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Spatial Price Analysis Incorporating Rate of Trade: Methods and Application to United States–China Soybean Trade

Shengfei Han and Catherine A. Durham

A regime-switching model for analysis of market integration has been developed that incorporates rate of trade information. An application of the methods to United States–China soybean trade demonstrates that the extended trade information allows better interpretation of market conditions. While the empirical results show that China's reform efforts since mid 1990s toward an open market have greatly improved United States–China soybean markets integration, about 40% of nontransitional disequilibrium occurrences likely indicate infrastructural limits such as the lack of information availability and limited competition. The United States–China price linkage is observed to be closer after China's World Trade Organization membership. The link has also been found relatively slack during the South American soybean harvest.

Key Words: China, futures markets, market integration, regime switching, soybeans, World Trade Organization

JEL Classifications: F15, G13, Q11

Most of the recent literature on market integration follows two major methodological approaches: cointegration and regime-switching. Cointegration studies that account for the nonstationarity of the time series data mostly attribute the lack of support for the Law of One Price (LOP) to the nonstationary unacknowledged transaction costs

(Baffes, 1991; Low, Muthuswamy, and Webb, 1999; Michael, Nobay, and Peel, 1994; Zanas, 1993). Studies regarding China's primary and agricultural goods find long-term international price responsiveness and increasing degree of integration due to government reforms, but a lack of short-term arbitrage (Shyy and Butcher, 1994; Yu, 2007; Yu and Huang, 1998). Unfortunately, without the actual information on transaction costs and trade, the tests have to depend on some unreliable assumptions and thus cointegration has been proved neither a necessary nor a sufficient condition for market integration because of such factors as nonstationarity of transaction costs and discontinuities in agricultural trade (McNew and Fackler, 1997). Furthermore, cointegration tests generate results that either point to an all cointegrated market or to an all segregated market.

Regime switching models have been developed to better model price relationships

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under varying market conditions and transaction costs (Baulch, 1997; Park et al., 2002; Sexton, Kling, and Carman, 1991). While these models allow for deviations from perfect integration over time, they do little to explain the most likely source of the deviation, and give no information on trade activity and what it means for market conditions. An important improvement in this regard is by Barrett and Li (2002), who explicitly introduces trade information into the price model. Their introduction of a dichotomous trade-no trade variable into the parity bound model developed by Baulch allows for possible trade flow discontinuity and directional switches, and incomplete and non-stationary transaction costs measurement, which enables a fundamental understanding of the distinction between market equilibrium and integration. For example, as long as transaction costs have been well measured, by estimating whether nonzero rents occur with or without trade the model allows such considerations as whether the likely source is a segregating trade-barrier with positive rents and no-trade versus imperfect integration where trade occurs but does not achieve zero rents.

Though this provides important information it does not separate the different sources of market inefficiency. Adding information on how trade varies inside and outside of the zero-rent efficient arbitrage condition improves our understanding of the causes of inefficiency that may arise. This is particularly important in emerging economies where market infrastructure and institutions are developing slowly and thus have a broad set of potential causes of imperfect integration. Under these conditions the degree of trade activity despite imperfect integration can be meaningful and possibly reduce concerns about the degree of integration and permit a better assessment of its source for improvement of policy. An example of how information about changes in trade can improve interpretation is by considering conditions under positive arbitrage rent. When trade volume is rising, this situation is most likely to indicate a normal response by traders to increase trade to capture the rent in a competitive market. As prices may not instantaneously adjust as they might in a more developed market, the market is responding normally and thus can be inferred to

be a transitional period. On the other hand with trade declining at positive rent, transitional disequilibrium is less *plausible* as an interpretation and instead, there are likely to be such factors as risk aversion or imperfect information, where some but not all agents are responding to opportunities. Observation only that trade occurs or not, as in the Barrett–Li model, does not distinguish between these different possibilities.

This study attempts to overcome this shortcoming by generalizing the joint probability model that accounts for how trade varies (no trade, trade declining, trade constant, and trade rising) with positive, zero, or negative rent that may render some explanation of market integration or failure more likely than the other. A second innovation in this study is to model the deferred market response in international commodity trade. The present value framework is employed to reflect the cash flow aspect in making arbitrage decisions, with a futures price as importers' expected revenue. Previous studies in international trade either apply quarterly data based on the assumption of a corresponding delivery or try various lags when using high frequency data; however, aggregation obscures the variation in the relationship between partners. Biweekly data are used in this analysis. The approach in this analysis may provide a useful framework to applied researchers in analyzing market linkages, particularly when wholesale cash market information is not readily available as is common in many developing economies.

As a subject the soybean market in China is of particular interest in several regards although little empirical investigation has taken place with regard to international linkages. Soybeans are important to food supply in China as a major source of vegetable oil and livestock feed, and, as one of world's leading importers and producers, its integration with international markets is important to world supply and demand. It is also the first of what China considers to be the strategic agricultural staples (the others being wheat, rice, and corn) to have achieved this level of trade freedom, so that this study can help understand the effects of China's agricultural policy toward freer trade and markets.

This study is the first to combine analysis of the relationship between profit margins and

trade responses with the temporal and spatial considerations in international market analysis, which distinguishes between equilibrium, disequilibrium (nonzero rent without trade correction), and transitional (nonzero rent with trade adjusting toward equilibrium) periods, and thus permits further clarification of market conditions. Empirical results indicate a significant frequency of disequilibrium moderated by transitional periods in United States–China soybean trade.¹ We also observe a closer market relationship after the institutional changes including the end of the COFCO (China National Oils and Foodstuffs Import and Export Corporation) monopoly on trade and post China's entry into the World Trade Organization (WTO). A traditional seasonal pattern is apparent in that the two markets are less closely linked in the South American harvest season.

The next section provides information on the state of Chinese soybean markets with respect to trade, followed by the model specification. Finally, the method is applied to the United States–China soybean markets, and the results are contrasted with the trade/no trade model. Graphical and trade frequency distribution analyses are also provided as corroboration to the parametric results.

China's Soybean Market and Trade

To put China's Soybean market and trade in relative terms, in the year 2000, the United States was producing about 50% of the world's soybeans and 70% of the exports among the top-four soybean producing countries.² Meanwhile, China absorbed 20% of world soybean exports during the 2000–2001 marketing year and over 40% in 2004–2005, the U.S. portion of which has ranged from 35–70% (United States Department of Agriculture–Foreign Agricultural Service (USDA–FAS), 2005, 2006).

