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ANALYSIS ON INFLOWS OF INDEX INVESTORS AND DETERMINANTS OF FUTURES PRICE

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ABSTRACT

In this paper, based on a description of the four major players of commodity spot and futures markets, we establish a multi-phase equilibrium model of price determination, and then analyze the influence of the entry of a large number of index investors on the risk premium, inventory management, and different traders' positions of commodity futures. The result shows that, the correlation between the stock market and commodity futures markets, the index investors' entering and demanding for commodity spot both are important factors to decide the price of the commodity futures market and the trader behavior. The empirical results also support this view.

Keywords: *Commodity Future Market, Index Trader, Risk Premium, Position*

1. INTRODUCTION*

Traditionally, the main functions of the commodity futures market are price discovery and hedging. Another function of the commodity futures market is increasingly prominent, that is, as an important class of assets, diversifying portfolio risk. Since the U.S. Commodity Futures Modernization Act came into effect in 2000, institutional investors can invest in commodity futures index through swap. The report on index trading of the U.S. Commodity Futures Trading Commission (CFTC) in 2008 shows that the size of the commodity futures index trading in 2003 was $ 15 billion, and increased to over two hundred billion U.S. dollars in mid-2008 [5].

2. LITERATURE REVIEW

In the early days, there are mainly two perspectives on futures prices determination in the academia. One is the theory of normal backwardation. The theory is that the commodity producers need oversell futures contracts to avoid future price risk. Speculators as a buyer of the futures contract is due to take risks and get some rewards, the so-called risk premium. The other is the theory of storage[8,13,3,12]. The theory emphasizes the important role of storage in the futures price determination, and introduces convenience yield as the reason of storage, supposing that futures price is jointly decided by the cost of inventories, interest rates and convenient benefits.

Since 2000, with the massive influx of index investors, the commodity futures market was experiencing the financing process. Not only the correlation between commodity futures price index and other major financial market indices increased significantly, and the correlation between the different commodity futures is also increasing[11]. The correlation between commodity futures markets and stock markets over the past 20 years the stock market has significantly increased through multivariate GARCH model[10]. In the oil futures market since 2004 that, the linkage between the contract price of long maturity and short maturity was growing, and they thought swap dealers, hedge funds and other institutional behavior in recent years led to this change[4]. In contrast, index investors did not cause significant impact on the commodity futures market[7].

In domestic research, since financial crisis in 2008, as international commodity price soars, Chinese scholars pay more and more attention to the commodity futures market. About the influence of commodity futures index investment instruments and trader behavior on the spot and futures markets, a commodity futures contract pricing model is constructed, which showed that the price of commodity futures contracts is jointly determined by the capital market systemic risk premium and the spot market special risk premium, and if there is a sufficient number of commodity futures market traders, commodity spot prices will affect the prices of commodity future. Commodity futures price is

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determined by financial factors and the supply and demand factors, and commodity index investment tools is an important guarantee of the healthy development of the commodity futures market. The increase in yield will cause the rise of the fund's net position; vice versa does not hold.

We can see from the literature review, the current domestic and foreign scholars' attention is mainly concentrated in three areas: the entry of index investors, emerging market demand for commodities; correlation between different financial markets. However, most of the researches only talk about one aspect. This paper attempts to portray index investor behavior, and established multi-phase equilibrium commodity future pricing model to analyze the correlation between the stock market and commodity futures markets, index investors, capital inflows and commodity spot demand for the commodity futures market. Although not many index investors come into the commodity futures market, but there is reason to believe that the U.S. Commodity Futures market research helps to further explore and improve and develop our own market.

The current commodity futures market models mostly only consider the interaction between producers and traditional speculators. Due to the large-scale entry of index investors and index investors can both invest in the stock market and commodity futures market, the cross-market portfolio optimization allows us to take full account of the influence of correlation between different markets on the commodity futures market prices and the risk premium, and further the impact on other different types of Traders behavior.

3. MULTI-PHASE COMMODITY FUTURE EQUILIBRIUM MODEL

We established a multi-phase commodity futures market equilibrium model[1,6].

First, assuming that there are five types of assets in the economy: a stored commodity, the future contracts based on the commodity, commodity futures index as the underlying investment vehicles (such as ETF), other financial assets (such as stock index), as well as risk-free bonds (or bank account).

