: Section 2 presents the major articles inspired us. In Section 3, we propose an expectation-oriented approach to deals with the futures pricing bias under unknown parameters. In Section 4, we propose an approach to model risk factors. Section 5 deals with the risk factors identification. Finally, we propose a model for futures pricing in emerging markets and gives an empirical application of the proposed approach.

II. BACKGROUND AND LITERATURE REVIEW

Up to now, the mainstream method of modeling price fluctuations in agent-based models is excess demand model or market impact function.

For example, Day and Huang (1990) identified three types of market participants: alpha-investors, beta-investors and the market maker. The price change p(t+1)–p(t) was determined by the total excess demand E (p(t)) [1]:

$$p(t+1)-p(t) = c\gamma[Ep(t)],$$

where $\gamma(0)=0$ and c is an adjustment coefficient .

Westerhoff and Reitzb (2005) proposed to model the price change as a sum of time-invariant mean-reversion orders of fundamentalists, time-varying trend-extrapolating orders of chartists, and random shocks [2], i.e.:

$$p(t)-p(t-1)=a(f-p(t-1))+\delta(p(t-1)-p(t-2))/[1+\exp(-\varphi)|f-p(t-1)|/\sigma(t)]+\varepsilon(t).$$

Alfi et al.(2009) proposed to model the price formation as excess demand (ED) plus a noise term (ξ)[3]:

$$p(t+1)-p(t)=ED+\sigma\xi(t), ED=ED_f+ED_c,$$

$$ED_f=\gamma(N_f/N)(p_f-p(t)), ED_c=b(N_c/N)(p(t)-p_M(t))/(M-1).$$

where N denotes the total number of agents, N_c indicates the number of chartists and N_f is the number of fundamentalists, $p_M(t)$ is the moving average of previous prices of M steps.

On the other hand, dynamic replication and risk free arbitrage in equilibrium are prevailing tools for derivatives pricing. For example, Gibson and Schwartz (1990) introduced a two-factor constant volatility model where the spot price follows a geometric Brownian motion and the convenience yield follows a mean reverting stochastic process [4] , i.e.:

$$dS_t=-\mu S_t dt+\sigma_1 dz_S \ , \ d\delta_t=\kappa(\alpha-\delta_t)dt+\sigma_2 dz_\delta .$$

Ribeiro and Hodges (2004) proposed to model the convenience yield as a Cox-Ingersoll-Ross (CIR) process [5], i.e.:

$$dS_t=(\mu-\delta_t)S_t dt+\sigma_S S_t \delta_t^{1/2} dz_S \ , \ d\delta_t=\kappa(\alpha-\delta_t)dt+\sigma_\delta \delta_t^{1/2} dz_\delta .$$

Schwartz and Smith (2000) decomposed the spot price into two unobserved stochastic factors : the equilibrium level and the short-term deviation. The short-term deviation (χ_t) and the equilibrium level (ξ_t) are assumed to follow a mean reverting process (toward zero) and a standard Brownian motion respectively [6,7], i.e.

$$S_t = f(t) + \xi_t + \chi_t$$
$$d\xi_t = \mu_\xi dt + \sigma_\xi dW_\xi,$$
$$d\chi_t = -\kappa\chi_t dt + \sigma_\chi dW_\chi,$$
$$dW_\chi dW_\xi = \rho dt$$

where z_χ and z_ξ are standard Brownian motions with correlation $dz_\chi dz_\xi=\rho$, κ represents the rate at which the short-term deviations revert toward zero , μ_ξ is the drift of equilibrium level, σ_χ and σ_ξ are volatilities of the short-term deviation and the equilibrium level respectively.

Here, the f(t) is considered to be totally predictable, and is represented by a known deterministic function of time.

Villaplana(2004) extended the above model to include a jump component[8,9]:

$$S_t = f(t) + \chi_t + \xi_t$$
$$d\chi_t = -k_\chi \chi_t dt + \sigma_\chi dZ_\chi + J_u(\eta_u)dN(\lambda_{t,u}) - J_d(\eta_d)dN(\lambda_{t,d})$$
$$d\xi = \mu_\xi dt + \sigma_\xi dZ_\xi$$
$$dZ_\chi dZ_\xi = \rho dt$$

All of these risk neutral pricing models implicit assume that the risk factors and the parameters within the model are known with certainty.

