AN ABSTRACT OF THE THESIS OF

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In 1996, China started to increase its annual soybean imports at a tremendously high speed. It has become one of the most important soybean import markets for the world's largest soybean producers: the United States, Brazil and Argentina. In the meantime, the Dalian Commodity Exchange (DCE), a Chinese soybean futures market, has developed very rapidly. Its soybean futures price has become an important market signal for Chinese soybean producers, crushers, importers and other soybean market participants. These two market developments not only highlight the motivation of study on Chinese soybean market, but also provide possibilities of study on it.

In order to have a thorough understanding of the Chinese soybean market and have a better forecast of the possible future development of the Chinese soybean futures market, this thesis attempts to analyze the soybean futures price relationship between the Dalian Commodity Exchange and the Chicago Board of Trade (COBT) on the basis of the law of one price theory. The law of one price asserts that the prices of a common commodity in two markets will converge to an equilibrium price after

trading the commodity between the two markets, assuming no market barriers to this trading. This thesis hypothesizes that the Chinese soybean futures market has been integrated with the world's largest soybean futures market, the Chicago Board of Trade, in the late 1990s. In this thesis both the conventional OLS and relatively more recent cointegration test estimating techniques are applied to the DCE and the CBOT soybean futures prices and soybean ocean shipping freight rate for the study period from 1996 through 1999.

The estimated results from the OLS procedure show that the DCE soybean futures price has not been integrated with the CBOT soybean futures prices in the short run. But the bivariate cointegration test procedure shows that there is a long-run price relationship between the two markets. The estimated results reveal price deviations between the two markets in several cases. These price deviations indicate the necessity for further exploration of them in future study.

China's Soybean Futures Contract:

China's Integration with the U.S. Soybean Futures Market

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Wenguang Si, Author

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CHAPTER 1 MOTIVATION AND OBJECTIVES

1.1 INTRODUCTION

Since 1996, China's soybean imports have been increasing rapidly. Before 1996 China was a net soybean exporter and its annual soybean imports were less than 10 thousand metric tons. From 1996 to 2000 its annual imports of soybeans rose from 0.8 million metric tons to 10.1 million metric tons. The large soybean imports pulled down Chinese high domestic soybean prices to the international soybean market level. At the same time, the Dalian Commodity Exchange (DCE), a Chinese soybean futures market has been developing quickly in its annual business turnover and the number of the market participants. The local soybean futures market development has caused many Chinese soybean futures brokers, speculators, hedgers, soybean importers, crushers and farmers gradually to be more and more concerned about both the DCE soybean futures price fluctuation and its relationship with the soybean futures price fluctuation of the Chicago Board of Trade (CBOT), the largest soybean futures market in the world. The Chinese soybean futures market participants have been trying to reduce their price risks and increase profits by better understanding the price relationship between these two soybean futures markets. Among them, many Chinese soybean futures traders have developed a common belief that the DCE soybean futures price is becoming more and more closely related with the CBOT soybean futures price. The U.S. soybean market participants have also started to pay more attention to the DCE soybean futures price development, because they have realized that the DCE soybean futures price is the most reliable market indicator in the Chinese soybean market.

Under these circumstances, this thesis attempts to provide empirical evidence on whether the Chinese soybean futures market has been integrated with the U.S. soybean futures market by exploring the price relationship between the DCE and the CBOT soybean futures markets.

This thesis applies two empirical estimating techniques to compare the estimated results in order to obtain a more reliable conclusion. It first uses the traditional OLS approach to estimate the law of one price model and obtain an empirical conclusion on the price relationship of the two markets. The law of one price stipulates that if these two markets are integrated, their soybean futures prices finally must converge to an equilibrium price. That is, the parameter of the soybean futures price must equal one. Then, this thesis uses the bivariate cointegration test approach to estimate a similar model with the same data set, trying to get more empirical evidence on the validity of the law of one price for the two markets.

1.2 THESIS HYPOTHESES

The primary hypothesis to be tested is that the law of one price is valid for the Chinese and the U.S. soybean futures markets in the study period from January 1996 through April 1999. The test of the hypothesis will show whether the Chinese soybean futures market has been integrated with the U.S. soybean futures market in the short or long run.

1.3 THESIS OBJECTIVES

The main objective in this thesis is to examine the soybean futures price relationship between the DCE and the CBOT by conducting an OLS estimation and a bivariate cointegration test. The two soybean market developments in China mentioned in Section 1.1 make these empirical tests possible. First, the successful operation of the DCE provides the necessary soybean futures prices to be compared with the CBOT soybean futures prices. Second, the large scale of soybean imports from the U.S. into China provides possible arbitrage opportunities between the Chinese and the U.S. soybean futures markets. Thus, the soybean trade between China and the U.S. stimulates the soybean futures prices between the two markets to come closer each other and makes it possible that the soybean futures prices between the two markets can keep a steady relationship.

Other objectives in this thesis are to provide helpful information for a better understanding of the Chinese soybean market mechanism and its integration with world soybean markets. The mechanism underlying the Chinese soybean market integration process is complex. It is believed that analysis of the soybean price relationship between China and the United States will benefit both Chinese and American soybean market participants, and provide valuable information for exporters and importers of other commodities to China. For China, a better understanding of the interrelationships among the world commodity futures markets is critical for its further market-oriented economic development. Soybean futures market participants in the United States can also benefit by clearly understanding Chinese soybean futures price, the operation of Chinese soybean futures market and its related regulations and policies.

1.4 THESIS ORGANIZATION

This thesis consists of six chapters. Chapter One is a brief introduction covering the motivation, the hypotheses for empirical analysis and the main objectives of the study.

Chapter Two provides background information on the Chinese soybean market, the Chinese soybean futures market and its regulations, Chinese soybean imports and exports, and Chinese soybean trade policies.

Chapter Three discusses the economic theory of the law of one price used as a theoretical framework for the empirical analysis in this thesis. This chapter also reviews the relevant previous research papers on empirical work of the law of one price.

Chapter Four presents a discussion of the OLS and the bivariate cointegration test estimating approaches and their econometric models.

Chapter Five discusses the construction of the weekly time-series price data sets and shows the estimated results by applying the data in the two different estimating approaches.

Chapter Six summarizes the conclusions of the two different estimating approaches on the basis of their estimated results and presents a descriptive interpretation of the factors that may cause price deviations. This chapter also points out study limitations, and concludes the thesis with suggestions for future research endeavors.

CHAPTER 2 BACKGROUND INFORMATION ON THE CHINESE SOYBEAN MARKET

2.1 CHINESE COMMODITY EXCHANGES AND THE DCE

China's first commodity exchange was established in 1990, and more than forty had followed by 1993 as China accelerated its transition from a centrally planned to a market-oriented economy. At least fourteen commodity futures exchanges were established based on the design borrowed from the Chicago Board of Trade (CBOT). One of them is the Dalian Commodity Exchange (DCE). After five years of rapid growth, the DCE has become one of the most successful and important commodity futures exchanges in China.

In 1998 China restructured its newly-established commodity exchanges according to the central government's modified regulations and policies. Most of the Chinese commodity exchanges and commodity futures exchanges were closed or merged.[1] By the end of 1998, only the three most successful commodity futures exchanges were allowed by the central government to continue operations. The DCE was one of the three.

The DCE was established on February 28, 1993. In 1998 it had 136 members, including 79 brokerage firms and 40 grain enterprise members. It had 8500 clients; 4500 of which were grain enterprises. In 2000, its members further rose to 148 and its clients jumped to 15000.[2] Initially, the DCE major futures products were corn and

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[1] Securities Time, 10-20-1998, downloaded from http://www.securitiestimes.com.cn/199810/20/data/newfiles/0010110.htm

[2] The DCE, 02-07-2001, downloaded from http://www.dce.com.cn/dce/default-1.htm

soybean contracts, but later the corn contract was cancelled due to a serious market manipulation. In 2000 soybean meal contract was added into operation. At present, the soybean contract is the DCE major trading futures product.

The DCE annual commodity (soybeans) futures turnover has increased rapidly since its establishment. In 1995, it ranked ninth in commodity futures turnover among the 14 commodity futures exchanges in China. By May of 1998, it had become the second largest commodity futures exchange in China. Its soybean futures turnover in 1998 was 669.2 billion Chinese Yuan, equivalent to 10% of the CBOT soybean futures turnover in 1998. In 1999 the DCE soybean futures turnover was 642.2 billion Chinese Yuan, slightly lower than that in the previous year, but its corresponding percentage rose to 20% of the CBOT soybean futures turnover in that year.[3]

2.2 CHINESE COMMODITY FUTURES EXCHANGE REGULATIONS

After the Chinese communist party took power in 1949, the stock exchanges and commodity futures exchanges in China were closed under the government mandate, because the Chinese government at that time regarded them as purely speculative economic organizations and concluded that their existence was harmful to China's planned economy. However, since China started its economic reform in 1978, the Chinese government has realized that China's market-orientated economy must have both stock exchanges and commodity futures exchanges to stimulate the development of its economy. Therefore, in 1990, the first Chinese commodity futures exchange after 1949, Zhengzhou Commodity Exchange (ZCE), was set up at

[3] As of footnote 2.

Zhengzhou, Henan Province where is the center of the Chinese wheat producing area. The ZCE was designed to mainly trade wheat futures.

Given this background, it is not surprising that the development of the Chinese commodity futures exchanges has been highly influenced by the government regulations and policies. For example, the ZCE was initiated by both the Ministry of Domestic Trade of China and the Henan provincial government agencies and was being run by the exchange officials rather than by its members. Because the ZCE was a new market mechanism in the Chinese economy, even the top Chinese leadership paid much attention to its development. Many of the top Chinese leaders have visited the ZCE and given their comments on its operation and development.[4]

The strong government influence is also evident in the exchange restructuring noted earlier. In 1998 the State Council of China issued a document demanding the restructuring of the existing exchanges. By observing the central government's regulations, more than 14 existing commodity futures exchanges were reduced to three: the ZCE, the DCE and the SCE (Shanghai Commodity Exchange).

At present, the China Securities Regulatory Commission (CSRC) directly regulates and monitors development and operation of Chinese commodity futures exchanges. It is a ministerial agency directly under the State Council of China, responsible for formulating government policies and regulations for Chinese commodity futures business.

Up to now, no law specifically concerning commodity futures business has ever been enacted in China. Only the central government's regulations and policies are

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[4] The ZCE, 02-08-2001, downloaded from http://www.czce.com.cn/chinese/index_ns.html

used to administer the Chinese commodity futures exchanges and business. Among those regulations and policies, the Futures Trading Administration Temporary Regulations formulated by the State Council of China are the most important and have been in effect from September 1, 1999.

The Chinese government regulations and policies have exerted intense influence on the development of the Chinese commodity futures exchanges over the last decade. Initially, those commodity exchanges lacked the detailed feasible and strict rules and regulations necessary to observe and keep the commodity exchanges operating smoothly according to the three commodity futures business principals: openness, integrity and fairness. As a result, market manipulations by speculators have occurred from time to time in many Chinese commodity futures exchanges. This is one reason that the Chinese central government demanded the restructuring of the Chinese commodity futures exchanges in 1998.

It should be also noted that the existing Chinese government commodity futures regulations and policies still do not permit Chinese individuals or enterprises to participate freely in foreign commodity futures exchanges, nor do they allow foreign investors to enter into the Chinese commodity futures markets. The Chinese government argues that the Chinese commodity futures participants are still immature and inexperienced and they need more practice in the domestic commodity futures markets. The Chinese commodity futures exchanges still lack the knowledge and experience to supervise international speculative investment in their commodity futures markets.

2.3 DCE SOYBEAN CONTRACTS VS. CBOT SOYBEAN CONTRACTS

The DCE soybean futures contracts were designed to follow the format of CBOT soybean futures contracts. Table 2.1 provides a comparison of the main contents for the DCE and the CBOT soybean futures contracts.

Table 2.1 Comparison of the DCE and CBOT Soybean Futures Contracts

	DCE	CBOT
Exchange	Dalian Commodity Exchange	Chicago Board of Trade
Location	Dalian, P.R.China	Chicago, U.S.A.
Trading Hours:	Mon-Fri	Mon-Fri
Beijing Time	9:00-11:00 am, 1:30-3:00 pm	9:30 pm-1:15 am
Chicago Time	9:00-11:00 pm, 1:30-3:00 am	9:39 am-1:15 pm
Currency Denomination	Chinese Yuan	US dollars
Deliverable Grades	Grade 3 Yellow at par and substitutions at differentials	No.2 Yellow at par and substitutions at differentials
Trading Unit	10 metric tons per contract	5000 bushels per contract
Contract Month	Jan, Mar, May, Jul, Sep, Nov	Jan, Mar, May, Jul, Sep, Nov, Aug
Last Trading Day	Tenth business day of the delivery month	Seventh business day before the last business day of the delivery month
Last Delivery Day	Seventh business day after the last business day of the delivery month	Last business day of the delivery month

Source: The DCE and the CBOT (February 2001).

Although the DCE soybean contracts are based on the CBOT contracts, there are following differences:

(1) The DCE soybean contracts have one monthly trading contract less than the CBOT soybean contracts. There is no August contract at the DCE.

(2) The CBOT soybean contract unit is 5,000 bushels per contract (=136 metric tons), much larger than the DCE contract unit, which is 10 metric tons per contract.

