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The Increasing Participation of China in the World Soybean Market and Its Impact on Price Linkages in Futures Markets

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This paper examines price linkages between soybean futures contracts traded in China, U.S, Brazil and Argentina for the period ranging from 2002 to 2011. The main findings show that U.S. prices still appear to have a dominant role to explain price changes in international markets. Results also indicate stronger linkages between prices in China and in the other three markets, especially after 2006. This result suggests the Chinese market has become more integrated with international markets in recent years, which might reflect the growing participation of China in international trade and the development of its soybean futures contract.

Keywords: soybeans, futures markets, China, price linkages

INTRODUCTION

The world market for soybeans has typically been characterized by high concentration on both supply and demand sides. U.S, Brazil and Argentina are the major producers and exporters. According to the UN-COMTRADE (2011), total exports by these countries responded for almost 90% of all soybeans traded over the past eleven years. On the demand side, data from the UN-COMTRADE (2011) show that China and E.U. currently account for approximately60% and 15%, respectively, of all soybean imports in the world.

However, China only emerged as a major soybean importer during the last decade. Until 2002 China was the second largest importer in the soybean market, but since then it started to import increasing quantities of soybeans. Between 2002 and 2010 soybean imports by China grew at an average rate of 23% per year. This expansion implies that China currently buys most of the soybeans exported by Brazil, U.S. and Argentina. In 2010, China was the destination of 64% of Brazilian soybean exports, 56% of U.S. soybean exports, and 82% of Argentine soybean exports (UN-COMTRADE, 2011).

During the last decade China has also expanded its futures markets. Data from the Futures Industry Association (FIA) shows that eight of the ten most traded commodity futures contracts in the world are currently in China.[1] The Dalian Commodity Exchange (DCE) is one of the most important commodity exchanges in China and has reached records of trading volume in recent years. The volume of DCE's soybean futures contract increased almost tenfold between 2002 and 2008 (from 25.4 million contracts in 2002 to 227.4 million in 2008), and then dropped to 50.5 million contracts in 2011 (DCE, 2011).

No recent study has explored how the increasing participation of China in the soybean world trade since 2002 and the expansion of its futures markets have affected price relationships between all four major soybean countries. Only Zhao et al. (2010) attempted to investigate price linkages between China, Brazil, U.S. and Argentina recently, but they only used spot prices from Brazil, U.S. and Argentina between November 2006 and July 2009. In addition, they focused on changes in price relationships before and after September 2008. Further studies are needed in this topic in order to also incorporate futures prices in all

[1]White sugar, rubber, cotton, soybeans, soybean oil, soybeans meal are some examples. However, note that contract size in Chinese futures markets tend to be smaller than in other countries.

countries, expand the sample period to capture the strong growth of Chinese imports in the early 2000's, and take into account the large increase and subsequent decrease in Chinese futures trading.

The objective of this paper is to explore price linkages in soybean futures markets. In particular, this study will investigate the existence of short- and long-run price relationships between soybean futures contracts traded at the Dalian Commodity Exchange (DCE) in China, CME Group in U.S, BM&FBOVESPA in Brazil and Mercado a Término de Buenos Aires (MATba) in Argentina. These four countries were selected because they have been the most active players in the soybean market for several years and their exchanges offer futures contracts on soybeans. The sample period goes from 2002 to 2011 and will be divided into three sub-periods so that it will be possible to analyze how recent changes in international trade of soybeans and futures trading volume in China affected price linkages. The first sub-period will be 2002-2006 when China was importing growing quantities of soybeans from U.S and Brazil, but the trading volume at the DCE was still low. The second sub-period will be 2006-2009, which was still characterized by rising imports and also by large increases in futures trading volume in China. The third sub-period will be 2009-2011 when futures trading volume decreased in China.

Results from this research can provide new insights into the role of international trade and futures trading in the development of price linkages between emerging and developed markets, along with correlation structures between those markets. Further, it can help shed light into the dynamics of the soybean world market and provide updated information on how prices are transmitted as China emerges as a major importer and develops its own domestic market.

PREVIOUS RESEARCH

The literature has generally recognized the benchmark role of the U.S soybean futures contract. The U.S. market presented in many studies a dominant role in the transmission of returns and volatilities. However, other studies have also shown evidence of bidirectional price relationships between Argentina, Brazil, China and Japan.

A study focusing exclusively on spot prices was conducted by Margarido et al. (2007). They used import prices from the Rotterdam port and export prices from Brazil, Argentina and U.S. on a monthly basis from October 1995 to October 2003. Their findings suggest the existence of a long-run relationship between the four prices, but limited short-run interaction. Rotterdam and U.S. appeared to be price makers in the international market, while prices from Brazil and Argentina did not influence the behavior of U.S. and Rotterdam prices. Moreover, the large Brazilian soybean exports to E.U. may have explained the most relevant impacts of price changes from the Rotterdam price variations to Brazilian prices, when compared to the effects from the U.S. market to Brazilian market.

During the sample period adopted by Margarido et al. (2007) the E.U. was still the major importer of soybeans in the world market, while U.S., Brazil and Argentina were already the main exporters. More recent studies considering a time period when China had already developed its futures market and become the largest soybean importer started to explore price linkages with China, both in the spot and futures markets. Liu and An (2009) investigated linkages between soybean prices using daily spot and futures prices in China and futures prices in the U.S. from January 1998 to December 2008. They found bidirectional relationships between spot and futures prices in China, spot prices in China and futures prices in the U.S., and futures prices in both countries. Additionally, there was significant volatility spillover between markets, with greater magnitude from U.S. futures market to the Chinese futures market. The authors also used information shares adjusted for non-synchronous trading to explore the price discovery process. They found the U.S. contribution was 42.71%, while the shares of the Chinese futures and spot markets were 40.21% and 17.08%, respectively.