However, nobody knows the market dynamic model, and it is not clear which of these factors listed above is the best way to explain the behaviors of the futures prices.

Therefore, traders have to form their price expectations themselves based on experiences. For so many possible models existed shown above, expectations may be quite different among traders even to the same observed price series .

So, the fundamental problem is how expectations are formed and why they are specified so. A further question is how the impact of traders' price expectation and learning on the market price formation process. In such cases, an interesting equilibrium concept related is Consistent Expectations Equilibrium (CEE).

Consider the discrete market system given by

$$p(t+1) = G(p(t)^e),$$

where G(.) is a function relating the realized market price to the expected price . Suppose traders believe that the prices are generated by an AR(1) process : $p(t)^e = \alpha+\beta(p(t-1)-\alpha)$. A CEE is a price sequence with such a belief process that is self-fulfilling in terms of sample averages and autocorrelation [10].

Furthermore, a Stochastic Consistent Expectations Equilibrium (SCEE) obtains when the sample mean and correlation coefficients of the non-linear stochastic process coincide with those predicted by the traders [11]. In such situations, traders have no reason to change their beliefs because their beliefs are not generating systematic errors.

Such considerations lead to the use of methods that explicitly address the expectation formation and the expectation bias in the presence of incomplete information. We will show that these concepts can be extended to expectation models in the form of Itô processes.

III. Pricing Bias vs Heterogeneous Expectation under Unknown Parameters

First, we review the standard futures pricing approach in the case of complete information (known parameters) as a benchmark.

Assume that the spot price (S) of the commodity follows the Itô process :

$$dS/S = \mu(S,t)dt + \sigma(S,t)dW, \quad (1)$$

where W is the standard Wiener process, $\mu(S,t)$ is the instantaneous drift and $\sigma(S,t)$ is the instantaneous volatility.

Let *F*(S,t) denotes the price at time *t* of a futures contract maturing at *T*,assuming that *F*(S,t) is a twice continuously differentiable function of *S.*

By Itô's lemma :

$$dF = F_S dS + F_t dt + F_{SS}(dS)^2/2 .$$

If $\mu(S,t)$ and $\sigma(S,t)$ are known functions of (S,t), then

$$dF = (F_t dt + F_S\mu(S,t)S + F_{SS}\sigma(S,t)^2S^2/2)\, dt + F_S\sigma(S,t)SdW$$

Using the approach of Schwartz (1985), a risk free portfolio can be constructed with futures contract and the spot commodity [9], leads to the well-known partial differential pricing equation [10],

$$(\mu(S,t)dt - \lambda\sigma(S,t))F_S + F_{SS}\sigma(S,t)^2/2 + F_t = 0. \quad (2)$$

Sometimes, we may even obtain a closed-form solution for the given drift and volatility function by the partial differential pricing equation, and we can estimate the parameters inside the model using kalman filter as [12] .

Now, consider the pricing approach under incomplete information (unknown parameters).

Unlike standard assumptions, if $\mu(S,t)$ and $\sigma(S,t)$ are unknown ,denote the estimated price process for trader i is $dS/S=\mu^e_i(S,t)dt+\sigma^e_i(S,t)dW$.Here, μ^e_i and σ^e_i indicate the private price forecasting function of trader i at present time t (Heterogeneous).

Thus, biased estimations $(\mu^e_i(S,t),\sigma^e_i(S,t))\neq(\mu(S,t),\sigma(S,t))$ occurred for some i.

Clearly, pricing equation (2) did not hold for such biased estimations $(\mu^e_i(S,t),\sigma^e_i(S,t))$.

In order to clarify the differences with respect to the case of complete information, we propose to model the pricing bias as a kind of derivative security ,a bivariate function of objective market price process and the private price forecasting.