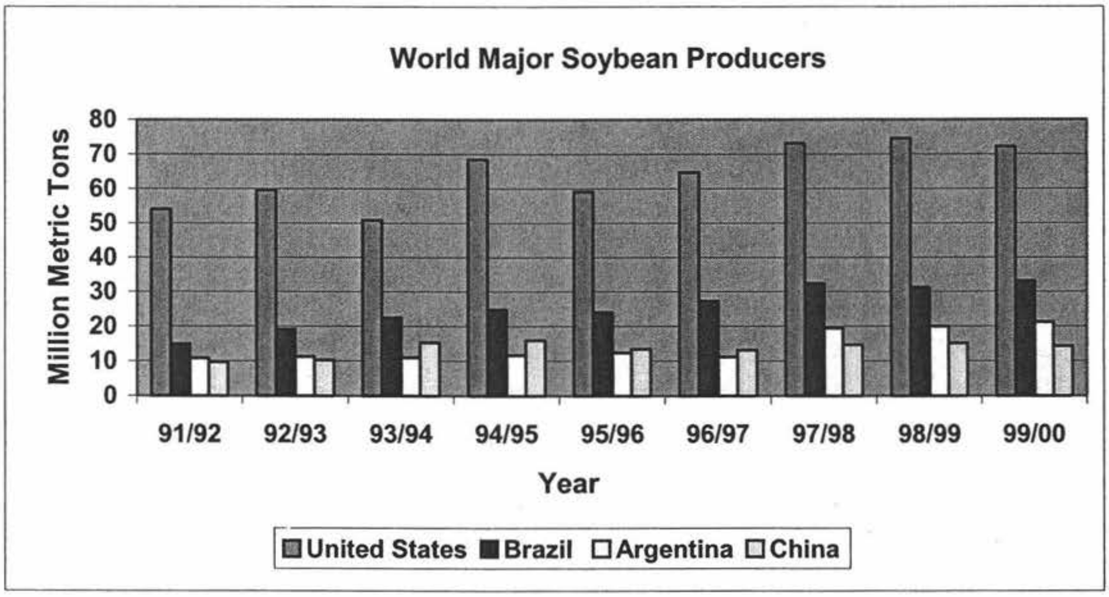
(3) The DCE soybean contracts are denominated in Chinese Yuan.

(4) The DCE soybean contracts are traded 14 hours earlier than the CBOT contracts each day, due to the DCE and the CBOT locations in different time zones.

For quality specification, both the U.S. and Chinese soybean futures contracts almost have the same mandatory requirements. The U.S. No. 2 Yellow Soybeans are almost equivalent to the Chinese Grade 3 Yellow Soybeans in quality specification requirements. But, specifically speaking, oil and protein contents of the U.S. soybeans are generally different from those of the Chinese soybeans. On average, the former has relatively higher oil and lower protein contents, while the latter has relatively lower oil and higher protein contents. The differences in oil and protein contents come from different seed selection priorities. The U.S. soybeans are mainly used for crushing to get oil and meal. So, higher oil content is a top priority for soybean seed selection. However, the Chinese soybeans are mainly consumed for soyafood that needs lower oil and higher protein contents of soybeans to improve their product flavor and quality. But in the Chinese soybean market the differences in oil and protein contents of soybeans are not considered by Chinese soybean traders. Only the contents of moisture, impurity and foreign material are stipulated in quality specification. Although the quality of the U.S. soybeans is in essence (oil and protein contents) different from that of the Chinese soybeans, the U.S. soybeans are allowed to deliver in the DCE designated delivery warehouses according to the DCE delivery regulations.

2.4 CHINESE SOYBEAN PRODUCTION AND MARKETS

Soybeans were first domesticated in China about 2000 years ago, and were introduced to Brazil and the United States in recent centuries. China was once the largest soybean producer in the world, but, after World War II, the United States became the largest soybean producer. China is now the fourth largest soybean producer after the United States, Brazil and Argentina. Figure 2.1 shows the soybean outputs from 1992 to 2000 for the four largest soybean producers in the world.



Source: Counselor and attaché reports statistics and USDA estimates (Feb. of 2001).

Figure 2.1: World Major Soybean Producers

Before 1990, the Chinese soybean production was lower than 10 million metric tons each year. In the 1990's, its soybean production began to exceed 10 million metric tons annually. With the increase of planting acreage and output per acre, its annual soybean production rose to 16 million metric tons by 1995. This output increase, though large in percentage, did not match the absolute increases of soybean production in other leading producing countries, the United States and Brazil over the same period. Especially, the Chinese soybean production stopped rising after 1995. But the soybean productions in the United States, Brazil and Argentina have continued to grow to a tremendously high level over the last five years, with a increase of 22 %, 38 % and 71 % in the United States, Brazil and Argentina respectively.

In recent years, the Chinese agricultural government departments have been encouraging farmers to grow more soybeans to improve Chinese self-sufficiency in soybean supply, but the Chinese farmers have been choosing to grow other plants with higher economic returns. In the past three years, the soybean planting acreage in China stopped increasing due to lower economic returns in comparison with those of producing corn or rice. Moreover, as the U.S. soybean price has kept staying at a low level in recent years, many Chinese soybean crushers have switched to importing large quantities of soybeans from international markets. Under these circumstances, it can be expected that the Chinese soybean production will unlikely continue rising in the near future.

Soybeans can grow under various environmental conditions and are planted in most of provinces in China. However, only Heilongjiang Province at the northeast corner of China is a major soybean surplus-producing area. The soybeans produced in other provinces are usually consumed locally.

The priority use of soybeans in China is for human direct consumption, such as producing tofu and other types of soyafood. This quantity of soybean consumption accounts for more than 70% of the Chinese total annual soybean production. The share of soybean crushing consumption is only about 20%. Such a soybean consumption structure is quite different from those of other world major soybean producing countries. In the United States, Brazil and Argentina, almost all of their soybeans are crushed for soybean oil and meal. Only very small quantity of food-grade soybeans in these countries are used for human direct consumption, though this share of soybean consumption has been increasing year by year.

In China, although most of the surplus soybeans are produced in the northern part of China, they are consumed in the southeastern coastal provinces. Each year Heilongjiang Province produces more than 4 million metric tons of soybeans, accounting for about 30% of the Chinese total annual soybean output. More than half of its soybean output is shipped to the southeastern provinces of the country for consumption, due to Heilongjiang Province's relatively low population and less developed economy.

Heilongjiang Province's soybeans are shipped in two ways to the southeastern area of China. One is to ship the soybeans first by railway to Dalian, the seaport city at the southern tip of Liaoning Province, where the DCE is located. Dalian is the largest and most important seaport importing and exporting agricultural commodities in the northern part of China (Figure 2.2). Then, the soybeans are transshipped by sea to the southeastern coastal cities. The other way is to ship the soybeans by railway directly to the southeastern area of China. But, only a limited quantity of soybeans goes this way due to lack of railcars and a bottleneck for the railway, about 200 miles away from the north of Beijing, the capital of China. Most of Heilongjiang Province's soybeans go the land-sea route to the southeastern area.

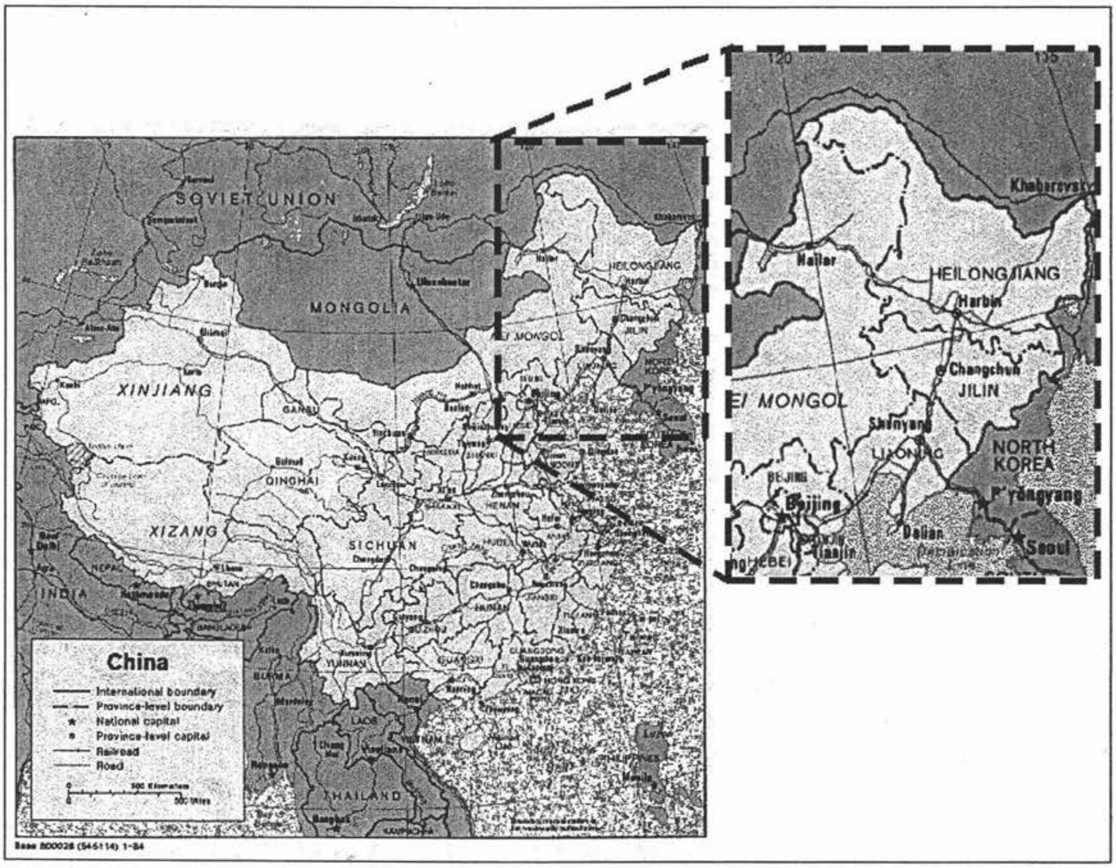


Figure 2.2: Map of China Showing Soybean Surplus Production Area and Dalian[5]

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[5] This map was developed using a map from the Perry-Castañeda Library Map Collection at the U. of Texas at Austin online website at http://www.lib.utexas.edu/Libs/PCL/Map_collection/

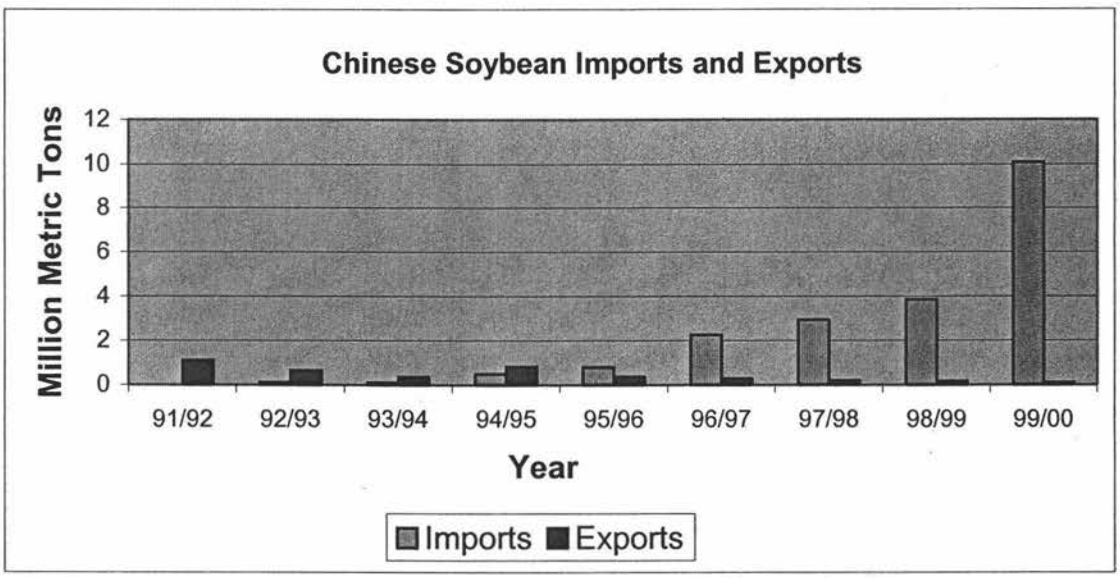
The cash soybean markets in Heilongjiang Province are scattered throughout the soybean growing areas. Soybeans are purchased from individual farmers or state-owned soybean producing farms. Except for a few individual soybean buyers, the initial buyers in the cash soybean markets are usually the local state-owned grain enterprises that form a soybean purchasing network. These grain enterprises are distributed in each grain-producing county. On the one hand, they represent the government to purchase soybeans from farmers with government funds. On the other hand, they also work independently for themselves. Therefore, a relatively complicated marketing system both in finance and administration has been developed.

The cash soybean prices in the production areas are usually decided by the general soybean supply and demand conditions in China. The DCE soybean futures price is the basic market indicator for the cash soybean prices. But a specific local soybean price is also influenced by the distance from soybean farmers to railway stations where the grain enterprises' soybean warehouses are located. This slight price difference is based on truck transportation costs. There is not a general and clear price premium system for higher quality soybeans. The soybean buyers and sellers negotiate their prices on a case by case basis for a quality premium. The soybean buyers and sellers are only concerned about the external quality of soybeans, such as cleanness and outlook, not about the internal quality, such as oil and protein contents. The soybeans with low moisture does not receive a price premium.

The Chinese soybeans are usually packed in gunny bags, 90 kilograms each, and stored in warehouses, because only a limited number of elevators and silos are available for storage. The grain enterprises in Heilongjiang Province resell their soybeans to the domestic buyers throughout the country. These grain enterprises are responsible for arranging railway transportation. After the soybeans are shipped by railway to Dalian, Liaoning Province, they are stored in numerous warehouses around the city ready for resale to other parts of China or abroad.

2.5 CHINESE SOYBEAN IMPORTS AND EXPORTS

Before 1996, China was a net soybean exporter. China imported a small quantity of soybeans every year and its exports of soybeans far exceeded its imports (Figure 2.3).



Source: Counselor and attaché reports statistics and USDA estimates (Feb. of 2001).