Chinese soybean imports have been steadily increasing since 1996 because of fast-growing

domestic meat and oil demand and the relaxation of government restrictions on trade. The market for imports has also increased because of high cost, low oil content, foreign materials of domestic soybeans, and domestic transportation problems in terms of cost and ease of availability for Chinese domestic soybeans to be transferred to major crushing areas. The major soybean production area is in Northeast China, while the crushers are mostly in the southern port cities such as Guangzhou, Shanghai, and Shenzhen.

The study period witnesses several major policy and institutional changes. Toward the end of 1995 COFCO lost its exclusive right to import soybeans, and in December 2001 China resumed WTO membership. Prior to these events as part of earlier market-oriented economic reform, the Chinese government established futures markets in the early 1990s to help stabilize the grain supply.

The Dalian Commodity Exchange (DCE), established in 1993, is among the first futures markets in modern China, and is currently the only Chinese futures market trading soybeans. Its soybean futures contracts were based on those of the Chicago Board of Trade (CBOT) contracts. The principle differences between the DCE and the CBOT soybean futures contracts include 1) no August contract at the DCE; and 2) the contract size at the DCE is 10 metric tons, about 7% of the 5000 bushel contract size at the CBOT. Timely information on domestic demand and available supply has been limited in China, and quotes only became regular on soybean futures at the DCE since 1996,³ the first evidence of increased market liquidity. The DCE soybean futures contract emerged as the most important market signal, as well as a risk hedging instrument, for Chinese soybean producers, importers, oil crushers, and other market participants. By January 2003, total soybean trading volume at the DCE was 30% of those at the CBOT, and about 11 times that of the Tokyo Grain Commodity Exchange.

¹Transitional disequilibrium may not seem as much a concern to economists in terms of deviation from long-run competitive equilibrium.

²Food and Agriculture Organization of the United Nations, FAOSTAT Online.

³Our raw data shows that quotes are available for only 30% of the working days in the second half of 1994, 47% of days in 1995, while all contracts show trades more than 85% of the time from 1996 onward.

Due to some instances of market manipulation by speculators, the Chinese government tightened its regulation in 1998 through direct supervision and monitoring by the China Securities Regulatory Commission—a ministerial agency under the State Council of China. The DCE does not operate like futures markets in other countries in a number of ways. Trading is not open to foreign speculators and only since 2006 have a few foreign firms, among which are Bunge, Cargill, and Louis Dreyfus, been approved to use Chinese futures to hedge based on their status as resident cash commodity companies in China. Furthermore, only since May 2001 have a number of Chinese enterprises been given official permission to access foreign futures markets for hedging purposes. While the intent of the original and remaining restrictions is to protect the DCE and domestic market participants before they accumulate sufficient experience and expertise, they may also affect the market liquidity at the DCE and thus market efficiency.

As an important part of the information system, data collecting institutions started to develop only in recent years. For example, in the process of this project, we contacted Shanghai Shipping Exchange, the only freight rate exchange in China, by phone and e-mail in October 2008. The conclusion was that it is not possible to obtain the complete inland water barge rate because freight rate quotes for bulk goods started in 2002 and the quoted cost is \$3000 per year. The situation and cost for wholesale grain price data are approximately the same according to the National Grain and Oil Information Center.

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. soybeans (USDA-FAS, 2001). The U.S. harvest season gets into gear in September and 90% of shipments from the United States to China depart October through March. Most of the import demand in China for the rest of the year is met by soybeans from South American countries (SA).

Table 1 provides the means, standard deviations (SD), minimum and maximum values of the biweekly sample data of the U.S. soybean exports to China, and the differences of mean

and SD during the U.S. season as compared with SA season, and before and after China joined the WTO. Over the sample period, the average margin falls from 118 to 66 yuan post WTO,⁴ corresponding to a dramatic increase in average U.S. biweekly exports to China from 111,354–282,466 metric tons. The average U.S. exports to China in the U.S. season are six times that in the SA season, but interestingly price margins are close over the two periods. A plausible implication from this is that even though the average margins are not affected because of the synchronized seasonal shifts between China and the U.S. harvests, the relatively less expensive SA soybeans take over the market. These implications regarding volume and margins will be discussed in relation to the estimation results.

Model and Methods

The Barrett and Li Model

The basis for the model developed in this paper is from the Barrett and Li (B-L) (2002) who express marginal rent to arbitrage at time t as

$$(1) \quad R_t = P_{mt} - P_{xt} - T_t$$

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

$$(2a) \quad R_t = v_t + u_t \quad \text{if } R_t > 0$$

$$(2b) \quad R_t = v_t \quad \text{if } R_t = 0$$

$$(2c) \quad R_t = v_t - u_t \quad \text{if } R_t < 0$$

where v_t represents independent and identically distributed normal error with zero mean and variance σ_v^2 , u_t is a one-sided, positive error with variance σ_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, the

⁴The allowance of some major Chinese agricultural trade companies to enter international futures markets since 2001 may also contribute to the closer link.

Table 1. Descriptive Statistics of United States–China Soybean Trade Data: 11/1995–01/2004, (Biweekly, Prices in Chinese Yuan)

	Seasons ^a						Before WTO ^b Mean (SD)	After WTO ^b Mean (SD)
	Mean	SD	Min	Max	South America	United States		
					Mean (SD)	Mean (SD)		
Trade volume in metric tons	155,332	238,719	0	1,190,900	42,290 (65,655)	264,225 (289,564)	111,354 (159,961)	282,466 (357,430)
# of Vessels Shipping Bulk Soybeans	2.93	4.38	0	23	0.92 (1.38)	3.43 (3.70)	2.18 (3.06)	5.11 (6.46)
U.S. cash price (USP)	1783	394	1218	2699	1801 (424)	1766 (364)	1806 (424)	1718 (285)
Transport costs (TC)								
Ocean rates	190	68	103	488	179 (43)	200 (84)	169 (31)	248 (103)
U.S. Barge rates	66	19	36	126	59 (16)	74 (19)	66 (19)	67 (17)
Chinese price (CP) – time value adjusted	2480	466	1809	3515	2475 (475)	2485 (460)	2496 (489)	2433 (395)
Price margin (inc. tariff & tax) = CP-TC-USP	105	151	-254	765	100 (151)	109 (152)	118 (147)	66 (157)

^a April–September as United States soybean season, October–March as South American season.

^b China joined WTO in December 2001.

consistency of a maximum likelihood estimator for either a linear or nonlinear regression model with auto-correlated errors is well established (Dhrymes 1971; Frydman 1980). Furthermore, the conditions of rent analysis should induce caution when determining whether it is appropriate to transform data to achieve serial independence. In less open markets under conditions of risk aversion, nontariff barriers, etc., the rent or returns to trade data may display persistent periods of positive or negative rent followed by periods of zero rent. If an attempt is made to adjust such data by methods such as partial differencing or the AR(1) process, which actually gives the changes in the rents, it would be expected to downwardly bias the nonzero rent regime estimates, and additional negative or positive differences may contribute to estimates of the opposite regime from series returning to zero rent.

