ABSTRACT
A market regime-switching model is developed that has rate of trade identified using a rent-weighted approach. The model also indirectly accounts for the impacts of other competitors through separate specifications of variation parameters across alternate seasons. Commodity futures prices are utilized as the expected revenue indicator in a present value framework. An application of the methods to US-China soybean trade demonstrates that knowing how trade change allows more precise understanding of market conditions. Nontrivial deviations from efficient arbitrage are detected in US-China soybean trade, although the two markets are integrated most of the time. The prices link more closely after China joined WTO. A significantly higher rent variation has also been found during the South American harvest season.

Key Words:
China, Futures, Market Integration, Regime Switching, Soybean Trade, WTO effects

JEL Classifications: F15, C20, Q11
INTRODUCTION

The past three decades have seen tremendous market-oriented reforms in the emergence economies. However, the effect of these efforts on the extent and efficiency of the markets remain an empirical question because as the literature has pointed out, a well-functioning market needs facilitating institutions and infrastructure (Yu and Huang 1998, Young 2000, Park et al 2002). How to measure the impacts of the relatively limited developments in the market infrastructures such as information and transportation systems in these countries has been one of the major considerations, particularly for the study of international commodity trade which involves longer time and higher transaction costs.

Given the difficulty to observe all the transaction costs and/or the costs of collecting some of these data can be prohibitive, methods have been developed to overcome the problems, among which the most innovative is the joint probability model developed by Barrett and Li (2002). They are the first to explicitly introduce trade information, with a trade/no trade indicator variable, into the price model which may provide indirect evidence of the unmeasured transaction costs and enables distinction between the four market conditions, i.e., perfect and imperfect integrations, and segregated equilibrium and disequilibrium. For example, a market situation with positive arbitrage rent and positive trade may indicate either imperfect integration due to such factors as non-tariff trade barriers/unmeasured transaction costs, or temporary disequilibrium because of delivery lag in international trade. By contrast, positive rent with zero trade is suggestive of a true lack of market integration. Apparently, evidence of trade activities is required to make the distinctions.

However, with the binary trade/no-trade specification some aspects of the market conditions remain unclear. Without knowledge of how trade is changing, the interpretation of the changes in the net price differential or rent (price difference less transaction costs) is still limited. Positive arbitrage rent with

1 Delivery lag here refers to the time needed to physically transfer the commodity from the exporter’s warehouse to the importing country.
trade volume rising may likely indicate a temporary disequilibrium because it is a logical response for traders to increase trade to capture the rent in a competitive market. On the other hand, when trade declines with positive rent temporary disequilibrium is less plausible as an interpretation. Instead, unmeasured transaction costs or trade barriers may exist. Observation only that trade exists does not differentiate these possibilities, and thus could lead to multiple interpretations. Theoretically, the price changes due to the changes in demand and supply, not to the existence of demand and supply. To obviate the problem, this study brings in the information on trade variation, in particular, by separating trade activity into four categories: no trade, trade declining, trade constant, and trade rising. A rent-weighted method is developed to determine the rate of trade threshold in this new model. Some descriptive and nonparametric statistics are also computed to corroborate the model analysis.

The movement of commodities between two spatially separated markets may be affected by one or more of the following factors: (1) profit margins determined by price differentials, transaction costs, demand and supply in either or both regions, seasonality, etc.; (2) market competitiveness (Sexton, Kling, Carman, 1991); (3) market obstacles to arbitrage efficiency such as imperfect information, trade barriers, and risk aversion (Ravallion 1986). A more competitive market improves arbitrage efficiency and thus enhances trade flow. Likewise, a lower risk premium and improved price information may also expand trade activities (Buccola 1985). Therefore, knowing the specific direction in which trade changes in response to price differentials strengthens the evidence as to the specific market conditions.

Another modeling issue that is not receiving adequate attention in market integration analysis is the deferred market response that arises from substantial delivery lags in international trade. Because international commodity arbitrage is over time, as well as across border, the relevant revenue indicator for an arbitrage decision is the expected selling price for the time when delivery is taken, rather than
current price. Previous studies in international trade either apply quarterly data based on the assumption of a corresponding delivery lag or try different lags when using high frequency data. While aggregation often obscures the variation in the data, insufficient attention has been paid to the actual arbitrage decision making process when using shorter time periods, both may reduce the significance of the results. To our knowledge, this paper is the first attempt to utilize futures price as an expected revenue indicator in commodity arbitrage analyses and apply the present value concept to reflect the actual cash flow consideration when making arbitrage decisions. This may provide a useful framework to applied researchers in analyzing market linkages, particularly when wholesale cash market information is not readily available which is common in many developing economies.

A third difference of this study is the indirect modeling of the impacts of other competitors on the pair-wise market relationships in an application to Sino-US soybean trade analysis. The prices in the U.S. and Chinese markets are expected to link more closely and with lower margin variations during the densely traded months in the U.S. harvest season, while in the off-season a relatively looser price relationship may result from sparser trading activities. To examine this possibility, our likelihood function allows for different variances over the two seasons.

The efficiency and responsiveness of China’s soybean market to world conditions should be of great interest, particularly given the fact that the prices of China’s agricultural products are determined by a mixture of government control and market forces. It is of particular interest to test the market performance after the important reform measures such as setting up futures markets and de-monopolizing the soybean imports, and also to see if there have been changes under the current WTO agreement. Although soybean tariffs and VAT are still the same after China’s WTO accession,

\[2\] During the sample period, Brazil, and more recently Argentina were the major competitors to the US for the Chinese soybean market.
the structural shifts such as the lowered share of the state trading agency in the within-tariff imports quota have greatly weakened the government control over the trade which is also evidenced in the drastic trade increase after year 2001 (table 1). As the first of what China considers the strategic agricultural staples (the others being wheat, rice, and corn) to have been allowed to trade freely, China’s soybean imports increased tremendously after 1996 (Table 1), with the US portion ranging from thirty-five to seventy percent since that time. In the 2000/01 marketing year, nearly one-fifth of world soybean exports were destined for China, and since 2004/05 that total has been over 40%.