At the same time, it is assumed that there are four categories of participants: consumers, producers, speculators and index traders in the economy as a whole. Consumer is the demand side of the spot commodity, not involved in any transactions of financial assets. As the supply side of the commodity, the commodity outputs of the producers in the beginning is non-negative, and part of them as inventory, with the rest sold to consumers, forming the current income. In order to hedge against future price uncertainty, producers oversell commodity futures contracts to achieve hedge. The traditional speculators are just the buyer of the commodity futures market without commodity production. Comparing to traditional speculators, index investors invest in commodity futures through exchange-traded fund (ETF), to diversify risk relying on weak correlation between commodity futures market with other markets. Therefore, this article assumes that index investors hold both commodity futures positions and the stock and risk-free bonds. Index investors initially apportion wealth to these assets and try to maximize the wealth. Ultimately, the futures market clearing determines the optimal behavior of all types of traders, and thus determines the equilibrium spot and futures prices. Next the behavior of the various participants will be discussed.

3.1 Consumers

In each period, according to the foregoing assumptions, the consumers only purchase goods. Under the given supply of commodities, consumer inverse demand function can be expressed as:

$$S_t = \omega\left(\frac{A_t}{Q_t}\right)^{\frac{1}{\varepsilon}} \quad (1)$$

Where t = 0, 1, ..., T, S_t the spot price of goods, Q_t —equilibrium commodity supply, A_t — demand shocks for commodities. It is assumed that the demand shock follows a lognormal distribution, ie $\ln A_t \sim N(\mu_A, \sigma_A^2)$. ω, ε are parameters. Without loss of generality, it is assumed when t=0, no demand shocks, i.e. A_0 = 1.Then the spot price of 0 depends only on the balanced supply $S_0 = wQ_0^{-\frac{1}{\varepsilon}}$. Consider in period t, when the producer inventories choice is given, we can infer that S_t also follows the lognormal distribution, and the period t information-based conditional mean and conditional variance can be expressed as:

$$E(S_t) = \omega Q_t^{-\frac{1}{\varepsilon}} \exp\left(\frac{\mu_A}{\grave{o}} + \frac{1}{2}\left(\frac{\sigma_A}{\grave{o}}\right)^2\right) \quad (2)$$

$$Var(S_t) = \omega^2 Q_t^{-\frac{2}{\varepsilon}} \exp\left(\frac{2\mu_A}{\grave{o}} + \left(\frac{\sigma_A}{\grave{o}}\right)^2\right)\left(\exp\left(\frac{\sigma_A^2}{\grave{o}^2}\right) - 1\right) \quad (3)$$

3.2 Producers

On the one hand, producers engaged in commodity production, inventory management, the formation of commodity supply; on the other hand, hedging in the futures market. First, consider the

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inventory behavior of the producer. Assume that commodity outputs are given exogenously, denoted as gt. the commodity supply of period 0 and t can be expressed as:

$$\begin{aligned} Q_0 &= g_0 - i \\ Q_t &= g_t + i_{t-1}(1-\delta) \\ t &= 1,\cdots,T \end{aligned} \tag{4}$$

Where it is inventory level and δ is natural attrition rate of inventory.

Assume that there are many homogeneity producers in the market, which means producers are in a perfectly competitive market. Taking a representative producers as an example, he storages part of the merchandise as inventory it of Period t, while he sells the remaining merchandise to consumers to earn income, and holds the commodity futures short ξ_{pt}; To t +1, he makes the inventory choice, selling the remaining commodity (the current output plus previous inventory minus the current inventory), and opens futures contracts and goes into the next phase. Suppose that the producer is risk adverse, pursuit individual wealth maximization, and expected utility function is expressed as mean - variance utility form. The producer's decision problem can be expressed as follows:

$$\max_{t=0,\cdots,T-1} \sum_{t=0}^{T} \beta^t \left\{ E[\tilde{W}_{pt}] - \frac{\gamma_p}{2} Var[\tilde{W}_{pt}] \right\} \max_{t=0,\cdots,T-1} \sum_{t=0}^{T} \beta^t \left\{ E[\tilde{W}_{pt}] - \frac{\gamma_p}{2} Var[\tilde{W}_{pt}] \right\} \tag{5}$$

$$\text{s.t.} W_{po} = S_0(g_0 - i_0)$$

$$\begin{aligned} \tilde{W}_{pt} &= S_t\left(g_t + i_{t-1}(1-\delta)\right) + \xi_{pt}\left(f_{t-1} - S_t\right), \\ t &= 1,\cdots,T \\ i_t &\geq 0 \end{aligned} \tag{6}$$