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

$$(3a) \quad f_t^+ = \left[\frac{2}{(\sigma_v^2 + \sigma_u^2)^{1/2}} \right] \varphi \left[\frac{R_t - b}{(\sigma_v^2 + \sigma_u^2)^{1/2}} \right]$$

$$(3b) \quad f_t^0 = \left[\frac{1}{\sigma_v} \right] \varphi \left[\frac{R_t - b}{\sigma_v} \right]_s$$

$$(3c) \quad f_t^- = \left[\frac{2}{(\sigma_v^2 + \sigma_u^2)^{1/2}} \right] \varphi \left[\frac{R_t - b}{(\sigma_v^2 + \sigma_u^2)^{1/2}} \right] \left[1 - \Phi \left[\frac{(R_t - b) \sigma_u / \sigma_v}{(\sigma_v^2 + \sigma_u^2)^{1/2}} \right] \right]$$

Here $\varphi(\cdot)$ and $\Phi(\cdot)$ denote the standard normal density and cumulative functions respectively. The parameter b is used to examine time invariant aspects of the price differentials other than the measured transaction costs; it could also represent risk aversion or market power as in Sexton, Kling, and Carman (1991). It can be associated with a dummy variable when an unmeasured effect is hypothesized to exist over specified periods.

Then, the B-L model is estimated with a joint probability distribution of $\{R_t - b, k_t\}$,

where k_t is trade volume at time t . The probability parameters, λ^B 's, of six regimes are estimated,⁵ where

$$(4a) \quad \lambda_{\emptyset T}^B = \text{Prob}\{R_t - b = 0 \text{ and } k_t > 0\}$$

$$(4b) \quad \lambda_{\emptyset N}^B = \text{Prob}\{R_t - b = 0 \text{ and } k_t = 0\}$$

$$(4c) \quad \lambda_{+T}^B = \text{Prob}\{R_t - b > 0 \text{ and } k_t > 0\}$$

$$(4d) \quad \lambda_{+N}^B = \text{Prob}\{R_t - b > 0 \text{ and } k_t = 0\}$$

$$(4e) \quad \lambda_{-T}^B = \text{Prob}\{R_t - b < 0 \text{ and } k_t > 0\}$$

$$(4f) \quad \lambda_{-N}^B = \text{Prob}\{R_t - b < 0 \text{ and } k_t = 0\}$$

The model above is a regime-switching system estimated using maximum likelihood methods. Regimes $\emptyset T$ (trade) and $\emptyset N$ (no trade) with zero (\emptyset) arbitrage rent are defined as efficient arbitrage conditions. Regimes $+T$ (trade) and $+N$ (no trade) with positive (+) arbitrage rent are interpreted as existence of trade barriers, unmeasured transaction costs, information gaps, etc. Regime $-T$ with negative (−) arbitrage rent and positive trade implies imperfect information, contracting lags, and unmeasured transaction benefits. Finally, regime $-N$ with negative rent and zero trade represents segmented equilibrium. Note that this discussion refers to trade in one direction because there are no soybean exports observed from China to the United States in the sample period.

The Extended Model

As pointed out in the introduction, without information on how trade varies, price relationship tests may have multiple interpretations which may lead to, if not incorrect, at least ambiguous conclusions. In this analysis we extend the Barrett and Li model by specifying a rate of trade, i.e., decomposing the positive trade in B-L model into three cases of “down,” “constant,” and “up.” This market information is built in through four index variables including zero trade, to form 12 regimes in the likelihood function. In particular, let k_t be a variable of trade volume, and K_{ti} be a rate of

⁵ B-L use the numbers 1–6 to designate the six regimes, however this made comparison with the extended model difficult and so the subscripts are altered to limit notational confusion.

trade index variable with $i = 1 \dots 4$, 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 $K_{t4} = 0$.

The complete set of situations described in Equations (5a)–(5d) combined with those in Equations (2a)–(2c) gives 12 regimes denoted by λ_1 to λ_{12} in Table 2 in which the positive trade regimes $\lambda^B_{\emptyset T}$, λ^B_{+T} , and λ^B_{-T} in Equation (4) are decomposed into ($\lambda^B_{\emptyset T} = \lambda^E_6 + \lambda^E_7 + \lambda^E_8$), ($\lambda^B_{+T} = \lambda^E_2 + \lambda^E_3 + \lambda^E_4$), and ($\lambda^B_{-T} = \lambda^E_{10} + \lambda^E_{11} + \lambda^E_{12}$), respectively. The model is now estimated with the joint probability distribution of $\{R_t - b, K_{ti}\}$, as compared with $\{R_t - b, k_t\}$ in B–L model.

Equation (3a), the density function for the observations with positive marginal returns, is appropriate for the regimes represented by λ_1 to λ_4 , i.e., $f_{t1}^+ = f_{t2}^+ = f_{t3}^+ = f_{t4}^+$, Equation (3b) for λ_5 to λ_8 , i.e., $f_{t5}^0 = f_{t6}^0 = f_{t7}^0 = f_{t8}^0$, and finally Equation (3c) for λ_9 to λ_{12} and $f_{t9}^- = f_{t10}^- = f_{t11}^- = f_{t12}^-$, 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 with Equation (1), is:

$$(6) \quad R_t = \delta_{m,t+j} E(P_{m,t+j}) - P_{xt} - T_t$$

where $\delta_{m,t+j}$ is importer's discount rate for time periods j . Equation (7) is estimated with condition Equation (6) as the definition of R_t in the

maximum likelihood system. The likelihood of observing the sample data $\{R_t - b, K_{ti}\}$ is therefore given by

$$(7) \quad L = \prod_{t=1}^n \{K_{t1} (\lambda_1 f_{t1}^+ + \lambda_5 f_{t5}^0 + \lambda_9 f_{t9}^-) + K_{t2} (\lambda_2 f_{t2}^+ + \lambda_6 f_{t6}^0 + \lambda_{10} f_{t10}^-) + K_{t3} (\lambda_3 f_{t3}^+ + \lambda_7 f_{t7}^0 + \lambda_{11} f_{t11}^-) + K_{t4} (\lambda_4 f_{t4}^+ + \lambda_8 f_{t8}^0 + \lambda_{12} f_{t12}^-)\}$$

The four terms in Equation (7) are associated with the four different trade flow circumstances (Table 2). For each circumstance, there are three regimes associated with the marginal arbitrage rent: positive, zero, and negative.