**Table 1** Chinese soybean imports and exports (in millions of metric tons)

| Marketing Year 92/93 93/94 94/95 95/96 96/97 97/98 98/99 99/00 00/01 01/02 02/03 03/04 04/05 05/06 |
|----------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Imports              | 0.15             | 0.13             | 0.16             | 0.80             | 2.27             | 2.94             | 3.85             | 10.10            | 13.25            | 10.39            | 21.42            | 16.93            | 25.80            | 28.32            |
| Exports              | 0.30             | 1.10             | 0.39             | 0.22             | 0.20             | 0.17             | 0.19             | 0.23             | 0.21             | 0.30             | 1.42             | 0.38             | 0.39             | 0.35             |
| Net Imports          | -0.15            | -0.97            | -0.23            | 0.58             | 2.07             | 2.77             | 3.66             | 9.97             | 13.04            | 10.09            | 20.00            | 16.55            | 25.41            | 27.97            |

Data source: USDA-FAS, 2007 and earlier years

The next section provides information on the state of Chinese soybean markets with respect to trade. The data of price margins and trade are also summarized with simple descriptive statistics, as both a preliminary analysis and comparison to the later estimated results. Then followed is a brief discussion of prior approaches in testing market integration. The fourth section outlines the extended model specifications. Finally, the method is applied to the analysis of U.S.-China soybean markets.

**BACKGROUND**

As noted in the introduction, several important policy and institutional changes took place since the end of 1995, which are related to the China’s agricultural markets. Among others, COFCO ³ lost its exclusive right to import soybeans (Crook, Hanson, Hsu, Karmen, and Laney, 1998) which is

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³ China National Cereals, Oils & Foodstuffs Import & Export Corporation.
expected to improve the market competitiveness and promote trade flows (Table 1). As another advance in the market-oriented reforms, Chinese government had established futures markets in early 1990s to help stabilize the grain supply. The Dalian Commodity Exchange (DCE), currently the only Chinese futures market trading soybeans, is among the first futures markets in modern China. Established in 1993, the DCE is still largely restricted to domestic investors, but its soybean futures contracts were designed based on the Chicago Board of Trade contracts (CBOT).

Due to some instances of market manipulation by speculators, the Chinese government tightened its regulation of the futures markets in 1998 through the direct supervision and monitoring by the Securities Regulatory Commission--a ministerial agency under the State Council of China. There are a number of ways in which the DCE does not operate like futures markets in other countries. Trading is still not open to foreign investors, and only recently have a number of Chinese enterprises been given official permission to access foreign futures markets for hedging purposes. While the intent of these restrictions is to protect the DCE and domestic futures market participants before they accumulate sufficient market experience and expertise, they may also affect the market liquidity and efficiency at the DCE.

Nonetheless, timely information on domestic demand and available supply has been limited in China. Furthermore, the soybean futures in DCE had started to give regular quotes since around 1996, which may indicate improved market liquidity. The DCE soybean futures contract appears the most important market signal for Chinese soybean producers, importers, oil crushers and other market participants, and its role as an information center as well as a risk hedging instrument has become important to deriving a market-based expectation about supply and demand relationship and price changes.
As discussed earlier, China has been a leading soybeans importer and a major purchaser of the U.S. soybeans. Chinese soybean imports have been steadily increasing since 1996, as a result of fast-growing domestic meat and oil demand and the relaxation of government restrictions on trade. In addition, Chinese domestic beans as a substitute are considered to be of relatively high cost and unsatisfactory quality because of its low oil content, and foreign material, etc., which may also motivates the trade spikes. The major competition as an export supplier to China’s soybean market comes from South American countries such as Brazil and Argentina, despite the more stable quality and reliability of the U.S. beans (USDA-FAS, 2001). In the study period the U.S. harvest season gets into gear in September and 90% of shipments from the US to China depart October through March. Most of the import demand in China for the rest of the year is accommodated by South American suppliers (SA).

Table 2 demonstrates the biweekly soybean exports of the U.S. to China during the U.S. season as compared to SA season in the study period, and before and after China joined WTO. The average rent falls from RMB119 to RMB 66 post WTO, corresponding to a dramatic surge in average U.S. biweekly exports to China from 114,777 to 288,689 metric tons. The average exports to China in the U.S. season quadruple that in the South American season in Pre-WTO periods and are 15 times that in post-WTO periods.

In line with the thin trading activities amidst the U.S. off-season pre-WTO, a relatively lower (mean) rent of 104 is observed, most probably due to the low stock in the U.S. and competing price from South America. On the other hand, a post-WTO mean of 45 with a high average trade of 518,307 MT in the U.S. season may likely indicate a relaxation of trade barrier and the highly concentrated trade flows in the season. The post-WTO trade volume totals 15,877,924 MT in the study period, 95 % of which takes place in the U.S. season. Another pattern from table 2 is that the rents, no matter in or
off season and pre- or post-WTO, are all substantively positive, which may either imply the existence of unmeasured transaction costs or rents unexploited because of trade barriers or the infrastructural limitations such as transportation bottleneck or imperfect information. More analytical discussion can be found and compared when we look into the estimate results.

Table 2  Descriptive statistics of biweekly volumes and price rents

<table>
<thead>
<tr>
<th></th>
<th>Pre-WTO Volume</th>
<th>Post-WTO Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>114,777</td>
<td>288,689</td>
</tr>
<tr>
<td>Standard Err.</td>
<td>162,347</td>
<td>363,265</td>
</tr>
<tr>
<td></td>
<td>SA season</td>
<td>US season</td>
</tr>
<tr>
<td>Mean</td>
<td>46,696</td>
<td>185,547</td>
</tr>
<tr>
<td>Standard Err.</td>
<td>73,084</td>
<td>196,486</td>
</tr>
<tr>
<td></td>
<td>SA season</td>
<td>US season</td>
</tr>
<tr>
<td>Mean</td>
<td>104</td>
<td>133</td>
</tr>
<tr>
<td>Standard Err.</td>
<td>151</td>
<td>145</td>
</tr>
</tbody>
</table>

PREVIOUS APPROACHES

Most recent literature on market integration follows two major methodological approaches: co-integration and regime-switching analysis.

