AN ABSTRACT OF THE DISSERTATION OF

Shengfei Han for the degree of Doctor of Philosophy in Agricultural and Resource Economics presented on April 4, 2003.

Title: Spatial and Inter-temporal Price Analysis: Including Risk Perceptions and Dynamic Trade Flow Information

Abstract approved: Redacted for Privacy

Catherine A. Durham

A regime-switching model for market integration study is extended to incorporate dynamic trade flow information and risk perceptions based on an expected utility framework. An application of the extended model to the US-China soybean markets analysis shows that: One, the positive arbitrage rent uncounted-for in the extended model has been substantially reduced compared to the results from previous models. Two, dynamic trade information modeling provides more accurate information about market integration conditions. Three, inclusion of variables derived from the mean-variance expected utility function representing risk factors may help correct the weakness of the price relationship model in revealing the causes of observing or failure to observe the law of one price. Finally, US-China soybean markets are found to be integrated most of the time. However, significant deviations from efficient arbitrage are also detected.

Spatial and Inter-temporal Price Analysis: Including Risk Perceptions and Dynamic Trade Flow Information

by

Shengfei Han

A DISSERTATION

submitted to

Oregon State University

in partial fulfillment of

the requirement for the

degree of

Doctor of Philosophy

Presented April 4, 2003
Commencement June 2003

Doctor of Philosophy dissertation of Shengfei Han
Presented on April 4, 2003.

APPROVED:

Redacted for Privacy

Major Professor, Representing Agricultural and Resource Economics

Redacted for Privacy

Head of the Department of Agricultural and Resource Economics

Redacted for Privacy

Dean of the Graduate School

I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

Redacted for Privacy

Shengfei Han, Author

ACKNOWLEDGEMENTS

I would like to extend my heart-felt gratitude to my major professor Dr. Catherine A. Durham, whose academics, insight, creativity, professionalism, and generous support have been invaluable throughout my education and research at Oregon State University.

I also greatly appreciate the assistance, encouragement, and patience of my other committee members, Dr. Richard S. Johnston, Dr. Munisamy Gopinath, Dr. Jon Moulton, Dr. Claire Montgomery.

I would like to thank Dr. Steven T. Buccola, in the Department of Agricultural and Resource Economics, for sharing his expertise in market analysis.

I still, and will always remember all the encouragements and advice from Dr. William G. Boggess, Head of the Department of Agricultural and Resource Economics.

Sincere appreciation is also expressed to Dr. Joe Kerkvliet in Economics Department and Dr. Annie Qu in Statistics Department for their important assistance in econometrics and statistics in my dissertation research.

I also want to thank the AREc department staffs whose help and warmth is indispensable throughout my program at Oregon State University.

Thanks go to my family in China for their love and support.

Thanks go to all my friends, for their inspiring friendship, encouragement, enthusiasm, and generosity in sharing experiences and insight.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

To my mother, Fanghua Liu

Spatial and Inter-temporal Price Analysis: Including Risk Perceptions and Dynamic Trade Flow Information

CHAPTER 1 - INTRODUCTION

1.1. Context and Motivation

International commodity arbitrage is across border as well as over time because of the delivery lag. Compared to domestic transactions, a substantial level of risk is a reasonable assumption for international arbitragers under many circumstances. However, in international commodity market analyses, there have been few efforts in the literature modeling a price parity condition incorporating risk considerations. Empirical tests incorporating the trade flow change information have also been lacking because it is difficult to include a trade volume series in a price relationship model. Barrett and Li's inclusion of trade volume is an important step. However, without knowledge of how trade varies the interpretation of price relationship may be very difficult. Thus, there has been confusion in the profession when interpreting the test results from this type of model. A third area that has not received adequate attention regards the inter-temporal modeling of the international commodity arbitrage, such as the role of futures market in the arbitrage decision and the time value considerations.

This dissertation presents an attempt to model a price parity condition based on an expected utility function for a representative arbitrager, explicitly including risk perceptions, to derive a zero marginal benefit condition. The empirical model then extends a regime-switching model developed by Barrett and Li (2002). The extended model advances on their work by incorporating dynamic trade flow information.

As international commodity arbitrage involves a delivery lag, futures market integration has a crucial role in indexing the future spot price link between countries. Therefore, a parity condition is also derived for the futures markets between a pair of countries that do not have direct futures market arbitrage with each other.

Finally, the model developed in this study is applied to testing the soybean markets between the U.S. and China. The test results indicate that: 1. The extended model has provided more convincing information about market equilibrium conditions than prior models. 2. Inclusion of key structural variables derived from the expected utility function, such as risk perceptions, may help correct the weakness of the price relationship model in revealing the causes of observing or failure to observe the law of one price.

To better appreciate the motivation of this study, a brief look is taken at why it is important to analyze the market integration conditions.

1.2. Importance of Market Integration

Market integration has important implications for corporate and government policies. It is also an essential assumption in economic analysis.

First, in a better-integrated market, firms have the potential to increase sales and therefore take advantage of the economies of scale in production. With the elimination or reduction of trade barriers such as tariffs, for example, firms can trade more freely and locate production in the place with the lowest cost. Furthermore, a large combined market reduces price risk by providing a diversified source of absorption of the regional shocks, which in turn reduces the risk premium. Their sales can be increased by shipping to regions where insufficient market size or trade barriers may have previously excluded them (Bierlen et al 1998). An integrated market may also reduce the information costs to the firms.

Moreover, the degree of market integration has implications for government policies. For example, in a well-integrated international market, government intervention to control or stabilize prices may require greater resources such as complementary trade policy or international collaboration due to the large market size (Jain 1980; Young et al 2000). On the other hand, however, requirements for the government to prevent or stop price manipulations are much more relaxed for a well-integrated market compared with an un-integrated one. In a big market, it also takes a sizable manipulative action to interfere with the price, and such actions will be conspicuous.

Third, market integration and the LOP play an important role in the models of trade theories and exchange rate determination for at least two reasons (Protopapadakis and Stoll 1983; Goodwin et al 1990a; Michael et al 1994): a). Information regarding the extent of market integration for commodities provides important information about the market efficiency as defined by the satisfaction of zero marginal return equilibrium conditions. It is thus a concern as to 'whether there exist potential Pareto improvements' in the international economy (Barrett 2001). b). The LOP has often been assumed in economic analyses. However, lack of empirical evidence on integration may pose a challenge to this assumption. On the macroeconomic level, the validity of the purchasing power parity also relies on the individual market conditions as a whole.

1.3. Research Questions

This research is intended to answer the following two major questions:

a. Is time- as well as border-related risk consideration an important factor in the international commodity arbitrage decision? Does the addition of risk variables improve the model's analytical potential in terms of revealing their specific impact on the risk premium and market integration?

b. Is a more dynamic specification of trade volume variable feasible and helpful in providing more accurate information about market equilibrium conditions?

1.4. Objectives of This Dissertation

In order to search for an answer to the questions above, the following objectives are intended to be accomplished in this study:

a. Reformulating the price relationship model by deriving parity conditions from an expected utility function incorporating risk factors.

b. Utilizing the present value framework to account for the delivery lag in the international commodity arbitrage.

c. Taking into account the expected hedge returns when specifying importer's expected selling price, i.e. the importer's expected marginal revenue is a portfolio of expected future cash price and the marginal hedge return.

d. Extending the Barrett-Li regime-switching method by dividing trade volume observations into four groups: i.e. zero, fall, no change, rise, compared to the binary trade-no trade specification of Barrett and Li (2002).

e. Applying the extended model to the US-China soybean market analysis.

1.5. Arrangement of This Dissertation

Following the introduction, a review of the literature will be presented in chapter 2 to provide a more detailed context for this study. Then chapter 3 will be devoted to developing a parity condition from an expected utility function, extending a regime-switching model with dynamic trade flow information, and developing a framework for interpreting the different regimes that will be estimated in the regime-switching model. It should be noted that the framework is merely intended to present guidelines for how this extended model might work to answer the research questions raised for this study. Chapter 4 will present a brief background and data description as a preliminary to the empirical application of the extended model to the US-China soybean markets. Chapter 5 reports and discusses the estimation process and results. Finally chapter 6 summarizes what has been achieved in this research, its policy implications, the model's potential limitations, and further research suggestions.

CHAPTER 2 - LITERATURE REVIEW

Compared to structural market models, a price relationship analysis may reveal whether all the arbitrage profit has been exploited or not between spatial markets. On the other hand, its parsimonious specification has a disadvantage in providing accurate information on the specific causes of observing positive, zero, and negative profit margins. This, to some extent, undermines the analytical potential of this type of model. In the recent literature, a number of models have been developed to increase the information gained from research in this area, such as the parity bound model (Baulch 1997) and incorporation of trade volume (Barrett and Li 2002). Both of these studies apply the switching-regime methodology. Barrett and Li's analysis is the first application of this methodology to the study of international commodity arbitrage. Their model is unique in its incorporation of trade volume into the model.

A brief literature review shows that there are three major methodological approaches in the research on the price relationship: traditional regression methods without recognition of the non-stationary properties of the historical price data; the co-integration approach; and the regime-switching method using and structuring the non-stationary error term. These efforts examine: a. procedures to improve market integration analysis; b. factors that could affect integration between markets (e.g. change of foreign exchange regime, enhancing the information system, etc.);

and c. how to interpret the test results for the acceptance of the law of one price or the failure of it.

Before reviewing the three different approaches, it may be helpful to clarify some concepts that are heavily referred to throughout.

2.1. Definitions

Equilibrium: According to the Enke-Samuelson spatial equilibrium condition, an international market is said to be in equilibrium at time t when

$$R_t \leq 0 \text{ if } k_t^{xm} = 0 \qquad \text{(E1)}$$

$$R_t = 0 \text{ if } 0 < k_t^{xm} < \infty \qquad \text{(E2)}$$

where $R_t = p_t^m - p_t^x - T_t^{xm}$, p_t^m and p_t^x are the prices in the importer' and exporter's domestic countries, m and x, respectively, t stands for the time period, T_t^{xm} is the unit transfer costs to move the commodity from x to m, k_t^{xm} is the trade flow from x to m, T_t^{xm} is assumed to be exogenous to the arbitragers. Here for the sake of simplicity, an unidirectional trade flow is assumed though the model can be generalized to hold for the bi-directional scenario.

Equation (E1) says that if no trade flow is observed from x and m, markets x and m, are in equilibrium when price differential between them is equal or less than transfer costs-autarky. Equation (E2) says that, if trade flow is observed and there is no restriction on trade volume from x to m, the equilibrium occurs when price differential equals transfer costs.

It can be seen from E1 and E2 that trade flow is neither necessary nor sufficient for equilibrium.

Market integration: Based on Barrett and Li (2002), two levels of market integration and one of segregation can be defined as follows:

a. *'Perfect' integration*: Two markets are 'perfectly' integrated either when price differential equals the transfer cost and positive trade volume is observed, or when price differential equals the transfer cost but both zero trade volume at t and evidence of trade history are observed, i.e.

$$R_t = 0 \text{ and } \begin{cases} k_t^{xm} > 0 & (I1) \\ k_t^{xm} = 0, \text{ when there is evidence of trade history} & (I2) \end{cases}$$

where the notations are defined the same as in (E). Note that zero marginal arbitrage return is the necessary condition for 'perfect' integration, while zero marginal arbitrage return plus trade flow or evidence of history of trade constitute the sufficient condition for 'perfect' integration.

b. *'Imperfect' integration*: Two markets are 'imperfectly' integrated when price differential does not equal the transfer cost and positive trade volume is observed, i.e.

$$k_t^{xm} > 0 \text{ and } \begin{cases} R_t > 0 & (I3) \\ R_t < 0, & (I4) \end{cases}$$

c. *Market segregation*: Two markets are segregated when zero trade is observed and price differential does not equal transfer cost, i.e.

$$k_t^{xm} = 0 \text{ and } \begin{cases} R_t > 0 & (S1) \\ R_t < 0, & (S2) \end{cases}$$

Thus physical trade is sufficient for market integration, although not a necessary condition. For example, (I2) is an integration case because it indicates an indifferent point for an arbitrager.

Note that among the conditions defined above, the only overlap between market equilibrium and integration takes place in (I1), (I2) and (E2) and part of (E1), i.e. when the market is 'perfectly' integrated as well as in competitive equilibrium. In other words, conditions (E1) and (E2) include (I1) and (I2), but (E1) is still true even when (I1) and (I2) are not, e.g. when $R_t < 0$, $k_t^{xm} = 0$ in (E1). Market integration and equilibrium are distinct scenarios in all other cases (Barrett and Li 2002), such as in the 'imperfectly' integrated markets described in (I3) and (I4), apparently equilibrium is not manifested.

Law of one price (LOP): The LOP for an international economic market, based on the definitions by Marshall (1961, p325), states that, when trade occurs and is not restricted, domestic and foreign prices of a commodity will be equal when expressed in the same currency and net of transfer costs. Thus, the LOP is basically another way to express 'perfect' integration and the two concepts will be used interchangeably in this study.

2.2. Traditional Regression Method

The studies following the traditional regression method make efforts to improve the market integration analysis by testing the LOP: a). under 'better controlled' conditions, i.e. in an efficient (competitive) market environment such as primary commodity and commodity futures markets; b). by introducing lags to distinguish short-run and long-run adjustments; c). augmenting the test by looking at the real arbitrage process, e.g. the delivery lag in the international commodity trade and the rational price expectations; d). decomposing the transaction costs. Another point in consensus is that the deviations from the LOP tend to be commodity-specific.

The argument for testing in 'better controlled' conditions is that the rejection or acceptance of the LOP is more plausible when the tests are carried out under the circumstances in which all the requirements for 'perfect arbitrage' are met. Agricultural commodity futures markets are generally considered to meet the requirements for 'perfect arbitrage' due to their product homogeneity, large number of participants, relatively perfect information, etc. (Jain 1980). Based on this logic, researchers set the tests for agricultural commodities (Richardson, Ravallion), commodity futures price relationships (Jain and Carter), or comparing the results between spot price relationships and futures price relationships (Protopapadakis and Stoll, 1983, 1986). Although still mixed, their results have been more likely to show integration, particularly for the long-run and futures market price relationships.

To distinguish short-run and long-run adjustment processes, lag variables are introduced in the model (Protopapadakis and Stoll 1986, Ravallion). Delivery lags and the rational price expectation are considered also to reflect the actual arbitrage process. (Protopapadakis and Stoll 1986, Goodwin et al, 1990a, 1990b).

Efforts are also directed to testing international commodity markets. In addition to the attention to the delivery lags and expected price arguments, decomposing the transaction cost and risk premia (Goodwin et al, 1990a, 1990b), border effects (Engel and Rogers 1996), exchange rate (Richardson) are also explicitly specified.

Some comparisons indicate support for the LOP after delivery lags, transaction cost decomposition, and price expectations are taken into account. Exchange rate and other border effects have also showed a strong impact on price relationships.

2.3. Co-integration Approach

2.3.1. Limited Information, Maximum Likelihood: Two Steps and Single Equation Estimation (LIML)

In 1987, Engle and Granger developed the 'Granger Representation Theorem', which involves a two-step procedure to extend the concept and the application of the co-integration and error correction model. Following their research, the non-stationarity property of commodity prices and the spurious regression results started to be recognized in the study of market integration, since non-stationarity invalidates the usual estimation procedures and makes classical asymptotic theory inapplicable. Ardeni (1989), among the first to apply co-integration technique, finds invalidity of even the long-run LOP in the commodity market between Australia, UK, and the US, whereas Baffes (1991) gets opposite results using Ardeni's data after giving explicit attention to the transaction costs. Michael et al (1994) and Low et al (1999), both studying market integration in international commodities, also attribute the lack of co-integration to the non-stationary property of transaction cost, with the latter's focus being on international futures markets. Other authors attribute failures in detecting co-integration to such elements as non-tariff barriers (Zanias 1993). Another interesting study applies the present value model to test the co-integration between commodity spot price and forward price (Pindyck 1993). He credits the co-integration to the high convenience yield that stops the 'faddish' speculators.

The development of the co-integration technique is particularly important because it provides a way of modeling that accommodates both long-run equilibrium and the short-run dynamic structural analyses, and at the same time resolving the non-stationarity problem.

However, problems with the above-mentioned co-integration-based approach include the following. First, a single-equation specification implies the exogeneity of all the explanatory variables, which may not be the case and therefore cause bias in the estimates (Hamilton 1994, p630; Kennedy 1998, p270). Second, since the co-integrating vectors are not unique, which variable should appear on the left-hand side and thus whose parameter be normalized as one has become an arbitrary matter. Third, a related problem is that if the parameter is normalized as one while its true value is zero---meaning that it has no correlation with the explanatory variable, your model will end up being fundamentally mis-specified. d). There may be more than one co-integrating vectors with more than two variables. This multivariate feature allows estimation of an indirect link between two markets instead of only the direct link estimable in the bi-variate case. The Johansen procedure (Johansen, 1988, 1991; Johansen and Juselius, 1990,1992a, 1992b, 1994) is developed to fix these problems. It provides a more general simultaneous-equation formulation in which each variable is regressed on the lagged values of all variables (a full-information maximum likelihood (FIML) as compared to the limited information maximum likelihood (LIML) of a single equation two-step estimation) (Greene, 1997, p141, 744,754; Kennedy, 1998, p165-167). It is a version of error-correction representation of co-integrating relations in the form of vector auto-regression(VAR) (Johansen and Juselius, 1990). As Kennedy (1998, p270) has pointed out, it has become a common practice to start with a more general simultaneous equation formulation of the Johansen procedure instead of a single-equation model.

2.3.2. Full Information, Maximum Likelihood (FIML)

The Johansen procedure performs three tasks: find the space of the co-integrating vectors or the co-integrating rank, test the linear hypotheses about the co-integration vectors and perform the ECM Granger causality test.

Recognizing the Johansen procedure as a multivariate generalization of the Engle-Granger, researchers have extensively applied the approach to test LOP and market integration. Jumah et al (1999) found co-integration in the international cocoa market using Johansen procedure. They pointed out two reasons for the previous failures in detecting co-integration in both temporally and spatially separated markets, i.e. between spot and futures prices and between markets: a). the neglect of interest rates; b). the single equation method suggested by Engle and Granger(1987) which overlooks the interaction responses between other independent co-integration relationships. The latter may cause inefficiency in estimation. Yang et al, in their study of U.S. wheat markets (1999), finds that futures markets have a better price discovery function than cash markets. They also find the US as primary information source on the international soybean meal market in both long run and short run (2000).

All the studies discussed so far focus on accounting for the elements that may lead to false rejection or acceptance of the LOP. Along the other line of studying the LOP to inform policy makers on how to improve market integration, Bierlen et al (1998) found that the unilateral reforms of member countries have improved the extent of the market co-integration both inside and outside the trading blocs.

A brief summary of the studies that have accounted for the non-stationarity issue indicate several important points. First, while non-stationarity invalidates estimation results, it is a convenience for testing co-integration, and thus for testing the LOP. Second, when transfer costs such as interest rates and freight rates are incorporated, more research gives supportive evidence to the LOP. Third, as a general full-information model, the Johansen procedure allows for the interaction between several different markets that are correlated, which has lead to further consensus in manifesting the LOP in the tests.

2.4. The Regime-Switching Method

The Regime-switching technique has started to attract academic attention in domestic as well as international commodity trade, because of its advantages over other methodologies in fixing the following problems. First, the arbitrary selection of the price in one region as predetermined is avoided since the price differential is used as the dependent variable. Second, the time invariant measurement errors and unobservable transaction costs can be estimated within the model. Third, market integration is no longer treated as an 'all or nothing' proposition, i.e. the two markets may be integrated during a period of time, and may not be in other periods due to certain circumstances. Fourth, trade flow information, as an integral part of the LOP study, may be conveniently introduced in a joint probability model.

Lastly, its relatively parsimonious data requirements and yet flexibility in using the available economic theories may provide evidence on a number of market parameters, such as the causes of deviation from the long-run competitive equilibrium, and competitiveness of markets.

On the other hand, it should also be recognized that the regime-switching model used in this study does not fully accommodate dynamic analysis, such as the speed of price adjustment and Granger causality.

Basically, regime switching refers to the change in coefficients in response to some structural change. For example, the coefficients of a cost function may change because of a law concerning environmental protection; or the coefficients of a supply function may change because of an overseas cartel action. The periods within which the coefficients remain unchanged are called regimes.

Most studies using this concept to address LOP issues are based on a regime-switching model developed by Spiller and Huang (1986) and extended by Sexton et al (1991). This technique, applying a stochastic frontier production function (Weinstein, 1964; Aigner et al, 1977), structures the error terms in the model predictions into the following three regimes: a). Below the mean, implying a price differential less than the total transfer cost; b). Around the mean, the price differential equals transfer costs; c). Above the mean, the price differential greater than transfer costs. While (a) and (b) are generally viewed as in equilibrium, (c) is regarded as a deviation from equilibrium. Probabilities for each of the three regimes to occur are estimated using maximum likelihood method. A detailed discussion of this technique will be presented later in the empirical section.

Weinstein (1964), in his answer to an engineering query, first specified a distribution function for the sum of values of normal and a truncated normal distribution.

Aigner et al (1977) applied the model developed by Weinstein to specify a production frontier function, i.e. which is basically the normal plus the negative tail of the half normal since production frontier is the ceiling.

Spiller and Huang (1986) first applied the production frontier model in market integration analysis of gasoline in the northeast of the U.S. Their probability estimates of the two regimes, 'perfect' integration and the autarky prices, the latter being basically the negative error case, give quite intuitive results such as nearby cities are more integrated than further-away cities. The estimates of transaction costs and their percentage to the price level imply that the anti-trust markets may not be limited within the economic markets.