Denote the market futures prices follows the Itô process dY ,but the estimated or believed price process for trader i is dX ($dW^1dW^2 = \rho dt$).

$$dY/Y = \mu(S,t)dt+\sigma(S,t)dW^1, \; dX/X = \mu^e(S,t)dt + \sigma^e(S,t)dW^2 .$$

We designate the pricing bias as :

G(X,Y)=X/Y.Therefore,by bivariate Itô's lemma ,

$$dG=G_tdt+G_XdX+G_YdY+(G_{XX}dX^2+2G_{XY}dXdY+G_{YY}dY^2)/2.$$

Change of relative pricing bias is:

$$dG/G= (\mu^e(S,t)-\mu(S,t)-\rho\sigma^e(S,t)\sigma(S,t)+\sigma^2(S,t))dt+\sigma^e(S,t)dW^1-\sigma(S,t)dW^2 . \quad (3)$$

We begin our analysis of pricing bias resulting from (3) with three special cases.

If it happen to be that $(\mu^e(S,t), \sigma^e(S,t))=(\mu(S,t), \sigma(S,t))$ and $\rho=1$,then $E(dG/G)=0$.That is to say traders have perfect foresight, we come back to the traditional results (homogeneous under complete information).Following [11] ,we may call the believed price process (dX) is a consistent expectation model of dY.

In the case of $\mu^e(S,t)=\mu(S,t)$, and $\rho=1$,we have :

$$dG/G = \sigma(S,t)(\sigma^e(S,t)-\sigma(S,t))dt+\sigma^e(S,t)dW^1-\sigma(S,t)dW^2$$

Even no bias in drift estimation exists, the expected change of relative pricing bias may be nonzero because of the bias in volatility estimation may exists.

In the case of $\sigma^e(S,t)=\sigma(S,t)$, $\rho=1$, systematic bias in drift estimation may exists:

$$dG/G = (\mu^e(S,t)-\mu(S,t))dt+\sigma(S,t)(dW^1-dW^2).$$

In general, $\mu^e(S,t) \neq \mu(S,t)$, systematic bias in drift estimation may exist as the result of the difficulty in the estimation of drift. In such cases, we may hope the forecasting bias is bounded， and a important question is whether the cumulated forecasting bias is mean reverted to zero.

Thus, we hope the cumulated pricing bias (X) follow such stochastic process:

$$dX = \kappa(\alpha - X)dt + \sigma dW,$$

with ideal case $\alpha=0$, and the bigger κ, the better.

In a word, in the presence of incomplete information, systematic bias in drift estimation may exist .So, questions are twofold, one is to identify the market stochastic process (dY),another is how to deal with subjective estimation bias (dX).

IV. MODELING OF RISK FACTORS AND RISK EXPOSURE

Let x_i indicates the unobserved (or observed) risk factors identified by financial institutions. For example, this could be the mispricing in some assets markets, the leverage of the financial system as a whole, or credit default swaps index.

We denote the risk measurement of the entire financial system as a function of these risk factors : $F(x_1, x_2, x_3, ..., x_k, t)$. Once the risk function $F(x_1, x_2, x_3, ..., x_k, t)$ defined and risk factors identified, we can construct measures of risk exposure.

The main idea is to model the potential risk factors as stochastic processes, and take the complex interactions among these risk factors as a kind of derivative product.

Assume that systemic risk factor x_i follows the Itô process :

$$dx_i(t) = \mu(x_i, t)dt + \sigma(x_i, t)dW(t), \qquad (1)$$

where W(t) is the standard Wiener process, $\mu(x_i,t)$ is the instantaneous drift and $\sigma(x_i,t)$ is the instantaneous volatility.

Assuming $F(x_1, x_2, x_3, ..., x_k, t)$ is twice continuously differentiable function of x_i and t.

By Itô's lemma, we have

$$dF(x_1, x_2, x_3, ..., x_k, t) = \frac{\partial F}{\partial t} + \sum_{i=1}^{k} \frac{\partial F}{\partial x_i} dx_i + \sum_{i,j=1}^{k} \frac{\partial^2 F}{\partial x_i \partial x_j} dx_i dx_j .$$

(2)

If $F(x_1, x_2, x_3, ..., x_k, t)$, $\mu(x_i, t)$ and $\sigma(x_i, t)$ are known functions, we can easily measure the changing of risk exposure using time series observations.

However, in general, both $F(x_1, x_2, x_3, ..., x_k, t)$, $\mu(x_i, t)$ and $\sigma(x_i, t)$ are unknown : they are about movements of potential risk factors.