Studies using co-integration tests to account for the non-stationarity of the time series data in market integration analysis find supportive evidence to the LOP after transfer costs such as interest

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According to personal interview in August 2008 with Mr. Wang and Mr. Liu in the Research Office of the Dalian Commodity Exchange, the bargained freight charges are usually higher than official quotes due to the transport congestion.

Regarding the information system, Shanghai Shipping Exchange, the only freight rate exchange in China, was also contacted by phone and email in October 2008. The conclusion is that there is no feasibility to obtain the complete inland water barge rate information for the study period, because: a) freight rate quotes for bulk goods started in 2002; b) the cost is currently about $3000 for one year of data. The cost for wholesale grain price data is approximately the same according to the National Grain & Oil Information Center. Although over 20 Chinese firms including COFCO and China Grains and Oils Group Corporation are chartered to use international futures markets like CBOT for hedging purposes starting from May 2001, not until 2006 have foreign firms, just a few such as Bunge, Cargill, and Louisdrefs, been approved to use Chinese futures to hedge, only as resident cash commodity companies in China.

Unfortunately, co-integration is neither a necessary nor a sufficient condition for market integration because of such factors as nonstationarity of transaction costs and the discontinuities in agricultural trade (Barrett 1996, McNew and Fackler 1997). Furthermore, co-integration tests generate results that either point to an all co-integrated market or to an all segregated market.

Regime-switching methods, on the other hand, are based on the distribution function developed by Weinstein (1964) and Aigner, Lovell, and Schmidt (1977). It overcomes a number of methodological problems in previous price relationship models: 1) by allowing for the fact that the two markets may be integrated during a period of time and may not be so in other periods; 2) by introducing the actual trade information into the price model; 3) by including transaction costs which may be non-stationary themselves. Two papers, Spiller and Huang (1987), and Sexton, Kling, and Carmen (1991) utilize the regime switching method to look at domestic cash markets. Both of these studies assume constant transaction costs and implicitly assume continuous commodity flow. Baulch (1997), arguing that these assumptions may not be valid, adds the derived actual transaction costs to the market prices to formulate a parity bound model (PBM). Realizing the limitations of PBM in assuming perfect competition and the availability of complete transfer costs information, Barrett and Li (B-L),\textsuperscript{6}

\textsuperscript{5} Perfect integration and LOP are alternative terms in this paper.
\textsuperscript{6} B-L for short.
as discussed in the introduction, incorporated a dichotomous trade variable to formulate a joint probability model with prices adjusted by observable transaction costs, freeing the model from the strong assumptions and therefore strengthening its applicability in distinguishing between market integration and equilibrium conditions.

**MODEL AND METHODS**

**The B-L Methods**

The B-L model expresses the marginal rent to arbitrage at time $t$ as

\[ R_t = P_{mt} - P_{xt} - T_t \]

where $P_{mt}$ and $P_{xt}$ are prices at time $t$ in importing and exporting country respectively, $T_t$ is the transaction costs incurred in arbitrage activities. The data generating process for $R_t$ is assumed to be described by a normal plus half-normal distribution such that

\[
\begin{align*}
(2a) & \quad R_t = v_t + u_t \quad \text{if } R_t > 0 \\
(2b) & \quad R_t = v_t \quad \text{if } R_t = 0 \\
(2c) & \quad R_t = v_t - u_t \quad \text{if } R_t < 0
\end{align*}
\]

where $v_t$ represents i.i.d. normal error with zero mean and variance $\sigma_v^2$, $u_t$ is a one-sided, positive error with variance $\sigma_u^2$, and has a half-normal distribution. Both $u_t$ and $v_t$ are assumed to be serially uncorrelated, substantially simplifying the econometric model. In any case, Frydman (1980) has proven the consistency of a maximum likelihood estimator for a nonlinear regression model with auto-correlated errors.

Equation (2a) indicates a regime in which there exist unexploited arbitrage returns, (2b) for a regime in which there is no arbitrage return with markets well linked, and (2c) for a regime in which
price differentials are less than the transfer costs indicating an autarky situation. The distribution functions for the observations in each regime are:

\[(3a) \quad f^*_t = \begin{bmatrix} \frac{2}{(\sigma_v^2 + \sigma_u^2)^{1/2}} \phi \left( \frac{R_t - b}{\sigma_v^2 + \sigma_u^2} \right) \\
- \Phi \left( \frac{(R_t - b)\sigma_u}{\sigma_v^2 + \sigma_u^2} \right) \end{bmatrix} \]

\[(3b) \quad f^0_t = \begin{bmatrix} \frac{1}{\sigma_v} \phi \left( \frac{R_t - b}{\sigma_v} \right) \end{bmatrix} \]

\[(3c) \quad f^-_t = \begin{bmatrix} \frac{2}{(\sigma_v^2 + \sigma_u^2)^{1/2}} \phi \left( \frac{R_t - b}{\sigma_v^2 + \sigma_u^2} \right) \\
1 - \Phi \left( \frac{(R_t - b)\sigma_u}{\sigma_v^2 + \sigma_u^2} \right) \end{bmatrix} \]

Here, \( \phi(.) \) and \( \Phi(.) \) denote the standard normal density and cumulative functions respectively.

The intercept, \( b \), is intended to capture any permanent component of the price differentials other than the measured transaction costs, \( T_t \). Equations (3a), (3b), and (3c) are the density functions for the regimes expressed in (2a), (2b), and (2c) respectively.