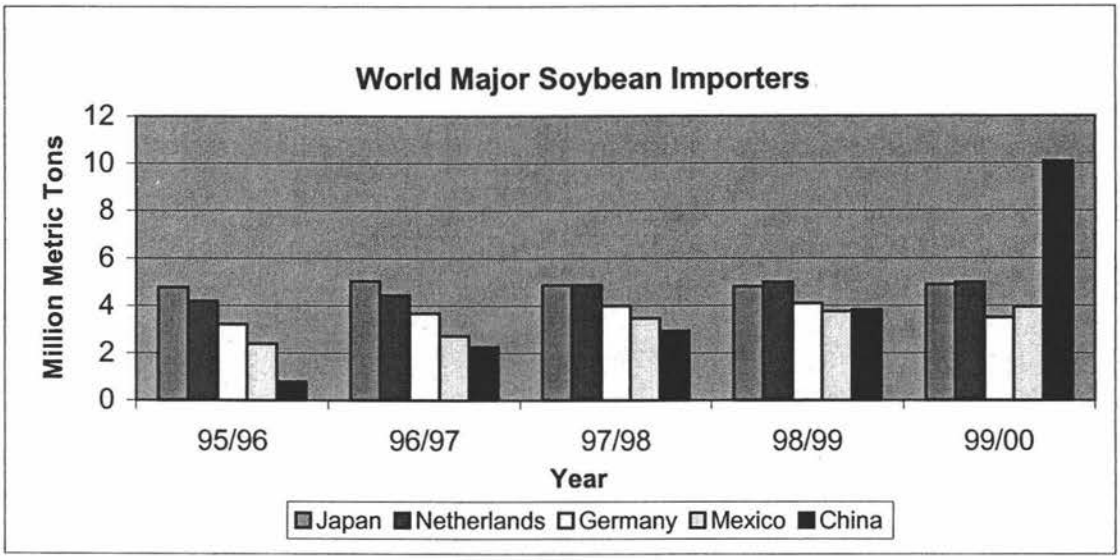
Figure 2.3: Chinese Soybean Imports and Exports

China was traditionally a food-grade soybean exporter to Japan, Indonesia, Malaysia and Hong Kong. But the Chinese soybeans have lost their price competitiveness to the U.S. and Canadian soybeans in recent years. Indonesia, Malaysia and Hong Kong stopped importing soybeans from China. Only Japan continues to import the Chinese soybeans. However, its imports have fallen each year and are now less than half of its previous quantity.

From 1996 on, the fast-growing domestic demand and the liberalization of the restrictive import policies for soybeans have been pushing up Chinese soybean imports. In 1996 China imported 0.8 million metric tons of soybeans. Three years later its soybean imports jumped to 3.86 million metric tons. In 2000 China once again made a huge jump, importing 10.1 million metric tons of soybeans. The USDA forecasts that China will import 8.6 million metric tons of soybeans in 2001.

If the increase of Chinese soybean imports in the last five years is compared with those of other world major soybean importers, this increase is even more impressive (Figure 2.4).

From 1996 to 2000, Japan and Germany, the former world first and third largest soybean importers, kept a relatively steady annual quantity of imports. Their soybean imports in 2000 are only a littler higher than those in 1996. During the same period, the Netherlands, the former second largest soybean importer, raised its soybean imports by 19 %, exceeding the Japanese soybean imports. The fourth largest importer, Mexico, increased its soybean imports relatively more, by 65 %. By contrast, China increased its soybean imports by 381 % in 1999. In 2000, its imports were about 12 times higher than those in 1996. China became the largest soybean importer in the world last year.



Source: Counselor and attaché reports statistics and USDA estimates (Feb. of 2001).

Figure 2.4: World Major Soybean Importers

The huge rise of the Chinese soybean imports has greatly encouraged the U.S., Brazilian and Argentine soybean producers. The United States, Brazil and Argentina are the primary sources for the Chinese soybean imports. These countries believe that the Chinese domestic edible oil supply shortage and the strong demand for soybean meal from the domestic feed producing industry will push China to keep a steady increase of soybean imports.

2.6 CHINESE SOYBEAN TRADE POLICIES

The Chinese government has long considered agricultural staples, such as rice, wheat, corn and soybeans, to be strategic commodities, extremely important to the stability of China's society and its economic development. In order to regulate domestic prices of these agricultural commodities, the Chinese government had adopted strict import and export policies to separate these domestic commodities markets from the world commodities markets for more than four decades. Over the past decade, the Chinese government has lowered import tariffs and removed import licenses for thousands of commodities. The restrictive import policy for soybeans has also been removed, because the Chinese government has no longer considered soybeans to be a strategic commodity. However, the restrictive import and export regulations and policies for rice, wheat and corn have remained unchanged.

China's restrictive import and export policies for the major agricultural commodities are carried out through mechanisms of the distribution of import or export licenses and the authorization of the exclusive operating rights. The making and modification of the Chinese import and export policies for these four major agricultural commodities are described below. Generally speaking, the Chinese import and export policies for rice, wheat, corn and soybeans are made out by mutual compromise and coordination among the State Council of China, the State Development and Planning Commission of China (SDPC), the Ministry of Foreign Trade and Economic Cooperation of China (MOFTEC), the Bureau of Domestic Trade of China and the Ministry of Agriculture of China. The MOFTEC is responsible for initiating a specific import or export policy document draft and sends it to the

SDPC for its amendment and approval. The Bureau of Domestic Trade and the Ministry of Agriculture review the policy document draft. If they disagree with it, they can submit their amendments to the SDPC. The SDPC is responsible for coordination. The SDPC develops its own document based on the MOFTEC's draft and the coordination results and submits it to the State Council of China for final ratification. If the State Council approves it, the SDPC will send the ratified document to the MOFTEC and demands it to carry out the ratified document as an established trade policy. Otherwise, the SDPC has to amend its document according to the comments of the State Council of China, and then submits it again to the State Council for ratification.

One of the important components of the Chinese import and export policies for these major agricultural commodities is the distribution of import and export licenses. These licenses are decided and declared annually by the SDPC. Each year, the provinces who plan to import or export these four agricultural commodities must submit their applications through their provincial development and planning commission to the SDPC and through their provincial foreign trade and economic cooperation department to the MOFTEC. The MOFTEC formulates its annual import and export plan of these four agricultural commodities based on the previous year's actual import or export results of the China National Cereals, Oils and Foodstuffs Import and Export Corporation (COFCO) and submits it to the SDPC as the license allocation basis. The SDPC allocates specific license quantities to the various provinces. Usually, the SDPC needs to reach an agreement with the MOFTEC before it decides which province can have how many license quantities. Each province allocates its license quantity to the qualified commodity buyers or sellers in its province.

In addition to the import and export license policies, China has adopted the policy of the authorization of exclusive operating right. As early as the 1950's, the MOFTEC authorized the COFCO exclusive rights to import and export rice, wheat, corn and soybeans for China. At that time, the COFCO was directly under the administration of the MOFTEC.

In the middle of the 1990's, the nationwide economic reform pressed the MOFTEC to cut off its direct relationship with the COFCO and other large-scale state-owned import and export corporations. The COFCO could no longer obtain low-priced soybeans and corn from the domestic state-owned grain departments to export. The COFCO became financially independent. But the COFCO is still not independent in its top administration personnel appointment. All the CEOs of the COFCO are still appointed by the MOFTEC.

The long-standing and entangled relationship between the MOFTEC and the COFCO has established a firm basis of mutual benefits for both parties: the COFCO obtained huge monopoly interests from the MOFTEC beneficial trade policies and the MOFTEC benefits financially in many ways from the COFCO. Therefore, up to now, the MOFTEC still favors keeping unchanged its decades-long policy of the exclusive operating right for the COFCO, though there has been a rising pressure of demolishing this policy from other government departments, industries and economic academics in recent years.

The main contents of the COFCO exclusive operating rights are that any unit in China who needs to import or export rice, wheat, corn and soybeans and has its license allocation must request the COFCO on its behalf to conclude sales or purchasing contracts with foreign buyers or sellers. After the conclusion of an import or export contract, the COFCO applies to the license issuing department of the MOFTEC for an import or export license based on the contract quantity. Any Chinese buyers or sellers has no right to conclude import or export contracts and apply for their import or export licenses by themselves even though they have import and export license allocation.

The Chinese government has been under intense pressure from several major agricultural commodity exporting countries for a long time during its undergoing WTO negotiations. Those countries have demanded the Chinese government to remove import barriers for their agricultural commodities. However, the Chinese government has only promised that it will gradually remove the import barriers on the Chinese major agricultural commodities according to the negotiated schedule.

The dramatic change of the Chinese soybean import policy started from 1995 is that the COFCO has lost its exclusive import right of soybeans. Chinese soybean buyers can purchase soybeans directly from foreign sellers and apply for their soybean import licenses by themselves.

At present, the tariff and tax for importing soybeans are 3 % tariff with import license, 114 % tariff without import license and 13 % VAT (value added tax). But the tariff actually implemented is 3 %, not 114 %, because it is not difficult for the

Chinese soybean importers to apply for their soybean import licenses from the government departments.

Several important changes of the Chinese soybean export policy have appeared in recent years. The COFCO's exclusive right to export soybeans has been eroded, because the SDPC and the MOFTEC have authorized three other Chinese companies the right to export soybeans.

In summary, the Chinese import and export policies for rice, wheat and corn have not much changed in the last decade. China's soybean trade policy has changed.

CHAPTER 3 THEORETICAL FRAMEWORK AND LITERATURE REVIEW

3.1 THE LAW OF ONE PRICE

In order to be accurate and valid, an empirical market analysis must be conducted on the basis of economic theory. Thus, empirical market hypotheses can be correctly modeled and tested. In this thesis, the economic theory applied in the empirical market analysis is the law of one price (LOP).

The LOP is basically defined that assuming that there are no impediments to international trade, as long as the price of a commodity in country A is higher than that in country B, buyers in country A will shift from purchasing the commodity in higher-priced country A to purchasing it in country B where the price is relatively lower. This process will continue until an equalization of the commodity prices in the two countries is observed.

As a general and basic concept in international trade theories, the LOP provides a simple but powerful foundation for the development of more complex international trade theories. According to its definition, the LOP is established on assumptions that do not exist in reality. The false assumptions do not signify its invalidity. On the contrary, this is where the attractiveness and importance of the LOP lie. Friedman (1953) says in his famous paper The Methodology of Positive Economics, "Truly important and significant hypotheses will be found to have 'assumptions' that are wildly inaccurate descriptive representations of reality." "The reason is simple. A hypothesis is important if it 'explains' much by little, that is, if it abstracts the common and crucial elements from the mass of complex and detailed circumstances surrounding the phenomena to be explained and permits valid predictions on the basis of them alone." It can be said that the LOP is one of "truly important and significant hypotheses."

Anyone might admit that the LOP itself is not complex and can be easily understood, because it simplifies the price relationship of a commodity moving between two regions or countries by assuming away many factors that complicate the price relationship. However, the tests of its validity have caused a lot of disagreement. Different empirical tests have resulted in different conclusions. In one empirical test, the LOP holds. In another, the LOP does not hold. As a matter of fact, it can be expected that an empirical test conducted under a different circumstance should result in a different conclusion, because the LOP is an abstracted economic theory about price relationship between two regions or countries derived from a mass of complex and detailed circumstances. The significance of an empirical test of the LOP validity lies in its improving the understanding of the LOP validity in particular conditions and providing policy directions.

3.2 LITERATURE REVIEW ON THE LAW OF ONE PRICE

In the last three decades, there has been a proliferation of literature trying to test the LOP validity. The economic and market researchers have attempted to apply the LOP to different specific circumstances and verify whether it is established under specific conditions. The conclusion of their empirical tests is that "although called a law, it has probably been violated more than any other economic law." (Miljkovic, 1999). Officer (1986) states that "incredibly, of the sixteen empirical studies on the issue of which I am aware, thirteen have negative implications for the law of one price." The possible factors caused the violation of the LOP might come from transportation (transaction) costs, tariffs, non-tariff barriers, pricing to market, exchange rate risk, and trade regionalization. Miljkovic (1999) has provided a survey paper about the previous studies on how these factors can prevent market arbitrage that causes prices in two regions or countries to converge to a common price.

The previous literature on the validity of the LOP can be divided from several perspectives. Some research papers conduct empirical tests with aggregated commodities, but more research papers used disaggregated commodities. The papers (Richardson, Isard, Jain etc.) in the 1970's and in the early 1980's usually use conventional econometric methods, OLS, to estimate their empirical models. The papers (Officer, Goodwin, Ardeni etc.) in the late 1980's and in the 1990's more often apply the cointegration test technique in their empirical analysis. In a more general classification, all the papers can be divided into two groups. One group of papers supports the validity of the LOP. The other does not. The following is not an exhaustive literature review but rather a summary of the research papers pertinent to this thesis. In particular, the review will pay more attention to the papers concerning price integration analysis of commodity futures markets.

3.2.1 Literature on supporting the LOP

Crouhy-Veyrac et al. (1982) argue that the major reason for failure of the LOP is leaving out transfer costs. Their empirical test results "clearly indicate a limited scope for establishing the law of one price without explicit attention to transfer costs." Therefore, their results do not signify strong evidence against the law of one price. They conclude that the general tendency to abandon the law of one price outside of primary products is still premature. Without incorporating transfer costs in an estimating model, the failure of the LOP is dubious. But, they also admit that it is not easy to obtain accurate information on transfer costs. It will probably be necessary to develop detailed information on transfer costs for specific industries in different countries.

Protopapadakis and Stoll (1983) tests the LOP validity for narrowly defined commodities traded in futures markets in different countries. In their study, they find that deviations from the LOP tend to be commodity specific rather than due to a common external factor. The variability of the deviations from the LOP is found to diminish with maturity of the futures contract.