In order to solve the problem, we propose to apply an expectation oriented approach, which is borrowed from the standard derivative pricing approach under complete information.However, the underlying economic mechanisms are quite different.

For simplicity, as a first step, the financial institution's subjective expectation model on risk factors may be constructed below:

$$F(x_1, x_2, x_3, ..., x_k, t) = \Pi x_i^{\alpha_i} . \qquad (3)$$

The expectation function considered here is to model the comprehensive impact created by a set of risk factors (x_i) identified .

Here, the expectation function F(.) is not a derivative asset in the usual sense, it is a subjective expectation to be verified.

Risk factors (x_i) identified may be known to the financial institution, but the risk function F(.) and parameters (α_i) are unknown to be determined.

Clearly, there is no partial differential pricing equation existed with such unknown functions. The final pricing formula is completely different and still unknown.

Because

$$\frac{\partial F}{\partial x_i(t)} = \frac{\alpha_i F}{x_i(t)},$$

$$\frac{\partial^2 F}{\partial x_i(t) \partial x_j(t)} = \frac{\alpha_i \alpha_j F}{x_i(t) x_j(t)}. \qquad (4)$$

$$\frac{dF}{F} = \sum \frac{\alpha_i dx_i(t)}{x_i(t)} + \frac{1}{2} \sum_{i,j=1}^{k} \frac{\alpha_i \alpha_j}{x_i x_j} dx_i dx_j . \qquad (5)$$

$$r_F = \sum_{i=1}^{3} \alpha_i r_{x_i} + \frac{1}{2} \sum_{i,j=1}^{k} \alpha_i \alpha_j r_{ij} . \qquad (6)$$

$$r_F \cong \frac{dF}{F}, r_{x_i} \cong \frac{dx_i(t)}{x_i(t)}, r_{ij} \cong \frac{dx_i dx_j}{x_i x_j} . \qquad (7)$$

With such subjective risk function, we can measure the changes in systemic risk as a linear combinations of changes in risk factors and their interactions (6).

More important ,with such defined risk function we can measure the risk exposure of financial institution.

V. IDENTIFICATION OF RISK FACTORS

To demonstrate this methodology of risk factors identification and measurement, we carry out an correlation analysis on the daily returns on the China commodity futures markets with potential risk factors.

According to our experience, three international factors are taken as potential risk factors to China commodity futures markets : the risk from US Dollar, the risk from european sovereign debt crisis, investor sentiment to these factors.

The U.S. Dollar Index (USDX) is an index of the value of the United States dollar relative to a basket of foreign currencies. We choose USDX as a measure of potential systemic risk resulting from Federal Reserve's expansionary monetary policy .

The CBOE Volatility Index (VIX), conveyed by S&P 500 stock index option prices, is considered to be a measure of market expectations and investor sentiment .

Five year sovereign credit default swaps (CDS), priced in spread (premium payment/year), are considered to be measure of sovereign credit risk. CDS data include Portugal, Italy, Ireland, Spain, German, France and UK.

We use data from domestic and corresponding international futures market : gold, copper, aluminium futures prices series of Shanghai Futures Exchange (SHFE), copper, aluminium futures prices series of London Metal Exchange (LME), cotton and sugar futures prices of Zhengzhou Commodity Exchange (ZCE) and IntercontinentalExchange (ICE), gold futures prices series of COMEX .

All of above data are taken from bloomberg.com, corresponding spot markets data are taken from fuyoo software (www.fuyoo.net). The data used consist of daily observations, ranging from 9/15/2011 to 11/25/2011, and calculated as daily returns .

Fig.1 plots the 5 year sovereign credit default swap spread time series . These CDS series exhibit a similar pattern. We may use one of them as a proxy of sovereign credit risk, for example, CDS of Portugal.

First, to demonstrate sovereign CDS, USDX and VIX are risky factors, as we anticipated, table I exhibits the high negative correlations on the daily returns between gold futures with these factors.

Table II exhibits the high correlations on the daily returns between sovereign CDS series with the other risky factors considered : USDX and VIX.

Because of these similar high correlations among them, for simplicity, we use a simple two factor (USDX and VIX) model as a approximation for the three factor risk model (sovereign credit, USDX,VIX) in the follow analysis.