Then, B-L estimates a joint probability distribution of \( \{R_t - b, k_t\} \), where \( k_t \) is trade volume at time \( t \). The probability parameters, \( \lambda^B \)'s, of six regimes are estimated, where

\[(4a) \quad \lambda^B_1 = \text{Prob} \{ R_t - b = 0 \text{ and } k_t > 0 \} \]

\[(4b) \quad \lambda^B_2 = \text{Prob} \{ R_t - b = 0 \text{ and } k_t = 0 \} \]

\[(4c) \quad \lambda^B_3 = \text{Prob} \{ R_t - b > 0 \text{ and } k_t > 0 \} \]

\[(4d) \quad \lambda^B_4 = \text{Prob} \{ R_t - b > 0 \text{ and } k_t = 0 \} \]

\[(4e) \quad \lambda^B_5 = \text{Prob} \{ R_t - b < 0 \text{ and } k_t > 0 \} \]

\[(4f) \quad \lambda^B_6 = \text{Prob} \{ R_t - b < 0 \text{ and } k_t = 0 \} \]
The above regime-switching system is estimated using maximum likelihood methods. B-L defines the regimes as follows. Regime one (trade) and two (no trade) with zero rent reflect efficient arbitrage conditions. Regimes three (trade) and four (no trade) with positive rent may imply either temporary disequilibria or existence of trade barriers and unmeasured transaction costs. Regime five with negative rent and positive trade likely demonstrates temporary disequilibria or information and contracting lags or transaction benefits such as convenience yield, while regime six with negative rent and zero trade indicates segmented equilibrium.

The Extended Model

As pointed out in the introduction, with only trade/no trade information, price relationship tests may lose important market information such as how trade and prices interacts, leading to multiple interpretations. To distinguish the different market conditions, the extended model specifies four trade indexes. In particular, let \( k_t \) be a variable of trade volume, and \( K_{ti} \) be a rate of trade index variable with \( i=1,2,3,4 \), the values of which can be defined as follows:

(5a) \( K_{t1} = 1 \) when \( k_t = 0 \) (no trade), otherwise \( K_{t1}=0 \);
(5b) \( K_{t2} = 1 \) when \( 0 < k_t < k_{t-1} \) (trade declining), otherwise \( K_{t2}=0 \);
(5c) \( K_{t3} = 1 \) when \( k_t = k_{t-1} >0 \) (trade constant), otherwise \( K_{t3}=0 \);
(5d) \( K_{t4}=1 \) when \( k_t > k_{t-1}>0 \) (trade rising), otherwise \( K_{t4}=0 \).

A complete set of situations described in (5a)-(5d) in combination with those in (2a)-(2c) gives twelve regimes denoted by \( \lambda_1 \) to \( \lambda_{12} \) (Table 3). The model is estimated with the joint probability distribution of \( \{ R_{t-b}, K_{t} \} \), as compared with \( \{ R_{t-b}, k_t \} \) in B-L model.

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7 Convenience yield refers to the benefit a firm receives from holding stocks. For lower stocks, for example, the convenience yield is relatively high, and may outweigh the marginal physical cost of storage in terms of cash-and-carry arbitrage.
Equation (3a), the density function for the observations with positive marginal returns, is appropriate for the regimes represented by $\lambda_1$ to $\lambda_4$, i.e. $f_r^+ = f_r^+ = f_r^+ = f_r^+$, (3b) for $\lambda_5$ to $\lambda_8$, i.e. $f_r^0 = f_r^0 = f_r^0 = f_r^0$, and finally (3c) for $\lambda_9$ to $\lambda_{12}$ and $f_r^- = f_r^- = f_r^- = f_r^-$, with the superscripts +, 0, and - denoting positive, zero, and negative rent regime respectively.

As a substantial delivery/payment lag is involved in international commodity arbitrage, denoting the importer’s expected selling price for time $t+j$ as $E(P_{m,t+j})$, the appropriate expression for the marginal rent to arbitrage at time $t$, compared to equation (1), is:

$$R_t = \delta_{m,t+j} E(P_{m,t+j}) - P_{xt} - T_t$$

where $\delta_{m,t+j}$ is importer’s discount rate for time periods $j$. Equation (7) is estimated with condition (6) as the definition of the $R_t$ in the maximum likelihood system. The likelihood of observing the sample data {$R_{t-b}, K_i$} is therefore given by

$$L = \prod_{i=1}^{n} \left\{ K_{r_1} (\lambda_1 f_{r_1}^+ + \lambda_5 f_{r_5}^0 + \lambda_9 f_{r_9}^-) + K_{r_2} (\lambda_2 f_{r_2}^+ + \lambda_6 f_{r_6}^0 + \lambda_{10} f_{r_{10}}^-) 
+ K_{r_3} (\lambda_3 f_{r_3}^+ + \lambda_7 f_{r_7}^0 + \lambda_{11} f_{r_{11}}^-) + K_{r_4} (\lambda_4 f_{r_4}^+ + \lambda_8 f_{r_8}^0 + \lambda_{12} f_{r_{12}}^-) \right\}$$

The four terms in equation (7) are associated with the four different trade flow circumstances. For each circumstance, there are three regimes associated with the marginal arbitrage rent: positive, zero, and negative.

The potential candidates for ‘perfect’ integration are regimes five through eight, as in Table 3, defined as unrestricted trade flow and zero rent unexploited, i.e. $k_i \geq 0$ and $R_t = 0$. Regime five, the zero
trade case, represents an indifference case. While regime seven indicates a market in equilibrium with a steady flow of trade for a normal profit, regime six and regime eight with trade decreasing and increasing respectively, could demonstrate temporary equilibrium for the former, or unmeasured transaction benefits for the latter (e.g. convenience yield).