They argue that commodity futures prices in different countries are determined at the same time regardless of the relative size of the countries. To remedy this price simultaneity problem, they modified the standard statistical model to put the two price variables on the left side. They argue that their procedure explicitly accounts for the simultaneous determination of the two prices.

They point out that the data from commodity futures markets are free of many of problems faced by other researchers. One of the difficulties met by former studies is that product mix or product quality is not held constant in price indices. As a result, the LOP can hold for individual commodities while failing for indices. The quality of commodities on commodity futures markets is well defined in futures contracts and remains unchanged over time. Price observations in different countries can be matched to the day. Therefore, the LOP can be investigated in its purest form.

They find that spot and near term commodity futures prices typically exhibit greater variability than prices of commodity futures contracts maturing in the more distant future, because the effect of unanticipated shocks on prices can be more readily mitigated when there is time to adjust supply.

Officer (1986) argues that the reason that the prior studies did not support the law of one price is that a disaggregative approach has been applied. He puts forward an aggregative technique to test validity of the LOP, because it has three advantages: theoretically, it accounts for cross-commodity substitution in production and consumption; statistically, it avoids the difficult task of matching individual products across countries; econometrically, it commits no specification errors.

Officer summarizes the reasons that give rise to deviations from the law of one price are (1) the purity of competition may be lacking; (2) the phenomenon of product differentiation can reduce the substitutability of manufactured goods of different countries; (3) and at an aggregate level, prices of tradables may have differing weighting patterns (that is, differing commodity compositions) in the countries involved.

Protopapadakis and Stoll (1986) report that their tests support the LOP in the long run, but reject the short-run LOP, for commodities traded in organized commodity markets. They formalize the distinction between short and long run by introducing lagged price adjustments, coupled with the informed expectations specification.

They point out that an important difficulty with the LOP tests for individual commodities is that the theory on which these tests are based explicitly predicts a discontinuity in the behavior of prices. The discontinuity arises because the LOP is based on the assumption that the supply of arbitrage funds is infinitely elastic outside a fixed transactions costs band, and it is zero inside the band. Their reformulation of the LOP, which involves specifying both a continuous price adjustment process and an expectations formation mechanism, means that the model can account for all the observations and not just for those on the transactions bands. They state that their new model makes it possible to distinguish a long-run behavior from a short-run behavior.

Goodwin et al. (1990) incorporate rational price expectations into their LOP test model. They argue that arbitrage and trade between two countries take time. Arbitragers are likely to act upon the expected sales prices. So, they expect that parity holds for expected prices, not for contemporaneous prices. They also argue that the standard approach to test the LOP has several inherent shortcomings. First, the standard approach implicitly assumes transportation costs to be constant or proportional to commodity prices over the period of a study. Thus, transportation costs can be represented in an intercept term. As a matter of fact, transportation costs can be highly variable. And deviations from parity may be correlated with transportation and interest costs. Second, the standard approach requires that one of the commodity prices should be exogenous. This may be incorrect for an individual commodity, because prices in two countries may be simultaneously determined. For example, information may be shared across markets or agents may operate in both markets. Such simultaneity biases the resulting parameter estimates and confounds statistical inference.

For a comparison, they use both the standard LOP model and their expectation-augmented models to test the price relationship of U.S. wheat, oilseed products, corn and grain sorghum between the U.S. and Japan or the U.S. and the Netherlands. They state that the "tests explicitly recognizing the role of expectations should find stronger empirical support for the concept of international price parity." Their empirical test results show that "the LOP appears quite strong" for the commodities analyzed when rationally expected prices instead of contemporaneous prices are used in the tests.

Baffes (1991) uses the cointegration test procedure with Ardeni's data to test a long-run relationship of the LOP, but results in opposite conclusions. His empirical test results show that "the failure of the LOP as a long-run relationship is a price-specific and time-period-specific problem rather than a general failure, and a possible reason for the LOP failure is transportation costs."

Baffes clearly discusses the procedures of stationarity and cointegration tests with relatively simple words. In particular, he extends his model by incorporating the variable of transportation costs in his test. He has also tried his tests with intentionally truncated data sets and found that transportation costs might be a possible reason for the LOP failure.

Goodwin (1992) tries multivariate cointegration test technique developed by Johansen, and Johansen and Juselius to verify the long-run LOP for wheat prices in five countries. He argues that the bivariate cointegration technique has two major weaknesses: (1) it is limited to pair-wise comparisons. However, this pair prices may be influenced by some other market prices; (2) it requires one of pair prices to be explicitly treated as exogenous price. He points out that the multivariate cointegration test technique provides a method to estimate all the cointegrating prices at the same time. Therefore, this procedure can overcome the above shortcomings and result in a better outcome.

His empirical test results have shown the importance of transportation costs in the estimation of a long-run equilibrium relationship among the wheat markets. He concludes that the long-run LOP is not supported without considering transportation costs. However, if the transportation costs are added to wheat prices, the LOP is fully supported.

3.2.2 Literature on rejecting the LOP

Isard (1977) denies the existence of the LOP for prices of manufactured goods between two countries. He claims that exchange rates substantially affects the prices of the most narrowly defined domestic and foreign manufactured goods so much that these goods become "differentiated goods," not "near-perfect substitutes, after he compares the exchange rate movements with U.S. and German industrial price movements, U.S. and German export prices movements for selected machinery categories and movements of U.S. export unit values and unit values of U.S. imports from Canada, Germany and Japan. He argues that the evidence that disparities between the common currency prices of different countries are systematically correlated with exchange rate, rather than randomly fluctuating over time, is a strong denial of the law of one price for the products being compared.

Richardson (1978) introduces an empirical model to test the LOP, which is very different from the estimating models proposed by the previous papers. His estimating strategy is regarded by later researchers as the standard (conventional) approach to test the LOP validity. In his paper, he does not advise others to directly apply his model with time-series price data, due to three problems: (1) a strong implication of commodity arbitrage for price levels, (2) presence of trend in time-series price data, and (3) absence of transportation cost data. He transforms his original statistical model to alleviate these three problems. His empirical estimating results show that the test for the law of one price fails for every commodity group under study. He points out that "In particular, it may be unwise to invoke disaggregated commodity-price parity conditions, as frequently is done."

Jain (1980) summarizes that in the previous studies there are two somewhat opposite approaches to account for price movement of similar commodities in different countries. The first approach is that according to the purchasing power parity theorem, exchange rates move to maintain the equality of prices in different countries. The second approach is that according to the LOP, prices are equalized through commodity arbitrage. The two approaches form opposite directions of causality. He states that significant theoretical problems inherent are in the use of the PPP and the LOP does not hold in all situations. He tries to define under what situations the LOP can be properly verified. He argues that three important characteristics are highly related with reliability of an empirical test for the LOP. First is the nature of commodities. If commodities tested for two countries are highly standardized, they are closer substitutes for each other and their compared prices are more reliable. Second is the liquidity of markets. The more participants are active in the markets, the more opportunities for arbitrage. Third is the existence of transfer costs. Transfer costs can impede perfect arbitrage.

He uses a similar estimating model as Richardson's to test the commodity futures price relationships between the U.S. and the U.K. commodity futures markets. He emphasizes that the model in his study is not much different in methodology. But the nature of commodity futures markets in his study makes his analysis much more comprehensive, because (1) commodities in futures markets are highly standardized in contracts in different countries and are highly comparable in quality; (2) commodity futures markets are the most liquid compared to any other commodity markets; (3) those tested futures commodities are all fully internationally traded commodities. Therefore, price changes in these futures markets have to be equal even if price levels are not equalized and even when transfer costs are positive.

His empirical results show that the LOP is not proved for the commodities under his study in the U.S. and the U.K. futures markets. Therefore, he concludes that the LOP validity is "highly questionable" for all other commodities under less favorable conditions. But he admits that "whether the law of one price is being observed is a matter of judgment and interpretation of how much deviation would fall within the law of one price." He points out that during an unstable exchange rate period, exchange rate changes will reduce degree of market integration, because commodity traders respond to their own expected exchange rates, not the market exchange rates. And he also states that other things such as differences in delivery months, possibilities of trade barriers in the future and small futures price differences will prevent traders from taking risks for arbitrage.

Ardeni (1989) argues that many of previous studies on the validity of the LOP are unreliable due to (1) non-exploration of time-series properties of data (nonstationarity), (2) inappropriate application of transformation on variable (first differencing). He points out that nonstationarity of price time series makes invalid the usual estimating procedures and classical asymptotic theory. However, the theory of cointegration can remedy this problem. Cointegration indicates that individual variables may not be stationary, but linear combinations of them can exist which present a long-run equilibrium relationship between variables. And he also points out that "differencing fundamentally alters the properties of error process." The transformation of the standard model (Richardson, 1978) has an incorrectly implicit assumption that after the transformation, the error term is not changed. He concludes that without correct specification of error structure, a model can be suspected of misspecification.

He states that for a vector of stochastic variables, the cointegration test can help in finding whether the time series of these variables move together in the long run. Therefore, the cointegration test becomes a natural statistical framework to test long-run (steady state) equilibrium relationships for a vector of stochastic variables.

He applies a bivariate cointegration test procedure introduced by Engle and Granger to evaluate the long-run relationship between pairs of seven commodities in four countries. His empirical test results do not support the LOP. He summarizes three major reasons to explain the empirical failure of the LOP as a long-run relationship. First are institutional factors. Institutional factors are sure to affect commodity prices under study. Second are arbitrage costs. Arbitrage costs can be very high for some periods of time due to high risks of price fluctuations. And third are errors in data and in price definitions.

3.3 LITERATURE REVIEW ON CHINESE COMMODITY FUTURES MARKETS

The new Chinese commodity futures markets have existed for only about ten years and the economic researchers outside China just start to know them. Therefore, there are few research papers about these commodity futures markets written by the researchers from other countries.

Williams, Peck, Park and Rozelle (1998) are the first group of economic researchers outside China who have published a paper on the development of the first Chinese agricultural commodity exchange: The Zhengzhou Commodity Exchange. While the Williams et al. study is, like most studies of new futures contracts, primarily descriptive, it makes clear that the ZCE mungbean contract's (its main product) development contradicts conventional expectations about how a commodity futures contract develops. One of the most interesting points made is that the development of the futures market for mungbeans aided the development of the cash market, because the mungbean physicals market has adopted higher quality and uniformity requirements in recognition of the futures contract standards to improve cash mungbean marketability. This finding contrasts with standard futures contract development where success requires adoption of the physicals market criteria (e.g. Sandor).

Williams et al. also suggest that futures contracts for Chinese strategic agricultural commodities, namely wheat, corn, rice and soybeans could not be expected to develop as rapidly as the mungbean futures contract. This prediction already appears to be contradicted for soybeans, whose contract is trading successfully. However, their prediction is based on an assumption of dispersed production and infrastructure, which does not appear to be fully applicable to Chinese soybean production and marketing. While soybean production is widely dispersed in China, surplus production is concentrated in one region, Heilongjiang Province, which has relatively good transportation avenues to the rest of China through the port city of Dalian, Liaoning Province. Dalian's location as a transportation hub for agricultural product distribution provides a good basis for the development of a commodity exchange.

Shyy and Butcher (1994) conduct an empirical test on the copper price equilibrium relationship between the London Metal Exchange (LME) and the Shanghai Metal Exchange (SME).

They hypothesize that the Chinese copper futures prices (SME prices) follow the international market prices (LME prices), after the adjustment of tariff and transportation costs. They test their hypothesis by employing bivariate cointegration test and Granger Causality procedures. In their tests, they use three sets of price data: the SME spot and three-month forward copper prices, the LME spot and three-month forward copper prices and the daily closing price of Chinese Yuan. Their study period is from June 1, 1992 through October 14, 1993. Their estimated results show that the SME copper prices (both spot and forward prices) are cointegrated with those of the LME, and there exists a unidirectional causality leading from the LME spot copper market to the SME spot market. However, the causality relationship in the forward copper market is less obvious than that in the spot copper market. They also conclude that "their empirical results probably raise more questions than answers" and "further research is needed," due to the limitation that the SME has existed for a short of period of time and can not provide a longer enough period of data.

CHAPTER 4 METHODOLOGY AND ECONOMETRIC MODELS

4.1 INTRODUCTION

The empirical tests in this thesis employ two different kinds of estimating procedures to verify the hypotheses in section 1.2. One is the conventional OLS (ordinary least squares) approach with modifications allowing for autocorrelation and heteroskedasticity. The other is the bivariate cointegration approach. In the following two sections the OLS and the cointegration approaches and their estimating models are discussed.

4.2 OLS APPROACH AND ESTIMATING MODELS

In econometrics, the classical linear regression (CLR) model is a basic statistical model for a standard estimating situation. The general CLR model is specified as

$$y_t = \beta_1 + \beta_2 x_{t2} + ... + \beta_k x_{tk} + \varepsilon_t \qquad (1)$$

For the CLR model, the OLS estimator is considered as the best linear unbiased estimator. The CLR model is established on five assumptions about variables and data used in the model. Violation of any of these assumptions creates a different estimating situation. Therefore, the OLS estimator may be no longer regarded as an optimal estimator for such a different estimating case. That is, any violation of assumptions may cause biases and inefficiency in estimating the CLR model by the OLS estimator. In other words, it may produce incorrect estimates and variances for parameters of variables, and thus, result in erroneous inference. If there is any violation of these five assumptions, one of ways to overcome the problems caused by such a violation is to transform the initial CLR model and choose an alternative estimator to estimate the transformed model.