Sexton et al (1991), in their study of the US celery markets, extended the SH model to the agricultural commodities, the production of which is concentrated in only one or a few regions. In this case, there does not exist indigenous supply and thus autarky prices can no longer be used for the purpose of interpretation as in Spiller and Huang (1986). A second extension to the SH model is the testing of product's substitutability in demand.

Both of the above analyses assume constant or stationary transaction cost and use the inter-market price differential to estimate this cost. Continuous trade flow is also implicitly assumed. Baulch (1997) argues that it is 'inadvisable' to do so, because: a). When trade flows are not continuous, price differentials 'do not reflect the cost of moving produce'. b). Price differentials may also reflect factors other than transaction costs. Furthermore, transaction cost may be non-stationary. Based on these arguments, Baulch adds the actual information of transaction costs to the market prices to formulate a parity bounds model (PBM). He applies the PBM to the Philippine rice markets and detects a well-integrated result when other tests do not.

However, it has been a consensus that it is impossible to observe all the transaction costs. Incorporating trade flow is necessary in that it can provide indirect information about the impacts of unobservable and omitted transaction costs, or such factors as trade barriers. Barrett and Li (B-L)(2002) expands Baulch's PBM by introducing trade volume, as a binary variable, into a joint probability model. An application is made to the trade in soybean meal among Pacific Rim economies. In the six regimes estimated, competitive equilibrium and tradability prevail most of the time in that market.

2.5. Potential Problems with Previous Works

The failure to observe the LOP may be due to a number of market factors. One, the markets are in autarky situation because of factors such as high transaction costs

(Spiller and Huang 1986) or high comparative production cost (Stigler and Sherwin 1985). Two, impediments exist to Marshallian arbitrage, such as trade barriers, government intervention (Carter and Hamilton 1989,Baulch 1997), transportation bottlenecks, imperfect information (Buccola 1985), or risk aversion (Ravallion 1986). Three, the existence of imperfect competition in one or more of the markets (Stigler and Sherwin 1985, Faminow and Benson 1990, Baulch 1997). Four, expected change in future market demand for inventory (Chow 1998), convenience yield for example, especially when expected future spot price is involved in international arbitrage. Five, other factors such as strategic behavior, product differentiation, and non-stationarity of some unobservable and omitted transaction costs.

However, while these are likely causes of deviations, cautions need to be taken when interpreting the observance of the LOP. For example, whether the market is competitive or not may affect the size of an economic market, just as monopoly will affect the price in a market (Stigler and Sherwin 1985), but market integration does not by itself mean the market is competitive (Baulch 1997). This can be illustrated by the following examples:

Example 1: Market integration may result from such oligopolistic pricing behavior such as base point pricing. (Faminow and Benson 1990).

Example 2: When a monopolist dumps his product in a foreign area and this price discrimination is protected by barriers to re-importation, parallel price tests will show market separation. But if it can be assumed that there is no transaction and information costs, and there is no barriers to re-importation, the price discrimination is temporary, since intermediate buyers who can buy from the monopoly will be more attractive sources of the good than the monopoly for those who must pay high prices (Nicholson 1995, p620). Thus the LOP can still hold.

Example 3: Suppose that two competitively organized markets, 1 and 2, are segregated by significant transaction costs and neither ships appreciable quantity to the other. The market test will reveal segregation. Now if a monopolist is formed in market 1 and chooses to set a higher price in its area equal to the price in 2 plus transaction costs to ship product to 1. The test in this case results in market integration although there is still no trade going on and the markets are not integrated. With the further information about the trade volume, it can be indicated that this result is due to the formation of the monopolist. (Stigler and Sherwin 1985).

An important point these examples make is that it takes additional information to determine, as in example 3, whether observing an increase in the market size has been due to the formation of a regional monopoly or due to a reduction in transportation costs, or a change in the comparative production costs in the two regions. However, if there is no appreciable trade flow from 2 to 1, then monopoly power is a likely explanation.

However, most spatial price relationship analyses on international commodities have failed to explicitly specify the information provided by actual trade flows.

Barrett and Li (2002) made the first attempt to encompass all the three elements--- prices, transfer costs, and trade volume---in the price relationship analysis. However, the information given by a static dichotomous specification of trade and no trade may be limited for revealing the true market status.

Another factor that has been missing in price relationship modeling is arbitrager's risk preferences and risk perception. International commodity arbitrage is two dimensional in terms of being both spatial and temporal (e.g. delivery lag). Inadequate consideration of risk perceptions such as those related to price and exchange rate fluctuations is naturally a concern regarding the validity of the testing results in the model.

Third, for an inter-temporal process, the time value is also a natural consideration in making arbitrage decisions.

Fourth, with commodity futures market being available, it is reasonable to assume the expected hedge returns as part of the importer's expected selling price.

The last two factors have not received adequate attention in previous market studies. This dissertation, as stated in the research questions and study objectives in chapter 1, attempts to make advances on the above issues.

CHAPTER 3 - MODEL AND METHODS

In this chapter a detailed discussion will be provided on the model extensions. Section 3.1 is focused on the derivation of four relevant parity conditions from a mean-variance expected utility function. The analysis in this study is based on the parity condition derived for an importer's arbitrage decision. Another important model is derived to present price relationship between futures markets. The other two, cash-and-carry and export parities are helpful either in derivation or in understanding the conditions of trade. Section 3.2 presents the linear approximations to the parity conditions derived in section 3.1. Section 3.3 discusses the econometric methodology and its extensions. Finally, in section 3.4, a tentative interpretational framework is derived based on economic theories.

3.1. Price Parity Conditions

It must be noted at the outset that only price and currency risks have been incorporated into the model developed for this analysis. Some other risks and risk perceptions that have not been explicitly modeled can play an important role in arbitrage decision-making and thus market integration. For example, in the importer's arbitrage model, there are two sources of risk explicitly specified: the commodity price volatility and the exchange rate fluctuations. However, some other risks and risk perceptions can also affect a real-life importer's decisions to import and to hedge. These decisions will in turn influence the market integration.

For example, change in the government quarantine policy on imports may simply pose trade impediments. A country's expected political and economic situation will also affect importer's risk perception and thus the requirement of risk premium.

There are a number of possible alternative motives for hedging that could affect the hedging decision which in turn effects the risk level. For instance, there may be some managerial motives for hedging (Siegel and Siegel 1990, p150), such as expected tax payment based on the income fluctuation. Firms with low levels of income may not be able to take advantage of tax credits and deductions that they could use if their incomes were higher, while firms with large profits may be subject to windfall-profit taxes. Therefore, the change in taxation policy may change importer's hedging behavior which will effect risk position as well.

Other possible sources of risk and factors that have to do with risk perceptions are default, weather, natural disaster and non-availability of the relevant insurance policies. These may increase the transaction or transportation cost, or even result in the loss of all or part of the trader's consignment. The same logic applies to wars in the trade area or en route.

Omission of relevant risk variables may limit the scope of our analysis in several respects. First, some risk factors cannot be included. Second, the model may over- or under-estimate the effects of the included risk variables depending on the relationship between the omitted and included variables. For example, ignoring other closely related sources of foreign exchange market uncertainty, such as expectations about alterations in exchange or capital control, or in trade barriers cannot be assessed during periods of controlled exchange rates. During the periods of stable exchange rate, those expectations have no effect on the variance of the future spot exchange rate since it is held constant, but both expected exchange control and trade barriers will impact the risk perception and risk premium involved in trade. The lack of variability with a stable exchange rate itself will not be able to explain the changes in the trade volume and the price differential between the two markets. These factors should be kept in mind throughout the analysis and considered when interpreting the following four arbitrage parity conditions developed in this chapter and in interpreting the results of the analysis.

In regard to risk preferences in general, three types of preferences are classified in economics literature: risk-averse, risk-neutral, and risk-loving. Both risk-averse and risk-loving arbitragers will choose the option that maximizes the expected utility; a risk-neutral arbitrager will choose the option that maximizes the expected profit. Among the three arbitrage strategies that will be investigated in this study, cash-and-carry is risk-free and the arbitrager in this strategy is assumed to be risk neutral, while the arbitragers in export and import strategies are assumed to be either risk-averse or risk-neutral.

3.1.1. Cash-and-Carry

As its name suggests, this strategy involves purchasing and carrying the underlying commodity of a futures contract for the duration of the storage. At any time t when there exists arbitrage profit, the domestic arbitrager will buy the commodity at price p_t^d in the cash market, and go short in the futures markets (selling) for maturity at time t+s. The arbitrager's profit at any time t is the present value of his revenue at t+s less the procurement cost at t and the present value of storage cost paid at t+s.

Assuming risk neutral behavior and no uncertainty is involved in the cash-and-carry strategy, the arbitrager's goal is to arbitrage, as long as there is positive profit, until she is indifferent about further trading, i.e. when there is zero marginal profit. Under the assumption of a competitive market, this zero profit point results from the pecuniary externality effect brought in through the market system by the activities of each and every individual arbitrager. The arbitrager's profit, $\pi^d(q_t^d)$, is given by

$$\pi^d(q_t^d) = D_s^d p_{t,t+s}^d q_t^d - p_t^d q_t^d - D_s^d \overline{B_{t,s}^d} q_t^d \qquad (1)$$

where

$D_s^d = 1/(1+i_t^d)^s$, $i_t^d = r_t^d/365$, r_t^d = arbitrager's domestic annual interest rate at time t;

s = the number of days;

p_t^d = arbitrager's domestic spot price at time t;

$p_{t,t+s}^d$ = arbitrager's domestic futures price at time t for maturity at t+s;

$\overline{B_{t,s}^d}$ = arbitrager's domestic marginal cost of storage which is known at t and expected to be paid at t+s. The 'bar' is used to show that the storage cost will limit the basis to the extent that whenever the latter is greater than the former by such an amount that arbitrage is profitable, there will be arbitrage.

q_t^d = quantity of an underlying futures contract commodity carried at

time t for delivery at t+s;

Note that the only choice variable is quantity, implying price taking behavior. The first term of (1) is the arbitrage revenue converted into present value with the discount rate D_s^d, the second the purchasing cost, the third the present value of the marginal cost of storage.

The first order condition for (1) is given by

$$\partial \pi^d / \partial q_t^d = D_s^d p_{t,t+s}^d - p_t^d - D_s^d \overline{B_{t,s}^d} = 0 \qquad (2)$$

Rearranging (2) results in

$$D_s^d p_{t,t+s}^d = p_t^d + D_s^d \overline{B_{t,s}^d} \qquad (3)$$

Equation (3) is the zero marginal profit condition under which the arbitrager is indifferent about further trading between the domestic cash and futures markets, i.e. the equalization of the present value of the marginal revenue to the marginal arbitrage cost which consists of two parts: per unit purchasing cost and the present value of the marginal cost of storage. When $B_{t,s}^d$ is such that

$D_s^d p_{t,t+s}^d - p_t^d - D_s^d \overline{B_{t,s}^d} > 0$, the arbitrager in the market will follow the cash-and-carry strategy until the profit margin is removed, i.e. up to a point when

$D_s^d p_{t,t+s}^d - p_t^d - D_s^d \overline{B_{t,s}^d} = 0$.

3.1.2. Export

Consider a representative risk-averse arbitrager engaged in export strategy for a certain commodity from home country to abroad. Her problem at any time t is to maximize the expected utility by choosing the export quantity at time t with a delivery lag in time t+j. Price-taking behavior is assumed. The price received by the exporter is determined at time t based on the expected price at time t+j. To physically transfer the commodity, the exporter faces transportation and non-transportation costs associated with the arbitrage activities. The latter costs include set-up costs, the costs of inputs into the arbitrage and trade process involved in both domestic and foreign markets, any applicable ad valorem or specific tariffs in the importing country, etc.

Assuming the exporter can only get paid after the delivery is taken at time t+j and thus the exchange rate fluctuation causes uncertainty in terms of the domestic currency income. Currency risk is assumed to be the major source of risk in the exporter's model. Thus the risk averse exporter's goal is to export up to a point when she is indifferent about further trading, i.e. when there is zero marginal expected utility. Trade may or may not continue at this point. With the often used mean-variance function form, the exporter's expected utility function, $E[U(\pi^x)]$, is an increasing function of the exporter's expected profits $E(\pi^x)$, and a decreasing function of the variance of the profits and the extent of her risk aversion (Duffie 1989):

$$E[U(\pi^x)] = E(\pi^x) - \gamma^x \left(\sigma^2_{\pi^x} \right)^{1/2} \qquad (4)$$

where $U(\pi^x)$ is the exporter's total utility of profit, E is the expected value operator, π^x is exporter's profit, γ^x is the relative measure of exporter's risk preference or risk-aversion co-efficient, i.e. $\gamma^x>0$ implies risk aversion, $\gamma^x=0$ risk neutrality, $\gamma^x<0$ risk loving(Hooper and Kohlhagen 1978), and $\sigma^2_{\pi^x}$ is the variance of the exporter's profit. It is expected that $\gamma^x \geq 0$ for the arbitragers in this study, though the model is not constrained. The second term of equation (4) basically reflects the risk premium determinants, i.e. the degree of the risk aversion and the variance of the profit. However, it should be noted that variance, as one measure of risk, can be an over-simplistic measure.

The exporter's domestic currency profit for time t, π^x, equals the present value at t of the revenue available at t+j less the purchasing and transfer costs at t for the commodity arbitrage:

$$\pi^x(q_t^x) = D_j^x p_{t+j}^x q_t^x W^x - p_t^x q_t^x - T_t^{x-m} q_t^x \quad (5)$$

where $T_t^{x-m} = f_t^{x-m} + z_t^{x-m}$ (5a)

$$W^x = \phi(h^x e_{t,t+j} + (1-h^x) e_{t+j}) + (1-\phi) e_{t,t+j} \quad (5b)$$

Note that the transfer cost T_t^{x-m} has two components, freight rate and other non-stochastic costs in exports. W^x is a weighted average of the cost of foreign exchange to the exporter, and it depends on the currency in which the export contract is invoiced and the extent to which the current value of the contract is hedged in the forward or futures foreign exchange market. Other variables in (5) are defined as follows:

j = the number of days;

$D_j^x = 1/(1+i_t^x)^j$, where $i_t^x = r_t^x/365$, r_t^x =exporter's domestic annual interest rate at time t;

p_t^x = exporter's domestic currency commodity price at time t;

p_{t+j}^x = exporter's contract price in importer's currency. It is determined at the time when the contract is signed, and expected to be available at t+j due to the delivery lag in international trade;

q_t^x = quantity of commodity for export at time t;

f_t^{x-m} = freight rate from exporting country to importing country;

z_t^{x-m} = other non-stochastic transaction costs in exports at time t, including some unobservable transfer costs;

ϕ =proportion the exports denominated in the importer's currency, while 1-ϕ is the proportion in the exporter's currency;

h^x = proportion of ϕ the exporter hedges in the forward exchange market;

$e_{t,t+j}$ =forward foreign exchange rate for period t+j at time t, defined as exporter's currency price per unit of importer's currency;

e_t =spot foreign exchange rate at t, defined as exporter's currency price per unit of importer's currency;

e_{t+j} =spot foreign exchange rate at t+j, defined as exporter's currency price per unit of importer's currency;

The first term of equation (5) is the present value of the exporter's revenue converted into his domestic currency, and the second and third terms are the procurement and transfer costs respectively. The assumption is that on the date the contract is made, the currency proportion ϕ is already given, and h^x is also determined based on exporter's risk aversion and how much product will be shipped.

Assuming the exchange rate fluctuation is the only major source of risk to hedge for the exporter, the $D_j^x p_{t+j}^x q_t^x W^x$ would be known with certainty if: (1) all exports were denominated in the domestic currency (ϕ=0), or (2) all exports denominated in importer's currency were hedged in the futures market (h^x=1).

Taking expected value of equation (5) gives

$$E(\pi^X) = D_j^x q_t^x p_{t+j}^x E(W^x) - p_t^x q_t^x - T_t^{x-m} q_t^x \qquad (6)$$

As has been shown in (4), the exporter's utility also depends on the variability of the income stream, $\sigma^2_{\pi^X}$, which is the variance of profit and affected by the variability of exchange rates. The variance of profit is based on equation (5):

$$\sigma^2_{\pi^X} = \text{var}(D_j^x p_{t+j}^x q_t^x W^x)$$

$$= \text{var}(D_j^x q_t^x p_{t+j}^x * \{\phi[(h^x e_{t,t+j} + (1-h^x) e_{t+j}] + (1-\phi) e_{t,t+j}\})$$

$$= \text{var}[(h^x\phi + 1 - \phi) D_j^x q_t^x e_{t,t+j} p_{t+j}^x + (1-h^x)\phi D_j^x q_t^x p_{t+j}^x e_{t+j})] \qquad (7)$$

Equation (7) can be developed by using the following formula:

$$\text{var}(a + b e_{t+j}) = b^2 \text{var}(e_{t+j}). \qquad (8)$$

where a= $(h^x\phi + 1 - \phi) D_j^x q_t^x e_{t,t+j} p_{t+j}^x$ whose terms are all fixed and thus drops out, and b= $(1-h^x)\phi D_j^x q_t^x p_{t+j}^x$

Substituting (6) and (8) into (4) and rearranging gives

$$E[U(\pi^x)] = D_j^x q_t^x p_{t+j}^x E(W^x) - p_t^x q_t^x - T_t^{x-m} q_t^x - \gamma^x (1-h^x) \ \phi \ D_j^x \ q_t^x * p_{t+j}^x \ \sigma_{e_{t+j}}$$

(9)

where $\sigma_{e_{t+j}}$ is the standard error of the future spot exchange rate. The first order condition for (9) is given by

$$\partial E[U(\pi^x)]/\partial q_t^x = D_j^x p_{t+j}^x E(W^x) - p_t^x - T_t^{x-m} - \gamma^x (1-h^x) \ \phi \ D_j^x$$

$$* \, p_{t+j}^x \, \sigma_{e_{t+j}} = 0$$

(10)

Rearranging (10) gives

$$D_j^x p_{t+j}^x E(W^x) = p_t^x + T_t^{x-m} + \gamma^x (1-h^x) \ \phi \ D_j^x \ p_{t+j}^x \ \sigma_{e_{t+j}}$$

(11)

Equation (11) is the zero marginal expected utility condition under which the exporter is indifferent about further trading between the domestic and foreign markets, i.e. the equalization of the present value of the expected marginal revenue from exports, $D_j^x p_{t+j}^x E(W^x)$, to the marginal arbitrage cost. The marginal arbitrage cost consists of three parts: per-unit purchasing cost p_t^x, per-unit transfer cost T_t^{x-m}, and the risk premium, the third term of the right-hand side of (11). Given the utility function (4), the risk premium is determined by trader's risk preferences and the variances of profit. With the assumption of exchange rate as the only source of risk in exporter's model, then the risk premium is basically determined by trader's risk preference denoted γ^x, and exchange risk indicated by

$\sigma_{e_{t+j}}$.

3.1.3. Import

A risk-averse importer's goal is, analogous to that of the exporter, is to import up to a point when she is indifferent about further trading, i.e. when there is zero marginal expected utility. Her goal is to maximize the expected utility at any time t by choosing the import quantity at time t with a delivery lag at time t+j. The import price is determined at time t based on the expected price at time t+j.

It should be noted that an importer may need to hedge both the price and the currency risks which are assumed to be the two major sources of risk. The former has to do with a long (bought) cash position at t and short (selling) cash position at t+j, while the latter with foreign currency payment to the exporter at t+j. So, an importer's expected utility, $E[U(\pi^m)]$, is also an increasing function of her expected profits and a decreasing function of the variance of the profits and the extent of her risk aversion:

$$E[U(\pi^m)] = E(\pi^m) - \gamma^m \left(\sigma^2_{\pi^m} \right)^{1/2} \quad (12)$$

where, symmetric to the exporter's case, $U(\pi^m)$ is the importer's total utility of profit, E is the expected value operator, π^m is importer's profit, γ^m is importer's mirror image to that of exporter's, $\sigma^2_{\pi^m}$ is the variance of the importer's profit.

The assumption is $\gamma^m \geq 0$ in this study. The second term of equation (12) reflects the risk premium determinants, i.e. the degree of the risk aversion and the variance of the profit.

In many cases, it is the exporter who handles the procurement and transportation. So the importer's domestic currency profit at t, π^m, equals the present value of the expected sales revenue at t+j less the present value of the total cost of import which consists of the payment to the exporter and the tariff and taxes on the import:

$$\pi^m(q_t^m) = D_j^m * [p_{t+j}^m + h_p^m * (p_{t,t+s}^m - p_{t+j,t+s}^m)] q_t^m - W^m D_j^m p_{t+j}^x e_{t,t+j} q_t^m * (1+t) \quad (13)$$

where

$$W^m = \phi e_{t,t+j}^{-1} + (1-\phi)(h_c^m e_{t,t+j}^{-1} + (1-h_c^m) e_{t+j}^{-1}) \quad (13a)$$

Note that it is the cost payment that brings in the currency risk issue to the importer. The first component of W^m, $\phi e_{t,t+j}^{-1}$, is the proportion of the import that is denominated in importer's currency, and no hedge issue involved. The inverse sign simply denotes that the exchange rate is now defined as importer's currency price per unit of exporter's currency, as opposed to the definition of $e_{t,t+j}$. W^m is a weighted average of the cost of foreign exchange to the importer, and it depends on the currency in which the import contract is invoiced and the extent to which the current value of the contract is hedged in the forward or futures foreign exchange market by the importer. $p^x_{t+j}e_{t,t+j}$ in the second term of (13) is the price the importer pays to the exporter in exporter's currency. (See variable definition for p^x_{t+j} in equation (5)). The whole second term is the present value of the total cost of the imports in importer's currency. The discount rate D^m_j pulls back the future profit to the present value, $\pi^m(q^m_t)$. Also note that t is defined as tariff rate when it appears in the form of 1+t. Other variables in (13) are defined as follows:

j = the number of days;

$D^m_j = 1/(1+i^m_t)^j$, where $i^m_t = r^m_t/365$, r^m_t = importer's domestic annual interest rate at time t;

p^m_{t+j} = importer's domestic currency price at t+j;

$p^m_{t,t+s}$ = importer's domestic currency futures commodity price at time t for the maturity at t+s, where s≥j;

$p^m_{t+j,t+s}$ = importer's domestic currency futures commodity price at time t+j for the maturity at t+s, where s≥j;

$q^m_t = q^x_t$ = quantity of commodity for import at time t;

ϕ and $(1-\phi)$: defined the same as in equation (5);

h_c^m = proportion the importer hedges for the currency risk of the proportion denominated in exporter's currency in the forward exchange market;

h_p^m = proportion the importer hedges for the price risk in the futures commodity market;

t = rate of tariff and taxes on import. Note that the notation 't' in the position of a subscript is defined as time period.