‘Imperfect’ integration, on the other hand, refers to those cases with trade flowing between the markets but non-zero marginal returns lingering. For the positive rent cases indicating the existence of unearned profit, regime two with trade decreasing may imply non-tariff trade barriers, risk aversion or unmeasured transaction costs, regime three for unchanging trade flow could indicate contracting and information lags, or the existence of unmeasured transaction costs which prevents trade from increasing. Regime four with trade climbing, on the other hand, likely implies a temporary disequilibrium, and the market is responding to the profit opportunities. Regarding negative rent cases, regime ten for declining trade, with same logic as regime 4, may indicate a market adjusting to the unprofitability; regimes eleven and twelve, on the other hand, may imply the existence of either information and contracting lags, or such factors as unmeasured transaction benefits respectively.

Finally, market segregation is defined as absence of trade no matter the profit margin is either greater or less than zero. Two regimes fall into this category. Regime one with \( R_t > 0 \) may be explained by non-tariff trade barriers, government intervention (e.g. quota), risk aversion, imperfect information (e.g. barriers to information entry) and imperfect competition. Regime nine, representing segregated equilibrium, implies an autarky situation due to either prohibitive transfer costs or higher comparative production costs

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8 Temporary disequilibrium may not seem as much a concern to economists in terms of deviation from long run competitive equilibrium. However, if the delivery lags in trade have already been appropriately considered when matching the data, further ‘delay’ may provide reason and interest for investigation.
Given the above discussion, the regimes of most concern to economists are those deviating from competitive equilibrium. Regimes one and two are cases of possible market distortions. Other potential disconcerting situations may include situations such as regimes three, eleven and twelve, because these cases, first of all, give positive or negative arbitrage profits when trade occurs, secondly, the potential causes of these regimes are most probably related to such factors as high risk, non-tariff trade barriers, and imperfect information/competition, etc. Temporary disequilibrium cases also turn out to be important in understanding the market performance in the emergence economies such as China because of the limited infrastructure developments. 

Advantage(s) of the Extended Model

In comparison with the B-L trade/no trade specification, some of the advantages of revealing the direction of trade change are illustrated in Table 4. Let us assume the six hypothetic types of economic interpretations of the regimes (Table 4a). Table 4b demonstrates how the extended system expands the regime switching space so as to reduce the interpretational multiplicity when disaggregating those ‘overall’ regimes as represented by $\lambda^B_1$, $\lambda^B_3$, and $\lambda^B_5$ in equation (4), into trade-change-specific cases (Table 3).

Regime three with positive rent and trade in the binary model ($\lambda^B_3$ in the pre-ultimate row of Table 4b) could imply any one of the three types of situations (1, 4, or 6 in Table 4a), whereas the extended model breaks it down into three regimes (represented by $\lambda_2$, $\lambda_3$, $\lambda_4$ in the third row of Table 4b) and thus narrows down the interpretations as imperfect integration, contracting or information lag, and temporary disequilibrium respectively.

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9 See footnote 3.
10 The logic still holds if more possibilities are added.
The zero rent with positive trade ($\lambda_B^1$), on the other hand, can decompose into three cases represented by $\lambda_6$, $\lambda_7$, and $\lambda_8$ in the new system. Regime seven indicates a market in equilibrium with a steady flow of trade for a normal profit (Situation 5 in table 4a), whereas regime six and regime eight with trade decreasing and increasing respectively, could demonstrate that the market is drying up at this price in the first case or that there continues to be market opportunities at prevailing prices (Situation 4 in table 4a). For comparison, trade/no trade specification obscures these differences in one overall regime parameter $\lambda_B^1$, and one joint interpretation, competitive equilibrium/perfect integration.\textsuperscript{11}

Parallel reasoning holds with negative rent and positive trade ($\lambda_B^5$).

**Table 4** Decomposing the trade regimes: Interpretations vs. Binary Model

<table>
<thead>
<tr>
<th>Economic Interpretations</th>
<th>Extended model regimes and interpretation</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Trade barriers/ Unmeasured transaction costs</td>
<td>$R_{t-b} &gt; 0$</td>
<td>$R_{t-b} = 0$</td>
<td>$R_{t-b} &lt; 0$</td>
<td></td>
</tr>
<tr>
<td>2. Unmeasured transaction benefits.</td>
<td>$\lambda_2^*$</td>
<td>$\lambda_3$</td>
<td>$\lambda_4$</td>
<td>$\lambda_6$</td>
</tr>
<tr>
<td>$1^{**}$</td>
<td>6, 1$^\wedge$</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

| Binary model regimes and interpretation | | | |
|------------------------------------------|---|---|
| $R_{t-b} > 0$ | $R_{t-b} = 0$ | $R_{t-b} < 0$ |
| $\lambda_B^5$ | $\lambda_B^1$ | $\lambda_B^3$ |
| 1, 4, 6 | 2, 4, 5 | 2, 3, 4, 6 |

* For the definition of $\lambda$’s and $\lambda_B$’s, see Table 3 and equations 4a-4f respectively.

** The Arabic numbers in the cells stand for the six numbered types of economic interpretations listed in table 4a.

$^\wedge$ The hat symbol denotes a weak case.

\textsuperscript{11} With the expanded regimes, competitive equilibrium can be defined as non-positive profit and either no trade or no change in trade, i.e. $\lambda_5 + \lambda_7 + \lambda_9$ in table 3.
EMPIRICAL ANALYSIS

Data

The log likelihood function of equation (7) was estimated with bi-weekly data of the US-China soybean prices, transaction costs, and trade volume from January 1996 to January 2004.

Assuming spot transaction as a general mode, the U.S. cash prices for wholesale No.2 soybeans and the Chinese equivalent of Class.3 yellow in DCE are used. The ocean freight rates, the U.S. domestic inland barge rates, tariff and VAT are the individual transaction costs measured. All other stationary costs can be captured by the estimated intercept, and by the random variation parameter $\sigma^2_v$, while the unmeasured non-stationary costs (benefits) will be picked up by the non-zero regimes.