where γ_p—producers' risk aversion, $\tilde{W}_{pt}$ — wealth of inventories at the end of t, it ≥ 0— inventory is non-negative. β^t is the discount factor. According to standard Lagrangian method can get the optimization first-order conditions:

$$\begin{aligned} \text{i}_0\text{:}\ \ & g_1 + i_0(1-\delta) - i_1 = \xi_{pt} \\ & + \frac{\beta(1-\delta)E[S_1] - S_0 + \lambda_1}{\beta(1-\delta)\gamma_p Var(S_1)} \end{aligned} \tag{7}$$

$$\begin{aligned} \text{i}_t : & -E[S_t] + \gamma_p Var[S_t]\left(g_t + i_{t-1}(1-\delta) - i_t - \xi_{pt-1}\right) \\ & + \beta\left\{(1-\delta)E[S_{t+1}] - \gamma_p\left(g_{t+1} + i_t(1-\delta) - i_{t+1} - \xi_{pt}\right)(1-\delta)Var[S_t]\right\} \\ & + \lambda_t = 0 \end{aligned} \tag{8}$$

$$\xi_{pt}: \left\{ \begin{aligned} & -E[S_{t+1}] + f_t + \\ & \gamma_p\left(g_{t+1} + i_t(1-\delta) - i_{t+1} - \xi_{pt}\right)Var[S_t] \end{aligned} \right\} = 0 \tag{9}$$

Then we can get

$$\begin{aligned} \xi_{pt-1} &= g_t + i_{t-1}(1-\delta) - i_t - \\ & \frac{E[S_t] - \beta(1-\delta) f_t - \lambda_t}{\gamma_p Var(S_t)} \xi_{pt-1} \\ &= g_t + i_{t-1}(1-\delta) - i_t - \frac{E[S_t] - \beta(1-\delta) f_t - \lambda_t}{\gamma_p Var(S_t)} \end{aligned} \tag{10}$$

where λ is non-negative Lagrange multiplier of inventory. If λ = 0, inventory is in a normal level. If λ> 0, i = 0, indicating the inventory depletion.

According to the first-order conditions, if the futures price is unbiased, $f = E[S_1]$, obviously the producers will hedge all output and inventories. In this case, the optimal numbers of futures positions and producers risk aversion are unrelated. However, if $E[S_1] - f > 0$, there is the risk premium and optimal futures position is less than the commodity supply. For producers, the optimal futures position can be seen as a combination of two different strategies. On the one hand, they hedge all of the output and inventories; on the other hand, to obtain long positions of the risk premium. In fact, the latter is the reason why traditional speculators are willing to hold long positions. In addition, the optimal futures position increases with the degree of risk aversion, which means that when the producers become more risk-averse, they will tend to hold more short positions.

When t=1, comparing（7）to（10）, we can get:

$$f_1 = \frac{1}{(\beta(1-\delta))^2} S_0 - \frac{(1+\beta(1-\delta))\lambda_1}{(\beta(1-\delta))^2} \tag{11}$$

Then we get (12) from（9）and (10)

$$f_{t+1} = \frac{f_t - \lambda_{t+1}}{\beta(1-\delta)} \tag{12}$$

By（11）and（12）:

$$f_0 = \frac{S_t - \lambda_1}{\beta(1-\delta)} \tag{13}$$

(13) is exactly the same with the relationship between futures and spot price under two-state model. Specifically, if you consider the discount factor, the futures price is only related to the current spot price and the rate of loss of inventory, and has nothing to do with the future spot price S_1. This result is consistent with the classic futures pricing theory in essence. It needs to be pointed out here, futures prices don't include convenience benefits,

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because we did not assume that producers benefit from stock†.

3.3 Speculators

The traditional speculators' main purpose is to earn risk premium, only participating in the commodity futures market. Under normal circumstances, the traditional speculators hold futures long positions. It is clear that in extreme cases, they can also hold short positions. In addition, assume that the traditional speculators have no other source of income. The optimization problem can be expressed as:

$$\max_{t=0,\cdots,T-1} \sum_{t=0}^{T} \beta^t \left\{ E[\bar{W}_{st}] - \frac{\gamma_s}{2} Var[\bar{W}_{st}] \right\} \quad (14)$$

s.t.

$$\bar{W}_{st} = \xi_{st-1}(S_t - f_{t-1}), \quad t = 1,\cdots,T \quad (15)$$

First-order condition:

$$\xi_{st} = \frac{E(S_{t+1}) - f_t}{\gamma_s Var(S_{t+1})} \quad (16)$$

where γ_s — traditional speculators risk aversion, ξ_{st} — commodity futures positions held by traditional speculators. If the traditional speculators are risk-neutral, that is γ_s=0, then the market clearing requires futures prices unbiased, that is, the futures price is equal to the expected future spot price.