While the “potential” candidates for perfect integration may be defined in general as unrestricted trade flow and zero rent unexploited (i.e., $k_t \geq 0$ and $R_t = 0$), distinctions could be made among regimes five through eight (Table 2). Regime five, with zero trade, represents an indifference case. For the positive trade cases, regime seven indicates a market in equilibrium with a steady flow of trade for a normal profit, 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 in the latter. For comparison, B–L model obscures the differences between regimes six, seven, and eight in an overall regime parameter $\lambda^B_{\emptyset T}$, and a single interpretation for perfect integration.

“Imperfect” integration, on the other hand, may generally refer to those situations with trade flowing between the markets but nonzero marginal returns (i.e., $k_t \neq 0$ and $R_t \neq 0$). While unmeasured transactions costs, trade barriers, and other competition constraints are the most likely explanations for no trade with positive rent, they become less likely when trade occurs, and less likely as the market moves from trade declining and constant trade toward increasing trade. As an illustration, in the early period of the empirical application, instances of positive rent with no or limited trade response seem most likely to indicate the restriction of trade to the COFCO monopoly. But limited trade response to positive rent once the market was opened via expansion of the number of trading companies agents is more likely to be explained by risk

Table 2. Twelve Regimes

	$k_{t1} = 1$	$k_{t2} = 1$	$k_{t3} = 1$	$k_{t4} = 1$
R-b	+	λ^E_1	λ^E_2	λ^E_3
	0	λ^E_5	λ^E_6	λ^E_7
	—	λ^E_9	λ^E_{10}	λ^E_{11}
				λ^E_{12}

aversion (e.g., agents concerned about government intervention or price risk). Regime two with trade decreasing instead of the normal profit-making response in this case—trade rising, is likely to be evidence of risk aversion or unmeasured transaction costs, while regime three indicating no trade adjustment could more likely imply contracting and/or information lags. Regime four with trade increasing as expected, on the other hand, implies a transitional period with evidence in both rent and the direction of change in trade, and agents responding to the positive profit margin. With λ^B_{+T} for all these three cases as in Equation (4c), the dichotomous trade/no trade specification fails to differentiate whether the market is moving toward the binding arbitrage condition, or indicating unmeasured transaction costs, risk aversion, or information lags.

Regarding negative rent cases in the category of imperfect integration, regime 10 for declining trade, with same logic as regime four, is likely indicating a transitional period with some delivery lags. Regimes 11 and 12 on the other hand, may be parallel in reasoning to regimes three and two respectively, with regime 11 showing a lack of adjustment and 12, a response completely inconsistent with the normal expectation of trade at negative rent. Therefore regimes 11 and 12 imply the existence of either contracting lags or information discrepancies (e.g., some traders speculating that cash market prices will rise by the time the soybeans are delivered), or such factors as unmeasured transaction benefits respectively (e.g., convenience yield, first mover advantage, monopolistic dumping). Again, λ^B_{-T} in Equation (4e), aggregating all negative rent cases with trade, lacks information to determine between the market movements toward efficient arbitrage condition (regime 10) and other possible imperfect market situations (regimes 11 and 12).

Finally, market segregation is defined as absence of trade when there are nonzero arbitrage returns (i.e., $k_t = 0$ and $R_t \neq 0$). Two regimes fall into this category. Regime one with $R_t > 0$ may be explained by nontariff trade barriers or unmeasured transaction costs. Regime nine implies an autarky situation due to either prohibitive transfer costs or higher comparative production costs.

Table 3 compares the two sets of indicators of market conditions using six- versus 12-regime systems, designated with a B superscript for Barrett and Li and E for the extended model. For the ease of comparison, B–L indicators have been written in the term of both regime systems (Columns 2 and 3). Columns 1 and 4 categorize the B–L and extended interpretations respectively, while Column 5 demonstrates the components for E indicators. As a simple example, in the third row, the second column (λ^B_{-N}) and the third column (λ^E_9) express the B–L indicator for segmented equilibrium, but the former in the term of trade/no trade system as in Equation (4), the latter based on extended regimes (Table 2), with the same interpretation and component(s) for the extended indicator (Columns 4 and 5).

With the trade change specifications, we can define the market conditions as follows. Competitive equilibrium becomes the situation, which refers to nonpositive profit with no-trade or no change in trade with zero profit ($\lambda^E_5 + \lambda^E_7 + \lambda^E_9$). In the Barrett and Li framework, the other two cases with zero rent and trade declining or increasing ($\lambda^E_6 + \lambda^E_8$) were included in competitive equilibrium though they indicate that the market is still responding. Typically, disequilibrium has been defined as the complement of competitive equilibrium (i.e., either with positive rent or trade occurring with negative rent), but we can define a transitional condition, or transitional disequilibrium, which is evident when the market displays movement toward equilibrium though rent is still nonzero ($\lambda^E_4 + \lambda^E_{10}$). For example, declining trade with negative rent (regime 10) may indicate that traders are not initiating new shipments—thus the decline in trade—but that there are still likely to be some remaining shipments for the contracts made with the long-run competitive equilibrium includes $\lambda^E_5 + \lambda^E_7 + \lambda^E_9 + \lambda^E_4 + \lambda^E_{10}$. Perfect integration refers to the cases with zero rent with or without trade. Imperfect integration implies nonzero rent with trade. Market segregation prevails with no trade for nonzero rent ($\lambda^E_1 + \lambda^E_9$). Intermarket tradability is then the complement to market segregation ($1 - \lambda^E_1 - \lambda^E_9$).