In this thesis, the soybean futures price relationship between the CBOT and the DCE is estimated to verify whether the LOP holds for these two soybean futures markets. At first, it is supposed that the hypothesized soybean futures price relationship can be characterized by the CLR model. Such a CLR model in the LOP research papers is called an LOP model. Therefore, the OLS approach should be applied in this LOP model. However, since time-series price data in several years are used in estimation, it is natural to expect that the autocorrelation will exist. And also, time-series price data sets are constructed year by year. So, it is likely that heteroskedasticity problem will exist at the same time. If such data problems do appear, one of ways to solve them is to transform the CLR model. So, the GLS (generalized least squares) estimator instead of the OLS estimator should be used in this LOP model.

In order to better understand how this LOP model is used in this thesis, the general LOP modeling methodology is briefly discussed by the following illustration which demonstrates how an LOP model is applied in an LOP study and how to avoid erroneous estimation when an LOP model is applied.

In a strict sense, that is, assuming that there are no transfer costs, an LOP model can be written as

$$P_1 = P_2 E \qquad (2)$$

where P_1 and P_2 are domestic and foreign prices and E is exchange rate. This economic model can be changed into a statistical model:

$$P_{1t} = \beta_1 + \beta_2 P_{2t} + \varepsilon_t \tag{3}$$

where P_{1t} and P_{2t} are domestic and foreign prices which have been converted into one currency and ε_t is error term. For this statistical model, the LOP requires that the estimated parameter β_1 should equal zero and β_2 should equal one.

In a more general sense, Richardson (1978) develops an economic model to test the validity of the LOP. Many economic researchers have conducted their LOP empirical tests on the basis of his model. Richardson models the LOP for a price relationship between two countries as

$$P_1 = \beta_0 E^{\beta_1} P_2^{\beta_2} T^{\beta_3} R^{\beta_4} \tag{4}$$

where

p_1 = price in country A.

p_2 = price in country B.

E = exchange rate.

T = transfer costs, including costs of transportation, insurance, tariffs, etc.

R = random factors.

In this economic model, if the LOP is completely satisfied, then,

$\beta_0 = \beta_1 = \beta_2 = \beta_3 = 1$ and $\beta_4 = 0$.

However, Richardson does not suggest using this equation, because several problems prevent equation (4) from being directly used. First of all, accurate information on transfer costs is not easy to collect, due to unavailability of transportation costs which account for most of transfer costs. It is known that there are only few publicly organized ocean shipping markets in the world to provide daily ocean shipping rate quotes. But, in many cases, those shipping rates are not appropriate to be used in empirical research for most of commodities under study. Many economic researchers believe that only the ocean freight rates for limited primary commodities traded in international markets are available and relatively reliable for use in empirical studies. Crouhy-Veyrac et al. (1982) warns that "to come to grips with these costs will probably entail detailed investigations of individual industries on an international basis." In other words, it is not possible to do such a thing in most of cases due to high costs. Therefore, it is practically impossible to obtain the accurate time-series data about the transportation costs necessary for empirical research.

In order to circumvent the obstacle of unavailability of time-series data about transfer costs, Richardson assumes that over a short period of time, transfer costs will not change much and they can be treated as nearly constant. Therefore, the change of transfer costs is very small and can be merged into the error term. On the basis of this assumption, the following transformation of equation (4) will merge variables T and R into error term ε:

$$\ln P_{1t} = \ln \beta_0 + \beta_1 \ln E_t + \beta_2 \ln P_{2t} + \beta_3 \ln T_t + \beta_4 \ln R_t \qquad (5)$$

$$\ln P_{1t-1} = \ln \beta_0 + \beta_1 \ln E_{t-1} + \beta_2 \ln P_{2t-1} + \beta_3 \ln T_{t-1} + \beta_4 \ln R_{t-1} \qquad (6)$$

Since it is assumed that transfer costs are almost not changed in a short time, that is, $\beta_3 \ln T_t \cong \beta_3 \ln T_{t-1}$ and $\beta_4 \ln R_t \cong \beta_4 \ln R_{t-1}$, thus,

$$\Delta \ln P_{1t} = \beta_0' + \beta_1 \Delta \ln E_t + \beta_2 \Delta \ln P_{2t} + \varepsilon_t \qquad (7)$$

In equation (7), variable T is not explicitly expressed. Therefore, under this circumstance, economic researchers need only time-series data for variables of commodity prices and exchange rate to estimate these variable parameters.

Equation (7) demonstrates the relationship of rates of change. Richardson argues that the rate of change in price equation is the weaker form for commodity arbitrage. It is probably better than a level price equation with strong implication for commodity arbitrage. Equation (4) implies a very strong form of commodity arbitrage for price levels. So, this is the second reason that equation (4) is not recommended by Richardson. The third reason that Richardson suggests to use equation (7) instead of equation (4) is that the time-series price data may have trends (nonstationarity). The trends of variable data will cause error term to show high positive serial correlation. However, equation (7) may solve the problem of nonstationarity, because many nonstationary time-series price data can be transformed to stationary time-series price data by differencing them. The transformation from equation (4) to equation (7) is in essence the procedure of first differencing.

Equation (7) may delete trends of variable data, but it is still possible that the problem of simultaneity between the pair of price variables exists in equation (7). The simultaneity problem in equation (7) will produce biases in estimated results. But Richardson argues that if one market is very large and the other is small, the simultaneous effect is not obvious. The reason is that unexpected shocks to the price in the small market will not exert large effects on the price in the large market. So, the price in the large market can be taken as an exogenous variable. His another argument is that if a test is conducted on a highly disaggregated commodity, there may not be the simultaneous problem, because a disaggregated commodity accounts for only a small part of the total trade volume in a country and the random shocks to this commodity price can only exert a limited influence on its exchange rate.

Richardson argues that equation (7) can avoid many estimating errors, but it still may have flaws. For instance, Ardeni points out that Richardson's transformed equation (7) may not be correctly specified, because equation (7) does not give a clear specification about the error structure. In Richardson's transformed equation (7), it is assumed that if $P_{1t} = \beta P_{2t} + \varepsilon_t$, then, $\Delta P_{1t} = \beta \Delta P_{2t} + \varepsilon_t$. Ardeni argues that if $P_{1t} = \beta P_{2t} + \varepsilon_t$, then, $\Delta P_{1t} = \beta \Delta P_{2t} + \Delta \varepsilon_t$. $\Delta P_{1t} = \beta \Delta P_{2t} + \varepsilon_t$ does not correctly specify the error term.

Although Richardson's statistical model may have flaws, it is still the model most widely applied by other economic researchers. Therefore, in this thesis, his model is adopted to test the soybean futures price relationship between the CBOT and the DCE markets. For variable specification, the CBOT and the DCE soybean futures prices are considered to be not determined simultaneously and the CBOT soybean futures price is taken as an exogenous independent variable and the DCE price as a dependent variable, because, technically, the CBOT and the DCE are located at different time zones and the DCE is open 13 hours earlier than the CBOT. Fundamentally, on the one hand, the CBOT soybean futures market has been the world largest soybean futures market and its soybean futures prices have been the leading market indicator for the soybean producers and consumers in the world for a long time. The CBOT soybean futures market is much larger than the DCE soybean futures market. The DCE soybean futures market is still at its initial stage of development. Its annual soybean futures business turnovers had not exceeded 20% of the CBOT soybean futures business turnovers. In addition, the United States is the largest soybean producer in the world and its soybean production accounts for about half of the world total soybean production. About two thirds of its production is consumed domestically. Therefore, the CBOT soybean futures price is more influenced by the changes of its own domestic soybean production and consumption than by those in other countries. Furthermore, the weather in the American soybean production area is one of the major factors which heavily affect the CBOT soybean futures prices in soybean production period.

As an increasingly large soybean importer, it is possible that Chinese soybean import news occasionally affects the CBOT soybean futures price in a short time. But observation shows that it is still a rare thing that the DCE soybean futures price directly affects the CBOT soybean price in the short run. In the analysis period of this thesis China was not yet the top soybean importer in the world. The visits to the Chinese soybean futures traders also show that in a large extent the DCE soybean futures price has been affected by the CBOT price, not the opposite.

In this thesis, it is expected that the empirical test results may be more reliable due to the unique characteristics of the tested futures commodity and markets. Jain (1980) points out that commodity characteristics and market liquidity may lead to different results of an LOP empirical test. The tested markets in this thesis are futures commodity markets. Futures soybeans are the highly standardized commodity. They are more substitutable and comparable in price between two markets than other ordinary commodities. Futures soybean markets in the United States at least are highly liquid. The high liquidity in commodity futures markets provides opportunities for arbitrage. Then, the commodity futures price is more quick and easy to come to an equilibrium price. Therefore, the test results in this analysis should have more chances to avoid estimating errors caused by commodity differentiation and thin markets.

4.3 COINTEGRATION APPROACH AND ESTIMATING MODELS

In the past LOP studies, most of empirical test results are unfavorable to the validity of the LOP. Economic researchers have tried in various aspects to find out why the long established LOP in the theory of international trade does not have a wide empirical support in the real world. Some economic researchers (Ardeni, Baffes, etc.) argue that the conventional OLS estimation approach has statistical drawbacks, due to the nonstationarity property of price time series. They propose to apply cointegration approach to test the validity of the LOP. Ardeni (1989) argues that many economic researchers have neglected the problem of nonstationarity of time-series price data. Nonstationarity makes the classical asymptotic theory invalid. Thus, the conventional OLS estimating approach based on the classical asymptotic theory will be inapplicable. Therefore, their empirical test results are suspicious. Ardeni (1989) applies the Engle-Granger cointegration procedure in his study. This is a two-step cointegration testing technique suitable for a pair of variables test. But, it is known that if more variables, such as transportation cost, could be tested at the same time with the pair of price variables, test results would be more reliable. Therefore, Goodwin (1992) proposes to apply Johansen multivariate cointegration approach in analysis. In his study, he adds transportation cost variable in the test and has found that transportation cost is the key element for the validity of the LOP. If the prices are adjusted for transportation costs, the LOP holds as a long-run equilibrium relationship. Otherwise, the LOP does not hold. In this thesis, the Engle-Granger bivariate cointegration procedure is applied in the empirical analysis. This procedure includes two major estimation parts. One is to test stationarity of the time-series price data for a pair of variables. The other is to test cointegration of this pair of variables.

4.3.1 Stationarity Test

For a price time series to be appropriately used in an AR, or an MA, or an ARMA model for an LOP empirical study, it must be stationary. A stationary time series is one whose mean, variance, and autocorrelation function do not change over time. A time series that trends upward or downward over time will violate this condition. Many commodity price time series are trending data, that is, they are nonstationary data. They can not be directly used in empirical tests, because they will cause biases in empirical estimation. Simple first differencing can usually solve the nonstationary problem of a trending data. Those nonstationary price time series which can be transformed to stationary ones by differencing once or more times are denoted by I(1) or I(d), that is, they are integrated of order 1 or d. If a time series is stationary without differencing, it is denoted by I(0). In most of cases, differencing once is enough, because most economic time series data are I(1) and rarely I(2). Whether a time series is I(0) or I(1) can be determined by various tests of stationarity. The most common test is called unit root test. The unit root test model can be generally written as an ARMA (1,1) model

$$y_t = \theta_1 y_{t-1} + \mu + e_t + \alpha_1 e_{t-1} \quad (8)$$

where y_t denotes the variable being tested and $\theta_1 = 1$. $\theta_1 = 1$ is a unit root for equation (8), because it is the root of a polynomial. And also, $\theta_1 = 1$ makes y_t a nonstationary I(1) series. If $-1 < \theta_1 < 1$, y_t becomes a stationary time series. Therefore, to test whether y_t is a nonstationary I(1) series, the hypothesis can be written as $H_0 : \theta_1 = 1$ against $H_1 : -1 < \theta_1 < 1$ for equation (8). Such a test of the hypothesis is called unit root test. To subtract y_{t-1} from both sides of equation (8), it is

$$y_t - y_{t-1} = (\theta_1 - 1) y_{t-1} + \mu + e_t + \alpha_1 e_{t-1}$$

$$\Delta y_t = \theta_1^* y_{t-1} + \mu + e_t + \alpha_1 e_{t-1} \quad (9)$$

where $\Delta y_t = y_t - y_{t-1}$ and $\theta_1^* = (\theta_1 - 1)$. So, after the transformation on equation (8), the unit root test can be conducted with the usual null hypothesis $H_0 : \theta_1^* = 0$ against $H_1 : \theta_1^* < 0$. If the null hypothesis can not be rejected for the level of a variable but is rejected for the first difference, then the variable is said stationary in the first difference. The critical values for a unit root test is not the usual t_c or F_c statistics. They need to be calculated particularly.

Dickey and Fuller (1979) have developed their test statistics (DF statistics) as critical values, which can be used to test stationarity of a time series. If the DF statistics are used as critical values in a unit root test, this stationarity test is usually called as Dickey-Fuller (DF) test. The DF test is performed on an AR (1) model

$$\Delta y_t = \theta_1^* y_{t-1} + \mu + e_t \quad (10)$$

where $\Delta y_t = y_t - y_{t-1}$ and $\theta_1^* = \theta_1 - 1$. y_t is the variable to be tested. The null and alternative hypotheses are the same as those for the above unit root test, but can be also expressed more directly in two steps: (1) for a level time series, null hypothesis $H_0 : y_t$ is not I(0) against alternative hypothesis $H_1 : y_t$ is I(0). If the coefficient of θ_1^* is negative and significantly different from zero, the null hypothesis H_0 is rejected. That is, if the estimated negative value is absolutely larger than the corresponding DF critical value, H_0 is rejected. That means that the tested level series is stationary, integrated of order 0. But it is known that usually this null hypothesis will not be rejected for most economic data. That is, most of level economic time series are nonstationary. Then, the second step needs to be taken: (2) for the first-differenced time series, $H_0 : y_t$ is not I(1) against $H_1 : y_t$ is I(1). This is achieved by first taking first-difference to the time series and then repeating the same test. If the estimated negative value is absolutely larger than the DF critical value, H_0 is rejected. Thus, the DF stationarity test for the time series is finished. That is, the test has proved that the tested time series is not I(0), but I(1). Based on these proved results, it is possible to implement cointegration test.