Rates reported in the *Grain Transportation Report* (USDA-Agricultural Marketing Service) are used to develop transportation estimates. The selected costs represent the most common method by which grain is shipped overseas, that is via barge from Central Illinois to Gulf of Mexico ports and from Gulf ports overseas. The rate used is for overseas shipment from the Gulf of Mexico to Japan, which is the most complete set available. The rate data is based on reports for individual ships, and is nearly complete as a weekly series. Missing values are filled with averages from adjoining weeks. This data series contains a limited number of observations on shipments to China and the applicability has been tested both analytically and by inspectional plots of the two series. The simple tests, while

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12 There was only one overall type of domestic soybean contract at the outset of DCE, called ‘soybean’, which has four classes with class 3 as par. Class 3 has relatively closer technical specifications as No.2 in CBOT. Then between March 2002 and December 2004, DCE only quotes No.1 soybean (Non-GMO), and both No.1 and No.2 (GMO) after December 2004. We have to use the-only-available- No.1 soybean prices for the period of March 2002 to January 2004. The two price series however, are closely interrelated with a correlation of 0.96 calculated based on the daily data from December 2004 to December 2005 when contracts for No.1 and No. 2 beans are both available, and the price of either type of bean could be higher than the other with mean prices of RMB2818 and RMB2784 respectively.
indicating co-movements in general, implies a possibly higher average rate to Japan than to China.\footnote{The existing Chinese freight rate data are regressed on the corresponding Japanese data. The estimation gives a relationship between the two as 0.92, which, although very close to 1, means that one unit of rate increase in the rate to Japan is corresponding to 0.92 unit increase in the rate to China.}

Insofar as the measurement errors are symmetric and random, they could be captured by $\sigma_r^2$, and the $b$ parameter in equations (3a)—(3c) is intended to pick up the time-invariant measurement gap. But in case the differences between the US-Japan and US-China freight rates are themselves non-stationary, and cannot be well picked up either by $\sigma_r^2$ or the intercept, the margin estimates could be biased, which is not very likely if not impossible. But these differences must be considered when interpreting the estimation results.

A 13 percent value added tax is levied in China on top of the landed price that includes a 3 percent tariff (Branson, 2004). So the total price paid by the Chinese importers is calculated as: (US price + transport cost)\*(1.03)\*(1.13), adjusted with interest rates due to the payment lags. All prices and transaction costs are converted to Chinese RMB per metric ton for which the exchange rate is virtually fixed in the sample period with a less than 0.2% standard deviation.\footnote{To the best of our knowledge, this study is the first to compile such inclusive transaction cost data in the study of China’s markets.}

The daily Chinese futures price series is changed into bi-weekly data by simple averaging,\footnote{Reuters Ltd and Dalian Commodity Exchange supplied the data by electronic file.} same for the weekly transportation charges and US soybean prices. To account for the payment lag in international commodity trade, the importer’s expected cash market price at time $t$ for $t+j$ is extrapolated by discounting, to the time $t+j$, the futures price of the nearest contract which matures at time $t+s$, where $s>j$. A former COFCO manager (Si 2001) and industry traders (Meyer and Rameker 2001) indicated that a three month delivery/payment lag was normal in the US-China soybean trade, so the US price is adjusted for interest until the payment time using the weekly US 3-month T-bill interest rate which is
available from the US Federal Reserve Board.\footnote{According to these individuals the process takes 75-90 days to complete and that the Chinese importers mostly pay after delivery is taken and therefore the cash price needs be interest-adjusted.} For example, the interest-adjusted U.S. cash price on January 20 1996 will match the expected Chinese cash market price around April 20 1996. We pick the nearest May contract 1996 maturing on May 13, and discount it to April 20 1996 using the monthly Chinese 3-month lending interest rate published by International Monetary Fund which is the most complete set available.

As discussed earlier, during the study period no reliably reported /cost-feasible cash, let alone forward, market price is reported for bulk soybeans in China,\footnote{China National Grain & Oil Information Center was contacted by phone and email in October 2008. The conclusion is that it's not feasible to procure the wholesale cash price data for the study period, because: a) Data are only available for the period after 2002; b) the cost is currently about $3000 for one year of data.} and for analysis as well as for Chinese traders the DCE futures price is the best publicly available information. Although it is still in debate as to whether futures prices are biased as a future spot price indicator, no firm empirical evidence has been found for the ‘biased’ argument (Blank and Schmiesing\citeyear{Blank:1991}). However, the imported soybeans land at different ports in China (e.g. Dalian in the north, Guangzhou in the south) and the futures prices contains different species which are also different from imported beans. This disjuncture likely introduces some bias attributable either to product differentiation or different freight rates at different ports. Although it is not easy to determine the direction of the bias the higher prices in the northeast Dalian compared to the southern cities likely lead to upward-biased rent estimates.\footnote{Interview with Mr Li, a business representative at a state-owned internet information company www.dadou.cn, shows that the prices of imported beans are substantively lower in southern cities, and there is no direct arbitrage between southern and northern areas. One of the major reasons, in addition to the product quality, is the transportation bottleneck and the resultant high rates.}

The trade volume data comes from the Port Import-Export Recording Service data set (PIERS) collected by the \textit{Journal of Commerce}. The small volume shiploads were often labeled as a container rather than bulk shipment, and so regarded mostly as identity preserved or seed soybeans which are not
typical shipments for wholesale trade and therefore classified as zero trade. The specification of the trade volume change defined in (5a)-(5d) was based on the rent-weighted expected value of rate of trade defined by the equation

\[ E(\Delta k_t/ k_{t-1}) = \sum_t \left( \frac{\Delta k_t}{k_{t-1}} \cdot \left( \frac{r_t}{\sum_t r_t} \right) \right) \]

where \( \Delta k_t = k_t - k_{t-1} \), \( r_t = (R_t - R_{t-1}) / R_{t-1} \), and therefore \( r_t/\sum_t r_t \) is the period share of total rates of change in arbitrage rents. This ‘benchmark’ value is determined by the mean of \( E(\Delta k_t/ k_{t-1}) \) sampling distribution, 0.81 (standard deviation=0.13) given by 10000 bootstrap replicates of \( E(\Delta k_t/ k_{t-1}) \). This value is utilized in the model to indicate an increase or decrease in demand. In particular, if the rate of trade change at time t, i.e. \( \Delta k_t/ k_{t-1} \), is positive and higher than 0.81, then a ‘trade up’ indicator is assigned to this observation; if it is negative and its absolute value higher than 0.81, then a ‘trade down’ indicator is assigned. All other positive trade observations are regarded as no change and categorized as ‘trade constant’.