TABLE I
CORRELATIONS BETWEEN GOLD FUTURES AND RISK FACTORS

	SHFE_gold	COMEX_gold
SHFE_gold	1	0.741218
COMEX_gold	0.741218	1
VIX	-0.30886	-0.34545
USDX	-0.29792	-0.48169
portugal	-0.06836	-0.34297
italy	-0.06259	-0.27404
ireland	-0.02109	-0.28265
german	-0.22912	-0.44399
france	-0.16998	-0.40969
uk	-0.19141	-0.41913

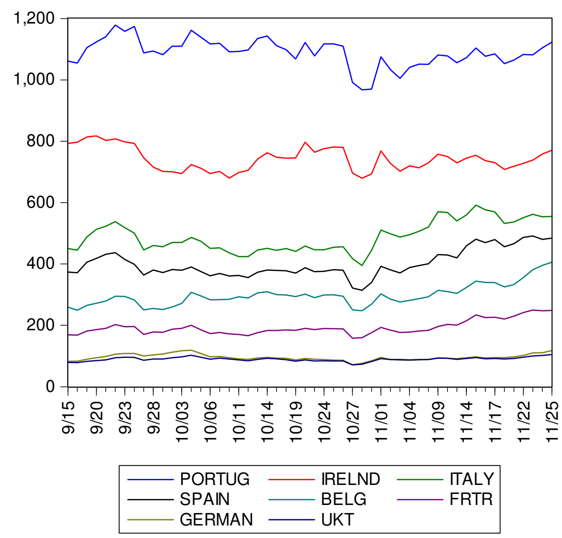

Fig. 1. 5 year sovereign credit default swap spread time series .

Furthermore, if USDX and VIX are systemic risk factors, they should affect all assets markets, including commodity futures markets in China. Therefore, by risk function defined in (3), (6) suggests we can observe more influence in these factors on commodity futures returns than traditional factors, such as spot market prices, convenience yield .

TABLE II
CORRELATIONS BETWEEN SOVEREIGN CDS WITH USDX VIX

	USDX	VIX
Portugal	0.606016	0.415058
Italy	0.726438	0.636026
Ireland	0.560551	0.406886
Spain	0.739324	0.606447
German	0.770556	0.579924
France	0.765113	0.571726
UK	0.768953	0.560888

TABLE III

CORRELATIONS BETWEEN COPPER AND RISK FACTORS

	SHFE_copper	spot_copper	LME_copper
SHFE_copper	1	-0.01506	0.021303
spot_copper	-0.01506	1	0.753398
LME_copper	0.021303	0.753398	1
VIX	-0.49715	0.047269	-0.12306
USDX	-0.46461	-0.03395	-0.17093

TABLE IV

CORRELATIONS BETWEEN ALUMINUM AND RISK FACTORS

	SHFE_aluminum	spot_aluminum	LME_aluminum
SHFE_aluminum	1	0.098656	0.318307
spot_aluminum	0.098656	1	0.008704
LME_aluminum	0.318307	0.008704	1
VIX	-0.44294	0.113127	-0.64521
USDX	-0.38924	-0.03058	-0.7029

As we expected, Table III witness the highly negative correlations between the daily returns of SHFE copper futures with the propsed risk factors.

First, both domestic spot market and international futures market (LME) play little role in the SHFE copper futures market, but international futures market (LME) has a great influence on the copper spot market in China.

Second, systemic risk factors (USDX and VIX) may have influence on LME copper futures, but they give a great influence on the SHFE copper futures market, which can not be resulted in transmission from these factors to LME copper futures. This suggests that systemic risk factors affect domestic copper futures market directly.

These results are supportive of our hypothesis : highly negative correlations suggests USDX and VIX are systemic risk factors to domestic futures markets .

To further verify our intuition, we examine whether the same pattern existed in domestic aluminium futures market from SHFE (Shanghai Futures Exchange) and cotton and sugar futures markets from ZCE (Zhengzhou Commodity Exchange).

As we anticipated, Table IV, V and VI exhibits the high negative correlations on the daily returns between the domestic futures markets with the systemic risk factors.

Contrary to the SHFE copper futures market, table IV exhibits the highly negative correlations between LME aluminium futures with the systemic risk factors. This suggests another complex pattern existed in SHFE aluminium futures market : systemic risk factors may affect domestic futures market both directly and indirectly (systemic risk factors affect international futures market, international futures market affects domestic futures market).