In addition, in order to improve estimating precision and avoid the possibility that y_t follows a higher order autoregressive process, additional Δy_{t-i} terms can be added to the right-hand side of equation (10). Thus, the DF test is changed to the augmented Dickey-Fuller (ADF) test. The statistical model used in the ADF test can be written as

$$\Delta y_t = \theta_1^* y_{t-1} + \mu + e_t + \sum_{i=1}^{n} \phi_i \Delta y_{t-i} \tag{11}$$

where n is selected so that e_t is white noise. According to the ADF test, n can be allowed up to the fourth lag. One way to determine the exact number of n is to calculate the Akaike [check spelling] information criterion equation by plugging in different n respectively. The smallest Akaike's AIC value among the four calculated values corresponds to the n to be selected. The null hypotheses of ADF test are the same as those for the DF test.

In this thesis, both the DF and ADF test procedures are employed to test the stationarity of the DCE close price time series and the landing price (only CBOT close price plus ocean freight rate) time series and to compare the sensitivity of estimated results from these two tests. Here the landing price is constructed to change two original independent variables into one processed independent variable in order to use a bivariate cointegration test model. If there is more than one independent variable to be separately estimated, the model applied should be a multivariate cointegration test model which is beyond the scope of study in this thesis.

4.3.2 Cointegration Test

As discussed above, if a pair of price time series, P_{1t} and P_{2t}, are both nonstationary in levels but stationary in first difference, it is said that P_{1t} and P_{2t} are integrated of order 1, denoted as I(1). If it can be proved that the price time series P_{1t} and P_{2t} are I(1) by the DF and the ADF tests, these two tests can continue to verify whether or not this pair of price time series, P_{1t} and P_{2t}, are cointegrated. The following is a brief discussion on the bivariate cointegration test procedure.

For a simple regression model with one independent variable and one dependent variable,

$$P_{1t} = \beta_1 + \beta_2 P_{2t} + \varepsilon_t \tag{12}$$

suppose that P_{1t} and P_{2t} are both nonstationary I(1) series, it is reasonable to expect that $\varepsilon_t = P_{1t} - \beta_1 - \beta_2 P_{2t}$ will also be I(1). Engle and Granger (1987) show that if variables x_t and y_t are both I(d), then it is generally true that the linear combination $z_t = x_t - ay_t$ will also be I(d). If ε_t is I(1), it cannot be a serially uncorrelated random error with constant variance; it will be autocorrelated and its variance will change over time. More specifically, the implication for ε_t being I(1) is that

$$\varepsilon_t = \varepsilon_{t-1} + \eta_t \tag{13}$$

where η_t is a stationary, but not necessarily serially uncorrelated, random error. Equation (13) can be rewritten as

$$\varepsilon_t = \theta_1 \varepsilon_{t-1} + \eta_t \tag{14}$$

where $\theta_1 = 1$.

Under these circumstances, Granger and Newbold show that least squares is not a suitable estimating technique, because least squares is likely to produce an apparently highly significant relationship between P_{1t} and P_{2t}, even when $\beta_2 = 0$. A regression model that has its error term with such serially correlated properties is called a spurious regression model which invalidates conventional procedures of inference in regression. Spurious regressions can be usually detected by low Durbin-Watson statistic values.

However, when P_{1t} and P_{2t} are I(1), it does not always imply that the error ε_t is I(1). There is a possibility that the error ε_t is stationary, or I(0). Engle and Granger also show that if variables x_t and y_t are both I(d), it is possible that $z_t = x_t - ay_t$ will be I(d-b). For a special case d=b=1, z_t will be I(0). Under this particular circumstance, when P_{1t} and P_{2t} are I(1) and the error term ε_t is I(0), P_{1t} and P_{2t} are called cointegrated. This possibility does not seem unreasonable, because intuition can be that an individual price of a commodity (P_{1t} or P_{2t}) may fluctuate widely (becoming nonstationary), but a pairs of prices of same commodity (P_{1t} and P_{2t}) in different markets can be expected to fluctuate in such a way that they do not separate too far away; that is, although individually P_{1t} and P_{2t} are I(1), a particular linear combination of them is I(0). Cointegration implies that both P_{1t} and P_{2t} have similar stochastic trends. They exhibit a long-term equilibrium relationship that is defined by $P_{1t} = \beta_1 + \beta_2 P_{2t} + \varepsilon_t$ and ε_t represents a short-term deviation from the long-term equilibrium relationship. If P_{1t} and P_{2t} are cointegrated, applying least squares estimating method to equation (12) will yield consistent estimates of parameters β_1 and β_2.

The above brief theoretical reasoning provides the last step of the whole procedure to detect whether or not P_{1t} and P_{2t} are cointegrated. So, all the estimating steps of the bivariate cointegration test procedure applied in this thesis can be summarized more clearly as follows.

First, apply the DF or the ADF test, or both, to determine the orders of P_{1t} and P_{2t} time series. The orders of P_{1t} and P_{2t} time series can have three possibilities: (1) P_{1t} and P_{2t} are both I(0). This implies that they have constant means and variances and the LOP can hold as a long-run equilibrium relationship. (2) P_{1t} is I(d) and P_{2t} is I(b), d $\neq$ b. The different integrated orders of P_{1t} and P_{2t} imply that the LOP does not hold because at least one of the prices has an explosive tendency. (3) P_{1t} and P_{2t} are both I(d), d>0. In this case, the cointegration theory shows that it is possible that P_{1t} and P_{2t} are integrated and the LOP holds. Second, run regression on equation (12) to obtain a residual time series. Finally, apply again the DF or the ADF test, or both to the residuals from this regression to test the cointegration of the variables, P_{1t} and P_{2t}, in the model.

More specifically, the first step is to perform the DF test on the model :

$$\Delta y_t = \theta_1^* y_{t-1} + \mu + e_t \tag{15}$$

or the ADF test on the model:

$$\Delta y_t = \theta_1^* y_{t-1} + \mu + e_t + \sum_{i=1}^{n} \phi_i \Delta y_{t-i} \tag{16}$$

The purpose of this step is to make sure whether the further cointegration test can be performed on those price series. The null hypotheses are given in details in section 4.2.1.

The second step is to estimate the regression model $P_{1t} = \beta_1 + \beta_2 P_{2t} + \varepsilon_t$ to obtain its error time series and its difference of the error time series. The error time series can be written exactly as equation (14):

$$\varepsilon_t = \theta_1 \varepsilon_{t-1} + \eta_t \tag{17}$$

then, $\Delta\varepsilon_t = \varepsilon_t - \varepsilon_{t-1} = (\theta_1 - 1)\varepsilon_{t-1} + \eta_t$, thus,

$$\Delta\varepsilon_t = \theta_1^* \varepsilon_{t-1} + \eta_t \tag{18}$$

where $\theta_1^* = \theta_1 - 1$.

The third step is again to conduct a unit root test on equation (18). This is a DF test. When additional differenced leg terms are added to equation (18), an ADF test can be conducted on the model:

$$\Delta\varepsilon_t = \theta_1^* \varepsilon_{t-1} + \sum_{i=1}^{n} \phi_i \Delta\varepsilon_{t-i} + \eta_t \tag{19}$$

The null hypothesis is $H_0 : \theta_1^* = 0$ against $H_1 : \theta_1^* < 0$. If θ_1^* is significantly negative, the null hypothesis is rejected. The hypotheses can also expressed more directly as the null hypothesis is H_0 : P_{1t} and P_{2t} are not cointegrated against H_1 : P_{1t} and P_{2t} are cointegrated. Thus, if the estimated DF and ADF values are negative and their absolute values are larger than their corresponding absolute DF critical values, P_{1t} and P_{2t} are cointegrated. Thus, it can be said that there is a long-run equilibrium relationship existed between P_{1t} and P_{2t}. Thus, if all of these tests are positively verified, the LOP on the price relationship between the DCE and CBOT soybean futures markets is supported.

CHAPTER 5 DATA ANALYSIS AND EMPIRICAL RESULTS

5.1 DATA ANALYSIS

In this thesis, two soybean futures price time series and one soybean ocean freight rate time series for an individual soybean futures contract are used in the estimated models. One price time series is the CBOT soybean futures close prices. The other price time series is the DCE soybean futures close prices. The soybean ocean freight rate time series is the price of shipping the American soybeans from the Gulf of Mexico to China, Japan, South Korea and Taiwan. The soybean freight rate data comes from the USDA while the DCE soybean futures price data is provided by Reuters Ltd..

The DCE started its operation in 1994, but its soybean futures business was not very active in 1994 and 1995. Often no business activities occurred for several consecutive days in 1994 and 1995. So, the incomplete DCE soybean futures price time series in 1994 and 1995 are dropped. The soybean ocean freight rate time series is also limited and started in 1996. Therefore, due to the adjustment of both the DCE soybean price data and the soybean ocean freight rate data, the empirical analysis period in this thesis covers from 1996 through 1999.

A commodity futures quote usually has five prices: open, high, low , close and settlement. Commodity futures market researchers often use close prices in their studies, because they are believed to contain the best price information. In this thesis the CBOT and the DCE soybean futures close prices are used.

The CBOT soybean futures market has seven soybean contracts in a year, while the DCE has only six contracts without August contract. The lack of the August contract in the DCE results in dropping the CBOT August soybean price data in the study.

Each DCE soybean contract in a year is traded for only one year. However, a CBOT soybean contract is typically traded for more than one year, sometimes, two years, because it starts earlier than its corresponding DCE contract. So, each longer CBOT contract price time series has to be truncated to the length of its corresponding DCE contract.

When a CBOT or a DCE price time series has missing prices due to holidays or other reasons, but the other still has prices. These price observations are deleted. The details of all the price data sets from the CBOT and the DCE used in estimation are shown in Appendix I.

The original CBOT and DCE soybean futures prices are daily prices. In this study, only weekly prices are used in estimation in order to obtain better estimated results. The weekly prices are produced by averaging the close prices in each week. The details of the average weekly prices series from the CBOT and the DCE are shown in Appendix II.

The last and most important step to process the price data sets is to connect CBOT or DCE soybean futures price time series from 1996 to 1999 year by year. How can these daily prices be better connected? Gray (1960) proposes a method which is that the nearby contract "rolls over" to the next contract on the last day before the delivery month. For example, Chicago soybean May contract in 1998 is used from the beginning of March to the end of April. Then the price time series rolls over to July contract of the same year. July contract is used from the first day of May to the last day of June and then rolls over to September contract in 1998, and so on. Gray explains that "the ideal date for switching from one future to another in such a routine is at or near the first trading day of the delivery month, this being the time at which the futures contract effectively 'becomes' a spot commodity, in that delivery can then be made on the contract." Many commodity futures market researchers follow Gray's method. In this study, his method is not followed, because if followed, time-series observations would be lost. There would be more times that a price time series of a previous contract did not smoothly roll over to its next contract at the connecting date like the original contract, but instead, skipped over to its next contract. As a result, these breaks in a price time series would increase possibilities of producing erroneous regression results. Therefore, another method is adopted to produce a soybean futures price time series for the period of study. This method used by commodity futures industry goes by connecting the end of a price time series in a previous year to the head of a price time series in the next year for a particular contract year by year. For example, the Chicago May 1996 contract "rolls over" on its last trading day to the May 1997 contract on its first trading day and then the May 1997 contract is connected to the May 1998 contract in the same way, and so on. This method clearly reduces the breaks caused by connecting daily prices year by year, because there are fewer roll-overs. In this way, six soybean futures price time series from 1996 to 1999 (January, March, May, July, September and November price series) are respectively produced from the original CBOT and DCE daily prices.

5.2 EMPIRICAL RESULTS FOR OLS ESTIMATING APPROACH

Based on Richardson's economic model, $P_1 = \beta_0 E^{\beta_1} P_2^{\beta_2} T^{\beta_3} R^{\beta_4}$ and his recommended statistical form, equation (7) $\Delta \ln P_{1t} = \beta_0^{'} + \beta_1 \Delta \ln E_t + \beta_2 \Delta \ln P_{2t} + \varepsilon_t$, the OLS procedure in this thesis is firstly conducted on the following log-log differenced statistical model:

$$\Delta \ln P_{1t} = \beta_0^{'} + \beta_1 \Delta \ln T_t^{*} + \beta_2 \Delta \ln P_{2t} + \varepsilon_t \qquad (20)$$

where the hypotheses of equation (20) are $\beta_1 = \beta_2 = 1$ and $\beta_0^{'} = 0$.

The difference between equations (20) and (7) is that the independent variable exchange rate is replaced by the variable freight rate. The explanations are that in the period of this study China adopted a controlled-floating exchange rate policy and its exchange rate did not change much over the period. And more important, in this thesis ocean freight rate data for shipping soybeans from America to China is available and freight rate variable shows a large fluctuation over the study period. Therefore, the freight rate variable replaces the exchange rate variable to be explicitly expressed as an independent variable in equation (20). The exchange rate variable is not explicitly expressed, but instead, directly merged into the CBOT soybean futures price P_2 by multiplying CBOT price by the exchange rate. P_2 is denominated in Chinese Yuan, in the same currency as P_1.

In equation (20), further modifications on the freight rate and price are as follows. T^* is an index of the freight rate, not the freight rate T. T^*=1+ (T/P_2). T and P_2 are both converted in Chinese Yuan per metric ton. Due to 3 percent Chinese soybean import tariff and 13 percent value added tax, the final aggregated C & F

Chinese soybean price should incorporate these two factors. So, the CBOT price and ocean freight rate need to be transformed by multiplying (1 + 0.03)(1 + 0.13).