Table 3. Indicators of Intermarket Conditions: B–L versus Extended

Indicators (Assuming no significant unmeasured transaction costs)				
Market Conditions	Defined in B-L Regimes: B-L	Included from		
	indicators	Extended Regimes	Defined using Extended Regimes	
Market equilibrium	$\lambda^B_{\emptyset T} + \lambda^B_{\emptyset N} + \lambda^B_{-N}$	$\lambda^E_5 + \lambda^E_6 + \lambda^E_7 + \lambda^E_8 + \lambda^E_9$	Same – Market equilibrium	$\lambda^E_5 + \lambda^E_6 + \lambda^E_7 + \lambda^E_8 + \lambda^E_9$
Segmented equilibrium	λ^B_{-N}	λ^E_9	Same – Segmented equilibrium	λ^E_9
Segmented disequilibrium	λ^B_{+N}	λ^E_1	Same – Trade Barriers	λ^E_1
Perfect integration	$\lambda^B_{\emptyset N} + \lambda^B_{\emptyset T}$	$\lambda^E_5 + \lambda^E_6 + \lambda^E_7 + \lambda^E_8$	Weakening market	λ^E_6
Imperfect integration	λ^B_{+T}	$\lambda^E_2 + \lambda^E_3 + \lambda^E_4$	Steady conditions	$\lambda^E_5 + \lambda^E_7$
			Strengthening market	λ^E_8
			Transitional Up	λ^E_4
	λ^B_{-T}	$\lambda^E_{10} + \lambda^E_{11} + \lambda^E_{12}$	Contracting and/or information lags	λ^E_3
			Risk aversion/Trade barriers	λ^E_2
			Transitional Down	λ^E_{10}
Transitional disequilibrium Intermarket tradability Column 1	Not measured in B-L $\lambda^B_{\emptyset T} + \lambda^B_{\emptyset N} + \lambda^B_{+T} + \lambda^B_{-T}$ Column 2	Contracting and/or information lags	λ^E_{11}	
		Unmeasured benefits	λ^E_{12}	
			$\lambda^E_4 + \lambda^E_{10}$	
			$1 - \lambda^E_1 + \lambda^E_9$	
			Column 4	
		Same	Column 5	

In summary, although the extended model is not expected to change the estimates of perfect and imperfect integration relative to Barrett and Li and earlier models, it does improve the understanding of the imperfectly integrated situations, and thus has several advantages. First, the extended system substantially reduces the interpretational multiplicity when disaggregating those “overall” regimes, such as $\lambda^B_{\emptyset T}$, λ^B_{+T} , and λ^B_{-T} into trade-change specific cases. Second, the trade adjustment information improves the model’s inferential capacity to distinguish between equilibrium and disequilibrium, and thus allows for a relatively better defined market condition, transitional (temporary) disequilibrium, which is important in understanding market performance particularly in emerging economies, and in the study of international commodity trade which involves longer time and higher transaction costs. Finally, it should be noted that we can always express a B–L indicator using extended regimes, which confirms the generality of the model developed in this paper.

Data

The log likelihood function of Equation (7) was estimated using biweekly data for the United States-China soybean trade and prices during the period from November 1995 to January 2004. The sample period is selected with several considerations. The period coincides with China’s reforms since mid 1990s in an effort to join WTO, and witnesses the nonmonopolization of the country’s soybean imports and China’s resumption of WTO membership in December 2001.

The U.S. cash price data are for Central Illinois No.1 soybeans. The ocean freight rate and the U.S. domestic inland barge rate are included as transportation costs. A 13% value added tax is levied in China on top of the landed price that includes a 3% tariff (Branson, 2004). The total price paid by the importer is calculated as: (U.S. price + transport cost)*(1.03)*(1.13). All U.S. prices are converted to Chinese yuan per metric ton for which the exchange rate is essentially fixed by the Chinese government with a less than 0.2%

standard deviation in value over the sample period. The Chinese futures price series is daily,⁶ and is changed into biweekly data by taking a simple average, as are the weekly transportation charges and U.S. soybean prices. Given a substantial delivery and payment lags in international commodity trade, 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 $s > j$. A former COFCO manager (Si, 2001) and industry traders (Meyer and Rameker, 2001) indicated that a 3-month delivery and payment lag was normal in the United States-China soybean trade, so the U.S. price is adjusted for interest until payment using the weekly U.S. 3-month T-bill interest rate which is available from the U.S. Federal Reserve Board. For example, the interest-adjusted U.S. cash price on January 20, 1995 will match the May contract 1995 maturing on May 13 which is discounted to the date of April 20, 1995 using the monthly Chinese 3-month lending interest rate published by International Monetary Fund, which is the most complete set available. 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, Carter, and Schmiesing, 1991). It should be noted, however, the DCE futures reflect the price in northeast China area where the harvest season coincides with that in the United States. The seasonal effect may be manifested in the off-season due to the low

⁶ Reuters Ltd. and Dalian Commodity Exchange supplied the data by electronic file. There was only one type officially called “soybean” contract at the outset of DCE, which is virtually for No. 1 soybeans (Non-genetically modified organism) and had four classes with Class 3 as par and Class 1 and Class 2 with 30 yuan and 10 yuan per metric ton higher respectively, and Class 4 at 30 yuan lower. Then between March 2002 and December 2004, DCE changed the contract name to “No. 1 soybean,” and started to quote both No. 1 (Non-GMO) and No. 2 (GMO) after December 2004. We basically use the Chinese futures prices for Class 3 No. 1 which has technical specifications most similar to No. 2 in CBOT.

inventory and convenience yield.⁷ Furthermore, because most of the crushers are located in the southern cities, the Chinese importers' revenues may be upwardly biased with DCE futures prices, which is partly offset with the use of No. 1 U.S. soybean prices.⁸

Rates reported in the *Grain Transportation Report* (USDA–Agricultural Marketing Service) are used to develop transportation cost 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 overseas rate used is for shipment from the Gulf of Mexico to Japan, which is the most complete set available. The rate data are 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 rate observations on shipments to China, which showed a satisfactory relationship when regressed on the corresponding Japanese rates; the relatively small differences between the rates for shipping to China and to Japan are assumed to be captured in typical variation around zero or nonzero rent.⁹

The specification of the trade volume indicator defined in Equations (5a)–(5d) was determined at a vessel level. The logic behind this decision is based on an analysis of shipping data and consideration of the fact that the majority of the vessels to China are filled to capacity. This data comes from the Port Import-Export Recording Service data set collected by the *Journal of Commerce*.

⁷ Convenience yield refers to the benefit a firm receives from holding stocks. For lower stocks, convenience yield is relatively high, and it may outweigh the marginal physical cost of storage in terms of cash-and-carry arbitrage between cash and futures markets.

⁸ An interview with Mr. Li, a business representative at a state-owned internet information company, www.dadouc.cn, shows that the prices of imported beans are substantively lower in southern cities than the northern area.

⁹ The estimation gives a relationship between the two as 0.98, which is not statistically different from one, with an insignificant positive intercept. The average difference between available contemporaneous rates (78 observations) to China and Japan was 0.84 \$/metric ton (standard deviation of 3.65), which is a small part of the overall cost of imported soybeans and about 3% of the average shipping cost of 26\$/metric ton to China during period.