The first term of (13), the present value of the expected sales revenue at t+j, tells that the importer sells q_t^m at t+j in the domestic market at the then spot price p_{t+j}^m and lifts the price hedge at the same time by buying back the futures contracts at $p_{t+j,t+s}^m$, which she sold at t for $p_{t,t+s}^m$. The hedge ratio, h_p^m, is chosen based on the variability of the hedge returns which relies on the variability of basis defined as futures price less cash price. Taking the expected value of (13) gives us

$$E(\pi^m)=D_j^m q_t^m E[p_{t+j}^m + h_p^m * (p_{t,t+s}^m - p_{t+j,t+s}^m)] - E(W^m)[D_j^m (p_{t+j}^x e_{t,t+j}) q_t^m] * (1+t)$$

(14)

Recall that the importer has a long cash position at t and a short cash position at t+j, and thus his expected revenue depends on the expected price at t+j.

With all variables, except p_{t+j}^m and $p_{t+j,t+s}^m$ in the first term of (13) and e_{t+j}^{-1} in (13a), known with certainty on the contract date, the variance of the importer's profit is:

$$\sigma^2_{\pi^m} = \mathrm{var}\{D_j^m[p^m_{t+j}+h_p^m*(p^m_{t,t+s}-p^m_{t+j,t+s})]q_t^m - W^m*(D_j^m p^x_{t+j}e_{t,t+j}q_t^m)*(1+t)\}$$

$$= \mathrm{var}\{D_j^m[p^m_{t+j}+h_p^m*(p^m_{t,t+s}-p^m_{t+j,t+s})]q_t^m - (D_j^m p^x_{t+j}e_{t,t+j}q_t^m)(1+t)[\phi e^{-1}_{t,t+j}$$
$$+(1-\phi)(h_c^m e^{-1}_{t,t+j} + (1-h_c^m)e_{t+j}^{-1})]\}$$
$$= \mathrm{var}[D_j^m q_t^m\ p^m_{t+j} - D_j^m q_t^m\ h_p^m p^m_{t+j,t+s} - (D_j^m p^x_{t+j}e_{t,t+j}q_t^m)(1+t)(1-\phi)(1-h_c^m)e_{t+j}^{-1}]$$
$$= D_j^{m^2} q_t^{m^2}\sigma^2_{p^m_{t+j}} + D_j^{m^2} q_t^{m^2}(h_p^m)^2\sigma^2_{p^m_{t+j,t+s}} + (D_j^m p^x_{t+j}e_{t,t+j}q_t^m)^2(1+t)^2$$
$$*(1-\phi)^2(1-h_c^m)^2\sigma^2_{e^{-1}_{t+j}} - 2D_j^{m^2} q_t^{m^2} h_p^m \mathrm{cov}(p^m_{t+j}, p^m_{t+j,t+s}) - 2D_j^m q_t^m$$
$$*(D_j^m p^x_{t+j}e_{t,t+j}q_t^m)(1+t)(1-\phi)(1-h_c^m)\mathrm{cov}(p^m_{t+j}, e_{t+j}^{-1}) + 2D_j^m q_t^m\ h_p^m(D_j^m p^x_{t+j}e_{t,t+j}q_t^m)$$
$$*(1+t)(1-\phi)(1-h_c^m)\mathrm{cov}(p^m_{t+j,t+s}, e_{t+j}^{-1})$$

(15)

Substituting (14) and (15) into (12) and rearranging gives

$$E[U(\pi^m)] = D_j^m q_t^m E[p^m_{t+j} + h_p^m*(p^m_{t,t+s} - p^m_{t+j,t+s})] - E(W^m)[D_j^m(p^x_{t+j}e_{t,t+j})q_t^m]*(1+t)$$
$$-\gamma^m D_j^m\ q_t^m \left\{ \begin{array}{l} \sigma^2_{p^m_{t+j}} + (h_p^m)^2\sigma^2_{p^m_{t+j,t+s}} + (p^x_{t+j}e_{t,t+j})^2(1+t)^2*(1-\phi)^2(1-h_c^m)^2\sigma^2_{e^{-1}_{t+j}} \\ -2h_p^m \mathrm{cov}(p^m_{t+j}, p^m_{t+j,t+s}) - 2(p^x_{t+j}e_{t,t+j})(1+t)(1-\phi)(1-h_c^m) \\ *\mathrm{cov}(p^m_{t+j}, e_{t+j}^{-1}) + 2h_p^m p^x_{t+j}e_{t,t+j}*(1+t)(1-\phi)(1-h_c^m)\mathrm{cov}(p^m_{t+j,t+s}, e_{t+j}^{-1}) \end{array} \right\}^{1/2}$$

(16)

The first order condition for (16) w.r.t q_t^m is:

$$\partial E[U(\pi^m)]/\partial q_t^m = D_j^m E[p_{t+j}^m + h_p^m * (p_{t,t+s}^m - p_{t+j,t+s}^m)] - E(W^m)[D_j^m (p_{t+j}^x e_{t,t+j})] * (1+t)$$

$$-\gamma^m D_j^m \left\{ \begin{array}{l} \sigma^2_{p^m_{t+j}} + (h_p^m)^2 \sigma^2_{p^m_{t+j,t+s}} + (p_{t+j}^x e_{t,t+j})^2 (1+t)^2 * (1-\phi)^2 (1-h_c^m)^2 \sigma^2_{e^{-1}_{t+j}} \\ -2h_p^m cov(p_{t+j}^m, p_{t+j,t+s}^m) - 2(p_{t+j}^x e_{t,t+j}) * (1+t)(1-\phi)(1-h_c^m) cov(p_{t+j}^m, e_{t+j}^{-1}) \\ +2h_p^m p_{t+j}^x e_{t,t+j} * (1+t)(1-\phi)(1-h_c^m) * cov(p_{t+j,t+s}^m, e_{t+j}^{-1}) \end{array} \right\}^{1/2}$$

$$= 0$$

(17)

Rearranging (17) gives

$$D_j^m E[p_{t+j}^m + h_p^m * (p_{t,t+s}^m - p_{t+j,t+s}^m)] = E(W^m)[D_j^m (p_{t+j}^x e_{t,t+j})] * (1+t) - \gamma^m D_j^m$$

$$* \left\{ \begin{array}{l} \sigma^2_{p^m_{t+j}} + (h_p^m)^2 \sigma^2_{p^m_{t+j,t+s}} + (p_{t+j}^x e_{t,t+j})^2 (1+t)^2 * (1-\phi)^2 (1-h_c^m)^2 \sigma^2_{e^{-1}_{t+j}} \\ -2h_p^m cov(p_{t+j}^m, p_{t+j,t+s}^m) - 2(p_{t+j}^x e_{t,t+j}) * (1+t)(1-\phi)(1-h_c^m) cov(p_{t+j}^m, e_{t+j}^{-1}) \\ +2h_p^m p_{t+j}^x e_{t,t+j} * (1+t)(1-\phi)(1-h_c^m) cov(p_{t+j,t+s}^m, e_{t+j}^{-1}) \end{array} \right\}^{1/2}$$

(18)

As a strategy of international arbitrage, import implies a delivery lag. Thus the price parity condition of interest involves the price in the exporting country at t and the price in the importing country at t+j. For this purpose, let the proportion of exports denominated in the importer's currency, ϕ, equal to zero, i.e. $E(W^x) = e_{t,t+j}$. Rearranging equation (11), the exporter's parity condition, we have

$$p_{t+j}^x e_{t,t+j} = (p_t^x + T_t^{x-m}) / D_j^x \qquad (19)$$

where $T_t^{x-m} = f_t^{x-m} + z_t^{x-m}$ (19a)

Substituting (19) into (18) and re-arranging gives

$$D_j^m E[p_{t+j}^m + h_p^m * (p_{t,t+s}^m - p_{t+j,t+s}^m)] = E(W^m)[D_j^m((p_t^x + T_t^{x-m})/D_j^x)] * (1+t) - \gamma^m D_j^m$$
$$* \left\{ \begin{array}{l} \sigma^2_{p^m_{t+j}} + (h_p^m)^2 \sigma^2_{p^m_{t+j,t+s}} + (p_{t+j}^x e_{t,t+j})^2 (1+t)^2 * (1-\phi)^2 (1-h_c^m)^2 \sigma^2_{e^{-1}_{t+j}} \\ -2 h_p^m cov(p_{t+j}^m, p_{t+j,t+s}^m) - 2(p_{t+j}^x e_{t,t+j}) * (1+t)(1-\phi)(1-h_c^m) cov(p_{t+j}^m, e_{t+j}^{-1}) \\ +2 h_p^m p_{t+j}^x e_{t,t+j} * (1+t)(1-\phi)(1-h_c^m) cov(p_{t+j,t+s}^m, e_{t+j}^{-1}) \end{array} \right\}^{1/2}$$

(20)

or if there is no currency risk:

$$D_j^m E[p_{t+j}^m + h_p^m * (p_{t,t+s}^m - p_{t+j,t+s}^m)] = e_{t,t+j}^{-1}[D_j^m((p_t^x + T_t^{x-m})/D_j^x)] * (1+t)$$
$$-\gamma^m D_j^m \left\{ \sigma^2_{p^m_{t+j}} + (h_p^m)^2 \sigma^2_{p^m_{t+j,t+s}} - 2 h_p^m cov(p_{t+j}^m, p_{t+j,t+s}^m) \right\}^{1/2}$$

(20')

There is no currency risk for the importers under three situations: a). All imports were denominated in the importer's domestic currency (ϕ=1). b). All imports denominated in exporter's currency were hedged in the forward market h_c^m=1. c). The currency exchange rate between the two countries is fixed, which is equivalent to h_c^m=1.

The interpretation of (20), similar to (11), is the zero marginal expected utility condition under which the importer is indifferent about further trading between the domestic and foreign markets, i.e. the equalization of the present value of the expected marginal revenue from imports, $D_j^m E[p_{t+j}^m + h_p^m * (p_{t,t+s}^m - p_{t+j,t+s}^m)]$, to the expected marginal arbitrage cost which consists of: the first term---the marginal procurement and transfer cost, p_t^x and T_t^{x-m}, and the second term---risk premium, on the right-hand side of (20). Given the utility function (12), the risk premium is determined, as in (4) in exporter's model, by trader's risk preferences and the variances of profit. The assumption for importer's model is that an importer faces both price and currency risk. Therefore her risk premium is determined by her risk preference denoted γ^m, and price and exchange risks indicated by variances of price and exchange rate, and co-variances between prices and exchange rate.

3.1.4. Futures Markets

The futures market parity condition is derived from the assumption that an exporter has two alternatives for temporal arbitrage, one between the domestic spot and the futures markets, the other is export. The latter also involves spatial arbitrage. The second alternative, export, simultaneously involves an importer. The importer in turn refers to the futures market price as an indicator of the future spot price and hedges its revenue in the futures market. Theoretically, the arbitrage activities along these two lines may continue until equilibrium is reached between the two futures markets prices, even though there is no direct arbitrage between them.

If the cash-and-carry strategy is looked at as an alternative to the exporter and rearrange (3), it becomes

$$p_t^x = D_s^x p_{t,t+s_t}^x - D_s^x \overline{B_{t,s}^x} \qquad (21)$$

Then assuming $h_p^m = 1$ to simplify the exposition and rearranging (20) gives

$$p_t^x = E[p_{t+j}^m + (p_{t,t+s}^m - p_{t+j,t+s}^m)] D_j^x / [E(W^m)(1+t)] - T_t^{x-m} - \gamma^m D_j^m$$

$$* \begin{Bmatrix} \sigma^2_{p^m_{t+j}} + (h_p^m)^2 \sigma^2_{p^m_{t+j,t+s}} + (p_{t+j}^x e_{t,t+j})^2 (1+t)^2 * (1-\phi)^2 (1-h_c^m)^2 \sigma^2_{e^{-1}_{t+j}} \\ -2h_p^m cov(p_{t+j}^m, p_{t+j,t+s}^m) - 2(p_{t+j}^x e_{t,t+j}) * (1+t)(1-\phi)(1-h_c^m) cov(p_{t+j}^m, e_{t+j}^{-1}) \\ +2h_p^m p_{t+j}^x e_{t,t+j} * (1+t)(1-\phi)(1-h_c^m) cov(p_{t+j,t+s}^m, e_{t+j}^{-1}) \end{Bmatrix}^{1/2}$$

$$* D_j^x / [E(W^m) D_j^m (1+t)]$$

(22)

Note that the left-hand sides of (21) and (22) are identical. Manipulating the equality of the right-hand sides of the two equations leads to the following relationship between the futures commodity markets in the importer and exporter countries:

$$
\begin{aligned}
p^{m}_{t,t+s} &= D^{x}_{s}\, p^{x}_{t,t+s_t}\, E(W^{m})(1+t)/D^{x}_{j} - \{E(p^{m}_{t+j}) - E(p^{m}_{t+j,t+s})\} - D^{x}_{s}\, \overline{B^{x}_{t,s}}\, E(W^{m})(1+t)/D^{x}_{j} \\
&+ T^{x-m}_{t}\, E(W^{m})(1+t)/D^{x}_{j} - \gamma^{m} D^{m}_{j} \\
&* \left\{ \begin{array}{l} \sigma^{2}_{p^{m}_{t+j}} + (h^{m}_{p})^{2} \sigma^{2}_{p^{m}_{t+j,t+s}} + (p^{x}_{t+j} e_{t,t+j})^{2} (1+t)^{2} * (1-\phi)^{2} (1-h^{m}_{c})^{2} \sigma^{2}_{e^{-1}_{t+j}} \\ -2 h^{m}_{p} \operatorname{cov}(p^{m}_{t+j}, p^{m}_{t+j,t+s}) - 2(p^{x}_{t+j} e_{t,t+j}) * (1+t)(1-\phi)(1-h^{m}_{c}) \operatorname{cov}(p^{m}_{t+j}, e_{t+j}^{-1}) \\ +2 h^{m}_{p} p^{x}_{t+j} e_{t,t+j} * (1+t)(1-\phi)(1-h^{m}_{c}) \operatorname{cov}(p^{m}_{t+j,t+s}, e_{t+j}^{-1}) \end{array} \right\}^{1/2} \\
&* D^{x}_{j} / [E(W^{m})\, D^{m}_{j} (1+t)\, D^{x}_{j}]
\end{aligned}
$$

(23)

Equation (23) shows that, if the magnitude of the second term is small enough (e.g. assuming convergence between cash and futures prices at the time of maturity, p^{m}_{t+j} should be very close to $p^{m}_{t+j,t+s}$ when t+j is close to t+s), the futures commodity price in the importer's country basically equals the sum of exporter's futures market price---first term on the right-hand side, the transfer cost incurred in the international arbitrage---fourth term, and the risk premium---fifth, net of the marginal cost of commodity storage in the exporter's country---third term. Intuitively, the relevant prices in international trade are exporter's domestic spot price at time t and importer's expected future spot price at t+j. Assuming positive basis and no direct arbitrage between the two futures markets, the exporter's domestic futures price in equilibrium is basically the current spot price plus the marginal cost of commodity storage. Therefore, the equilibrium differential between the two futures market prices equals the transfer costs in trade and risk premium, less the marginal storage cost.

3.1.5.Market Equilibrium Conditions of Major Interest in This Study

The equilibrium conditions (3), (11), and (20), derived as the equilibrium conditions for individual arbitragers, also apply to the market if the trade volume is aggregated in arbitrage over a large number of identical competitive arbitragers. Equation (23) is derived from the first three conditions and thus holds true also for the market equilibrium.

Equations (20) and (23) for international commodity arbitrage and futures markets respectively are the two major parity conditions derived in this dissertation.

3.1.6. Model Generalization

The equations (20) and (23) can be generalized to apply to the following different trade arrangement procedures, the market stability, and infra-structural situations:

a. Stable exchange rate regime

a). Exporter handles the commodity procurement and transportation at time t and importer pays the total cost at t+j: equation (20') applies.

b). Exporter handles the commodity procurement and transportation at time t and importer pays the total cost immediately at time t through means such as 'letter of credit on sight': $E(W^m) = e_t^{-1}$ which means no currency risk is involved and equation (20') applies.

b. Non-stable exchange rate regime: Availability vs. non-availability of Forward foreign exchange market.

a). Exporter handles the commodity procurement and transportation at time t and importer pays the total cost at t+j: h_c^m=0 when the forward foreign exchange market and other hedging instruments are not available, which means that, compared to when hedging is possible, a stronger impact is expected from $\sigma^2_{e^{-1}_{t+j}}$, $\mathrm{cov}(p^m_{t+j}, e^{-1}_{t+j})$ and $\mathrm{cov}(p^m_{t+j,t+s}, e^{-1}_{t+j})$ in the second term of (20).

b). Exporter handles the commodity procurement and transportation at time t and importer pays the total cost immediately at time t through means such as 'letter of credit on sight': E (W^m)= e_t^{-1} which means no currency risk is involved and equation (20') applies.

c. Stable commodity cash market price: components 1, 4, 5 of the second term of (20) drops out.

d. Non-stable commodity cash market price (Availability vs. non-availability of Commodity Futures market): h_p^m=0 when futures commodity market and other hedging tools are not available, and all the components that are related to futures commodity market in the second term of (20) will drop out. The consequence is an increase of price risk and trade may fall. For example, with futures market available, the higher is $\mathrm{cov}(p^m_{t+j}, p^m_{t+j,t+s})$ in the 4th component of second term of (20), the lower the variance of hedge returns. Arbitragers therefore have a greater incentive to hedge and reduce the price risk, which may in turn increase the trade activity.

3.2. Linear Approximation to the Parity Conditions: (20) and (23)

In this section, a linear version is developed for each of the two parity conditions described by (20) and (23).

3.2.1. Importer's Arbitrage Price Parity

Recall that importer's model is given by (20). Substituting (19a) into (20), we have

$$D_j^m E[p_{t+j}^m + h_p^m * (p_{t,t+s}^m - p_{t+j,t+s}^m)] = E(W^m) * [D_j^m ((p_t^x + f_t^{x-m} + z_t^{x-m}) / D_j^x)] * (1+t) + \gamma^m D_j^m$$

$$* \left\{ \begin{array}{l} \sigma^2_{p_{t+j}^m} + (h_p^m)^2 \sigma^2_{p_{t+j,t+s}^m} + (p_{t+j}^x e_{t,t+j})^2 (1+t)^2 * (1-\phi)^2 (1-h_c^m)^2 \sigma^2_{e_{t+j}^{-1}} \\ -2 h_p^m cov(p_{t+j}^m, p_{t+j,t+s}^m) - 2(p_{t+j}^x e_{t,t+j}) * (1+t)(1-\phi)(1-h_c^m) cov(p_{t+j}^m, e_{t+j}^{-1}) \\ +2 h_p^m p_{t+j}^x e_{t,t+j} * (1+t)(1-\phi)(1-h_c^m) * cov(p_{t+j,t+s}^m, e_{t+j}^{-1}) \end{array} \right\}^{1/2}$$

(24)

The importer's price hedge ratio h_p^m is assumed to be constant and equal to one. This assumption is a strong one. However, it is not unreasonable to assume a risk-averse importer to hedge her price risk at a fairly high ratio. Furthermore, direct inspection of (24) shows that if this assumption is close to reality, then strong effects are expected of the relevant risk indicators, i.e. futures price variance $\sigma^2_{p_{t+j,t+s}^m}$, co-variance between cash price and futures price $cov(p_{t+j}^m, p_{t+j,t+s}^m)$, and covariance between futures price and exchange rate $cov(p_{t+j,t+s}^m, e_{t+j}^{-1})$. The variance of hedge returns is expected to be negatively related with

$cov(p^m_{t+j}, p^m_{t+j,t+s})$, but positively with $\sigma^2_{p^m_{t+j}}$ and $\sigma^2_{p^m_{t+j,t+s}}$. Theoretically, if the correlation coefficient between p^m_{t+j} and $p^m_{t+j,t+s}$ is equal to one, the variances and co-variance offset each other completely with hedge ratio equal to one and the price risk is totally eliminated (Blank et al 1991). $cov(p^m_{t+j,t+s}, e^{-1}_{t+j})$ is expected to show a positive relation with the variance of the hedge returns. These arguments are consistent with the intuition that a lower variance in hedge returns will normally be an incentive to a risk-averse arbitrager for a higher hedge ratio. Thus assuming that the arbitragers 'perfectly' hedge their price risk in the first place, then the expected revenue is expected to be fairly responsive to the change in these risk indicators. If not, it most probably means either a relatively low hedge ratio or a lack of expertise of using the hedge instruments. It should be noted that if the cash and futures markets are highly correlated, the impacts of those risk variables may also cancel each other.