Table 5.1 shows the preliminary results from regressing equation (20) for the six soybean futures contracts. The estimated standard errors are in parenthesis. The six estimates of β_2 or β_1 are all not close to one. Their t-test statistics show that their null hypotheses, $H_0 : \beta_2 = 1$, are all rejected at a 5% significance level. The estimated intercept parameters are close to zero. But three of six contracts reject the null hypothesis, $H_0 : \beta_0^{'} = 0$, at a 5% significance level. More significantly, the R squares are very small. This indicates that the dependent variable, the DCE soybean futures price, is almost not explained by the independent variables, the CBOT soybean futures price and the freight rate. In summary, the preliminary estimated results show a conclusion that there is no close relationship between the DCE and the CBOT soybean futures prices in the short run.

To further explore the price relationship between the DCE and the CBOT soybean futures markets in the long run, the first estimating method in this thesis is to conduct OLS procedure on the following log-log level model:

$$\ln P_{1t} = \beta_0^{'} + \beta_1 \ln T_t^* + \beta_2 \ln P_{2t} + \varepsilon_t \tag{21}$$

where $\beta_0^{'} = \ln \beta_0$ and the hypotheses are $\beta_1 = \beta_2 = 1$ and $\beta_0^{'} = 0$.

Table 5.1 Summary of Regression Coefficients for the Log-Log Differenced Model: $\Delta \ln P_{1t} = \beta_0^{'} + \beta_1 \Delta \ln T_t^{*} + \beta_2 \Delta \ln P_{2t} + \varepsilon_t$

Contract	$\beta_0^{'}$	β_1	β_2	R^2
January	-0.0029* (0.0019)	-0.4086 (0.4157)	0.2002 (0.0869)	0.068
March	-0.0035 (0.0015)	-0.4847 (0.3574)	0.1163 (0.0736)	0.057
May	-0.0032 (0.0013)	-0.5122 (0.3038)	0.1386 (0.0571)	0.099
July	-0.0028 (0.0014)	-0.4695 (0.3172)	0.1274 (0.0602)	0.075
September	-0.0009* (0.0014)	-0.2388 (0.3094)	0.0749 (0.0599)	0.027
November	-0.0017* (0.0018)	-0.4977 (0.4026)	0.1443 (0.0868)	0.048

Note: * indicates null hypothesis is not rejected at a 5% significance level.

Table 5.2 presents the estimated results. The six parameter estimates for β_2 are all very close to one which is one of the hypotheses to be tested. t test statistics show that Contracts March and November do not reject their null hypotheses, $H_0 : \beta_2 = 1$ at a 5% significance level. Contract January does not reject its null hypothesis at a 1% significance level. The other three contracts reject their null hypotheses. For the parameter β_1 of the freight rate variable, five of six contracts have produced the expected estimates which do not reject $H_0 : \beta_1 = 1$. Only contract July rejects its null hypothesis. In summary, these estimates seem to show that the prices in the two markets have moved together in the long run. But this conclusion is not confirmative. For example, Contract July does not fully support this conclusion.

Table 5.2 Summary of Regression Coefficients for the Log-Log Level Model: $\ln P_{1t} = \beta_0' + \beta_1 \ln T_t^* + \beta_2 \ln P_{2t} + \varepsilon_t$

Contract	b_0'	b_1	b_2	R^2
January	-0.7526* (0.3904)	1.4478* (0.5045)	1.1051** (0.0519)	0.802
March	-0.1744* (0.3352)	1.5810* (0.4706)	1.0272* (0.0441)	0.818
May	1.3028 (0.2970)	1.6730* (0.4573)	0.8357 (0.0385)	0.767
July	1.3497 (0.2504)	2.1710 (0.3994)	0.8251 (0.0324)	0.825
September	0.9715 (0.3087)	1.1539* (0.4645)	0.8910 (0.0406)	0.789
November	0.6541** (0.3128)	1.1926* (0.4252)	0.9331* (0.0413)	0.795

Note: * indicates null hypothesis is not rejected at a 5% significance level.
** indicates null hypothesis is not rejected at a 1% significance level.

In order to get a more reliable conclusion, the estimates in Table 5.2 still need to be fixed by correcting possible autocorrelation and heteroskedasticity problems. Plots of the six time-series price sets and examination of their values suggest that these price series depart their means at certain periods of time (Appendix II). More convincingly, the Durbin-Watson test identifies that all the six time-series soybean price and the freight rate data sets have very low DW statistics and high first order autocorrelation. The Breusch-Godfrey test also confirms that there is a heteroskedasticity problem in these data sets.

To remove both heteroskedasticity and autocorrelation problems in the data sets, equation (21) is first to be transformed by dividing each observation by the square root of the estimated variance of the error term. In this way, the heteroskedasticity problem in the data sets can be properly overcome. Then, based on this procedure, Durbin's two-stage method is employed to transform again the transformed model to fix the autocorrelation problem.

After the heteroskedasticity and autocorrelation problems in the data sets are removed, run regression to obtain parameter estimates without heteroskedasticity and autocorrelation errors. Table 5.3 presents these estimates.

Table 5.3 Summary of Regression Coefficients after Correcting Heteroskedasticity and Autocorrelation for the Log-Log Level Model:
$\ln P_{1t} = \beta_0' + \beta_1 \ln T_t^* + \beta_2 \ln P_{2t} + \varepsilon_t$

Contract	b_0'	b_1	b_2	R^2
January	-0.00038 (0.00011)	2.6086 (0.4422)	1.0085* (0.0045)	0.9992
March	-0.00025* (0.00028)	3.4433 (0.7451)	0.9957* (0.0040)	0.9993
May	0.00017* (0.00013)	1.6611* (0.7433)	0.9978* (0.0048)	0.9994
July	-0.00028* (0.00017)	3.2662** (0.8967)	0.9994* (0.0035)	0.9992
September	-0.00023* (0.00012)	2.7546 (0.4229)	1.0106 (0.0040)	0.9997
November	-0.00022* (0.00012)	2.0485* (0.5473)	1.0177 (0.0051)	0.9993

Note: * indicates null hypothesis is not rejected at a 5% significance level.
** indicates null hypothesis is not rejected at a 1% significance level.

The parameter estimates of β_2 for all the six contracts in Table 5.3 remain very close to the hypothesized one. t-test statistics do not reject the null hypothesis $H_0 : \beta_2 = 1$ for Contract January, March, May and July, but reject it for Contract

September and November at a 5% significance level. The parameter estimates of β_1 are changed to be not close to the hypothesized one. Comparing the estimates in Table 5.2 with those in Table 5.3, the transformations of the model for correcting heteroskedasticity and autocorrelation problems have improved b_2 and $b_0^{'}$ estimates which are closer to their hypotheses. However, b_1 estimates have become less closer to their hypotheses. In summary, the procedure of correcting heteroskedasticity and autocorrelation problems has not helped to eliminate ambiguity of the conclusion. The collinearity test of independent variables CBOT soybean futures price and freight rate has confirmed this point. The Pearson correlation test shows that the correlations between the two variables are very high after the model transformation, ranging from 88% to 98%.

After all, based on the estimates of Table 5.2 and Table 5.3, it is still difficult to conclude whether or not there is a correlated price relationship between the DCE and the CBOT soybean futures markets in the long run. As section 4.1 states, the nonconclusion may come from nonstationarity of the time-series price data used in the OLS estimation. In order to obtain a definite conclusion, this thesis in the following sections follows Ardeni's proposed cointegration procedure to test whether the DCE and the CBOT soybean futures markets are correlated in the long run.

5.3 EMPIRICAL RESULTS FOR STATIONARITY AND COINTEGRATION TEST APPROACHES

The empirical cointegration test approach in this thesis consists of two estimation steps: a stationarity test and a bivariate cointegration test. The stationarity test is a precondition which must be satisfied before the cointegration test for the pair of time-series price variables, the DCE and the landing prices (only including CBOT price and ocean freight rate) is performed. This stationarity test is proceeded in two steps. The first step is to test whether level price time series of dependent and independent variables, the DCE price and the landing price, are nonstationary or not I(0). The second step is to test whether these price time series which are not I(0) become stationary, or I(1), after they are transformed by first difference procedure. If results of these two stationarity tests are as what expected, then, the second estimation step is to test whether this pair of the DCE and the landing price time series is cointegrated.

Table 5.4 shows that the estimated results of stationarity test for the level time series of the DCE and the landing price. In Table 5.4, for simplicity, CBOT price is used to indicate the landing price. There are twelve weekly price time series which cover the study period from 1996 through 1999. The number of weekly price observations in these twelve weekly price sets spreads from 118 to 211. Since the numbers of all the price observations in the data sets are larger than 100, the corresponding critical values for the DF and ADF tests is –3.43 at an 1% significance level and –3.12 at a 2.5% significance level. In the ADF test estimation, one additional lag term is arbitrarily added, because the estimated values by adding one to four terms are not much different, and they produce the same final inference result.

Table 5.4 reports that both the estimated DF and the ADF values are negative and their absolute values are smaller than the absolute critical value –3.43 (1% significance level). That means that the null hypothesis that $H_0 : y_t$ is not I(0) is not rejected for all the DCE and the landing prices at a 1% significance level. Both the

DF and the ADF tests prove that all the twelve price time series of the DCE and the landing prices are not I(0). So, the first part of precondition for implementing the bivariate cointegration test for a pair of the DCE and the landing prices variables is satisfied.

Table 5.4 Summary of Stationarity Tests for DCE and CBOT (landing) Level Prices:

$$\Delta y_t = \theta_1^* y_{t-1} + \mu + e_t + \sum_{i=1}^{n} \phi_i \Delta y_{t-i}$$

Variable		Observation No.	DF	ADF
CBOT/JAN		133	-1.42	-1.22
DCE/JAN		190	-0.28	-0.35
CBOT/MAR		118	-1.40	-1.30
DCE/MAR		195	-0.32	-0.35
CBOT/MAY		139	-1.32	-1.34
DCE/MAY		211	-0.24	-0.38
CBOT/JUL		138	-1.32	-1.18
DCE/JUL		193	-0.38	-0.28
CBOT/SEP		133	-1.11	-1.06
DCE/SEP		190	-0.29	-0.44
CBOT/NOV		134	-1.26	-1.18
DCE/NOV		166	-0.40	-0.28

Note: 1. Critical values for DF and ADF tests (Fuller, 1976, p. 373):
(1) 100 observations (AR model with intercept): -3.51 (1%) and -3.17 (2.5%) or –2.58 (10%).
(2) ∞ observations (AR model with intercept): -3.43 (1%) and -3.12 (2.5%).

2. The null hypothesis that $H_0 : y_t$ is not I(0) is not rejected for all DCE and landing prices at both 1% and 2.5% significance levels.

Table 5.5 shows the estimated results of both the DF and the ADF tests for the same twelve but first differenced time series of the DCE and the landing prices.

Table 5.5 Summary of Stationarity Tests for DCE and CBOT (landing) First-Difference Prices:

$$\Delta y_t = \theta_1^* y_{t-1} + \mu + e_t + \sum_{i=1}^{n} \phi_i \Delta y_{t-i}$$

Variable		Observation No.	DF	ADF
CBOT/JAN		129	-10.48	-8.64
DCE/JAN		189	-12.18	-9.88
CBOT/MAR		112	-10.11	-7.44
DCE/MAR		194	-12.58	-9.52
CBOT/MAY		132	-9.38	-8.24
DCE/MAY		210	-12.46	-8.94
CBOT/JUL		131	-10.95	-9.29
DCE/JUL		192	-10.54	-8.99
CBOT/SEP		118	-11.61	-9.53
DCE/SEP		173	-11.81	-9.28
CBOT/NOV		127	-10.90	-8.58
DCE/NOV		165	-11.30	-9.57

Note: (1) The critical values for DF and ADF tests are as Table 5.3.
(2) The null hypothesis that $H_0 : y_t$ is not I(1) is rejected for all DCE and landing prices at both 1% and 2.5% significance levels.

It reports that both the DF and the ADF estimated values are all negative and their absolute values are larger than the absolute critical value –3.43 (1% significance level). Therefore, the null hypothesis that $H_0 : y_t$ is not I(1) is rejected for all the DCE and the landing prices at the 1% level of significance. That is, all the twelve time series of the DCE and the landing prices are I(1) price time series. This means that the second part of precondition for performing the bivariate cointegration test is satisfied. After all, the two stationarity test results jointly verify that the twelve time series of the DCE and the landing prices are I(1) price time series. They are qualified to be used in the bivariate cointegration test.

In Table 5.6 six pairs of the DCE and the landing price time series are used in the cointegration test to verify whether these pairs of price variables are cointegrated respectively. The estimated DF and ADF values show that the absolute values for three contracts (January, March and September) are larger than the absolute critical value –3.43 (1% significance level). For these three contracts, the null hypothesis H_0 : P_{1t} and P_{2t} are not cointegrated is rejected at the 1% level of significance. For other three contracts, inference is a little different. For November Contract, its absolute ADF estimated value is larger than the absolute critical value –3.43, but its absolute DF is smaller than the absolute critical value –3.43 and larger than the absolute critical value –3.12 (2.5% significance level). The absolute estimated DF and ADF values of July Contract are both smaller than the absolute critical value –3.43, but the ADF value is larger than the absolute critical value –3.12. Only the absolute DF and ADF values of May Contract are not only smaller than the absolute critical values –3.43, but also smaller than the absolute critical value –3.12. This means that the null hypothesis H_0 : P_{1t} and P_{2t} are not cointegrated is not rejected at both an 1% and a 2.5% significance levels for May Contract. However, if the significance level is changed from a 1% to a 10%, the null hypothesis is rejected for all six contract. In a word, the majority of the estimated DF and ADF values shows that the null hypothesis H_0 : P_{1t} and P_{2t} are not cointegrated is rejected at either an 1% or a 2.5% significance level. And all the estimated DF and ADF values reject the null hypothesis at a 10% significance level.