**Results and Discussion**

Table 5 reports the results for equation (7) estimated with the gradient-based minimized-sums (MS) algorithm in the S-plus package.

As noted earlier, specific circumstances for the China soybean trade model are incorporated into (7). In this analysis ocean transportation, the U.S. barge rates, tariffs and VAT have all been included, but pre-WTO constraints on the market and risk aversion could be expected to impact profit-seeking. A dummy variable WTO is included to examine the possibility that the market constraints relaxed after China’s membership in 2001. ‘\( R_t-b \)’ in equation (3) is re-specified as ‘\( R_t-b_{post-WTO} * WTO \)’, where \( b_{post-WTO} \) represents the likely markdown of the rent required by market participants pre-WTO and the
dummy variable equals one post WTO and zero before. A negative parameter estimate would indicate the more likely reduction of non-trade barriers or a risk premium on either or both sides of the market. To model the impacts of the competition from SA as described in table 2, different variation parameters are assigned in estimating equation (7) to the period from March to August (σ_{v,SA}, σ_{u,SA}) than the rest of the year (σ_{v,US}, σ_{u,US}).

Table 5. Regime Switching Model Estimates

<table>
<thead>
<tr>
<th>Arbitrage Rent</th>
<th>Regime Frequencies</th>
<th>Intercepts and Variation Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No trade</td>
<td>Trade down</td>
</tr>
<tr>
<td>+</td>
<td>λ₁</td>
<td>0.14*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.04)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3.45)</td>
</tr>
<tr>
<td>0</td>
<td>λ₅</td>
<td>0.09*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.04)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.45)</td>
</tr>
<tr>
<td>-</td>
<td>λ₀</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Log likelihood is -1615.71. The number of bi-weekly observations = 209

Standard errors and t-statistics are in parentheses below the parameter estimates.

* indicates statistically significant above 95% level in t-test.

'SA' indicates South America harvest season
1. Regime probability parameters

The non-zero probability coefficients (Table 5) are all statistically significant above 95 percent level except $\lambda_4$ and $\lambda_6$. When no trade is taking place, occurring in 23 percent of the periods in the sample, the model returns a regime probability of 14 percent for positive rent ($\lambda_1$), 9 percent ($\lambda_5$) for zero rent, no feasible solution is found that includes a negative rent for any trade situation. The trade-constant case occurs 38 percent of the time within the sample, all with positive rent. In the trade-up case with about 24 percent of the whole sample, positive rent ($\lambda_4$) and zero rent ($\lambda_8$) returns a 16 and 8 percent frequency respectively. The remaining observations take place with trade declining and these are mostly allocated to a positive rent distribution.

Regime one with positive rent and no trade and regime two with trade declining and rent remaining unexploited are in violation of efficient arbitrage expectations. The probability estimated for these within the study period is $\lambda_1 + \lambda_2 = 26$ percent. Regime one, a case of market segregation, may be a concern since trade does not occur even when a profit margin exists. Regime two indicates imperfect market integration when trade is expected to increase in an efficient market when there are positive rents.

Regime three likely represents information and contracting lag or unmeasured transaction costs that prevent trade from increasing. Regime four indicates trade increasing in response to profitable opportunities. Regime five, with zero profit/no trade, shows that demand and supply conditions are such that the price differential equals transaction costs, while regime six with zero rent / trade falling likely implies a temporary disequilibrium. Regime eight may represent unmeasured transaction benefits or the contract/information lags.

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21 A negative rent regime is not produced even for a simpler model without any trade specifications included.
In summary, the results indicate that in the time period analyzed, the US and Chinese soybean markets are integrated about 77 percent of the time \((1-\lambda_1 \lambda_5)\). The competitive equilibrium and temporary disequilibrium occur respectively about 10 percent (regime five) and 64 percent of the sample periods (regimes four, six, eight, and potentially regime three). 12 percent of the time the markets are imperfectly integrated (regime two) most probably attributable to the unmeasured transaction costs, non-tariff barriers or risk aversion. In the remaining 14 percent, the two markets are segregated (regime one). A total estimate 26 percent for \(\lambda_1\) and \(\lambda_2\) cause a rejection of the hypothesis that the LOP holds for all time \(t\). The impacts of unmeasured transaction costs on the markets that is mainly reflected in regime two and large frequency estimate of temporary disequilibrium (regimes three, four, and eight) may indicate the limitations of the market infrastructure and institutions.\(^{22}\)

2. **Intercept and WTO effect**

As discussed earlier, \(b_{\text{post-WTO}}\) is designed to examine the possibility that the restrictions on trade relaxed after China’s WTO membership. The significantly negative estimate of \(b_{\text{post-WTO}}\), as expected, implies a decline of trade barriers after China joined WTO, most probably attributable to such changes as the weakened government controls over the imports. As is also evident in trade activity, 70 % of the total post-WTO periods witness trade compared with 55 % for the rest of the sample, and the average volume nearly triples after the membership (table 2).

3. **Variance parameters and seasonality**

The higher \(\sigma_{v,SA} (112)\) estimate for the South American season, as compared to that for the \(\sigma_{v,US} (81)\) (Table 5), demonstrates that a larger share of the US season observations fall within the zero rent regime. The gap between \(\sigma_{v,US} (81)\) and \(\sigma_{U,US} (195)\) illustrates the contrasting increase in volatility

\(^{22}\) See note 7
when the markets are out of the parity bound. Same logic holds for different magnitudes of $\sigma_{v,SA}$ (112) and $\sigma_{u,SA}$ (182). These estimated parameters, which are also consistent with the outcomes in table 2, confirm the assumption that the link between the US-China markets loosens given the lack of trade activities in the off-season largely because of the much cheaper SA soybeans.