Though the model is simplified, when the price hedge ratio notation is in parameters associated with risk variables they are retained in the equations for the purpose of interpreting their relationship.

Given the assumption of h^m_p being equal to one, (24) becomes, with some canceling and rearrangement:

$$[E p^m_{t+j} + (p^m_{t,t+s} - Ep^m_{t+j,t+s})] = E(W^m) z_t^{x-m}(1+t)/D^x_j + E(W^m)((p^x_t + f^{x-m}_t)/D^x_j) * (1+t)$$
$$+\gamma^m \begin{Bmatrix} \sigma^2_{p^m_{t+j}} + (h^m_p)^2 \sigma^2_{p^m_{t+j,t+s}} + (p^x_{t+j} e_{t,t+j})^2 (1+t)^2 (1-\phi)^2 (1-h^m_c)^2 \sigma^2_{e^{-1}_{t+j}} \\ -2h^m_p cov(p^m_{t+j}, p^m_{t+j,t+s}) - 2(p^x_{t+j} e_{t,t+j}) * (1+t)(1-\phi)(1-h^m_c) cov(p^m_{t+j}, e_{t+j}^{-1}) \\ +2h^m_p p^x_{t+j} e_{t,t+j} * (1+t)(1-\phi)(1-h^m_c) * cov(p^m_{t+j,t+s}, e_{t+j}^{-1}) \end{Bmatrix}^{1/2}$$

(25)

or

$$[E p^m_{t+j} + (p^m_{t,t+s} - Ep^m_{t+j,t+s})] = e^{-1}_{t,t+j} z_t^{x-m} * (1+t)/D^x_j + e^{-1}_{t,t+j}((p^x_t + f^{x-m}_t)/D^x_j) * (1+t)$$
$$+\gamma^m \left\{ \sigma^2_{p^m_{t+j}} + (h^m_p)^2 \sigma^2_{p^m_{t+j,t+s}} - 2h^m_p cov(p^m_{t+j}, p^m_{t+j,t+s}) \right\}^{1/2}$$

(25')

based on (20') with no currency risk involved.

Note that the first term on the right-hand side of (25), as intercept, was originally part of the second term on the right-hand side of (24)---transfer costs. Its interpretation will be discussed below.

The sum of the left-hand side variables gives the importer's expected selling price for t+j with full hedge assumed, i.e. the expected future spot price at t+j plus the balance in the Futures market transactions.

On the right-hand side, the first term, intercept, captures any time invariant component of unobservable transfer costs in the importing process or measurement error caused by such factors as product differentiation. Note that z_t^{x-m} has a slightly different interpretation than that defined in (5a), it now includes those non-stochastic costs incurred to both exporter and importer. The second term represents the purchasing and observable transaction costs. The transaction costs included here are not exhaustive. However, consideration should be given to the fact that one can never observe all the possible transaction costs, though those of tariffs and transportation costs are covered. If an assumption can be made that these omitted costs are stationary, most of them can be picked up by the intercept, and should not affect the results qualitatively. Nonetheless, the potential problem with the lack of all transaction costs information must be born in mind when analyzing and interpreting the results, particular if they are non-stationary.

The remaining right-hand side variables are specified to estimate the impact of risk premiums. The third term on the right-hand side of (25) gives the risk-related factors. Note that the risk perceptions may be related to different sources. For instance, futures price influence may come from the fluctuation, the length of time from the futures contract maturity date, the trader's expectation about prices, etc. Furthermore, it may depend on information about the different contracts based on the time of the year when the transaction happens.

The second term, purchasing and observable transaction costs, on the right-hand side is subtracted from the left-hand side to get the price differential, Y_t:

$$Y_t = [E\,p^m_{t+j} + (p^m_{t,t+s} - Ep^m_{t+j,t+s})] - e^{-1}_{t,t+j}[((p^x_t + f^{x-m}_t)/D^x_j)](1+t) \qquad (26)$$

Note that (26) is the price differential net of the variable transfer costs. The implicit assumption for this is perfect correlation of importer expected selling price with her purchasing price and transfer costs, i.e. a one-to-one relationship is imposed. In estimation, different specifications may be utilized such as defining Y_t as only the price differential and treat the transfer costs as exogenous explanatory variables. This may reveal the actual impacts of transfer costs on prices.

Defining the first of the remaining terms on the right-hand side of (25) as intercept b_0, the linear approximation to (25) can be written as

$$Y_t = b_0 + b_1\gamma^m \left\{ \begin{array}{l} \sigma^2_{p^m_{t+j}} + (h^m_p)^2 \sigma^2_{p^m_{t+j,t+s}} + (p^x_{t+j} e_{t,t+j})^2 * (1+t)^2 * (1-\phi)^2 (1-h^m_c)^2 \sigma^2_{e^{-1}_{t+j}} \\ -2h^m_p cov(p^m_{t+j}, p^m_{t+j,t+s}) - 2(p^x_{t+j} e_{t,t+j}) * (1+t)(1-\phi)(1-h^m_c) cov(p^m_{t+j}, e^{-1}_{t+j}) \\ +2h^m_p p^x_{t+j} e_{t,t+j} * (1+t)(1-\phi)(1-h^m_c) * cov(p^m_{t+j,t+s}, e^{-1}_{t+j}) \end{array} \right\}^{1/2}$$

(27)

or

$$Y_t = b_0 + b_1\gamma^m \left\{ \sigma^2_{p^m_{t+j}} + (h^m_p)^2 \sigma^2_{p^m_{t+j,t+s}} - 2h^m_p cov(p^m_{t+j}, p^m_{t+j,t+s}) \right\}^{1/2}$$

(27')

if there is no currency risk as expressed in equation (25').

While b_0 is the intercept, b_1 picks up the impact of the importers' risk perceptions. The intercept b_0 captures the unmeasured non-stochastic transfer costs and the time-invariant measurement error or permanent price gap such as that associated with product differentiation. It may be either zero or nonzero depending on the relationship and magnitudes of the variables that are captured by the intercept. b_1 is expected to reveal the positive impact of the risk premium on the expected revenue. The marginal effect of each of the components in the risk perception term can be calculated. Specifically, an increase in $\sigma^2_{p^m_{t+j}}$ and $\sigma^2_{p^m_{t+j,t+s}}$ leads to a higher variance of hedge returns, and thus increases the hedge risk and risk premium. As discussed in equation (24), the impacts of these variables may be offset by perfect correlation of cash and futures markets. Increase in $\sigma^2_{e^{-1}_{t+j}}$, variance of exchange rate, is generally expected to increase the currency risk and the risk premium. $cov(p^m_{t+j}, p^m_{t+j,t+s})$ and $cov(p^m_{t+j}, e_{t+j}{}^{-1})$ are expected to have an opposite effect on the risk premium because the increase of the former indicates a reduction of the hedge risk while the latter indicates a natural hedge, the loss from the increase of e^{-1}_{t+j}, defined as importer's currency price per unit of exporter's currency, will be offset by the increase in the future spot price p^m_{t+j}. Finally, an expectedly positive marginal effect of $cov(p^m_{t+j,t+s}, e_{t+j}{}^{-1})$ says that a higher positive co-variance between the futures price $p^m_{t+j,t+s}$ and future spot exchange rate e^{-1}_{t+j} is expected to increase the price risk and the risk premium---a rise in the commodity futures price is not favorable to a short position holder in terms of foregone returns and its positive covariance with exchange rate increases the risk premium.

3.2.2. Futures Markets Price Parity

Recall that futures market parity is given by (23). Substituting (19a) into (23) gives

$$p^m_{t,t+s} = D^x_s p^x_{t,t+s_t} E(W^m) * (1+t)/D^x_j - (E(p^m_{t+j}) - E(p^m_{t+j,t+s})) - D^x_s \overline{B^x_t} E(W^m)(1+t)/D^x_j$$

$$+ \{(f^{x-m}_t + z^{x-m}_t) * E(W^m)(1+t)/D^x_j\} + \gamma^m \begin{Bmatrix} \sigma^2_{p^m_{t+j}} + (h^m_p)^2 \sigma^2_{p^m_{t+j,t+s}} + (p^x_{t+j} e_{t,t+j})^2 \\ *(1+t)^2 * (1-\phi)^2 (1-h^m_c)^2 \sigma^2_{e^{-1}_{t+j}} \\ -2h^m_p \mathrm{cov}(p^m_{t+j}, p^m_{t+j,t+s}) - 2(p^x_{t+j} e_{t,t+j}) \\ *(1+t)(1-\phi)(1-h^m_c)\mathrm{cov}(p^m_{t+j}, e^{-1}_{t+j}) \\ +2h^m_p p^x_{t+j} e_{t,t+j} * (1+t)(1-\phi)(1-h^m_c) \\ *\mathrm{cov}(p^m_{t+j,t+s}, e^{-1}_{t+j}) \end{Bmatrix}^{1/2}$$

$$* D^x_j / [E(W^m)(1+t) D^x_j]$$

(28)

When the futures price model is simplified with the same assumption as for (24), i.e. $h^m_p=1$, the ratio notation, as in the importer's model, is kept the same as in the interactive relationship with any of those variances and co-variances, so as to make different interpretations associated with different assumptions. For example, that if the assumption $h^m_p=1$ is close to reality, then a strong effect will be expected of the relevant risk indicators such as co-variance between cash price and futures price $\mathrm{cov}(p^m_{t+j}, p^m_{t+j,t+s})$. Otherwise it may indicate a lower hedge ratio. Now applying the assumption to (28) and rearranging gives

$$p^{m}_{t,t+s} = z^{x-m}_{t} E(W^{m}) * (1+t) / D^{x}_{j} + D^{x}_{s} p^{x}_{t,t+s_t} E(W^{m}) * (1+t) / D^{x}_{j}$$

$$- [E(p^{m}_{t+j}) - E(p^{m}_{t+j,t+s})] - D^{x}_{s} \overline{B^{x}_{t,s}} E(W^{m})(1+t) / D^{x}_{j} + \{(f^{x-m}_{t}) E(W^{m})(1+t) / D^{x}_{j}\}$$

$$+ \gamma^{m} \begin{Bmatrix} \sigma^{2}_{p^{m}_{t+j}} + (h^{m}_{p})^{2} \sigma^{2}_{p^{m}_{t+j,t+s}} + (p^{x}_{t+j} e_{t,t+j})^{2} * (1+t)^{2} * (1-\phi)^{2} (1-h^{m}_{c})^{2} \sigma^{2}_{e^{-1}_{t+j}} \\ -2 h^{m}_{p} cov(p^{m}_{t+j}, p^{m}_{t+j,t+s}) - 2(p^{x}_{t+j} e_{t,t+j}) * (1+t)(1-\phi)(1-h^{m}_{c}) \\ * cov(p^{m}_{t+j}, e_{t+j}^{-1}) + 2 h^{m}_{p} p^{x}_{t+j} e_{t,t+j} * (1+t)(1-\phi)(1-h^{m}_{c}) * cov(p^{m}_{t+j,t+s}, e_{t+j}^{-1}) \end{Bmatrix}^{1/2}$$

$$* D^{x}_{j} / [E(W^{m})(1+t) D^{x}_{j}]$$

(29)

or if there is no currency risk:

$$p^{m}_{t,t+s} = z^{x-m}_{t} e^{-1}_{t,t+j} * (1+t) / D^{x}_{j} + D^{x}_{s} p^{x}_{t,t+s_t} e^{-1}_{t,t+j} * (1+t) / D^{x}_{j}$$

$$- [E(p^{m}_{t+j}) - E(p^{m}_{t+j,t+s})] - D^{x}_{s} \overline{B^{x}_{t,s}} e^{-1}_{t,t+j} (1+t) / D^{x}_{j} + \{(f^{x-m}_{t}) e^{-1}_{t,t+j} (1+t) / D^{x}_{j}\}$$

$$+ \gamma^{m} \left\{ \sigma^{2}_{p^{m}_{t+j}} + (h^{m}_{p})^{2} \sigma^{2}_{p^{m}_{t+j,t+s}} - 2 h^{m}_{p} cov(p^{m}_{t+j}, p^{m}_{t+j,t+s}) - \right\}^{1/2} * D^{x}_{j} / [e^{-1}_{t,t+j} (1+t) D^{x}_{j}]$$

(29’)

Note that the first term on the right-hand side of (29), as an intercept, was originally part of the fourth term on the right-hand side of (28), transfer costs. It captures any time invariant component of unobservable transfer costs in the importing process or measurement error caused by such factors as product differentiation. The second, fourth, fifth, and sixth are, respectively, futures price in exporter’s country, marginal cost of storage in exporter’s country, observable variable transfer costs that have been incorporated in the model, and the risk premium. The third term is the expected basis at t for cash at t+j and futures prices at t+j for maturity at t+s. The intuition of (29) can be found in the explanation of (23) in the theoretical model.

Now the left-hand side of (29) is combined with the second (futures price in exporter's country), third, fourth, and fifth terms, on the right hand side, to get the differential, X_t:

$$X_t = p^m_{t,t+s} + [E(p^m_{t+j}) - E(p^m_{t+j,t+s})] - D^x_s p^x_{t,t+s_t} E(W^m) * (1+t) / D^x_j$$
$$-[(f^{x-m}_t) E(W^m)(1+t) / D^x_j + D^x_s \overline{B^x_{t,s}} E(W^m)(1+t) / D^x_j]$$

(30)

Note that (30) is the price differential of the two futures markets net of the sum of per-unit variable transfer costs and the marginal cost of storage in exporter's country. Again, as in (26), this specification implies a one-to-one relationship between importer's futures price and the remaining right-hand side terms of (30). Again, as in the importer's model, different specifications may be tried to estimate the actual relationships.

Define first term of (29) as intercept a_0, and the risk premium parameter as a_1. The linear approximation to (29) may be written as

$$X_t = a_0 + a_1\gamma^m \left\{ \begin{array}{l} \sigma^2_{p^m_{t+j}} + (h^m_p)^2 \sigma^2_{p^m_{t+j,t+s}} + (p^x_{t+j} e_{t,t+j})^2 \\ *(1+t)^2 * (1-\phi)^2 (1-h^m_c)^2 \sigma^2_{e^{-1}_{t+j}} \\ -2h^m_p cov(p^m_{t+j}, p^m_{t+j,t+s}) - 2(p^x_{t+j} e_{t,t+j}) \\ *(1+t)(1-\phi)(1-h^m_c) cov(p^m_{t+j}, e_{t+j}^{-1}) \\ +2h^m_p p^x_{t+j} e_{t,t+j} * (1+t)(1-\phi)(1-h^m_c) \\ * cov(p^m_{t+j,t+s}, e_{t+j}^{-1}) \end{array} \right\}^{1/2} * D^x_j / [E(W^m)(1+t) D^x_j]$$

(31)

or if there is no currency risk:

$$X_t = a_0 + a_1\gamma^m \left\{ \sigma^2_{p^m_{t+j}} + (h^m_p)^2 \sigma^2_{p^m_{t+j,t+s}} - 2h^m_p cov(p^m_{t+j}, p^m_{t+j,t+s}) \right\}^{1/2} * D^x_j / [e^{-1}_{t,t+j}(1+t) D^x_j]$$

(31')

Note that a_0 and a1 are both interpreted the same as for b_0 and b_1 in equation (27). a_0 could either be zero or non-zero, $a_1$is expected to be positive. The marginal effect of each of the components in the risk perception term can be calculated the same way as in equation (27). In particular, an increase in $\sigma^2_{p^m_{t+j}}$ and $\sigma^2_{p^m_{t+j,t+s}}$ leads to a higher variance of hedge returns and increase the risk of hedge and risk premium; $\sigma^2_{e^{-1}_{t+j}}$ is expected to indicate a higher risk premium requirement due to the higher currency risk; the expected positive $cov(p^m_{t+j}, p^m_{t+j,t+s})$ and

$\text{cov}(p^{m}_{t+j}, e^{-1}_{t+j})$ should reduce the hedge risk. The latter works as a natural hedge and thus reduce risk premium---any loss incurred in an increase of e^{-1}_{t+j}, defined as importer's currency price per unit of exporter's currency, will be offset by its inflationary effect on p^{m}_{t+j}. A higher positive co-variance between futures price $p^{m}_{t+j,t+s}$ and future spot exchange rate e^{-1}_{t+j} is expected to increase the price risk and risk premium---a rise in commodity futures price is against the interest of a short hedger.

3.3. Econometric Methods

Recall the model developed by Sexton et al (1991). It structures the error terms in the model predictions into the following three regimes: a). Below the mean, implying a price differential less than the total transfer cost; b). Around the mean, the price differential equals transfer costs; c). Above the mean, the price differential greater than transfer costs. In this section, these three basic regimes are specified based on the linear models described by equations (27) and (31). Since the two parity conditions are identical in the econometric setting, only importer's model, (27), is illustrated.

3.3.1. Three Regimes and Their Density Functions: Importer's Model

Following Weinstein (1964), Aigner et al (1977), Sexton et al (1991), Baulch

(2001), Barrett and Li (2002), the data generating process for the following is assumed to be described by a normal plus half-normal distribution such that

$$Y_t - \beta_t^{x-m} = \begin{cases} v_t + u_{to} & \text{if } Y_t - \beta_t^{x-m} > 0 \quad (32a) \\ v_t & \text{if } Y_t - \beta_t^{x-m} = 0 \quad (32b) \\ v_t - u_{ti} & \text{if } Y_t - \beta_t^{x-m} < 0 \quad (32c) \end{cases}$$

where

$$\beta_t^{x-m} = b_0 + b_1\gamma^m \begin{Bmatrix} \sigma^2_{p^m_{t+j}} + (h_p^m)^2 \sigma^2_{p^m_{t+j,t+s}} + (p^x_{t+j} e_{t,t+j})^2 * (1+t)^2 * (1-\phi)^2 (1-h_c^m)^2 \sigma^2_{e^{-1}_{t+j}} \\ -2 h_p^m cov(p^m_{t+j}, p^m_{t+j,t+s}) - 2(p^x_{t+j} e_{t,t+j})(1+t)(1-\phi)(1-h_c^m) \\ * cov(p^m_{t+j}, e_{t+j}^{-1}) + 2 h_p^m p^x_{t+j} e_{t,t+j} * (1+t)(1-\phi)(1-h_c^m) cov(p^m_{t+j,t+s}, e_{t+j}^{-1}) \end{Bmatrix}^{1/2}$$

(33)

or

$$\beta_t^{x-m} = b_0 + b_1\gamma^m \left\{ \sigma^2_{p^m_{t+j}} + (h_p^m)^2 \sigma^2_{p^m_{t+j,t+s}} - 2 h_p^m cov(p^m_{t+j}, p^m_{t+j,t+s}) \right\}^{1/2}$$

(33')

if there is no currency risk as expressed in (27').

Note that in (32), v_t represents i.i.d. normal error around the perfect integration bound, defined by β_t^{x-m}, with variance σ_v^2, u_{to} is a one-sided, positive error above the perfect integration bound (32a) and independent of v_t with variance $\sigma^2_{u_o}$, u_{ti} is defined the same but below the perfect integration bound (32c) with variance $\sigma^2_{u_i}$.

Subscripts 'o' and 'i' symbolize 'outside' and 'inside' the bound respectively.

(32a) indicates a regime in which there exists unexploited arbitrage returns, (32b) for a regime in which there is no arbitrage returns with markets well linked, and (32c) for a regime in which price differentials are less than the transfer costs. The distribution functions for the observations in each regime are:

$$f_{to} = \left[\frac{2}{(\sigma_v^2+\sigma_{uo}^2)^{.5}}\right]\phi\left[\frac{Y_t - \beta_t^{x-m}}{(\sigma_v^2+\sigma_{uo}^2)^{.5}}\right]\left[1-\Phi\left[\frac{-\left(Y_t - \beta_t^{x-m}\right)\sigma_{u_o}/\sigma_v}{(\sigma_v^2+\sigma_{uo}^2)^{.5}}\right]\right] \tag{34a}$$

$$f_t = \left[\frac{1}{\sigma_v}\right]\phi\left[\frac{Y_t - \beta_t^{x-m}}{\sigma_v}\right] \tag{34b}$$

$$f_{ti} = \left[\frac{2}{(\sigma_v^2+\sigma_{ui}^2)^{.5}}\right]\phi\left[\frac{Y_t - \beta_t^{x-m}}{(\sigma_v^2+\sigma_{ui}^2)^{.5}}\right]\left[1-\Phi\left[\frac{\left(Y_t - \beta_t^{x-m}\right)\sigma_{u_i}/\sigma_v}{(\sigma_v^2+\sigma_{ui}^2)^{.5}}\right]\right] \tag{34c}$$

Here ϕ (.) and Φ (.) denote the standard normal density and cumulative functions. Equations (34a), (34b), and (34c) are the density functions for the regimes expressed in (32a), (32b), and (32c) respectively. It is interesting to note the relationship between σ_u and σ_v in equation (34). In (34c) for example, if σ_v approaches to infinity, then the symmetric error dominates in the determination of the total error term and (34c) becomes the density of a N(0, σ^2) random variable, where $\sigma^2 = \sigma_v^2 + \sigma_u^2$. If on the other hand, σ_u approaches to infinity, then (34c) will take on the form of a half-normal.

It should be noted that the choice of distribution might make a difference in estimation (Barrett and Li 2002). Unfortunately, there is no theory about the true distribution for non-zero rent situations.