Vessels carrying soybeans are aggregated and the difference from period to period calculated to assess trade changes. Over the sample period the average number of biweekly vessels shipping to China is 2.93 with a standard deviation of 4.38, the minimum was 0 (37.4% of observations) and the maximum is 23 vessels. The minimum volume for a shipload to be counted as a vessel for positive trade is 7500 metric tons, as smaller loads are considered to be identity preserved or seed soybeans not typical of wholesale trade. However the majority of shipments (82%) are essentially full Panamax size vessels carrying more than 50,000 metric tons of soybeans. In particular, if the observation at time t (k_t) is positive and one or more vessels less than shipped out during the observation for time $t - 1$ (k_{t-1}), then a “trade down” indicator is assigned to this observation. If the number of vessels shipping out is greater than the prior period then a “trade up” indicator is assigned. All other positive trade observations are regarded as no change and a “trade constant” indicator is assigned.

Empirical Model

Specific circumstances for the China soybean trade model are incorporated into Equation (7) as follows. In this analysis transportation, tariffs and discount rates have all been incorporated, but preWTO constraints on the market and risk could be expected to impact profit-seeking. A dummy variable is included to examine the possibility that the market situation induced traders to seek a higher return on their trades preWTO, “ $R_t - b$ ” in Equation (3) is respecified as “ $R_t - b_{\text{preWTO}} * \text{NWTO}$,” where b_{preWTO} represents the additional rent (or possibly discount) required by market participants preWTO and NWTO is a dummy variable that equals one preWTO and zero after.¹⁰ A positive parameter estimate would indicate the situation of nontariff barriers or a risk premium on either or both sides

¹⁰ An intercept was assigned to allow a non-zero intercept for all periods also, but dropped as it is not significantly different from zero. Estimation of an intercept in the regime model is not recommended unless there is a reason to expect one as when transactions costs are not measured.

Table 4. Regime Switching Model Estimates

Regime Frequencies									
Trade Information									
		No Trade		Trade Down		Trade Constant		Trade Up	
Arbitrage Rent	+	λ^E_1	0.13* (0.05)	λ^E_2	0.13* (0.03)	λ^E_3	0.11* (0.03)	λ^E_4	0.14* (0.04)
	0	λ^E_5	0.24* (0.05)	λ^E_6	0.03 (0.03)	λ^E_7	0.01 (0.03)	λ^E_8	0.20* (0.04)
	—	λ^E_9	0.00 (0.00)	λ^E_{10}	0.00 (0.00)	λ^E_{11}	0.00 (0.00)	λ^E_2	0.00 (0.00)
Intercepts and Variance Parameters									
$b_{\text{PRE-WTO}}$		$\sigma_{v,\text{US}}$		$\sigma_{u,\text{US}}$		$\sigma_{v,\text{SA}}$		$\sigma_{u,\text{SA}}$	
60.9* (13.5)		103.5* (12.5)		166.1* (24.8)		132.3* (11.1)		133.8* (24.7)	
Log likelihood: -1643.04. The number of biweekly observations is 214.									

Note: Standard errors are in parentheses below the parameter estimates.
* Indicates statistically significant above 95%.
SA = indicates South America harvest season.

of the market. To model the seasonal effects because of the SA competition, different variation parameters are assigned in estimating Equation (7) to the period from March to August ($\sigma_{v,\text{SA}}$, $\sigma_{u,\text{SA}}$) than the rest of the year ($\sigma_{v,\text{US}}$, $\sigma_{u,\text{US}}$).

The model is estimated in the maximum likelihood procedure in TSP 5.0 with the Broyden-Fletcher-Goldfarb-Shanno method for calculating the asymptotic covariance matrix of the parameter estimates via analytic first derivatives. Regime frequencies are derived from constrained¹¹ estimates (Tostão and Brorsen, 2005) and their standard errors are calculated using the delta method as found in the ANALYZ procedure in TSP.

Results and Discussion

Table 4 reports the results for Equation (7).

Regime Frequency Parameters

The frequency estimates for all non negative regimes are statistically significant above the 95% level except for λ_6 and λ_7 which are small. When no trade is taking place, occurring in 37% ($\lambda^E_1 + \lambda^E_5$) of the periods in the sample,

the model returns a regime frequency estimate of 13% for positive rent (λ^E_1), 24% for zero rent (λ^E_5). The trade-constant case occurs 12% of the time, 11% with positive rent. In the trade-up case with 34% of the periods observed, positive rent (λ^E_4) is observed less frequently than zero rent (λ^E_8) with 14 and 20% of the observations. The remaining observations take place with trade declining and 13% of these are allocated to a positive rent.¹²

Table 5 is presented based on the definitions in Column 3 and Column 5 of Table 3 and the estimates in Table 4, which empirically illustrates some of the conceptual points made earlier regarding the advantages of the broader approach. For example, the expanded regime switching space in the new model breaks down the 38% under “imperfect integration” into transitional-up ($\lambda^E_4 = 14\%$), information lags/uncertainty ($\lambda^E_3 = 11\%$), and risk aversion or trade barriers ($\lambda^E_2 = 13\%$).

The United States-China soybean markets are tradable 87% of the time, with 62% either in market equilibrium (λ^E_5 through λ^E_8) or transitional disequilibrium (λ^E_4). A significant estimate (13%) of regimes two and three (11%) demonstrates that the tradable markets can remain imperfectly integrated, and a total

¹¹ Tostão and Brorsen (2005) utilized a procedure to constrain the sum of the probability estimates to lie between 0 and 1. Their procedure overcomes the problem reported by many analysts using the parity bounds model when a probability regime approaches zero. This procedure was adapted to our four trade regimes.

¹² The average estimated margins of 104, 98, and 38 yuan for trade going down, constant, and up respectively indicate increasing degrees of market linkage with different trends in trade.

Table 5. Probability Estimates of Intermarket Conditions

B–L Indicators		Extended Indicators	
Market equilibrium	0.48	Same	0.48
Segmented equilibrium	0.00	Same	0.00
Segmented disequilibrium	0.13	Same	0.13
Perfect integration	0.48	Trade Down – Weakening market	0.03
		Trade Steady – Steady conditions	0.25
		Trade Up – Strengthening market	0.20
+ Rent Imperfect	0.38	Transitional Up	0.14
integration – Rent		Information and/or contracting lags	0.11
		Risk aversion/Trade barriers	0.13
	0.0	Transitional Down	0.00
		Information and/or contracting lags	0.00
		Unmeasured transaction benefits	0.00
Not available		Transitional disequilibrium	0.14
Intermarket tradability	0.87	Same	0.87

probability estimate of 37% for segregated disequilibrium (λ^E_1) and nontransitional disequilibria (λ^E_2 and λ^E_3) causes rejection of the hypothesis that the LOP holds for all time t . The causes of deviations from the long term competitive equilibrium are most likely those factors that tend to distort the market operations in the earlier periods, such as lack of price information (λ^E_3), limited competition or trade constraints (λ^E_1), and risk aversion in United States–China soybean trade (λ^E_2).