Table 5.6 Summary of Cointegration Tests for DCE and CBOT (landing) Prices:
$\Delta\varepsilon_t = \theta_1^* \varepsilon_{t-1} + \sum_{i=1}^{n} \phi_i \Delta\varepsilon_{t-i} + \eta_t$

Contract		Observation No.	DF	ADF
January		143	-3.626	-3.819
March		135	-3.459	-3.700
May		153	-2.743*	-3.068*
July		152	-2.770*	-3.282**
September		142	-3.709	-3.602
November		149	-3.121**	-3.959

Note: (1) The critical values for DF and ADF tests are as Table 5.3.
(2) * indicates that the null hypothesis H_0 : P_{1t} and P_{2t} are not cointetrated is not rejected at both 1% and 2.5% significance levels.
(3) ** indicate that the null hypothesis is not rejected at a 1% level but rejected at a 2.5% level.

In summary, the stationarity tests for soybean futures level prices of six contracts show that these price time series are all nonstationary. But they become stationary after they are transformed by first difference procedure. On the basis of these stationarity test results, the cointegration tests for the majority of six contracts prove that the DCE and the CBOT soybean futures markets are correlated in the long run.

CHAPTER 6 CONCLUSIONS AND IMPLICATIONS

The empirical objectives in this thesis are to test if the Chinese soybean futures market, the Dalian Commodity Exchange, has been integrated with the world largest soybean futures market, the Chicago Board of Trade in late 1990s, that is to see if the law of one price is valid for the soybean futures markets in the DCE and the CBOT. Prices of soybeans traded on these two commodity futures exchanges are analyzed by using both the OLS and the bivariate cointegration test techniques. In addition, six soybean futures price time series are compared by using these techniques. The methodology applied in this thesis is similar to those in other research papers of testing the validity of the law of one price. The significance of this thesis is that it may be the first empirical research paper out of China attempting to explore the price relationship between the Chinese and American soybean futures markets. The empirical test results provide helpful information for people to better understand the developing Chinese soybean futures market and its soybean futures price relationship with the soybean futures market of the Chicago Board of Trade. However, due to the limitation of the relatively short period of the Chinese soybean futures price time series, the estimating precision might be adversely affected.

6.1 CONCLUSIONS OF OLS ESTIMATING APPROACH

The hypotheses of the OLS approach in this thesis are that $\beta_1 = \beta_2 = 1$ and $\beta_0^{'} = 0$. For the short-run price relationship, the OLS estimated results of the differenced log-log model $\Delta \ln P_{1t} = \beta_0^{'} + \beta_1 \Delta \ln E_t + \beta_2 \Delta \ln P_{2t} + \varepsilon_t$ do not support the conclusion that the DCE and the CBOT soybean futures markets are integrated in the short run. Table 5.1 shows that the estimates for b_1 and b_2 are much different from the hypothesized one. The t- statistic tests reject the null hypotheses for almost all the parameters. The six very small R squares also help to confirm that the two markets are not related in the short run. For the long-run price relationship, the estimated results of the level log-log model $\ln P_{1t} = \beta_0^{'} + \beta_1 \ln T_t^{*} + \beta_2 \ln P_{2t} + \varepsilon_t$ neither definitely support nor deny the conclusion that the DCE and the CBOT soybean futures markets are integrated in the long run. Table 5.3 shows that the estimates of b_2 and $b_0^{'}$ are very close to the hypothesized one and zero. Most of the t- statistic tests of the parameters b_2 and $b_0^{'}$ do not reject their null hypotheses. But the b_1 estimates are much larger than one. And more important, these estimates of the parameters are not fully reliable due to collinearity of the independent variables the CBOT soybean price and the freight rate.

Therefore, according to the estimated results from the OLS approach, it can be concluded that in general, the DEC soybean futures market has not been integrated with the CBOT soybean futures markets in the short run for the period of study. The DCE soybean futures price does not quickly respond to the price change of the CBOT soybean price. The law of one price is not valid for these two markets. On the other hand, the OLS approach can not provide an unambiguous conclusion whether these two soybean futures markets have been integrated in the long run, due to the reason that the conventional OLS estimating procedure can not properly deal with the nonstationarity property of the time-series soybean futures price data used in level model estimation of the empirical analysis in this thesis.

6.2 CONCLUSIONS OF COINTEGRATION ESTIMATING APPROACH

Section 5.3 discusses the estimated results of two estimation steps in a bivariate cointegration test approach. In the first estimation step, the stationarity tests show that all the twelve DCE and the landing price time series are nonstationary. Then, after these nonstationary price time series are first differenced, the stationarity tests show that these first differenced price time series become stationary. The second estimation step is the bivariate cointegration test. Table 5.5 indicates that at either an 1% or a 2.5% significance level, except that the estimated results of May Contract do not support the hypothesis that the DCE and the landing prices are cointegrated, other five contract estimated results support the hypothesis. If the signigicance level is extended from an 1% to a 10%, all the estimates in Table 5.5 support the hypothesis.

Therefore, it can be concluded that the estimated results of the bivariate cointegration test validate the law of one price in the long run for the DCE and CBOT soybean futures markets. There is a long-run equilibrium relationship between the two markets. The slight different understanding from a definitely unanimous conclusion is only a matter of how a different significance level is selected. However, at the same time, it is understood that the several different estimates in Table 5.5 indeed imply that it will be more helpful if they are further explored.

6.3 IMPLICATIONS

In section 5.2 the OLS estimated results indicate that the DCE and the CBOT soybean futures markets have not been integrated in the short run in the period of study. That means that the DCE soybean futures price does not fully adjust itself according to the CBOT soybean futures price change in a short period of time. One of possible explanations is that daily soybean futures arbitrage activities do not actually exist between these two markets, due to various reasons including different delivery requirements for quality specifications, government restrictive policy, etc..

The OLS estimates in Table 5.3 clearly indicate price deviations in the long run. The estimated parameter coefficients are not as what are hypothesized. The price deviations not only imply that the OLS estimating procedure may not be applicable for the time-series data used in this thesis, but also imply possible model misspecification. For instance, due to unavailability of data, the artificial landing price does not include the FOB price premium from Chicago to New Orleans port. This inland barge freight rate has an important portion in American soybean export price composition. The landing price does not include many other costs, either, such as loading and unloading costs, ocean shipping insurance, etc..

The ambiguous conclusion of the OLS estimating procedure may also be caused by the DCE own soybean futures price change. Sometimes, the effect of Chinese domestic market factors may override the effect of the CBOT soybean price. Then, the DCE soybean futures price is dominated by the local market factors in a short period of time. These market factors can be briefly listed here:

(1) Chinese domestic soybean supply. In the past years whenever the Chinese major soybean producing area (Heilongjiang Province) had a bumper or poor harvest, the DCE soybean futures prices fell or rose after the harvest time. Weather affects soybean railway transportation in the northeastern part of China during the winter. So, when a heavy snow fell, the DCE soybean price sometimes rose.

(2) Chinese government farm policy. In recent years the Chinese government has tried several times to support its farmers in order to maintain China's grains and oilseeds self-reliance. One of its major farm policies was to purchase surplus grains and oilseeds from farmers at targeted floor prices if market prices fell below floor prices. This policy reduced soybean selling contracts in the DCE and prevented the DCE soybean price from falling below the government targeted floor price, even though the CBOT soybean futures price was below it over this period of time.

(3) Market manipulation. Nowadays, commodity futures market manipulation hardly happens in the CBOT. But market manipulation still more or less exists in Chinese commodity exchanges. The DCE is no exception. For instance, a small group of speculators in the DCE bought and sold by themselves a huge quantity of soybean contract to control price at the time of two or three months before a contract expired. During this period of time, the DCE soybean futures price fluctuated out of its normal range.

The cointegration tests in section 5.3 conclude that the DCE and the CBOT soybean futures markets have been integrated in the long run. The intuitive interpretation of this market integration is that Chinese soybean imports forced high Chinese domestic soybean price to fall to international price level. In early 1990s Chinese domestic soybean price rose above world market price with China's fast growing soybean consumption. From the middle of 1990s China started to import soybeans at a dramatically high speed. The huge quantity of soybean imports satisfied domestic demand and pulled down high domestic soybean price. It is clear that it takes several months for imported soybeans to influence Chinese domestic soybean price, due to the process of purchasing and shipping soybeans abroad.

In summary, Chinese soybean import scenario and other market factors can explain that the DCE and the CBOT soybean futures markets have been integrated in the long run but not in the short run.

6.4 STUDY LIMITATIONS

In this thesis the data used in empirical estimation spans from 1996 to the first half of 1999. This relatively short period of data duration limits the estimation precision. The six DCE soybean futures price time series have many missing observations, due to the DCE market close. These missing price observations may have negative impact on the estimated results.

As noted in section 6.2, some of other prices are not specified into variables in estimating models in this thesis. So, the estimating models may be misspecified. The specific characteristics of these price time series may qualify other better estimating models.

6.5 SUGGESTIONS FOR FUTURE RESEARCH

In order to overcome the above shortcomings of work and better understand Chinese soybean market, further efforts can be made in at least two aspects. First, try to add more variable data and expand data duration. For instance, it is possible to collect inland soybean barge freight rate and loading and unloading costs. Second, some other approached might provide more information. For example, switching regime models may better account for some of price deviations in certain periods of time. Multivariate cointegration test may provide more reliable conclusions with respect to transportation.

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APPENDIX

APPENDIX

Table 1 Description of the DCE and the CBOT Daily Price Data

Time	Description	Data No.	Unused No.	Used No.	Period
1995	CBOT/1	335	298	37	09/22/93-01/20/95
	DCE/1	38	1	37	07/04/94-01/12/95
	CBOT/3	330	266	64	11/29/93-03/22/95
	DCE/3	67	3	64	07/11/94-03/10/95
	CBOT/5	308	266	46	02/03/94-05/19/95
	DCE/5	46	0	46	07/26/94-05/10/95
	CBOT/7	390	368	22	01/03/94-07/20/95
	DCE/7	22	0	22	12/23/95-09/13/95
	CBOT/9	299	284	15	07/15/94-09/21/95
	DCE/9	15	0	15	03/13/95-09/13/95
	CBOT/11	484	477	7	11/22/93-11/20/95
	DCE/11	7	0	7	05/18/95-10/23/95
1996	CBOT/1	319	244	75	10/17/94-01/22/96
	DCE/1	76	1	75	07/24/95-01/16/96
	CBOT/3	332	206	126	11/28/94-03/20/96
	DCE/3	129	3	126	07/24/95-03/14/96
	CBOT/5	336	183	153	01/24/95-05/21/96
	DCE/5	156	3	153	06/28/95-05/15/96
	CBOT/7	544	347	197	05/27/94-07/23/96
	DCE/7	203	6	197	08/18/95-07/12/96
	CBOT/9	287	90	197	08/04/95-09/20/96
	DCE/9	203	6	197	10/10/95-09/13/96
	CBOT/11	629	426	203	05/27/94-11/20/96
	DCE/11	207	4	203	12/01/95-11/14/96
1997	CBOT/1	333	139	194	10/02/95-01/23/97
	DCE/1	199	5	194	03/06/96-01/15/97
	CBOT/3	351	163	188	11/22/95-03/20/97
	DCE/3	193	5	188	04/24/96-03/13/97
	CBOT/5	315	103	21	05/22/95-05/20/97
	DCE/5	217	5	212	06/05/96-05/14/97
	CBOT/7	651	437	214	01/09/95-07/23/97
	DCE/7	220	6	214	08/05/96-07/14/97
	CBOT/9	274	58	216	08/27/96-09/19/97
	DCE/9	222	6	216	10/04/96-09/12/97
	CBOT/11	709	493	216	12/14/94-11/19/97
	DCE/11	222		216	11/15/96-11/14/97

APPENDIX (Continued)

Table 1 Description of the DCE and the CBOT Daily Price Data

Time	Description	Data No.	Unused No.	Used No.	Period
1998	CBOT/1	338	118	220	01/23/96-01/23/98
	DCE/1	226	6	220	01/23/97-01/15/98
	CBOT/3	312	136	176	03/21/96-03/23/98
	DCE/3	183	7	176	03/26/97-03/13/98
	CBOT/5	307	84	223	03/05/97-05/22/98
	DCE/5	230	7	223	05/15/97-05/14/98
	CBOT/7	449	223	226	07/23/96-07/24/98
	DCE/7	234	8	226	07/15/97-07/14/98
	CBOT/9	255	28	227	09/25/97-09/21/98
	DCE/9	240	13	227	09/16/97-09/14/98
	CBOT/11	574	339	235	08/16/96-11/18/98
	DCE/11	243	8	235	11/17/97-11/13/98
1999	CBOT/1	303	64	239	01/23/97-01/20/99
	DCE/1	247	8	239	01/16/97-01/15/99
	CBOT/3	294	55	239	01/23/98-03/22/99
	DCE/3	246	7	239	03/16/98-03/12/99
	CBOT/5	267	58	209	03/11/98-03/31/99
	DCE/5	226	17	209	05/18/98-04/15/99
	CBOT/7	485	316	169	04/25/98-03/31/99
	DCE/7	184	15	169	07/15/98-04/15/99
	CBOT/9	177	102	75	07/27/98-03/31/99
	DCE/9	88	13	75	11/30/98-04/14/99
	CBOT/11	483	417	66	05/06/97-03/31/99
	DCE/11	79	13	66	12/09/98-04/15/99

Note: (1) 1=January, 3=March, 5=May, 7=July, 9=September, 11=November.
(2) Data No.=Numbers of original daily prices
(3) Unused Data No.=Numbers of original daily prices not used in the data sets.
(4) Used Data No.=Numbers of original daily prices used in the data sets.