Furthermore, the two components of the error term, u_t and v_t, are assumed to be serially uncorrelated. Otherwise, the econometric model will become very complicated. However, Roman Frydman (1980) has proved the consistency of maximum likelihood estimator of nonlinear regression model with auto-correlated errors.

3.3.2. Incorporating Trade Flow Information in a Joint Probability Model: 12 regimes

Dynamic trade flow information is introduced, through four index variables, to form 12 regimes in a likelihood function. This is an extension to the Barrett and Li's method that specifies trade volume information as a dichotomous variable: trade and no trade.

In particular, let k_t be a variable of trade volume, and K_{t1}, K_{t2}, K_{t3} be index variables, the values of which can be defined as follows:

$K_{t1} = 1$ when $k_t=0$, otherwise $K_{t1}=0$; (35a)

$K_{t2} = 1$ when $0<k_t < k_{t-1}$, otherwise $K_{t2}=0$; (35b)

$K_{t3} = 1$ when $k_t = k_{t-1} >0$, otherwise $K_{t2}=0$; (35c)

1- K_{t1}- K_{t2}- K_{t3} will pick up the observations when $k_t > k_{t-1}>0$;   (35d)

Let arbitrage rent be $R_t= Y_t - \beta_t^{x-m}$. An exhaustive combination of the situations described in (35a)-(35d) with those in (32a)-(32c) gives twelve regimes (table 1). The model is estimated with the joint probability distribution of $\{R_t, k_t\}$.

Table 1. Twelve regimes

	$k_t=0$	$0<k_t < k_{t-1}$	$k_t = k_{t-1} >0$	$k_t > k_{t-1} >0$
$R_t>0$	λ_1	λ_2	λ_3	λ_4
$R_t=0$	λ_5	λ_6	λ_7	λ_8
$R_t<0$	λ_9	λ_{10}	λ_{11}	λ_{12}

(34a), the density function for the observations outside the bound, is appropriate for the regimes represented by λ_1 to λ_4, i.e. $f^1_{to} = f^2_{to} = f^3_{to} = f^4_{to}$, (34b) for λ_5 to λ_8, i.e. $f^5_t = f^6_t = f^7_t = f^8_t$, and finally (34c) for λ_9 to λ_{12} and $f^9_{ti} = f^{10}_{ti} = f^{11}_{ti} = f^{12}_{ti}$. The likelihood of observing the sample data $\{R_t, k_t\}$ is therefore given by

$$L = \prod_{t=1}^{n} \{K_{t1}(\lambda_1 f^1_{to} + \lambda_5 f^5_t + \lambda_9 f^9_{ti}) + K_{t2}(\lambda_2 f^2_{to} + \lambda_6 f^6_t + \lambda_{10} f^{10}_{ti})$$
$$+ K_{t3}(\lambda_3 f^3_{to} + \lambda_7 f^7_t + \lambda_{11} f^{11}_{ti}) + (1 - K_{t1} - K_{t2} - K_{t3})(\lambda_4 f^4_{to} + \lambda_8 f^8_t + \lambda_{12} f^{12}_{ti})\}$$

(36)

Denote θ =(b_0 to b_6, λ_1 to λ_{12}, $\sigma_{u_o}^2, \sigma_v^2$, and $\sigma_{u_i}^2$) as the parameter vector for (36). θ can be obtained by maximizing the likelihood function of (36). The four terms of (36) are associated with the four different trade flow circumstances. For each circumstance, there are three regimes: outside the bounds, at the bounds and inside the bounds.

It should be noted that Table 1 is intended to give a relatively complete picture of all the regimes that could possibly be estimated. In actual estimation, however, due to such limits as potential lack of data richness and availability, or actual trading circumstances, some of them may need to be dropped or combined. For example, regime 2 and 3, 6 and 7, 11 and 12 can be paired up due to similar interpretation (See Table 2).

Given the information of the trade flow and price relationship in the above 12 regimes, economic theories are applied to develop a framework to interpret them in the next section.

3.4. An Interpretation Framework for the 12 Regimes

Table 2 has summarized all the regimes and their likely interpretations. The null hypothesis is that the markets are perfectly integrated.

Regime 1---positive marginal arbitrage profit and no trade, indicates that the positive profits remain unexploited by arbitragers. The plausible explanations for this regime are non-tariff trade barriers, government intervention (e.g. quota), risk aversion and risk perception, imperfect information market (barriers to information entry).

In regime 2---positive profit and trade down, non-tariff trade barriers, risk aversion.

Regime 3---positive profit and trade constant, can be a result of non-tariff trade barrier such as quota, and some unmeasured transaction costs such as cost of acquiring information. If there is no indigenous supply, a possible explanation for this regime is price discrimination to a foreign area by a monopoly in the exporting country who faces a relatively inelastic residual demand in the importing country.

Regime 4---positive profit and trade up, is most likely to indicate a temporary dis-equilibrium due to such factors as contracting and transport lags.

Regime 5---zero profit and no trade, is a ‘perfect’ integration case (Barrett and Li 2002), as long as there is history of trade, where an arbitrager is indifferent. It can also be due to the formulation of a regional monopoly (Stigler and Sherwin 1985).

Regime 6---zero profit and trade down, also indicates ‘perfect’ integration.

Regime 7---zero profit and trade constant, may be explained the same as regime 6.

Regime 8---zero profit and trade up, is again showing ‘perfect’ integration.

Regime 9---negative profit and no trade, a typical autarky situation due to either a prohibitive transfer costs or higher comparative production costs. Note that this is segregated market equilibrium case.

Table 2. 12 Regimes and Interpretations

Regimes / Interpretations	$R_t>0$				$R_t=0$				$R_t<0$			
	$k_t = 0$	$0<k_t<k_{-1}$	$k_t=k_{t-1}>0$	$k_t>k_{t-1}>0$	$k_t=0$	$0<k_t<k_{t-1}$	$k_t=k_{t-1}>0$	$k_t>k_{t-1}>0$	$k_t=0$	$0<k_t<k_{t-1}$	$k_t=k_{t-1}>0$	$k_t>k_{t-1}>0$
	λ_1	λ_2	λ_3	λ_4	λ_5	λ_6	λ_7	λ_8	λ_9	λ_{10}	λ_{11}	λ_{12}
Prohibitive transfer costs									×			
Structural change in transfer costs												×
High comparative production cost									×			
Non-tariff trade barriers	×	×	×									
Government intervention (e.g.embargo)	×											
Imperfect information.	×											
Risk aversion	×	×										
Imperfect competition (e.g. price discrimination)			×		×						×	
Unmeasured transfer benefit (e.g.convenience yield)											×	×
Unmeasured transfer cost			×									
Strategic behavior (e.g. first mover advantage)											×	
Temp. dis-equilibrium (e.g. contracting , or info. lags)				×						×		
Perfect integration					×	×	×	×				

Regime 10---negative profit and trade down, is likely to indicate a temporary dis-equilibrium due to the time lags between signing the contract or transporting the goods and realizing the final price.

Regime 11---negative profit and trade constant, may imply the same underlying causes as in regime 7. Other possibility is monopolistic dumping.

Regime 12---negative profit and trade up, a scenario that could be due to unmeasured transfer benefits. Another possibility is the structural change in transfer costs.

To summarize, regimes 5,6,7, and 8 are potential candidates for 'perfect' integration, defined as zero marginal arbitrage return and observation of trade flow or evidence of history of trade, i.e. $R_t=0$ and $k_t \geq 0$. For regime 5 to be likely as a case of perfect integration, there should be evidence of history of trade. Otherwise, as shown in Table 2, it could result from the formulation of a regional monopoly. Note that two markets can also be regarded as 'perfectly' integrated without trade if arbitragers face zero marginal returns, $R_t=0$, because traders are indifferent about trading at this point. (Barrett and Li 2002). Regimes 4 and 10, interpreted as temporary dis-equilibrium due to contracting or information lag in this study, are likely to be in transition to 'perfect' integration scenario. However, it should also be noted that, since international commodity trade involves issues such as contracting lag and trade barriers, without other a priori information about the market demand and supply, regimes 4 and 10 could also indicate a dis-equilibrium market if these two regimes occur alternately and with fairly high frequencies (Nancy E. Bockstael 1983).

'Imperfect' integration, on the other hand, refers to those cases with non-zero marginal returns and observation of trade flows. The potential candidates are regimes 2,3,11, and 12.

The remaining regimes, 1 and 9, in Table 2 are cases of segmentation. Barrett and Li (2002) call them segmented dis-equilibrium and segmented equilibrium respectively.

The regimes of most concern to economists are those deviating from long-run perfect market integration, i.e. regimes 1, 2, 3, 5, 9, 11, 12. These regimes, first of all, give positive or negative arbitrage profits; secondly, the potential causes of these regimes are most probably related to such factors as high transfer cost, high risk, non-tariff trade barrier, and imperfect information or imperfect competition.

In this study, the regimes deviating from the long-run competitive equilibrium are of major concern, thus regime 9, as an equilibrium case, can be removed from the list above. Furthermore, with evidence of trade history, regime 5 also falls in the category of integration.

CHAPTER 4 - BACKGROUND AND DATA

Chapter 4 provides a brief background and data description for the analysis in the empirical application. Note that in this dissertation only importer's model is applied in the empirical test. For a discussion of how the four parity conditions interact, see Appendix A.

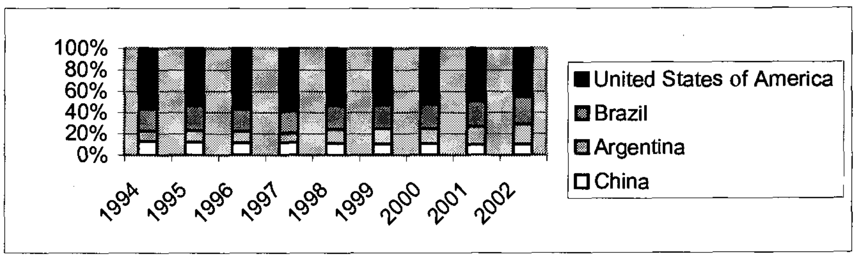
4.1. Background

The United States has been the leading producer and exporter in the world soybean market. China, on the other hand, is becoming an important soybean importer. Figure 1 and Figure 2 illustrate the soybean output and export shares of the four major producing countries. In all cases, the United States has by far the largest share, followed by Brazil. For example, in the year 2000, the U.S. had around fifty percent of the production and seventy percent of the exports among the top-four producing countries. On the import side, figure 3 illustrates a steady increase of China's share of soybean imports. By the 2000-2001 marketing year, more than 20 percent of world soybean exports were destined for China (figure 3).

These figures indicate the important positions of the two countries involved in this study and therefore add to the policy as well as academic interest of this analysis.

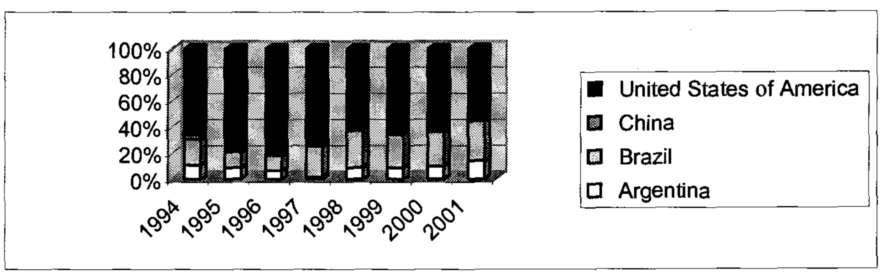
To better appreciate the subject of this study, a brief look will be taken at both the supply side, the U.S. as the exporter, and the demand side, China as the importer.

Figure 1. Soybean production shares of the four top countries: 1994-2002



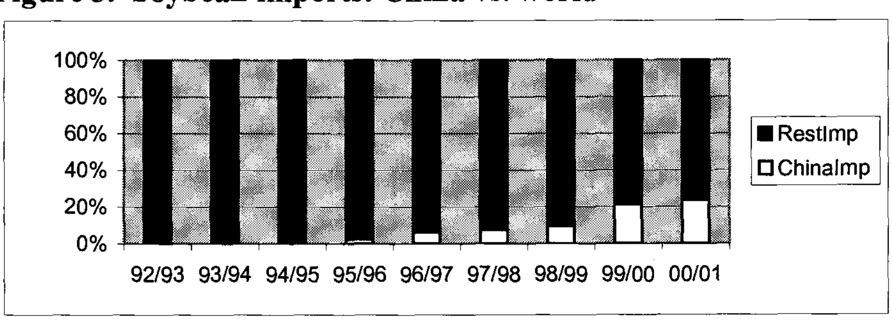
Data source: United Nations, Food and Agricultural Organization

Figure 2. Soybean export shares of the four top countries: 1994-2001



Data source: United Nations, Food and Agricultural Organization

Figure 3. Soybean imports: China vs. world

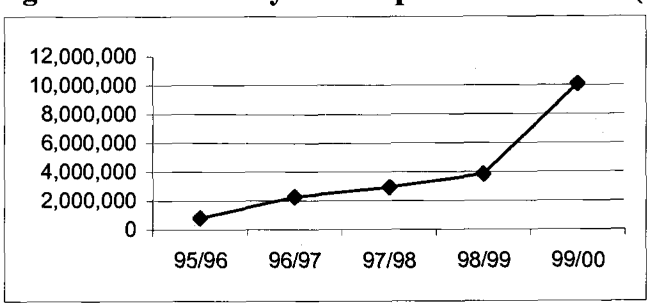


Data source: World Market and Trade Archives, FAS, USDA

Lying behind the strong momentum in the U.S. agricultural production and exports are the Uruguay Round of the GATT, now the World Trade Organization, and the 1996 Farm Bill. Breaking the link between farm support payments and production, removing supply control programs, capped export subsidies and price floors, have all increased U.S. competitiveness, production capacity, and flexibility. This reflects a steady shift from government interventionist in markets to greater reliance on market forces to determine production and marketing. (Collins 1998).

On the importer's side, Chinese soybean imports have been steadily increasing since 1996 because of fast-growing domestic demand and the relaxation of government restrictions on trade (Figure 4).

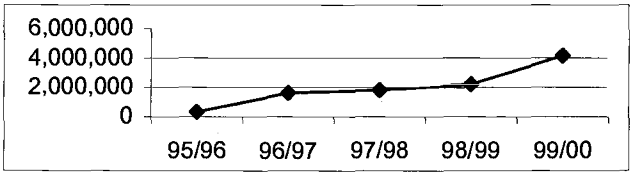
Figure 4. China's soybean imports: 1996-2000 (in metric tons)



Data source: World Market and Trade Archives (online), FAS, USDA

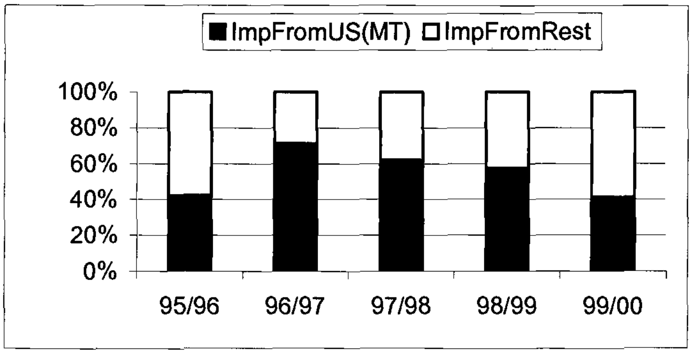
Among the soybean importers to China, the United States and Brazil took the lead before 1999. In the 1999/00 marketing year, Argentina passed Brazil and became the second largest exporter to China. (Foreign Agricultural Service USDA 2001, GAIN Report, p25). Figure 5 demonstrates the increasing Chinese soybean imports from the U.S. It is shown in figure 6 that the U.S. has averaged 50 percent of the total world soybean export supply to China from the marketing year 95/96 to 99/00.

Figure 5. China soybean imports from U.S.: 1996-2000 (in metric tons)



Data source: *Journal of Commerce's* US Port Import-Export Recording Service data set (PIERS).

Figure 6. The U.S. share to the China soybean imports



Data source: World Market and Trade Archives, FAS, USDA; PIERS.

Besides the rising domestic demand as an underlying force behind the increasing imports, the Chinese domestic beans as a substitute are considered to be of relatively poor quality. This is because of its high cost, low oil content, and foreign material, etc. The oil extraction rate of the U.S. beans is 18.5 percent, Brazilian beans at a little bit higher rate of 20 percent, compared to the Chinese domestic soybeans at 15.5 percent. But the soybean meal produced using Brazilian beans is darker and redder than what the Chinese customers prefer. Some crushers mixed the U.S. and Brazil soybeans together. Compared to Brazilian beans, U.S.

beans have higher protein content and less foreign material. (Crook et al 1998, p72). Moreover, there is a wide gap between the contracted quality and the actual shipments from South America (USDA FAS 3/9/2001). Therefore, the U.S. is still the predominant source of import supplies in spite of its higher prices compared to Brazil. However, it has also been pointed out by some Chinese crushers that the quality of U.S. beans has deteriorated, mostly because of the shift of the U.S. soybean production to the west and north of the corn belt (Crook et al 1998).

Domestic transportation also poses a problem, in terms of cost and ease of availability, for the Chinese domestic beans to be transferred to the major crushing area. About 40-50 percent of the Chinese domestic grain products are shipped by water, while railway shipments are slower and more expensive. (Crook et al 1998). The major soybean production area is in the Northeast China, while the major crushers are in the southern port cities such as Guangzhou, Shanghai, and Shenzhen.

Regarding government policy and regulation, there has been a 3 percent tariff and 13 percent VAT levied in China on soybean imports since 1994. However, the VAT will be reimbursed if the crusher exports the oil and meal. A 13 percent value-added tax was also imposed on soy-meal since July 1999 (USDA FAS 3/9/2001).

An important policy change in the Chinese marketing system took place in 1995 when COFCO, China National Cereals, Oils & Foodstuffs Import & Export Corporation, lost its exclusive right to import soybeans, introducing competition into the system (Crook et al 1998). Furthermore, the restrictions on the direct foreign investments in the crushing industry started to be lifted in the last decade.

Also in 1995, to stabilize the grain supply, the Chinese government initiated the 'Governor's Grain Bag Responsibility System'. Declining area sown to grains and rising grain retail prices led to the adoption of this system. Under this policy, provincial governors are responsible for balancing the demand and supply by using market as well as administrative price control measures. For example, at a time of supply shortage, a price support policy may be promised as an incentive to farmers to increase their production. After fulfilling their 10 percent fixed mandatory quota at a fixed price, farmers can sell their harvest to the grain station at market price or a support price if the market price is lower than the support price. The major grains related to this policy are wheat, rice, corn, and soybeans.

The Chinese government also established futures markets to help stabilize the grain supply. The Dalian Commodity Exchange (DCE), currently the second largest in the world in number of soybean transactions (DCE online introduction 3/25/2003), came into operation in February 1993. The DCE's soybean futures contracts were designed based on the Chicago Board of Trade (CBOT) contracts. The specifics of the DCE soybean futures contracts are described in table 3 in comparison with CBOT.

By 1998, DCE boasted 136 members and 8500 clients, 40 and 4500 of which, respectively, are grain enterprises. 79 members are brokerage firms. In the year 2000, DCE witnessed a membership and client spike to 148 and 15000

Table 3. DCE futures contracts in comparison with CBOT

	DCE	CBOT
Contract Size	10/metric tons	5,000 /bu
Deliverable Grades	Grade 3 Yellow at par	No. 2 Yellow at par
Tick Size	1 yuan/MT	1/4 cent/BU ($12.50/contract)
Price Quote	Yuan/MT	Cents and quarter-cents/bu
Contract Months	Jan, Mar, May, July, Sep, Nov.	Sep, Nov, Jan, Mar, May, Jul, Aug
Last Trading Day	Tenth business day of the delivery month	The business day prior to the 15th calendar day of the contract month.
Last Delivery Day	Seventh day following the last trading day	Second business day following the last trading day of the delivery month.
Trading hours	Beijing time: Mon-Fri. 9:30-11:00 a.m. 1:30-3:00 p.m.	Sun-Thurs.: 9:30 p.m.-1:15 a.m.
	Chicago time Tue-Sat.: 9:30-11:00 p.m. 1:30-3:00 a.m.	Mon-Fri.: 9:30 a.m. - 1:15 p.m.
Ticker Symbols	S	S
Daily Price Limit	3% above or below the previous day's settlement price	50 cents/bu ($2,500/contract) above or below the previous day's settlement price.

Data source: DCE, CBOT (March 2003)

respectively. Meanwhile, the trade volume at DCE jumped from the ninth in 1995 to the second largest in 1998 among the 14 commodity exchanges in China. Although the soybean transactions at DCE declined from 669.2 billion Chinese yuan to 642.2 during 1998-1999, the percentage to CBOT volume has gone up from 10 percent to 20 percent. By January 2003, the total soybean transactions at the DCE was 30.49 percent of those at the CBOT, and about 11 times that of the Tokyo Grain Commodity Exchange.

The DCE's operations have improved and developed over time, with adoption of new rules and regulations. Due to some instances of market manipulations by speculators in Chinese futures markets, the Chinese central government tightened its regulation in 1998 through the direct supervision and monitoring by the China Securities Regulatory Commission (CSRC)---a ministerial agency under the State Council of China.

The DCE is not operating in all ways like the major futures markets in other countries. Trading is still not open to foreign investors, and Chinese individuals and enterprises are not allowed to access foreign futures markets, though activities of Chinese firms operating in other countries cannot be assessed. While the intent of these restrictions is to protect the DCE and domestic futures market participants before they accumulate sufficient market experience and expertise, this administrative control may also affect the market liquidity at the DCE and thus the efficient operation of the market.