**Some Nonparametric Statistics**

Another approach that is alternative to the parametric estimation is to let the data speak for themselves, freeing the analysis from the assumptions about the data generating process. The trade weighted average rates of arbitrage returns are computed by the following equations

\[
(9) \quad \text{Trade weighted average rate of arbitrage returns} = \frac{\sum_t (R_t / C_t) \cdot [k_t / \sum_t k_t]}{
\]

where $C_t =$ (US cash price) + (ocean freight rate) + (US barge rate) at time $t$. Results are presented in table 6.

<table>
<thead>
<tr>
<th>Trade-weighted average rates of arbitrage returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>zero trade</td>
</tr>
<tr>
<td>trade-weighted average rate of return</td>
</tr>
<tr>
<td>(simple average)</td>
</tr>
</tbody>
</table>

First, the average rates of arbitrage return are positive for all the four trade cases, which is consistent with the large magnitudes of probability parameters for positive rents and implies significant deviations from market equilibrium, according to the hypothesis that the average or expected value of

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23 This is consistent with the observance by Baulch (1997).

24 In their Monte Carlo analysis, Barrett and Li (2002) demonstrate that the normality assumption in the model may lead to overestimation of the nonzero rent frequency in the joint probability model if the true data generating process significantly deviates from normality. So in the application of the extended model of this paper, our results, if any bias arises because of the distributional assumption, may overestimate the temporary disequilibrium ($\lambda_3$ and $\lambda_4$), segmented disequilibrium ($\lambda_1$), and imperfect integration ($\lambda_2$ and probably $\lambda_3$).

25 The trade weighted average rents are also computed per equation $\sum_t R_t / [k_t / \sum_t k_t]$, and the results are 75, 132, 128, and 72 respectively for zero, falling, constant, and increasing trade cases, for which similar logic holds as the results in table 6.
the rates of arbitrage return is less than or equal to zero for the long-run competitive equilibrium. Second, on average the rates of return are relatively higher when trade occurs, indicating the market response to the profit opportunities. Furthermore, the different sizes of average rent in positive trade cases most likely show the relationships between the two markets with different trade movements, e.g. the increasing trade tend to have stronger impact in closing the price differences. Recall the similar evidence of the much lower average rent after China’s WTO membership (66 in table 2), nearly half that pre-WTO (119) but with the trade volume more than double (table 2), which is also confirmed by the significantly negative estimate of \( b_{\text{post-WTO}} \) (table 5).

One can also compute the empirical conditional distribution \( f(R_t/k_t) \) in the sample. Compare Figure 1 to figure 4 which depict the distributions of rates of arbitrage returns \((R_t/C_t)\) in all the four trade cases. Apparently, the mean rates in figure 1 and figure 4 are both to the left of the observation-weighted average rent (5 percent) with the latter indicating a further departure, \(^{26}\) while the means for falling and constant trade lie to the right of 5 percent. These results confirm what we have seen in table 6. However, it should be kept in mind that the major shortcoming of using sample frequency distributions is the inability for a parametric re-centering of the distribution to allow for unmeasured transaction costs and time invariant data measurement errors, e.g. the error terms and intercept respectively.

\(^{26}\) The average rate of return weighted with the different shares of observations in all the four trade cases equals 0.05 or 5 percent.
Figure 1

US-China arbitrage rents without trade

Figure 2

US-China arbitrage rents with falling trade

Figure 3

US-China arbitrage rents with constant trade
CONCLUSIONS

This paper attempts to reduce the interpretational multiplicity that exists with the previous regime switching model by introducing information on how trade changes which has improved the model’s capacity to distinguish between equilibrium, disequilibrium, temporary disequilibrium, and imperfect integration. A rent-weighted average rate of trade change is developed to discern the alterations in trade (i.e. declining, constant, and rising). The new model also indirectly accounts for the impacts of the competition from SA on the US-China soybean market relationship by explicitly modeling the alternate seasonal variations of the price link, which actually combines the approach of price variance analysis with the regime switching model. In addition, a nonparametric view is provided, which has basically confirmed the model analyses.
Our findings suggest that market integration and competitive equilibrium prevail most of the sample periods between the US-China soybean markets \((1-\lambda_1=0.86)\) from 1996 to the beginning of 2004 during which some major institutional reforms took place. The two markets are found to bind more closely after China’s WTO membership. However, the estimates for \(\lambda_1\) (probability for positive rent with no trade) and \(\lambda_2\) (probability for positive rent with trade going down), cause a rejection of the hypothesis that the LOP holds for the entire period of the study. The large frequency of temporary disequilibrium and imperfect integration may likely imply the significant impacts of transport bottleneck, the resultant high/in-transparent transportation costs, and the limited information system developments in China. The price link has also been found relatively slack after the harvest months in South America, a major competitor to the US in the Chinese soybean market.

It should be noted that the likelihood estimates, the simple statistical descriptions in table 2, and the nonparametric test are generally consistent and corroborating each other although the parametric estimates are more exact. All demonstrate highly positive rents, closer US-China market link in the U.S. season and after China joined WTO in 2001.

There are several potential limitations in this study. First, the lack of cash market price series in the southern port cities of China, where most major crushers are located, prevents the estimation of the risk impacts from the Chinese cash market. The futures prices as expected revenue indicators could also lead to rent overestimation as a result of product differentiation and different landing ports. Second, with all the relevant transaction costs data other than the measured, the analysis could be improved if it is non-stationary because then it cannot be simply captured by the intercept and the random variation parameters around the zero rent. Third, if the relevant price and trade data are available for SA soybean exports to China, the analysis of the SA impact would be placed on a firmer ground. Lastly, further research may seek to improve the dynamic analysis. Among others, additional work can be directed to
measure the price adjustment speed, the direction of price information flow, and the relationship between the adjustments of price and trade flow.

REFERENCES


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