3.4 Index Investors

Assuming that index investors invest in different market to achieve risk benefit maximization, under normal circumstances, these investors are more concerned about the long-term investment performance, preferring passive investment strategy, that is allocating the existing funds to different asset classes in a certain proportion and maintaining the portfolio unchanged for a long time . It is assumed that the index investors primarily through tools such as ETF or ETN invest in commodity futures index, and do not invest in particular commodity futures. Therefore, the decision-making of index investor can be described as follows:

$$\max_{t=0,\cdots,T-1} \sum_{t=0}^{T} \beta^t \left\{ E[\bar{W}_{it}] - \frac{\gamma_i}{2} Var[\bar{W}_{it}] \right\} \quad (17)$$

s.t.

$$\bar{W}_{it} = W_{it-1}\left(1 + r + \theta_{t-1}\bar{R}_M + (1-\theta_{t-1})\bar{R}_C\right), \quad t = 1,\cdots,T \quad (18)$$

Where γ_i—index investors risk aversion, W_{i0} — initial wealth of index investors, θ_t—the proportion of investment in stock market, 1-θ_t —the proportion of investment in commodity futures markets, $\tilde{R}_M$ —the excess rate of return of stock market, $\tilde{R}_C$ —the excess rate of return of commodity futures index stock market.

A derivation of the θ_t, the optimization problem can be obtained:

$$\theta_t = \frac{\frac{E(\bar{R}_M) - E(\bar{R}_C)}{\gamma_i W_{it}} + Var(\bar{R}_C) - Cov(\bar{R}_M, \bar{R}_C)}{Var(\bar{R}_M) + Var(\bar{R}_C) - 2Cov(\bar{R}_M, \bar{R}_C)} \quad (19)$$

The proportion of investment in commodity futures markets:

$$1-\theta_t = \frac{\frac{E(\bar{R}_C) - E(\bar{R}_M)}{\gamma_i W_{it}} + Var(\bar{R}_M) + Cov(\bar{R}_M, \bar{R}_C)}{Var(\bar{R}_M) + Var(\bar{R}_C) - 2Cov(\bar{R}_M, \bar{R}_C)} \quad (20)$$

From (19) and (20), when the stock market is in recession and the commodity futures market has a higher return than the stock market, index investors have more initial wealth will lead to less proportion of commodity assets. The coefficient of relative risk aversion is a decreasing function of wealth. But the absolute amount of wealth invested in commodity index increase.

3.5 Equilibrium

Here we only consider the case of the commodity futures market equilibrium, that is, the market clearing requires short positions held by producers equal to long positions held by traditional speculators and index investors. Index investors invest in commodity futures index, not form a direct demand of commodity futures. Assuming long positions is proportional to the total amount of funds invested by index investors, and the proportion coefficient is α. The commodity futures market clearing conditions can be expressed as:

$$\xi_{pt} = \xi_{st} + \alpha W_{it}(1-\theta_t) \quad (21)$$

We define commodity futures risk premium as $E[S_{t+1}] - f_t$. First-order conditions on behalf of three types of traders of the market clearing condition can be obtained.

† Routledge, Seppi and Spatt (2000) pointed out in multi-period model, convenience earnings should exist as long as there is the possibility of inventory depletion.

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$$E(S_{t+1}) - f_t = \frac{\gamma_p \gamma_s Var(S_{t+1})}{\gamma_p + \gamma_s}[g_{t+1} + i_t(1-\delta) - i_{t+1} - \alpha W_{it0+} \frac{\frac{E(\tilde{R}_C) - E(R_M)}{\gamma_I W_{it}} + Var(\tilde{R}_M) + Cov(\tilde{R}_M, R_C)}{Var(\tilde{R}_M) + Var(\tilde{R}_C) - 2Cov(\tilde{R}_M, \tilde{R}_C)}] \quad (22)$$

By (22), we can see the factors of commodity futures risk premium mainly include the following aspects:

First, the degree of risk aversion of various traders in the market. When any type of trader's risk aversion increases, the risk premium of commodity futures will be reduced[1].

Secondly, the producer hedging demand, expressed as $g_{t+1} + i_t(1-\delta) - i_{t+1}$ .When hedging pressure becomes larger, inventories increase and commodity supply decreases. This is the biggest difference between multi-period model and two models.