In general, the development of DCE soybean futures market has made futures price the most important market signal for Chinese soybean producers, importers, crushers and other futures market participants. With a lack of other sources of information on the actual supply and demand and the stock changes, DCE's role as an information center as well as a risk hedging instrument has become very important in deriving a more market-based expectation about the supply and demand relationship and price changes. Meanwhile, it should also be noted that the DCE continues to develop in terms of management mechanisms and participants' experience.

4.2. Data

All the data involved in this study are transformed into bi-weekly averages from either daily or weekly original data. There are two major reasons for this aggregation: a). Trade flow is not presumed to occur continuously on a weekly basis. b). Price adjustments also take some time. So within the availability limit of the given data, bi-weekly series are used.

The U.S. dollar price is converted into Chinese yuan per metric ton. Given the data availability constraint, the period covered in this study is from January 1995 to April 1999.

The importer's expected cash market price was extrapolated for time t+j by discounting the futures price at time t of the nearest contract by s-j, where s>j. 12 weeks delivery lag is assumed in the US-China soybean trade. This assumption is based on the discussion with former industry traders, Patrick Meyer and Kim Rameker, currently International Trade Managers at Oregon Department of Agriculture, who are familiar with the timing in completing an international transaction that involves the physical exchange of commodities. According to these individuals the process takes 75-90 days to complete. This is further confirmed by a former COFCO manager Wenguang Si who used to handle the soybean imports from the U.S. The original futures price series is daily, and changed into bi-weekly data taking a simple average.

The freight rate data in use is the rate from the U.S. gulf to Japan since this is the most complete set available. The original series is weekly. The assumption is that the difference between China and Japan rates is constant and can be picked up by the intercept. Missing values are filled with averages. The data source is USDA.

Chinese cash price data have proved to be inadequate for estimation of the complete model for this analysis. The only cash market set which was found to cover the period of study was collected by China's National Market Administration Bureau (NMAB) at a 10 days frequency. (Park et al 2002). As a retail price set, it was found to have little relation to the wholesale market. In August 2002, Mrs. Zhu Lihong, the Chief Executive of the Research Division of DCE, was contacted by phone and fax about this issue as well the possibility of getting a longer DCE soybean futures series. During the phone conversation Mrs. Zhu revealed two considerations about the soybean cash price data: a). It is very difficult to get the Chinese soybean cash price data at wholesale level due to data documenting system. b). She herself is not satisfied with the semi-monthly data her division has compiled. Although the possibility was explored to share or purchase the cash data her division had found as well as the futures data from year 2000-2001, she was unwilling to do so. The current Chinese futures data are from Reuters Ltd.

Efforts were made to obtain the Brazilian soybean price data, but the cost was prohibitive.

For other data sets, the US cash market price data were procured from Bridge/CRB (CRB InfoTech) data company, Chicago USA, originally of daily frequency; US soybean exports volume to China from *Journal of Commerce's* US Port Import-Export Recording Service data set (PIERS); the U.S. 3-month T-bill interest rate is weekly from the US Federal Reserve Board; the Chinese monthly lending interest rate from International Monetary Fund. Theoretically, what is needed is three-month rate that is about the time length of the delivery lag specified in the model. Fortunately, in the period covered in this study, the rate was fairly stable and centrally controlled by the Chinese government.

CHAPTER 5 - RESULTS AND DISCUSSION

5.1. Estimation and Results

Recall the model in this study is derived from an expected utility function that consists of two components, expected profits and the risk premium. This empirical application is based on equation (25) and its linear approximation, equation (27).

In the specific US-China case, exchange risk is eliminated because there is a pegged relationship between the U.S. dollar and Chinese yuan. For price risk, three alternative specifications were tested for importers' risk perception and assessment about their future revenue. Three separate variables were tried first---standard deviations of Chinese cash price and Chinese futures price over the preceding 12 weeks, and the correlation between the cash market and futures market prices. These variables were first specified separately because it is assumed that the traders may not give equal weights to these risks. All the variables were highly insignificant. This result may be due to the problem with the Chinese cash price data that are from a retail price dataset collected by China's National Market Administration Bureau (NMAB) at a 10 days frequency. (Park et al 2002). Another possible reason for this result may be that there exist offsetting effects between the variances and co-variances of the cash and futures prices. A combined variable is then tried which exactly follows the original model given by equation (27)---the standard error of the profit specified as the square root of the summation of the relevant variances and co-variances. The estimate indicates the expected sign, but is statistically insignificant. Finally, a decision was made to omit variables based on the Chinese cash data, because tests showed that this data was not representative of the wholesale market. Given that there is not an accepted source of cash prices for traders in the Chinese market, this seems to be the situation that traders face. In the "Circular on implementing the Relevant Measures for Further Supporting the Development of China's Soybean Industry", newly announced by nine Chinese government departments, 'Establishing and perfecting the wholesale markets for soybeans' is also emphasized as an important policy target (USDA 3 /10/2003). The futures price standard error is retained and shows the expected sign, but is also statistically insignificant.

Two additional proxies of risk perceptions were considered: 1. The length of time from the maturity date of the futures contract for hedging; 2.The trend in the futures price. Of these variables, the futures price trend yielded both more significant coefficient and a higher likelihood value than other specifications.

The variable for the 'length of time from the futures contract maturity date' is specified as the number of weeks from the date the import contract is signed to the date the futures contract matures. The negative sign in the estimation, -0.98, demonstrates a decline of the risk premium with the length of maturity (Appendix C). This to some extent replicates the finding by Protopapdakis and Stoll (1983). In their study of the LOP between futures markets, Protopapdakis and Stoll find that the variance around the LOP declines with the maturity of the futures contract and the longer the planning horizon, the lower the arbitrage cost. This variable is dropped from the model because it is not statistically significant, presumably for its lack of variation. In fact, the auxiliary regression test indicates a very low sum of squared errors, which is a typical case of collinearity with the intercept. (Judge et al, p437).

The 'futures price trend' variable is specified as the average price change in the last 6 weeks. If the period t is in the maturity month, then the next nearest contract is chosen.

On the left hand side of the original model, there is a term for the expected hedge return as part of the expected revenue. It is dropped in the estimation based on the assumption of an efficient Chinese futures market, i.e. any expected returns different from zero will be removed by arbitrage activities. With the possibility of an inefficient Chinese futures market, there are some data limitations for testing some specifications of expected hedge returns other than zero. To some extent the model's inclusion of variances and covariance of cash and futures prices compensates for this lack. As pointed out in chapter 3, if the parameter estimates of such variables indicate a strong impact on expected future revenue, then it is most likely that the traders hedge their risk in the futures markets. Moreover, the conceptual existence of a likely non-zero expected hedge returns provides another perspective for the regime interpretation. For example, when the situation of positive rent and no trade occurs, a negative expected return is a likely attribute if appropriate a priori market information is available.

Regarding the statistical part of this application, the way the extended model is specified in a joint probability setting with 12 regimes has some special requirements for the statistical software to handle the constrained optimization problem. As a mixture of a normal and half normal distributions, the parameters have to be estimated by numerical optimization. First the whole sample is broken down into subsections based on the discrete trade flow information specification, then three regimes and their frequencies are estimated within each subsection. Another statistical complication is to distinguish the two components of the error term, symmetric and asymmetric parts. In this study these two parts are denoted as v_t and u_t. Limdep, TSP, and Gauss Software Packages were tested, but all had convergence problems. A gradient-based minimized-sums (MS) algorithm in the S-plus package (Turley and Ford 2000) is used for estimation, which was able to achieve stable convergence. The results reported in this study are provided by the maximum likelihood estimation in the S-plus package.

For the joint probability setting described by equation (36) in chapter 3, the trade volume indicators are specified in units of 20 metric tons, about half a standard container. For example, if the trade volume in period t is 100 metric tons, that in t+1 is 120 metrics tons, then the indicator will be 1 for category of trade going up for the period t+1. This seems very arbitrary, but fortunately, in most cases there is substantial difference across periods, and the average is 110,010 metric tons. The U.S. soybean trade volume data are retrieved from PIERS (Journal of Commerce's US Port Import-Export Recording Service) database. Six weeks of lag is assumed between signing the contract and the loading completed for shipping.

For the significance test, because the specific optimization function that has been used in the S-plus package does not provide a t-test statistic, the method of Berndt, Hall, Hall and Hausman (BHHH) is applied to calculate the variance-covariance matrix for the parameters (Appendix B). The t-statistic is then computed using the BHHH results.

Given the above statement, the parameter estimates summarized in table 4 are based on equation (27'), with the term expected hedge return dropped from the left hand side. On the right hand side, importer's risk aversion parameter γ^m and the price risk hedge ratio h_p^m are assumed to be one. 'Futures price trend' is introduced as a separate risk variable from the 'standard error of the profit'. In table 4, b_1 and b_3 indicates the impacts of the 'standard error of the profit' and 'futures price trend' respectively, and b_2 is the parameter for the freight rate. Note that 'future price trend' is added to reflect another possible source of risk related to hedging in the futures market---a downward bias of the futures price.

5.2. Discussion

5.2.1. Regime Probability Parameters

The probability coefficients are all statistically significant, among which $\lambda_2, \lambda_5, \lambda_4$, λ_8 are significant at 99 percent level. Under the no trade circumstances, which occurs in 53 percent ($\lambda_1+\lambda_5$) of the periods in the sample, 11 percent indicate positive rent (λ_1), 42 percent (λ_5) indicates zero rent. In the trade-up case of 37 percent of the whole sample, 19 percent occurs with positive rent (λ_4) and 18 percent with zero rent (λ_8). The remaining 10 percent of the periods indicate trade going down despite positive rent.

Table 4. Parameter Estimates for the US-China soybean market integration

Regime Frequencies

Trade info. / Arbi.Rent	No trade		Trade down		Trade constant		Trade up	
Positive	λ_1	0.11* (0.06) (1.96)	λ_2	0.1* (0.03) (3.29)	λ_3	0.00	λ_4	0.18* (0.07) (2.75)
Zero	λ_5	0.42* (0.07) (6.00)	λ_6	0.00	λ_7	0.00	λ_8	0.19* (0.07) (2.76)
Negative	λ_9	0.00	λ_{10}	0.00	λ_{11}	0.00	λ_{12}	0.00

Other Parameters

b0	b1	b2	b3	σ_u	σ_v
108.06 (86.36) (1.25)	0.02 (0.29) (0.07)	0.86* (0.34) (2.56)	1.19** (0.65) (1.84)	315.52* (45.16) (7.00)	110.85* (15.07) (7.36)

Note:

1. Log likelihood is -772.3012. The number of observations=103.
2. Standard errors and t-statistics are in the parentheses.
3. * indicates statistically significant at 95% level in t test, ** at 90% level.

Following the interpretation framework developed in chapter 3, the concerns arise about regime 1 with positive rent and no trade, and regime 2 represented by λ_2 with trade going down with rent remaining unexploited. The total of such occurrences given the sample is $\lambda_1 + \lambda_2$=21 percent. Regime 1, a case of market segregation, may be a concern to the economists and policy makers since trade is not occurring even when a profit margin exists. Regime 2 indicates imperfect market integration since trade is supposed to increase when there are positive margins and shift the market toward the competitive equilibrium. The bulky regime 5, a case of zero profit and no trade, should indicate that demand and supply conditions are such that the price differential equals to the transaction costs. Regime 4 is most likely a demonstration that it takes time for the traders to fully exploit the profit margin by increasing their trade activities, while regime 8 may represent the delivery lag when the transaction has been made.

In general, this result indicates that given the sample available in the study, the US and Chinese soybean markets are integrated 80 percent of the time either in competitive equilibrium or temporary disequilibrium (regimes 5, 8, and 4), and 10 percent imperfectly integrated (regime 2). In the remaining 10 percent, the two markets are segregated (regime 1). The highly significant estimates of λ_1 and λ_2, about 20 percent in total, cause a rejection of the hypothesis that the law of one price holds for all time t.

According to the interpretation framework developed in chapter 3 of this dissertation, situations represented by regime 1 and regime 2 reflect deviations from the long-run competitive market equilibrium. The causes of such deviations are most likely those factors that tend to distort the market operations, such as risk, non-tariff trade barriers, imperfect information, etc. Figures 7, 8, and 9 illustrate the time distribution of the estimated error terms in the no trade case, the trade going up, and the trade going down cases respectively. The band is made of one standard deviation of the error term v_t on both sides from the perfect integration bound. It can be noted that most points above the band in the no trade case happened before or around 1995/1996 marketing year, while for the case of trade going up, the points above the band are mostly clustering in the later part of or after the year 1996. The points at or within the bands most likely indicate either perfect integration or competitive equilibrium or both.

Figure 7. Time distribution of error terms: no trade

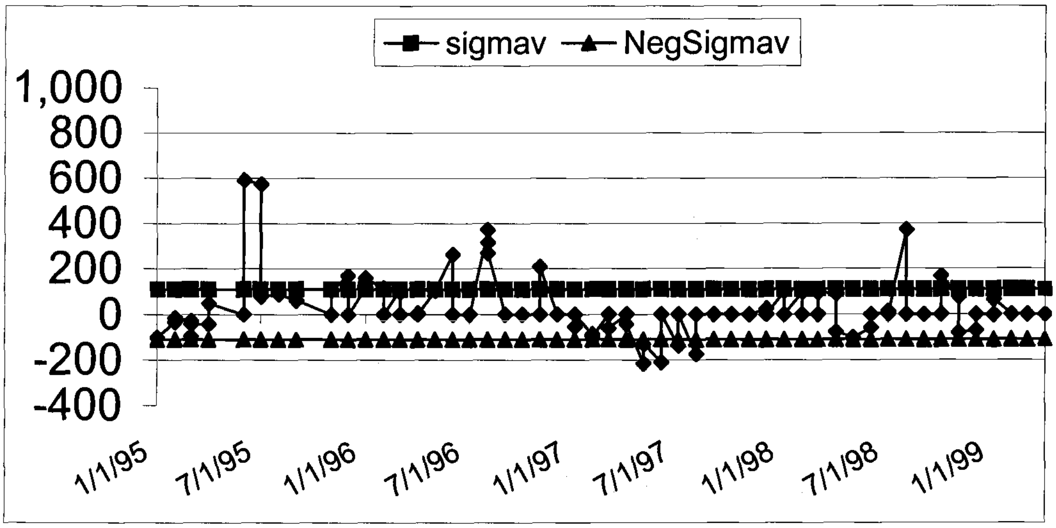


Figure 8. Time distribution of error terms: trade going up

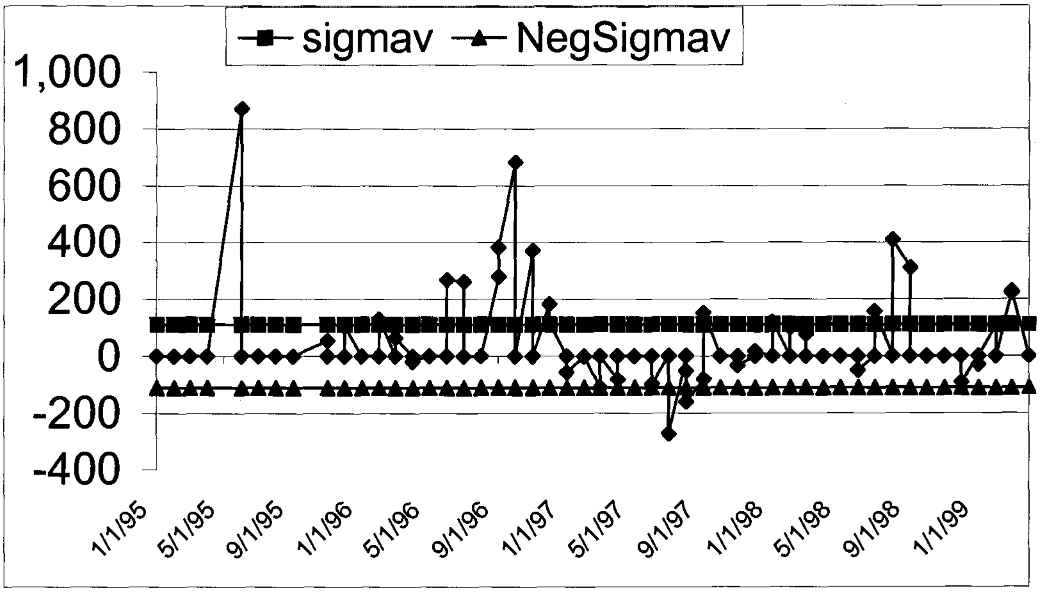
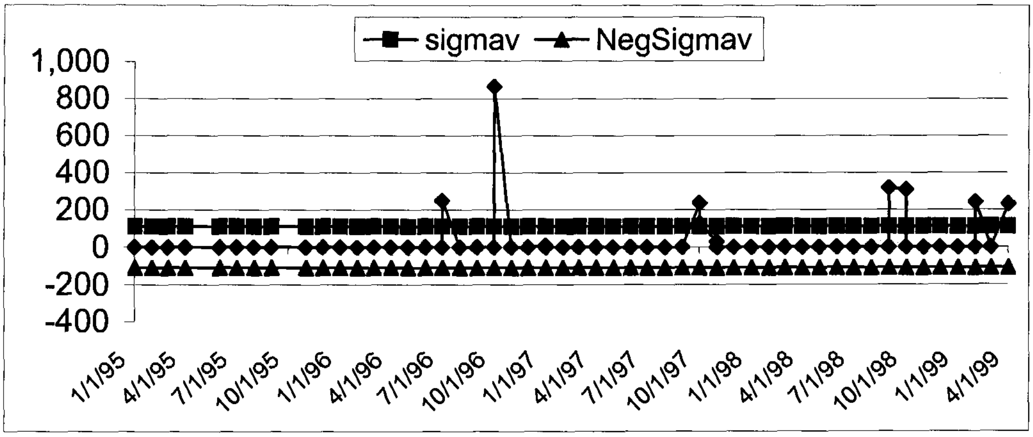


Figure 9. Time distribution of error terms: trade going down



According to the World Markets and Trade reports by USDA (USDA FAS 3/9/03) China imported a relatively small amount of soybean before 1995/1996 marketing year (Oct.-Sep.) and actually the exports exceeded the imports (table 5). A similar trend is observed about the imports from the U.S (table 6). It has been pointed out in chapter 4 that there were two major policy-related events in China around 1995-1996: one is COFCO's loss of exclusive import right of soybean, and the introduction of Dalian soybean futures markets which became increasingly active over time. A more competitive system is most likely one of the major attributes to the increased imports and thus an improvement of market integration. Meanwhile, DCE soybean futures market could have availed the traders of an instrument to reduce the price risk and risk premium. This may explain the situation depicted in figure 8 where trade flow increases and the market is either in a temporary disequilibrium (regimes 4 in table 4) or perfect integration (regime 8 in table 4).

Table 5. Chinese soybean imports and exports (in million metric tons)

	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Imports	0.150	0.130	0.160	0.800	2.270	2.940	3.850	10.100	13.250
Exports	0.300	1.100	0.390	0.220	0.200	0.168	0.187	0.230	0.208
Net Im.	0.150	0.970	0.230	0.580	2.070	2.772	3.663	9.970	13.042

Data source: World Market and Trade Archives (online), FAS, USDA.

Table 6. Chinese soybean imports from the U.S. (in million metric tons)

	95/96	96/97	97/98	98/99	99/00
Imp.	0.338	1.621	1.829	2.219	4.162

Data source: PIERS.

However, in regard to the above interpretation, two cautions should be made concerning the data availability limit in this study. First, in reality the physical flow of trade is not continuous exactly on a bi-weekly basis as specified, and the plausibility of the test results are expected to improve if the data availability allows us to apply longer time frequency for the data. A more accurate relationship between price and trade volume change may be described.

Second, positive rent with the presence of trade may also be attributed partly to the high domestic transportation costs. As mentioned in chapter 4, the major soybean production area in China is in the northeast, while most major crushers are located toward the south. Also as discussed in chapter 4, the domestic transportation cost in China could create a wedge in the price differential. For example, the positive rent in the estimated regime 2, and 4 may be partly attributed to the domestic transportation expense if it is known a priori that the amount of it may make a difference in the market integration.

For the purpose of illustration, two hypothetical cases regarding the domestic transportation cost are briefly discussed in the following paragraphs.

The expected futures price in the model is extrapolated from the futures market price in DCE in the northeast, but the import landing and crushing industry is mostly in the south.

Let us denote unit domestic transportation cost as t, and the unit international transaction costs to the southern port in China as T, price for the northeast Chinese beans as P_n, and price for the U.S. beans as P_u:

Case 1: The price differential is greater than T, i.e. P_n-Pu>T, P_n- P_u –T<t, and trade is observed with a positive rent. In this case, P_n and P_u are actually segregated. As a numerical example, if P_n- P_u –T=3 and t=6, there is a loss to transfer the imports from southern ports in China to the high-price location in the northeast. Therefore one can see imports landing in the southern port, and a still large positive rent. If, however, the domestic transportation information is incorporated, then the positive rent might be replaced by a loss and it is economically logical to conclude that the price in the northeast area is not always directly linked to the U.S. price even with trade flow being observed. If positive rent with trade going down is observed, then including domestic transportation costs may also turn the observed positive rent to negative, thus illustrating a situation where the market is adjusting itself and trade volume is observed to fall.

Case 2: The price differential is greater than T, i.e. P_n-Pu>T, P_n- P_u –T>t, and trade is observed with a positive rent. In this case, let us assume P_n- P_u –T=6 and t=3, there is profit to move the imports from a southern port to the high-price location in the northeast. If an increase in trade is also observed, then it is quite likely that the positive rent indicates a temporary disequilibrium (regime 4); with the case of a trading fall being observed, then it may be more valid to interpret it as imperfect integration (regime 2).