WTO Effect

The significant positive dummy variable parameter b_{preWTO} , as previously discussed, stands for the trade restrictions or the additional margin market participants required preWTO. This is consistent with the possibility that constraints to trade existed prior to China's membership that increased the price differential between markets, which is also confirmed by the drastic increase in trade post-WTO as shown in Table 1. Possible candidates include the reduction of formal and informal trade barriers and a reduction in perceived risk.¹³ As

additional private traders were allowed to import, more active reaction to opportunities in the market occurred. The risk premium may have come from either side of transactions by increasing the price charged to Chinese buyers or by reducing Chinese demand for imports unless the price difference between the two markets was higher. U.S. traders reported the occurrence of refused shipments by buyers in China over the period which might have induced them to charge more and Chinese buyers may have been wary about market interference leading them to demand a higher return before entering into trades.

Seasonality

The higher $\sigma_{v,SA}$ (132.3) estimate for the South American season, as compared with that for the United States $\sigma_{v,US}$ (103.5) (Table 4) demonstrates that a larger share of the US season observations falls within the zero rent regime. The difference between $\sigma_{v,US}$ and $\sigma_{u,US}$ illustrates the contrasting increase in volatility when the markets are linked less closely.

Corroboration: Graphs and Trade Frequencies

Figure 1A–D illustrate the time distribution of estimated deviations or rent in the cases of no trade, constant trade, trade going up, and trade going down, and the uneven shaded bands

¹³ Although there was no change in soybean tariffs and value-added tax post-WTO, changes such as the lowered share of the state trading agency in the soybean imports quota distribution have greatly weakened the government control over trade. The allowance of major Chinese companies to use international futures markets since 2001 may also help obviate the information lack and risk.

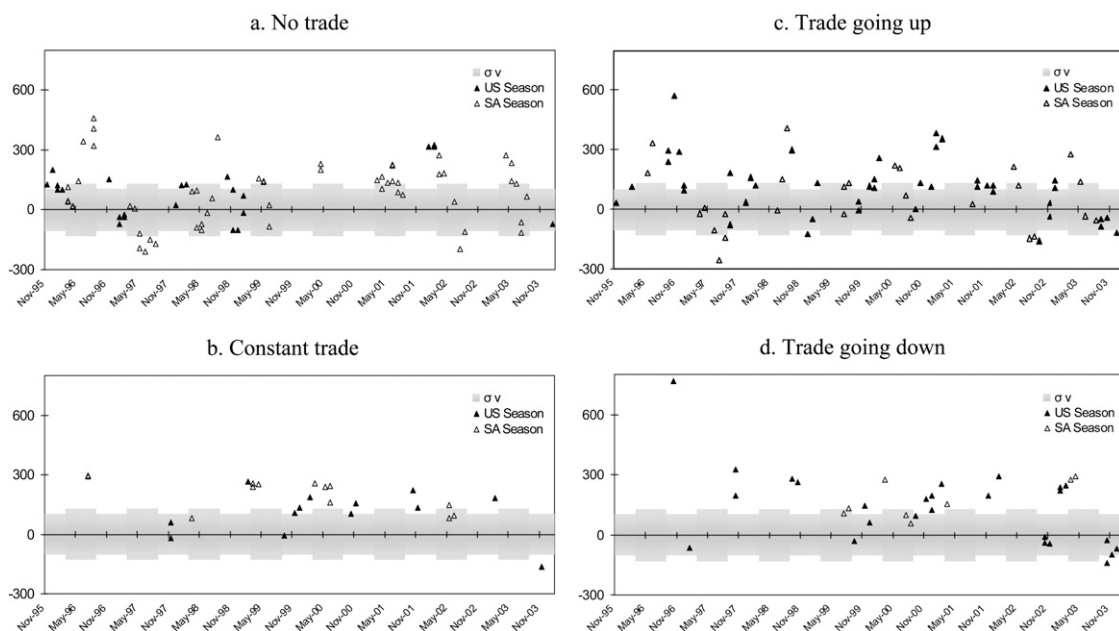


Figure 1. Time Distribution of Deviations around Zero Rent

comprise σ_v , US and σ_v , SA respectively.¹⁴ Greater deviations from zero are observed before the COFCO monopoly was terminated in 1996/1997. It seems logical to infer that increasing experience and growing confidence that trade would continue, and also that the price to be received could be estimated or locked in with futures contracts, led to increased trade and price responsiveness.

From the perspective of seasonal effects on the margins, 74% of the positive margin observations with zero trade occur in the SA season indicating that the United States–China markets are segregated because of the competitive prices from SA. The distribution of trading activities also confirms and substantiates the parametric results. The majority of zero-trade observations from the United States, 71%, take place during the SA season and this tendency increases post WTO. Most points with trade from United States to China

occur in the U.S. season; only 45.7% SA season observations show trade versus the U.S. season at 78.9%.

Conclusions

This paper examines the market integration and efficiency of soybean trade between the United States and China. The analytical model extends the development of Barrett and Li by using rate of trade rather than trade versus no-trade information in the joint probability model. This extension allows for separation of market conditions which previous methods do not, and improves analysts' capacity to distinguish between equilibrium, disequilibrium, and transitional periods.

The analysis also differs from previous works because it models prices intertemporally, accounting for the true arbitrage condition and the role of the futures commodity prices in formulating the expected prices. Another new feature in the extended model is the variation parameters that are designed to illuminate the seasonality effect which is common for agricultural products. The alteration in the market link in postWTO periods is also modeled explicitly.

¹⁴ Although there are observations around the zero line in the trade-down and trade-constant case, they are lop-sided toward being positive, and therefore captured by the σ_u 's and barely any probability is found for the zero-margin regime in maximizing the likelihood function.

Results from the application of the extended model to the United States–China soybean market indicate that the two markets are integrated in 87% of the sample periods, with over 60% of the study period in competitive equilibrium and transitional periods (Table 5). However, the frequency estimates of segmented disequilibrium and positive rent with trade going down or constant, cause a rejection of the hypothesis that the LOP holds for the entire period of the study, which likely indicates infrastructural limitations such as imperfect information and risk aversion which dampens market response in the country.¹⁵ By comparison, a trade-no trade specification could only show that efficient arbitrage conditions prevail less than 50% of the time, and it lacks the capability to differentiate the likelihood of transitional disequilibrium, imperfect information, risk aversion, and trade restraints.