Table V exhibits a similar pattern existed in ZCE sugar futures markets, however, international futures market (ICE) has a great influence on domestic futures market than systemic risk factors.

Table VI exhibits the same pattern existed in ZCE cotton futures markets : systemic risk factors may affect domestic futures market both directly and indirectly .

Whether systemic risk factors affect domestic futures market directly, or indirectly (systemic risk factors affect international futures, international futures affect domestic futures), the transmission mechanisms matter.

Anyway, these empirical results show that, there are strong correlations between domestic futures with such risk factors. That is to say, domestic futures exposed to such international risk factors, which may play more important role than domestic spot market .

This suggests further research on commodity futures pricing in emerging markets should take into account such effect.

VI. Domestic Commodity Futures Pricing with International Risk Factors

According to the results in Section V, we propose to model the spot price in emerging markets with both observed and usual unobserved stochastic factors (the equilibrium level and the short-term deviation).

$$\begin{aligned} \ln S_t &= V_t + \xi_t + \chi_t, \\ V_t &= f(Z_1, Z_2, Z_3, ..., Z_k) \\ dZ_i &= \mu_{Z_i} dt + \sigma_{Z_i} dW_{Z_i}, \\ d\xi_t &= \mu_\xi dt + \sigma_\xi dW_\xi, \\ d\chi_t &= -\kappa\chi_t dt + \sigma_\chi dW_\chi, \\ dW_\chi dW_\xi &= \rho dt \end{aligned} \quad (8)$$

The additional terms V_t try to capture the risk factors (Z_i) identified , such as the risk from US Dollar, the risk from european sovereign debt crisis, the risk from international futures markets,etc,.However,because such risk factors are to be identified ,we can not find a solution in general for such model (8).

For simplicity , as a first step ,we may take international futures markets as the observed risk factor, the spot prices in emerging markets decomposed into two components: the observed risk factor (international futures prices,y_{t-1}) and the short-term deviation (χ_t).

$$\begin{cases} S_t = \chi_t + \omega y_{t-1} \\ d\chi_t = -\left(\phi_\chi + \kappa\chi_t\right)dt + \sigma_\chi dW_\chi + J\left(\mu_J, \sigma^2{}_J\right)dN_t(\lambda) \\ dy_t = \left(\mu_y - \phi_y\right)dt + \sigma_y dW_y \\ dW_\chi dW_y = \rho dt \end{cases}$$
$$\kappa, \sigma_\chi, \sigma_y > 0 \qquad (9)$$

Assume China cotton spot market are driven these two underlying factors: international cotton futures prices (New York Board of Trade ,NYBOT) and a short-term deviation .

We get the pricing formulas below with the approach of Villaplana(2004)[8,9].

$$F(t,T,S_t) = e^{r(T-t)}\Psi(u,x,t,T)\cdot(A(t)+B_1(t)\chi_t+B_2(t)y_{t-1})$$
$$=e^{r(T-t)}e^{-r(T-t)}(A(t)+B_1(t)\chi_t+B_2(t)y_{t-1})$$
$$=\omega(\mu_y-\phi_y)(T-t)-\frac{\varphi_\chi}{\kappa}(1-e^{-\kappa(T-t)})+\lambda\frac{\mu_J}{\kappa}(1-e^{-\kappa(T-t)})+e^{-\kappa(T-t)}\chi_t+\omega y_{t-1}$$

VII. EMPIRICAL RESULTS

To demonstrate this methodology, we carry out an empirical exploration on the daily returns on the China cotton futures (traded in Zhengzhou Commodity Exchange, ZCE) from January 18, 2010 through January 18, 2013.

The China cotton spot prices and futures prices (CF1101,CF1201,CF1301) are getting from webstock software (www.webstock.com.cn), CF1301 indicates Contract 1301, delivery in January,2013.

Over the sample period, the spot copper prices are calculated as the average of daily bid and ask quotes, daily return series are calculated as the difference between current close price and previous close price divided by previous close price.

Fig.1 shows cotton futures prices over the sample period with considerable jumps.