Given the domestic transportation problems in China discussed in section 6.1, Case 1, i.e., segregation between the prices in northeast China and the U.S., is quite possible.

Therefore, a situation can be visualized that trade flow can take place extensively, but the price in the northeast is not directly linked to the U.S. price because of other unobserved stochastic transfer costs, especially those non-stationary costs that cannot be captured by the intercept. Of course this would only occur with positive profits observed. High domestic transportation costs, inefficient marketing system, among others, are possible explanations given the actual situation in the Chinese soybean market.

In summary, the results will be more informative if the data of the other domestic transfer costs and/or the prices in the south are available. In addition, as has been pointed out, data with longer time frequency is also a very important consideration for finding a more accurate relationship between price and trade volume change.

5.2.2. Intercept, Risk Variables, Freight Rate

The intercept b_0 is intended to capture all the unobserved non-stochastic and stationary transfer costs and the time-invariant measurement error or permanent price gap such as price premium. It is hard to interpret this parameter because it is a combination of several factors. However, the fact that it is statistically insignificant is to some extent an indication that the effects of these factors are either very small or offset each other.

The parameter of the standard error of profit, b_1, has a positive sign as expected, which indicates a higher risk premium requirement to compensate for the uncertainty of the market price change. Its statistical insignificance may indicate that traders are well hedged and thus no significant premium is required. However, it should be borne in mind that other possible causes of its insignificance include: a). The loss of variability information in the process of averaging; b). Standard error may not be the best measure of risk perception. As an indicator of deviation from the mean, it may not well reflect the price changes for some more relevant periods, for example the periods that are close to the day when decision is made.

In the model estimated for this analysis the freight rate parameter, $b_2=0.9$, is close to one as expected of the impact of the freight rate. Recall that the freight rate used in the estimation is the Japanese series because this is the most complete set. To further test this result, the existing Chinese freight rate data are regressed on the corresponding Japanese data. The estimation gives a relationship between the two as 0.92. This is consistent with the result for b_2, i.e., if a more complete set of

Chinese data was available and could be utilized, b_2 would be expected to be closer to 1. The freight rate to China may not be higher than that to Japan because of lower labor or port costs.

The risk parameter, b_3, tells about the impact of the 'futures price trend' as an indicator of trader's risk perception and the risk premium demand. The positive sign could indicate that, for an importer as a short hedger, the expected hedge return declines with an expected increase of futures price, thus raising the risk premium. The significant estimate of b_3 and its magnitude along with the insignificance of the variance of the futures price to some extent has confirmed the assumption that the importers hedge their price risk substantially in the futures market.

According Keynes' theory of normal-backwardation (1923), the purpose of the agricultural futures market is mainly to facilitate hedging the risk of carrying the underlying products. Therefore, the short hedgers have to pay an 'insurance' premium to the long speculators. Keynes suggested that this is borne out by a downward bias of the futures price as a forecast of the future spot price. As the futures contract approaches the maturity, the futures price has to increase toward the convergence with the cash price and thus give the speculator a profit margin over time. The higher the expected futures price goes, the higher the risk 'insurance' premium charge is indicated. While this is not generally accepted or found to be the case in modern futures markets (Blank et al, p73), the finding about the impact of the 'futures price trend' in this study, b_3, may reflect the situation that is consistent with that described by Keynes given the fact that the DCE is a young futures commodity market. The importers, as shorter hedgers, may thus include this expected premium in their expected revenue when making arbitrage decisions.

5.2.3. Variance Parameters: σ_u and σ_v

As discussed in chapter 3, the whole error term is composed of two components, v_t, and u_t, where u_t is assumed to be distributed independently of v_t with a one-sided half-normal distribution. Aigner et al (1977) pointed out in his analysis of production frontiers that these two terms represent two different sources of error, symmetric error (both above and below zero) in the production case due to luck, weather, measurement error, and asymmetric error (truncated in one direction from zero) which gives such information as the ability to utilize 'best practice' technology. In other words, the asymmetric error shows a persistency of error in one direction. Theoretically, either one of the two components could be greater than the other. However, σ_u is expected to be higher in the market integration application because they are either outside or inside the bound, which generally means a loss of direct link between the two market prices. As expected, the relative sizes of the variance parameters and their standard errors reveal a higher volatility in price outside the bound than at the bound, which is consistent with the observance by Baulch (1997). The average error term is 161, part of which is attributed to the normal random error v, part of it to the normal random error truncated from below at zero, u. The estimates of σ_u and σ_v reported in table 4 are

315.52 and 110.85 respectively. The two components sum up to 427. Compared to the standard deviation of 403.7 of the expected price on the left hand side, these estimates are reasonable. Moreover, the size of σ_v, 110, is about 4 percent of the average expected price of 2780.9, which is a reasonable magnitude in terms of representing the symmetric fluctuations around the bound.

5.2.4. Comparison with the Barrett-Li Approach

As discussed in chapter 1 and 2, this study has extended the Barrett-Li (B-L) approach in several respects (Barrett and Li 2002). In this section, a comparison is made between the results from the extended model and those found by using the B-L approach.

Barrett and Li are the first to combine trade volume with price and transfer costs in a price relationship model. They are also the first to apply a regime-switching approach in international commodity trade analysis. They classify the trade volume into two categories---trade and no trade, which gives 6 regimes in total. Table 7 presents the estimates using this method. Note that the regime notations have been changed because of the model change. Also note that the parameter of freight rate has been directly subtracted for the left hand side. However, this implicit restriction of the freight rate parameter as one should not affect this comparison qualitatively because it most probably will overstate the impact of the variable because the unrestricted estimate is less than one. Another admission should be made that the original B-L test was on a contemporaneous basis, i.e. the prices of the same time period are compared. The comparison made in this study has used the same inter-temporal cash-futures price data arrangements for both models in order to concentrate on the target parameters of interest.

Table 8 presents the estimates using the extended model. The parameter notations are kept the same as in table 4. Note that the freight rate parameter is also implicitly restricted as one in order to focus the comparison on the specifications risk variables and trade volume information. Thus, the freight rate parameter, b_2, cannot be seen in table 8.

First, a direct inspection of the estimates using the B-L approach (table 7) indicate a higher estimate of total probability for the regimes with positive rent, $\lambda_1 + \lambda_2 = 53$ percent, while the estimate using the extended model is 40 percent in total, i.e. $\lambda_1+\lambda_2+\lambda_4$ (table 8). This result indicates that inclusion of relevant explanatory variables, derived from the expected utility function, may increase the model's capacity to provide direct information about the impact of these variables and thus provides a more accurate basis for policy implications. The finding of a significant estimate of b_3 with a magnitude of 1.15 (table 8), for example, could be the result of Chinese importers hedging their price risk with an expectation that rising prices would lead to a loss on the hedging side of their transaction thus resulting in a risk premium being added to the expected future revenue. This role of risk variables in improving the inferential capacity of the model can be further proven when isolating the estimation to these variables, i.e., using the same specification as in the estimates of table 8 except dropping the two risk variables. The results are

Table 7. Parameter estimates for US-China soybean market: The B-L method

Regime Frequencies				
.	No trade		Trade	
Pos. rent	λ_1*	0.17 (0.07) (2.33)	λ_2*	0.36 (0.08) (4.48)
Zero rent	λ_3*	0.36 (0.08) (4.6)	λ_4	0.10
Neg. rent	λ_5	0.00	λ_6	0.00
Other parameters				
b0**	σ_u		σ_v	
47.08 (24.92) (1.89)	295.76 (35.12) (8.42)		103.78 (14.86) (6.99)	

Note:

1. Log likelihood is -751.3916. The number of observations=103.
2. Standard errors and t-statistics are in the parentheses.
3. * indicates statistically significant at 95% level. ** indicates statistically significant at 90% level.

Table 8. Estimates using the extended model: Comparison with the B-L method

Regime Frequencies								
Trade info. / Arbi.Rent	No trade		Trade down		Trade constant		Trade up	
Positive	λ_1	0.11* (0.06) (2.01)	λ_2	0.1* (0.03) (3.32)	λ_3	0.00	λ_4	0.19* (0.07) (2.87)
Zero	λ_5	0.42* (0.07) (5.93)	λ_6	0.00	λ_7	0.00	λ_8	0.18* (0.07) (2.67)
Negative	λ_9	0.00	λ_{10}	0.00	λ_{11}	0.00	λ_{12}	0.00

Other Parameters				
b0	b_1	b_3	σ_u	σ_v
70.20** (39.48) (1.78)	0.06 (0.29) (0.22)	1.15** (0.66) (1.73)	314.14* (43.84) (7.17)	110.08* (14.90) (7.39)

Note:

1. Log likelihood is -772.4574. The number of observations=103.
2. Standard errors and t-statistics are in the parentheses.
3. * indicates statistically significant at 95% level in t test, ** indicates statistically significant at 90% level.

reported in Appendix D. A similar loss of information occurred when the risk variables are dropped from the extended model using the same specification as in the estimates of table 4 except dropping these variables (Results reported in Appendix E). If relatively sound cash market price data were available, it would be possible to test the impact of risk perception about the cash market.

Second, breaking down the trade flow information into four cases has provided another avenue of reducing the unaccounted-for positive margins. For example, positive arbitrage rent with trade volume increasing (regime 4 in table 8) may indicate that the traders are trying to earn the rent by increasing trade, and that the market is responding appropriately. On the other hand, with positive rent and decreasing trade flows (regime 2 in table 8), temporary disequilibrium is less plausible as an interpretation. Rather, the situation may indicate the impact of some unobserved transfer costs. Clearly, it would provide more information if an estimate of 36 percent of the time with positive rent using B-L method (regime 2 in table 7) breaks down to different situations identified with different trade flow situations. Thus, from the perspective of analytical correctness, the extended model has provided a more plausible outcome in the interpretation of the results by using additional trade flow information.

In summary, the above comparison shows that introducing risk variables and trade flow change information into the model has reduced the unaccounted-for positive margins and therefore has strengthened the inferential capacity of the analysis.

CHAPTER 6 - CONCLUSIONS

6.1. Motivation of This Work

The focus of market integration analysis is to examine whether a commodity is efficiently traded between markets and whether the profit margin has been fully exploited or not via arbitrage activities. As one of the major economic forces to exhaust profit margin and bring the market to equilibrium, arbitrage decisions can be affected by many considerations.

As discussed in the introduction, a price relationship model has a disadvantage in providing accurate information on the specific causes of the different situations with the profit margins due to its parsimonious specification. This, to some extent, limits the analytical potential of this type of model. Some recent studies, such as the parity bound model (Baulch 1997) and incorporation of trade volume (Barrett and Li 2002), have made progress in correcting this problem.

International commodity arbitrage is spatial as well as inter-temporal with a considerable delivery lag, thus involving a substantial level of risk. However, there has been a lack of efforts in the price relationship literature that explicitly model risk considerations in a price parity condition. Failure to embrace this information may undermine the analytical potential of the model in terms of revealing a possibly sizeable risk premium that might be included in the arbitrage decision-making process. Explicit inclusion of risk perception has been infrequent in previous price relationship analyses probably because most of them assume contemporary linkages between the prices in different markets.

Empirical tests incorporating the trade flow change information have also been lacking. Without knowledge of how trade varies the interpreter of price relationship tests may not be able to draw a reasonable conclusion. For example, when positive arbitrage rent is observed with trade volume increasing (regime 4 in table 2), it is plausible to claim that the market is in a temporary disequilibrium because the traders are trying to capture rent by increasing trade. On the other hand, with positive rent and declining trade flows, temporary disequilibrium is less plausible as an interpretation. Clearly, without information on the trade change, it is difficult to provide convincing evidence about the market condition.

Some issues regarding the inter-temporal modeling of the international commodity arbitrage have been found not adequately dealt with, such as the role of futures market in the arbitrage decision and the time value considerations. The futures market has been designed as an information center about the future spot price of its underlying commodity, as well as a risk-hedging instrument. It is widely utilized in the international trade as well as in domestic business activities. With futures market information explicitly introduced into the model, the inter-temporal uncertainty of international commodity trade could be better captured in terms of price and hedge return expectations. For example, in the US-China soybean market application of this study, uncertainty about the hedge returns seems to be an important factor in importer's risk premium consideration.

Given the issues stated above, this dissertation presents an attempt to improve the market integration analysis in the following respects:

a. Reformulating the price relationship model so that it better describes the actual arbitrage process and makes it less difficult to discern the causes of observing or failure to observe the law of one price from the market integration tests.

b. Extending Barrett and Li's methodology (B-L) to combine the trade flow change with the prices and transfer costs so that the test results provide more accurate information about the market integration conditions.

First, parity conditions for international commodity arbitrage are derived from an expected utility function incorporating risk factors. This constitutes one of the major differences between the extended model and the Barrett and Li method. Since the actual outcome cannot be known with certitude at the time of making the transaction decision, the arbitrager has to depend on their expectation of future revenue and cost as discerned from the information available. A risk premium might be added to the expected earning due to the uncertainty involved in the transaction. Results indicate that the mean-variance expected utility function could be an appropriate tool to fit this modeling need. It embraces both expected profit and the risk perception.

Second, hedge returns, as part of the expected revenue, is introduced into the modeling framework. This inclusion adds an integral component of the total revenue; it also provides an additional perspective in understanding and testing the impact of traders' risk perceptions on the market integration. The B-L model, the first effort to add trade volume into the empirical model, has not accounted for hedging considerations.

Finally, the inter-temporal features of international commodity trade has been incorporated into the model. In this aspect, futures market information has been employed to extrapolate the expected future cash market price. Two parity conditions are derived within the present value framework, one for the import arbitrage, the other for testing the market integration between the two futures market that are not directly linked with direct arbitrage. For trade flow information, the lag between the time of contract being signed and the loading completed is allowed for. This explicit inter-temporal treatment has also been lacking in B-L model.

In regard to the econometric extension to the Barrett and Li's method, the trade volume change is introduced into the regime-switching model. Specifically, trade flow is broken down into four categories: no trade, trade going down, trade constant, trade going up. This classification gives a more complete picture of 12 regimes with some dynamics, compared to B-L that only distinguishes no trade and trade with 6 regimes. By combining the trade volume change information with the price relationship, the model allows more accurate assessment of market integration.

In the application to the US-China soybean trade, the comparison of the test results with those using B-L method indicates that the extended model does enhance the information that can be obtained from the estimation. For example, when positive arbitrage rent is observed with trade volume increasing (regime 4 in table 4), it is more plausible to claim that the market is in a temporary disequilibrium because the traders are trying to earn the rent by increasing trade, and that the market is responding appropriately. On the other hand, with positive rent and decreasing trade flows (regime 2 in table 4), temporary disequilibrium is less plausible as an interpretation. The B-L model does not distinguish between regime 2 and regime 4 in that regime 2 will also be regarded as temporary disequilibrium.

6.2. Empirical Findings

The results from the test indicates that within the sample period, the US and Chinese soybean markets are well-integrated 80 percent of the time either in perfect integration (regimes 5 and 8 in table 4) and temporary disequilibrium (regime 4 in table 4). As discussed in chapter 5, a substantial improvement of market integration has been observed after 1995/1996, most probably due to the introduction of more competition into the Chinese marketing system and the more liquid operation of soybeans futures markets at the DCE. The other 10 percent of the time (regime 2 in table 4) the two markets are also integrated but with some unexploited margin being observed. In the remaining 10 percent, the two markets are segregated (regime 1 in table 4). Based on the out of sample information in chapter 4, the possible explanations about the situations represented by regimes 1 and 2 include: a). Lack of competition in the Chinese marketing system and lack of liquidity at the

DCE prior to 1995/1996 (Crook et al 1998). b). The domestic transportation problem that has not been accounted for in the extended model, as discussed in chapter 5. c). Non-tariff barriers such as quota, quarantine policy and other protective measures given the traditional protection practice by the Chinese government. d). Other unmeasured transfer costs such as US freight rate, insurance, loading/unloading, and risk premium related to default, etc. when these costs are non-stationary. For example, as discussed in chapter 5, if the Chinese domestic transportation cost is provided, regime 1, even regime 2, are not unlikely to reflect a market segregation.

In general, the test results of this study show that the US-China soybean markets are well integrated. However, the estimates for λ_1 and λ_2 cause a rejection of the hypothesis that the law of one price holds throughout the analysis period.

Given the these results, although the interpretation of regimes 1 and 2 still requires out of sample information, the extended model has reduced the amount of work to accommodate this need. The estimates comparison in chapter 5 shows that this amount has narrowed to 21 percent (regimes 1 and 2 in table 8), compared to the estimate using the B-L method---53 percent (regimes 1 and 2 in table 7). This achievement most probably has come through two avenues provided in the extended model.

First of all, the explicit measurement of the impact of risk variables have reduced the total probability for the regimes with positive rent from 53 percent ($\lambda_1 + \lambda_2 = 0.53$ in table 7) to 40 percent ($\lambda_1 + \lambda_2 + \lambda_4 = 0.40$ in table 8). The remaining 13 percent is mostly accounted for by the risk variables. Although part of this reduction may be due to the general change in the model specification such as the breakdown of the trade information, inclusion of the risk variables is an important attribute to the reduction of the uncounted-for margins. A change of the same nature has also been observed when the risk variable is dropped from the extended model itself.

This indicates that inclusion of relevant explanatory variables, derived from the expected utility function, may increase the model's capacity to provide direct information about the impact of these variables and thus provides a more accurate basis for policy implications. The significant estimate of b3 with a magnitude of 1.15 (table 8), for example, most likely shows that the Chinese importers hedge their price risk and a possible loss in their price hedging in the futures market may affect their required margin being added to the expected future revenue.

The positive and statistically insignificant parameter estimate of another explanatory risk variable, the standard error of profit, conforms best to the possibility that the Chinese importers generally hedge their price risk at the DCE.

As another avenue of reducing the unaccounted-for margins, the extended model introduces the information of the trade volume change. For example, regime 4 in table 8, positive arbitrage rent with trade volume increasing, is more likely reflecting the market adjustment to reap the margin, while regime 2 in table 8 with trade going down and a positive margin is less plausible to be interpreted the same way as regime 8. The dichotomous specification of trade and no trade in B-L method regards both regimes 2 and 4 as temporary disequilibrium since it does not contain trade change information (table 7).

Finally, the freight rate to China has been found to be lower than that to Japan probably because of lower labor or port costs.

6.3. Policy Implications

With respect to policy, major result is that in general the two markets are well integrated, 80 percent of the time as shown in the last section. Furthermore, a better integration has taken place with the development of the soybean futures markets at the DCE and the introduction of competition into the Chinese marketing system. This message may be interesting to both firms and government as discussed in the introduction chapter. With a combined large soybean market, firms may be better able to take advantage of the economies of scale by increasing production, reducing risk premium requirement, etc. This is particularly true for the US exporting firms as an increasingly important soybean supplier to the Chinese market. The Chinese crushers may also be less worried about local supply and demand shocks due to the increased market size. Other implications include: a). Firms can also assume the price interrelationship and thus use base-point pricing. b). Price information is available with low cost and DCE soybean futures price may serve a relatively reliable role as a price signal. c). Chinese importers are most probably using the soybean futures markets for price information and hedging purposes, which may lead to a more rational pricing behavior on their part.

The authority, particularly the Chinese government, is also better informed when considering price or market regulations. For example, a complementary trade policy or other measures would have to be considered for the regulation to be implemented more effectively.

Finally, there still remains room to improve the link between the two soybean markets. For example, the significant impact of the futures trend variable detected in this study has indicated that revamping the operation of futures market in Dalian may reduce the risk premium requirement-a less downward bias in futures price as a forecast of spot price may be more favorable to the short hedger in terms of hedge returns. The lack of good cash price information in China also gives the futures markets a more crucial role as a market information center. Lastly, the possible causes of regimes 1 and 2 in this study, as discussed in the chapter 5, indicates that improvement in the domestic transportation system and marketing system may tighten the link between the two markets.

6.4. Limitations of This Study

Possible limitations of this research include: a). The assumption of stationarity of the unmeasured transaction costs. b). Lack of other important relevant transfer cost data such as the Chinese domestic transportation expense, particularly if it is non-stationary because then it cannot be captured by the intercept. c). Lack of a good cash price series. With good cash price data, the impact of the risk in the cash market may be estimated and the impact of the futures market fluctuation better understood. d). Estimation results are expected to be more informative and more accurately interpreted if the most relevant data are available, and with sufficient length of coverage period so that they can be specified with appropriate time frequency. Some further work can also be done about the specification of the expected hedge return if given enough data coverage. Last but not least, although efforts have been made in this study to correct the problem with the regime-switching model, further research might seek to improve the dynamic analysis. Among others, additional work can be directed to measure the relationship between the adjustment of price and the adjustment of trade flow.

6.5. Some Clarifications

As pointed out in section 6.1 and the introduction chapter, the price relationship model has a disadvantage in providing accurate information on the specific causes of the different situations with the profit margins due to its parsimonious specification. Another technical difficulty that may further weaken this type of model is that it is almost impossible to observe all the transfer costs or the costs of collecting these cost data may be prohibitive. This is why it has been assumed in this study that all unmeasured transfer costs are stationary, so that they can be reasonably well captured by the intercept and the random error 'v' as denoted in this study.

The Parity Bound Model (PBM) (Baulch 1997) has a strong argument about this issue and makes an attempt to extrapolate all the possible transfer costs to formulate an 'exact' spread band for perfect market integration, hence the 'parity bound'. As discussed in chapter 2, Barrett and Li (2002) follow the Baulch approach by "taking pains" to collect all the possible transfer costs, but still have to admit that "one can never observe all possible transaction costs such as subjective risk premium, discount rate..." This is the major reason why they extend the PBM and add the trade volume information. Under this background, this dissertation contends that with the limitation of the stationarity assumption in mind, efforts can be made to resort to other sources of important information, incorporating risk variables and dynamic trade flow information, among others.