Thirdly, the risk premium of commodity futures is not only determined by the spot futures market, but the stock market. Then you need to balance the risks and benefits of investing in the stock market and commodity futures index.

Finally, the amount of index investors fund is also an important impact on the risk premium of commodity futures. When the amount of index investors owned greater the amount of money and invest more in commodity futures index, the risk premium of commodity futures will be the smaller instead. Intuitively, when the index investors invest more, which means Indexation transactions generate greater demand for commodities futures, to some extent, competition forms between index investors and traditional speculators. The producers do not need to pay a high risk premium to traditional speculators and index investors, because the same purpose can be achieved by trading with index investor to the transfer risk.

3.6 Comparative Static Analysis

Taking corresponding variable into (22), we get an inventory dynamic non-linear equations, with numerical iterative for solving the optimal path of the inventory. During the numerical solution, first we give the parameter assignment that is setting parameter calibration (Calibration).

Reference to the method[1], with the risk-free rate of 1%, the discount factor $\beta = 1/(1+r) = 1/1.01$.The inventory loss ratio of δ = 0.01 and output is constant, g_t=2. The demand shock is equal to a quarter of the world's GDP growth μ_A = 0.004, σ_A = 0.02. Producers, traditional speculators and index investors' risk aversion coefficient are 8, $\gamma_p = \gamma_s = \gamma_t = 8$. ω = 10 and ε = 0.1. Index investors initial wealth W_{i0} = 10, the proportion of commodity futures accounting for commodity futures index is 10%. The expected return and variance of the stock market use quarterly average expected return and variance of S & P 500 index over the past 10 years, $E(\tilde{R}_M) = 0.005$, and $Var(\tilde{R}_M) = 0.0014$. Commodity futures index's returns and variance use the quarterly average return and variance of S & P Goldman Sachs commodity futures index (S & P-GSCI) in the past 10 years, $E(\tilde{R}_C) = 0.01$, $Var(\tilde{R}_C) = 0.0025$. The correlation coefficient between the stock market and commodity futures markets is set to the correlation coefficient between the quarterly return of the S & P 500 Index and the S & P-GSCI Index, ρ_{MC} = -0.16.

According to the above set of parameters, with a simple numerical iterative algorithm, we can easily get balanced inventories path. Then substituting optimal inventory into the first-order conditions, we get the solution of each variable. However, this article is concerned that when certain parameter value changes, how the other variables a deviate from the original path. So we change the correlation coefficient of the stock market and the commodity futures market, index investors' initial wealth, and study how stock futures prices, all kinds of positions held by traders change, and take commodity demand shocks into account.

The main results of comparative static analysis are summarized as follows:

Conclusions 1: the greater the correlation coefficient of the stock market and commodity futures markets, the greater the inventory, the greater the risk premium of commodity futures. Producers and index investors reduce positions, and traditional speculators will increase positions.

Shown in figure 1, the greater the correlation coefficient of the stock market and commodity futures markets, for index investors, means the risk diversifying of commodity futures index, as an asset class, weakens, and the positions of commodity futures index assets will be reduced. The producers have to reduce the futures positions for hedging, although traditional speculators can increase positions to bear the risk that the index investors are unwilling to bear, but this still cannot meet the demand for hedging by producers. As a response, producers will increase the inventory of each period, to reduce the commodities supply, leading rising commodity prices and a corresponding increase in the risk premium.

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The correlation between the stock market and commodity futures markets may be caused by the behavior of the traders, that is this correlation may be endogenous, but this is beyond the scope of this article.

Conclusion 2: the more funds that index investors invest in commodity futures index, the smaller the inventories, and the smaller the risk premium of commodity futures. Producers and index investors will increase positions, and traditional speculators will reduce positions.

Shown in Figure 2, the larger the amount of money that index investor invest in commodity markets, the greater the long positions held by commodity futures, largely easing the pressure on producer hedging, so that producers can trade with index investors. In this case, the producers can hedge in the futures market more easily and can hold less inventory so the spot supply of period increase. Under the demand for commodities is constant, the spot price of goods is expected to reduce and the risk premium also decreases. The traditional speculators will reduce the positions to earn a risk premium [11].

Conclusion 3: When demand for spot commodities increases, inventories will decrease, and commodity risk premium increases. Producers and traditional speculators increase positions, and index investors will not be affected.