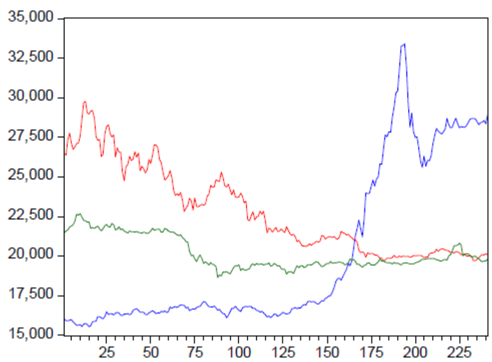

Fig.1 China cotton futures prices

Main estimation results are provided in Table I .

The results are supportive of our hypothesis: μ_J indicates the expected size of jump, λ indicates the probability of jump in a day, ω represents the influence of international cotton futures prices.As we expected,all of these coefficients are significant.

The signs of the coefficients are in the right direction, being in line with our intuition.

TABLE I. ESTIMATED PARAMETERS

	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error
σ_J	474.4	64.5200	147.1169	26.4527	90.6279	24.3970
μ_J	119.9979	0.1181	120.0000	0.0125	-9.9998	0.0073
σ_χ	1.23	0.5985	1.2417	0.6095	1.0017	0.0353
κ	0.0114	0.0016	0.0033	0.0008	0.230	0.0148
σ_y	1.027	0.3678	1.0274	0.5526	1.1038	0.5217
λ	0.7331	0.0897	0.3716	0.0629	0.2337	0.0902
ω	198.9976	0.1042	190.0007	0.0639	159.9972	0.0755
ρ	-0.3570	0.1272	-0.1119	0.0108	-0.3038	0.2153

Finally, the forecasting bias generated by the expectation model is shown in Fig.2 and Fig.3.

However,Fig.2 and Fig.3 shows considerable differences in our expected return in compare with the cotton futures market return.

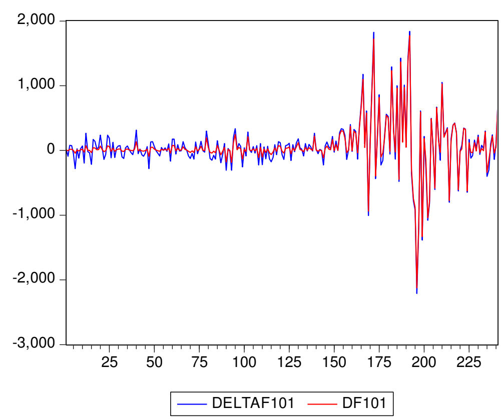

Fig.2 pricing bias of China cotton futures (CF1101)

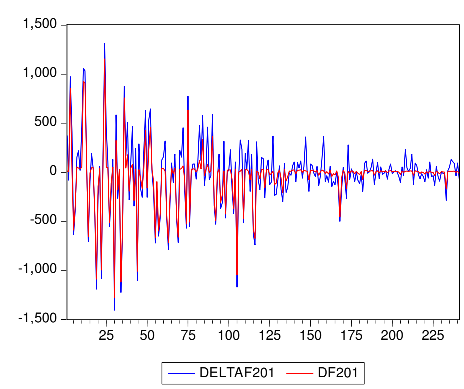

Fig.3 pricing bias of China cotton futures (CF1201)

Conclusion

This article deals with the uncertainty on futures pricing in developing countries such as China.

We proposed an expectation approach to explore the futures pricing which incorporate the parameters uncertainty.

The model considered here is expectation oriented, this differs to the previous futures pricing models in that it incorporates trader's subjective price expectation as the critical explanatory variables.

On the other hand, existing futures pricing models can be considered as candidate price expectations to be verified under incomplete information. This allows for the combination between the existing pricing model and agent-based models.

Consequently, we might be able to understand the complex dynamics of market price formation from agent's expectation and learning.

These results questioned those applications of no-arbitrage based pricing models in the presence of incomplete information. However, much more work remains to be done .

Acknowledgment

This project was supported by the fund for Discipline Construction (PXM2013_014212_000005) from Beijing Municipal Education Commission, the grant for grand research project on computational finance and oil derivatives from North China University of Technology and the Youth Project of Humanities and Sociology (08JC790004) from the Ministry of Education.

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