Reduction in extreme positive and negative returns is observed after 1996/1997, indicating improved integration after China's efforts to introduce more competition into their marketing system and the more liquid operation of soybean futures markets at DCE. The two markets are also found to be linked more closely after China's WTO membership, and a looser link is manifested during the South America shipping season, a major competitor to the United States in the Chinese soybean market.

Based on the empirical results above, we can reasonably argue that China's moves toward freer trade and markets since the mid 1990s in preparation for WTO membership have been fairly effective in opening the

Chinese agricultural markets to the world. To make the relationship closer, greater efforts are probably needed to improve information availability and the competitive structure, and relax the formal and informal trade barriers.

There are several limitations in this study. First, the lack of a cash market price series in the southern port cities of China prevents the estimation of risk impacts from the Chinese cash market. With the information in the spot market of the underlying commodity, the futures market fluctuation could also be better understood. Second, if unmeasured relevant transaction costs data are nonstationary they cannot be captured correctly by an estimated intercept, and the estimated variances may either reflect the price relationship or the trending transaction costs. Third, 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. Finally, the negative regimes don't emerge in the analysis of United States to China soybean trade. However, they might in other environments.

Much is yet to be learned regarding the usefulness of this expansion of the regime switching models. The expansion to four trade regimes does enable better understanding of market conditions, but as our application dealt with both a market in transition and seasonal variations in trade the model becomes quite complex. Researchers examining these models are advised to evaluate their underlying assumptions carefully and test the robustness of results across formulations. Experimentation with this expanded data set and its detailed information on transaction costs suggests that researchers should be careful about including an intercept in regime switching models as the estimates of the parity bound model variances can be profoundly affected by unnecessary ones, though they are appropriate in many circumstances. Future analysts may find this an interesting line to examine via simulation. Finally, our ability to estimate this complex model in the parity bounds framework is encouraging and will hopefully encourage

¹⁵ In their Monte Carlo analysis, Barrett and Li (2002) demonstrate that the normality assumption 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 could arise because of the distributional assumption, may overestimate the disequilibrium regimes (λ^E_1 , λ^E_2 , λ^E_3 , and λ^E_4). However, the large number of positive rent observations before estimation (156 versus 68 negative observations) should lessen that concern, in addition to the central limit theorem proposition that normality can be approximated as the sample size increases.

researchers to consider incorporating other aspects of market conduct into these types of models.

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References

- Baffes, J. "Some Further Evidence on the Law of One Price: The Law of One Price Still Holds." *American Journal of Agricultural Economics* 73(1991):1264–73.
- Barrett, C.B., and J.R. Li. "Distinguishing Between Equilibrium and Integration in Spatial Price Analysis." *American Journal of Agricultural Economics* 84(2002):292–307.
- Baulch, B. "Transfer Costs, Spatial Arbitrage, and Testing for Food Market Integration." *American Journal of Agricultural Economics* 79(1997):477–87.
- Blank, S.C., C.A. Carter, and B. Schmiesing. *Current Issues, Approaches, and Empirical Findings, Futures and Options Markets*, Chapter 14. Englewood Cliffs, NJ: Prentice Hall, 1991.
- Branson, A. Personal E-mail Communication. Agriculture Specialist, Agricultural Affairs Office, United States Embassy, Beijing, October 2004.
- Dhrymes, P.J. "On the Strong Consistency of Estimators for Certain Distributed Lag Models with Auto-correlated Errors." *International Economic Review* 12(1971):329–43.
- Frydman, R. "A Proof of the Consistency of Maximum Likelihood Estimators of Non-Linear Regression Models with Auto-Correlated Errors." *Econometrica* 48,4(1980):853–60.
- Low, A.H.W., J. Muthuswamy, and R.I. Webb. "Arbitrage, Cointegration, and the Joint Dynamics of Prices across Discrete Commodity Futures Auctions." *Journal of Futures Markets* 19(1999):799–815.
- McNew, K., and P.L. Fackler. "Testing Market Equilibrium: Is Co-Integration Informative?" *Journal of Agricultural and Resource Economics* 22,2(1997):197–207.
- Meyer, P., and K. Rameker. Personal Communication. Portland, Oregon, 2001.
- Michael, P., A.R. Nobay, and D.A. Peel. "Purchasing Power Parity Yet Again: Evidence from Spatially Separated Commodity Markets." *Journal of International Money and Finance* 13,6(1994):737–57.
- Park, A., H. Jin, S. Rozelle, and J. Huang. "Market Emergence and Transition: Arbitrage, Transaction Costs, and Autarky in China's Grain Market." *American Journal of Agricultural Economics* 84,1(2002):67–82.
- Sexton, R.J., C.L. Kling, and H.F. Carman. "Market Integration, Efficiency of Arbitrage, and Imperfect Competition: Methodology and Application to US Celery." *American Journal of Agricultural Economics* 73,3(1991):568–80.
- Shyy, G., and B. Butcher. "Price Equilibrium and Transmission in a Controlled Economy: A Case Study of the Metal Exchange in China." *Journal of Futures Markets* 14,8(1994):877–90.
- Si, W. Personal communication. Corvallis, Oregon, 2001.
- Tostão, E., and W. Brorsen. "Spatial Price Efficiency in Mozambique's Post-Reform Maize Markets." *Agricultural Economics* 33,2(2005):205–14.
- United States Department of Agriculture-Foreign Agricultural Service. *China, People's Republic of, Oilseeds and Products Annual, Part 1*. Washington, DC: United States Department of Agriculture, 2001. Internet site: <http://www.fas.usda.gov/gainfiles/200103/65679919.pdf> (Accessed September 2009).
- United States Department of Agriculture-Foreign Agricultural Service. *China: People's Republic of, Oilseeds and Products Annual, Part 1*. Washington, DC: United States Department of Agriculture, 2005 and various years. Internet site: <http://www.fas.usda.gov/scripts/AttacheRep/legacy.asp> (Accessed September 2009).
- United States Department of Agriculture-Foreign Agricultural Service. *Oilseeds World Markets and Trade-December*. Washington, DC: United States Department of Agriculture, 2006 and earlier years. Internet site: http://www.fas.usda.gov/oilseeds_arc.asp (Accessed September 2009).
- Yu, C. "Analysis on China's Soybean Price Co-integration." *International Business Journal of the University of International Business and Economics* 5(2007):44–48 [in Chinese].
- Yu, W., and J. Huang. "On the Reform of Chinese Grain Markets: An Co-Integration Analysis of the Chinese Rice Markets." *Economic Research Journal* 3(1998):50–57.
- Zanias, G.P. "Testing for Integration in European Community Agricultural Product Markets." *Journal of Agricultural Economics* 44,3(1993):418–27.