Shown in Figure 3, when the commodity spot demand increases, the most direct result is upward pressure on the expected spot price .Producers, in order to respond to increased demand, will reduce inventory and increase commodity supply. More commodity supply means that producers need to hold more futures short to hedge risk, and the traditional speculators are willing to take this risk for a higher risk premium. Optimal behavior depends on the risk and return of the index portfolio. Because we did not assume the link between the individual commodity futures prices and the futures index, the index investor behavior is not subject to a single commodity spot market supply and demand changes. The model of this paper gives a pathway of demand shocks push up futures prices.

4. CONCLUSIONS AND SHORTCOMINGS

In this paper, based on a description of the four major players of commodity spot and futures markets, we establish a multi-phase equilibrium model of price determination, and then analyze the influence of the entry of a large number of index investors on commodity futures market. Through comparative static analysis, we found that the correlation between the stock market and commodity futures markets, the index investors' entering and demanding for commodity spot are important factors to decide the price of the commodity futures market. The smaller the correlation between the stock market and commodity futures markets and the greater the index investor funds inflows, futures long positions held by index investors will be more , meaning producers have more opportunities to trade with index investors to meet their hedging needs. As another means of risk management, producers will reduce inventory, resulting the increase in the supply of every period, and expected price will decline as well as the risk premium. The traditional speculators will reduce their open positions due to the reduction of the risk premium. The conduction mechanisms above are the direct result of a large number of index investors entering. Commodity spot demand will drive the price, which is in line with the underlying supply and demand relationship.

The shortcomings of this article is that although we try to take any possible elements of the commodity futures market into consideration in the model, a lot of parameters set exogenous makes the model far away from the actual the market mechanism ,especially the correlation between the stock market and the commodity futures market in the model not endogenously determined. This means that this article only consider the influence of this correlation on other variables, and does not consider the factors of the correlation. Therefore, the endogenous of correlation coefficient is also very valuable study in one direction. In addition, subject to the limitations of types of goods and the sample size, we can analyze only a single commodity weekly data. Weekly data of a single commodity always dope other confounding factors, and to some extent this affected the credibility of the empirical results.

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APPENDIX

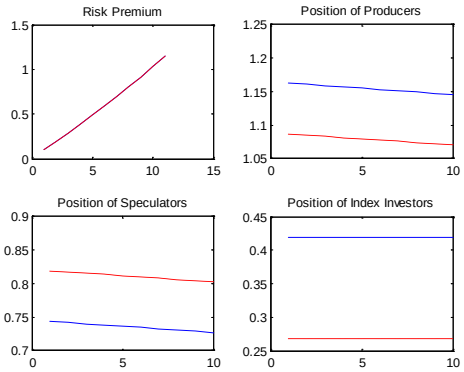

Figure 1: Correlation Between The Stock Market And The Commodity Futures Market

This figure shows the correlation between the stock market and the commodity futures market on open positions in futures risk premium, producers, speculators and index investors. The solid line represents the initial equilibrium path, and dotted lines correlation increases the equilibrium path.

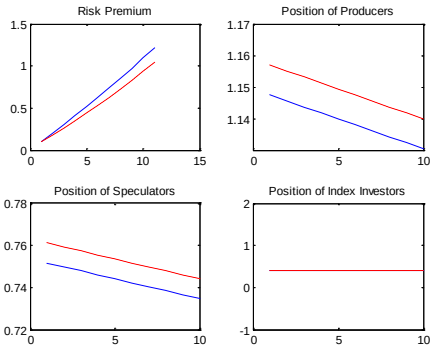

Figure 2: Capital Inflows Of Index Investors

The figure shows the index investors' capital inflows changes affect both the open positions of producers, speculators, index investors and the futures risk premium. The solid line represents the initial equilibrium path and the dotted line represents the equilibrium path after the increase of capital inflows.

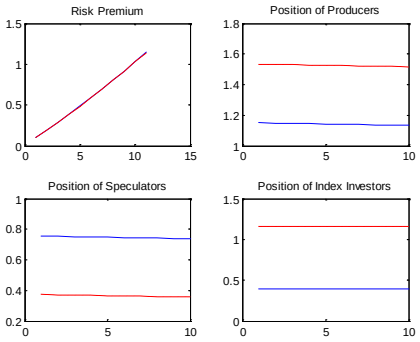

Figure 3: Spot Demand

The figure shows the demand for commodity spot affect both the open positions of producers, speculators, index investors and the futures risk premium. The solid line represents the initial equilibrium path and dotted line represents spot demand increases the equilibrium path.