With the above statement given, it should be admitted that the model developed in this dissertation still needs out of sample information to give a more convincing explanation under many circumstances. For example, had additional non-stationary Chinese domestic transportation costs been observed, regime 2 in table 2 with positive profit could have become regime 6 which shows zero profit, or regime 1---segregated disequilibrium--- would become regime 9---segregated equilibrium---if the Chinese transportation cost were prohibitive as discussed in chapter 5. Therefore, caution should be taken in interpreting the results when there is documented knowledge about the heavy domestic transportation costs in China, even though the actual numeric data are not available.

However, it is also possible that with the extra transportation cost added, the frequency estimate of regime 1 and 2 could have been lower instead of completely disappearing—market segregation (regime 1) and imperfect market integration (retime 2) can still exist. Second, as discussed in chapter 5, most observations above the perfect integration band in the no trade case happened before or around marketing year 1995/1996 which started to see real increase in soybean imports. Two major soybean-related policy events took place around that period of time: COFCO's loss of exclusive right to import soybean, DCE's more liquid operation (which can be witnessed through the fact that there started to be fewer missing data since that period). Assuming the Chinese domestic transportation costs had not significantly changed before and after 1995/1996, regime 1 is most probably reflecting market segregation.

REFERENCES

Aigner, D., C.A Lovell, and P. Schmidt. (1977). "Formulation and estimation of stochastic frontier production function models." *J. Econometrics* 6, 21-37.

Akaike, H. (1972). "Information theory and an extension of the maximum likelihood principle." *In Proc. 2nd Int. Symp. Information Theory, Supplement To Problems of Control and Information Theory* 267-281.

Akaike, H. (1974). "A new look at the statistical model identification." *IEEE Transactions on Automatic Control* AC-19, 716-23.

Ardeni, P.G. (1989). " Does the law of one price really hold for commodity prices?" *Amer. J. Agr. Econ.* 71, 661-69.

Baffes, J. (1991). "Some further evidence on the law of one price: The law of one price still holds." *Amer. J. Agr. Econ.* 73,1264-73.

Balbas,A., I.R.Longarela and A.Pardo. (2000). " Integration and Arbitrage in the Spanish Financial Markets: An Empirical Approach." *J. Fut. Markets* 20, 321-44.

Barret, C.B. (2001). " Measuring integration and efficiency in international agricultural markets." *Amer. J. Agr. Econ.* 23,19-32.

Barret, C.B. and J.R. Li. (2002). " Distinguishing between equilibrium and integration in spatial price analysis." *Amer. J. Agr. Econ.* 84,292-307.

Baulch, B. (1997). "Transfer costs, spatial arbitrage, and testing for food market integration." *Amer. J. Agr. Econ.* 79, 477-487.

Baumol, W.J. (1982). "Contestable markets: an uprising in the theory of industry structure." *Econ.Rev.* 72,1-15.

Bierlen, R., E.J.Wailes, and G.L.Cramer. (1998). "Unilateral reforms, trade Blocs, and law of one price: MERCOSUR rice markets." *Agribusiness* 14,183-198.

Blank, S.C.,C.A.Carter, and B.H.Schmiesing. (1991). *Futures and Options markets: Trading in Commodities and Financials.* Englewood Cliffs, NJ: Prentice Hall.

Bockstael, N.E. (1983). " Dis-equilibrium and seafood trade modeling." *Proceedings of the Int'l Seafood Trade Conference, September,1982.*

Bohrnstedt,G.W., and A.S.Goldberger. (1969). "On the exact covariance of products of random variables." *J. Amer. Stat. Assoc.* 64, 1439-1442.

Brennan, M.J. (1958). "The supply of storage." *Amer. Econ. Rev* 48,50-71.

Buccola, S.T. (1985). "Pricing efficiency in centralized and non-centralized markets." *Amer. J. Agr. Econ.* 67,583-90.

Buccola, S.T. (1989). "Pricing efficiency in agricultural markets: Issues, methods, and results." *West. J. Agr. Econ.* 14,111-121.

Carter,C.A. (1989). "Arbitrage opportunities between thin and liquid futures markets." *J. Fut. Markets* 9, 347-53.

Carter, C.A. and N.A. Hamilton. (1989). "Wheat inputs and the law of one price." *Agribuseness* 5,489-496.

Castelino, M.G. (1992). " Hedge effectiveness: Basis risk and minimum-variance hedging." *J. Fut. Markets* 12, 187-201.

Chiang,A.C. (1984). *Fundamental Methods of Mathematical Economics* 3rd ed. New York: McGraw-Hill, Inc.

Foreign Agricultural Service, USDA. (2001). " China, People's Republic of , Oilseeds and Products Annual (part 1)."

Chow, Ying-Foon. (1998). "Regime switching and co-integration tests of the efficiency of futures markets." *J. Futures Markets* 18, 871-901.

Collins, Keith. (1998). " Changing agricultural policy and implication for the U.S. marketing system." USDA Transportation Summit, Kansas City, Missouri.

Crook, Frederick W. et al. (1998). "Soybean consumption and trade in China: A trip report." USDA.

Daigler,R.T. (1993). *Financial Futures Markets.* New York, NY: HarperCollins College Publishers.

Dalian Commodity Exchange. http://www.dce.cn, viewed March 22, 2003 and March 25, 2003.

Dicky, D.A., and W.A. Fuller. (1981). "Likelihood ratio statistics for autoregressive time series with a unit root." *Econometrica* 49,1057-1072.

Doroodian, K., C.Jung, and R.Boyd. (1999). "Testing the law of one price under the fixed and flexible exchange rate systems." *App. Econ. Letters.* 6,613-16.

Duffie, D. (1989). *Futures Markets* Englewood Cliffs, NJ: Prentice-Hall.

Eiteman,D.K., A.I.Stonhill, and M.H.Moffett. (1998). *Multinational Business Finance* 8th ed. Reading, MA: Addison-Wesley Publishing Company.

Enders, W. (1988). "ARIMA and co-integration tests of PPP under fixed and flexible exchange rates regimes." *Review of Economics and Statistics.* 70,504-08.

Engle, C. and J.H.Rogers. (1996). "How wide is the border?" *Amer. Econ. Rev.* 86,1112-25.

Engle, R.F., and C.W.Granger. (1987). "Co-integration and error correction representation, estimation and testing." *Econometrica* 2, 251-76.

Enke, S. (1951). " Equilibrium among spatially separated markets: Solution by electric analogue." *Econometrica* 19,40-47.

Evans,D.D.M. and K.K.Lewis. (1995). "Do long-term swings in the dollar affect estimates of the risk premia?" *Rev. of Fin. Studies* 8,709-42.

Faminow, M.D. and B.L. Benson. (1990). " Integration of spatial market." *Amer. J. Agr. Econ.* 72,49-62.

Frankel, J.A. (1984). " Commodity prices and money: Lessons from international finance." *Amer. J. Agr. Econ.* 66,560-66.

Frydman,R. (1980). " A proof of the consistency of maximum likelihood estimators of non-linear regression models with auto-correlated errors." *Econometrica* 48,853-60.

Griffiths,W.E., R.C.Hill, and G.G.Judge. (1993). *Learning and Practicing Econometrics* New York: John Wiley & Sons, Inc.

Goodwin, B.K., T.L. Grennes, and M.K. Wohlgenant. (1990a). "A revised test of the law of one price using rational price expectations." *Amer. J. Agr. Econ.* 72,682-93.

Goodwin,B.K., T.L.Grennes, and M.K.Wohlgenant. (1990b). " Testing the law of one price when trade takes time." *J. Int'l Mon. and Fin.* 9,21-40.

Goldfeld, S.M., and R.E.Quandt. (1973). " The estimation of structural shifts by switching regressions." *Annals of Econ. And Soc. Measurement* 2/4,475-85.

Goodman,L.A. (1960). "On the exact variance of products." *J. Amri. Stat. Assoc.* 55,708-13.

Gray, R.W. (1960). "The characteristic bias in some thin futures markets." *Food Research Institute Studies* 1,296-312.

Greene, W.H. (1997). *Econometric Analysis* 3rd ed. Upper Saddle River, NJ: Prentice Hall.

Haigh, M.S. and M.T.Holt. (1999). " Volatility spillover between foreign exchange, commodity and freight futures prices: implications for hedging strategies." Faculty Paper 99-5, Department of Agricultural Economics, Texas A&M University.

Hamilton,J.D. (1994). *Time Series Analysis* Princeton, NJ: Princeton University Press.

Han, S. and Song L. (1997). *Brief Introduction to International Finance* Beijing: People's Press.

Hooper, P. and S.W.Kohlhagen. (1978). " The effect of exchange rate uncertainty on the prices and volume of international Trade." *J. Int'l Econ* 8, 483-511.

Jain, A.K. (1980). *Commodity Futures Markets and the Law of One Price* Michigan International Business Studies No. 16, University of Michigan, Ann Arbor.

Johansen, S.(1988). "Statistical analysis of co-integration vectors." *J. Econ. Dynamics and Control* 12, 231-54.

Johansen, S. and K.Juselius. (1994). "Identification of the long-run and the short-run structure: An application to the ISLM model." *J. Econometrics* 63, 7-36.

Jumah, A., S. Karbuz, and G. Runstler. (1999). "Interest rate differentials, market integration, and the efficiency of commodity futures markets." *App. Fin. Econ.* 9,101-08.

Kennedy, P. (1998). *A Guide to Econometrics* 4th ed. Cambridge, MA: The MIT Press.

Keynes, J.M. (1923). " Some aspects of commodity markets." *Manchester Guardian Commercial* European Reconstruction Series Supplement, May 29, 1923. Reprinted in *The Collected Writings of John Maynard Keynes: Vol. 12 Economic Articles and Correspondence* edited by Donald Moggridge, London: Macmillan, 1983, 255-266.

Kmenta, J. (1986). *Elements of Econometrics* 2nd ed. New York: Macmillan.

Krugman, P.R. and M. Obstfeld. (1997). *International Economics: Theory and Policy.* Reading, MA: Addison-Wesley.

Low,A. H. W., J. Mutheuswamy, and R.I. Webb. (1999). "Arbitrage, co-integration, and the joint dynamics of prices across discreet commodity futures auctions." *J. Futures Markets* 19, 799-815.

Marshall, A. (1961). *Principles of Economics* London: Macmillan.

McCallum, B. T. (1996). *International Monetary Economics* Oxford: Oxford University Press.

Michael, P. and A.R. Nobay.(1994). "Purchasing power parity yet Again: evidence from spatially separated commodity markets." *J. Int'l Mon. and Fin.* 13, 737-57.

Nicholson,W. (1995). *Microeconomic Theory: Basic Principles and Extensions* 6th ed. New York: The Dryden Press, Harcourt Brace College Publishers.

Park, A., H. Jin, S. Rozelle, and J. Huang. (2002). " Market emergence and transition: Arbitrage, transaction costs, and autarky in China's grain market." *Amer. J. Agr. Econ.* 84,67-82.

Phillips, P.C.B. and P. Perron. (1988). "Testing for unit root in time series regression." *Biometrica* 75, 335- 46.

Pantula, S.G., G. Gonzalez-Farias, and Wayne A. Fuller. (1994). "A Comparison of unit-root test criteria." *J. Bus. & Econ. Stat* 12,449-59.

Pindyck, R.S. (1993). "The present value model of rational commodity pricing." *The Econ. J.* 103, 511-30.

Protopapadakis, A. and H.R. Stoll. (1983). "Spot and futures prices and the law of one price." *J. Finance* 38, 1431-55.

Protopapadakis, A. and H.R. Stoll. (1986). "The law of one price in international commodity markets: A reformulation and some formal tests." *J. Int'l Mon. and Fin.* 5, 335-60.

Quandt, R.E. and J.B. Ramsey. (1978). "Estimating mixtures of normal distributions and switching regressions." *J. Amer. Stat. Asso.* 73,730-52.

Ravallion, M. (1986). " Testing market integration." *Amer. J. Agr. Econ,* 68, 102-09.

Richarson, J.D. (1978). "Some empirical evidence on commodity arbitrage and the law of one price." *J. Int'l Econ.* 8,341-51.

Samuelson, P. A. (1952). "Spatial price equilibrium and linear programming." *The Amer. Econ. Rev.* 42,283-303.

SAS Institute Inc. (1996). *Forecasting Examples for Business and Economics using SAS System.*

Schwarz, G. (1978). "Estimating the dimension of a model." *The Annals of Stat.* 6, 461-64.

Sexton, R.J., C.L. Kling, and H.F. Carman. (1991). "Market integration, efficiency of arbitrage, and imperfect competition: methodology and application to U.S. Celery." *Amer. J. Agr. Econ.* 73, 568-80

Siegel,D.R. and D.F. Siegel. (1990). *Futures Markets.* Orlando, FL: The Dryden Press.

Spiller,P. and C.J. Huang. (1986). "On the extent of the market: Wholesale gasoline in the northeastern united states." *J. Indus. Econ.* 35,131-45.

Spiller, P.T. and R.O. Wood. (1988). "The estimation of transaction costs in arbitrage models." *J. Econometrics* 39, 309-26.

Stoll, H.R. and R.E. Whaley. (1993). *Futures and Options: Theory and Applications.* Cincinnati, Ohio: South-Western Publishing Co.

Turley, Marianne C. and E. David Ford. (2000). " A comparison on consistency of parameter estimation using optimization methods for a mixture." NRCSE-TRS N0. 050, Environmental Protection Agency.

USDA, FAS. "World Markets and Trade Archives." **http://www.fas.usda.gov**, viewed March 9, 2003.

USDA, FAS. (March 9, 2001). " China, People's Republic of, Oilseeds and Products Annual (part I)." GAIN Report.

USDA, FAS. (March 10, 2003). " China, People's Republic of, Oilseeds and Products Policy Announcement for Domestic Soybean Industry 2003." GAIN Report.

Venables, W.N. and B.D.Ripley. (2000). *Modern Applied Statistics with S-plus.* 3rd ed. New York: Springer-Verlag New York, Inc.

Wackerly, D. D., W. Mendenhall III, and R.L. Scheaffer. (1996). *Mathematical Statistics with Applications* 5th ed. Belmont: Duxbury Press.

Weinstein, M.A. (1964). " The sum of values from a normal and a truncated normal distribution." *Technometrics* 6,104-105(with some additional notes,469-70).

Working, H. (1949). " The Theory of Price of Storage." *Amer. Econ. Rev.*39,1254-62.

Yang, J. and D.J. Leatham. (1999). "Price discovery in wheat futures markets." *J. Agr. and App. Econ.* 31,359-70.

Yang, J.,D.A. Bessler and D.J. Leatham. (2000). " The law of one price: Developed and developing country market integration." *J. Agr. and App. Econ* 32,429-40.

Zanias, G.P. (1993). "Testing for integration in European Community agricultural product markets." *J. Agr. Econ.* 44,418-27.

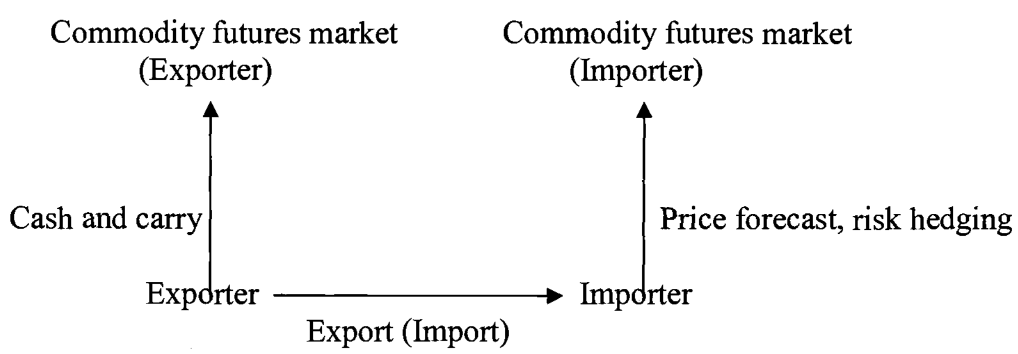
APPENDICES

Appendix A

A Sketch of Arbitrage Strategies and Market Relationships

In this dissertation, only the importer's parity condition is applied in the empirical test. It may be helpful to the see where this particular model fit in the four market parity conditions that are derived based on three arbitrage activities: cash-and-carry, export, and import.

Assuming that the commodity trade is unilateral and direct arbitrage between the futures markets of the trading countries are not allowed, these arbitrage activities can be illustrated as follows:



First, one of the two major conditions, importer's parity expressed by equation (20), involves export and import activities. Then, the futures markets of the trading countries are linked by the following facts: a). The cash-and-carry parity is satisfied in the exporter's country. b). There is commodity trade flow between the two countries. c). The importer is assumed to use the domestic futures price as a forecast of the future cash market price as well as a risk hedging instrument. In this way the futures market parity, expressed by equation (23), is derived.

Appendix B

BHHH Estimator of Asymptotic Variance of Maximum Likelihood Estimator

BHHH estimator of asymptotic variance is based on the result that the expected second derivatives matrix, $\left[\tilde{I}\left(\hat{\theta}\right)\right]^{-1}$, is the co-variance matrix of the first derivative vector:

$$\left[\tilde{I}\left(\hat{\theta}\right)\right]^{-1} = \left[\sum_{i=1}^{n} \hat{g}_i \hat{g}_i'\right]^{-1} = \left[\hat{G}'\hat{G}\right]^{-1}$$

where $\hat{g}_i = \dfrac{\partial \ln f\left(x_i, \hat{\theta}\right)}{\partial \hat{\theta}}$, $\hat{\theta}$ = the parameter vector to be estimated, x_i = the ith row of variable matrix, and $\hat{G} = \left[\hat{g}_1, \hat{g}_2, \ldots\ldots, \hat{g}_n\right]'$

$\hat{G}$ is an n×k matrix with ith row equal to the transpose of the ith vector of derivatives of the log-likelihood function.(Greene p139).

Appendix C

Table 9. The US-China Soybean Market Analysis: Another Specification

The following table reports the results estimated with the following variables on the left hand side: standard error of futures price (x_1), length of time from the futures contract maturity date (x_2), futures price trend (x_3), freight rate (x_4). b_0 is the intercept.

Regime Frequencies								
Trade info. / Arbi.Rent	No trade		Trade down		Trade constant		Trade up	
Positive	λ_1	0.11* (0.06) (1.99)	λ_2	0.1* (0.03) (3.29)	λ_3	0.00	λ_4	0.19* (0.06) (2.88)
Zero	λ_5	0.42* (0.07) (6.13)	λ_6	0.00	λ_7	0.00	λ_8	0.18* (0.07) (2.79)
Negative	λ_9	0.00	λ_{10}	0.00	λ_{11}	0.00	λ_{12}	0.00

Other Parameters						
b0	b_1	b_2	b_3	b_4	σ_u	σ_v
93.60 (156.59) (0.60)	0.32 (0.43) (0.74)	-0.97 (6.49) (-0.15)	1.45* (0.70) (2.08)	0.89* (0.35) (2.58)	320.03* (45.16) (7.00)	109.16* (15.07) (7.36)

Note:

1. Log likelihood is -771.8812. The number of observations=103.
2. Standard errors and t-statistics are in the parentheses.
3. * indicates statistically significant at 95% level in t test.

Appendix D

Table 10. Estimates Using Dynamic Trade Information: With no Risk Variables

Regime Frequencies								
Trade info. / Arbi.Rent	No trade		Trade down		Trade constant		Trade up	
Positive	λ_1	0.15* (0.06) (2.36)	λ_2	0.1* (0.03) (3.30)	λ_3	0.00	λ_4	0.23* (0.07) (3.38)
Zero	λ_5	0.38* (0.07) (5.23)	λ_6	0.00	λ_7	0.00	λ_8	0.14* (0.06) (2.28)
Negative	λ_9	0.00	λ_{10}	0.00	λ_{11}	0.00	λ_{12}	0.00

1 Other Parameters

b0	σ_u	σ_v
56.65* (22.11) (2.56)	304.38* (38.80) (7.85)	106.01* (14.45) (7.34)

Note:

1. Log likelihood is -774.1819. The number of observations=103.
2. Standard errors and t-statistics are in the parentheses.
3. * indicates statistically significant at 95% level in t test.

Appendix E

Table 11. Estimates Using Dynamic Trade Information and Dropping Risk Variables: Another Specification

The specification used to obtain the estimates reported in table 11 is different than that for table 10 in Appendix D that implicitly restricts the freight rate parameter b_2 as one.

Regime Frequencies								
Trade info. / Arbi.Rent	No trade		Trade down		Trade constant		Trade up	
Positive	λ_1	0.15* (0.06) (2.34)	λ_2	0.1* (0.03) (3.28)	λ_3	0.00	λ_4	0.22* (0.07) (3.30)
Zero	λ_5	0.38* (0.07) (5.22)	λ_6	0.00	λ_7	0.00	λ_8	0.15* (0.06) (2.30)
Negative	λ_9	0.00	λ_{10}	0.00	λ_{11}	0.00	λ_{12}	0.00

Other Parameters			
b0	b_2	σ_u	σ_v
77.39 (71.23) (1.09)	0.91* (0.32) (2.88)	303.58* (39.53) (7.68)	106.49* (13.60) (7.83)

Note:

1. Log likelihood is -774.1094. The number of observations=103.
2. Standard errors and t-statistics are in the parentheses.
3. * indicates statistically significant at 95% level in t test.