A broader study was conducted by Zhao et al. (2010), who examined how export prices from U.S., Brazil and Argentina were linked to spot and futures prices in China. They used daily prices from China (spot and futures), Brazil (FOB Paranaguá), Argentina (FOB Up River) and U.S. (CIF Gulf). The authors found that the relationship between Chinese futures prices and international prices is stronger than the one involving Chinese spot prices and foreign prices. Furthermore, the study presented that Chinese domestic market (spot and futures) has feedback effects of pricing in the international market, represented by U.S, Brazil and Argentina. The study found bidirectional relationship between Argentine prices and Chinese spot and futures prices, and also between DCE and U.S. (CIF Gulf). According to the authors, as a possible reflection of the reduction in Brazilian soybean exports to China in 2007, Brazilian prices seemed to be impacted by the Chinese futures prices, but the opposite relationship was not observed.

Zhao et al. (2010) also wanted to assess the impacts of the global financial crisis in 2008 on soybean markets. They split the sample into two subperiods, defining September 15th, 2008 as the break point. Their results show that, after September 2008, the magnitude of the VECM coefficients have considerably changed, including the error correction terms, whose estimated parameters increased comparing to the prior period.

Those recent studies show evidence of linkages between Chinese prices and international prices. These findings contrast with results from early papers on price linkages between China and other soybean markets, suggesting that the connection between China and the world market has emerged and become stronger in the last decade. One of the first studies on this topic is Si (2001), who used weekly closing prices between January 1996 and April 1999 to test the Law of One Price for soybean futures contracts traded in China (DCE) and U.S. (CME). The findings already indicated that both futures prices were integrated in the long run. However, linkages appeared to be weaker in the short-run dynamics. Si (2001) argued that price relationships in the short-run were not as clear as in the long run because the Chinese futures prices were still very sensitive to local factors. Some of those factors were (i) the domestic soybean supply system, whose railway transportation was very susceptible to climatic effects; (ii) the Chinese agricultural policy which implemented the Minimum Price Policy (MPP) in order to support the soybean farmers and ensure self-sufficiency for grains and vegetable oils; and (iii) market manipulation due to the action of speculators, because liquidity of Chinese futures markets was incipient during their sample period.

RESEARCH METHODS

Price linkages between China, U.S., Brazil and Argentina soybean futures markets will be investigated with cointegration techniques and error correction. Unit root (ADF) test will be adopted to test for stationarity of each price series and Johansen's cointegration will be used to test the existence of a long-run relationship between the four series. If the series are found to be cointegrated, a system with four equations will be estimated as in equations (1) to (4), where ΔP_{USA}, ΔP_{CHN}, ΔP_{BRA}, ΔP_{ARG} are daily futures price changes in the U.S., China, Brazil and Argentina, respectively, and ECT is the error correction term.

$$\Delta P_{USA,t} = \alpha_1 + \sum_{i=1}^{k} \varphi_1 ECT_{i,t-1} + \sum_{j=1}^{p} \beta_j \Delta P_{USA,t-j} + \sum_{l=1}^{q} \beta_l \Delta P_{CHN,t-l} + \sum_{m=1}^{r} \beta_m \Delta P_{BRA,t-m} + \sum_{n=1}^{s} \beta_n \Delta P_{ARG,t-n} + \varepsilon_t \quad (1)$$

$$\Delta P_{CHN,t} = \alpha_2 + \sum_{i=1}^{k} \varphi_2 ECT_{i,t-1} + \sum_{j=1}^{p} \gamma_j \Delta P_{USA,t-j} + \sum_{l=1}^{q} \gamma_l \Delta P_{CHN,t-l} + \sum_{m=1}^{r} \gamma_m \Delta P_{BRA,t-m} + \sum_{n=1}^{s} \gamma_n \Delta P_{ARG,t-n} + \varepsilon_t \quad (2)$$

$$\Delta P_{BRA,t} = \alpha_3 + \sum_{i=1}^{k} \varphi_3 ECT_{i,t-1} + \sum_{j=1}^{p} \delta_j \Delta P_{USA,t-j} + \sum_{l=1}^{q} \delta_l \Delta P_{CHN,t-l} + \sum_{m=1}^{r} \delta_m \Delta P_{BRA,t-m} + \sum_{n=1}^{s} \delta_n \Delta P_{ARG,t-n} + \varepsilon_t \quad (3)$$

$$\Delta P_{ARG,t} = \alpha_4 + \sum_{i=1}^{k} \varphi_4 ECT_{i,t-1} + \sum_{j=1}^{p} \theta_j \Delta P_{USA,t-j} + \sum_{l=1}^{q} \theta_l \Delta P_{CHN,t-l} + \sum_{m=1}^{r} \theta_m \Delta P_{BRA,t-m} + \sum_{n=1}^{s} \theta_n \Delta P_{ARG,t-n} + \varepsilon_t \quad (4)$$

The price discovery mechanism will be discussed based on the information shares developed by Hasbrouck (1995). This framework is based on the notion that there are transitory and permanent components in a system of prices. The permanent component is typically called common factor or common efficient price, and information shares look at the proportion of the total variance of the common factor that can be attributed to each price series in the system. Hasbrouck information shares (S) are calculated as in equation (5), where $\psi_j^2 \Omega_{jj}$ represents the contribution of market *j* to the variance of the common factor and $\psi\Omega\psi'$ represents the variance of the common factor. The term Ω corresponds to the covariance matrix of the set of prices, and ψ refers to the sum of the moving average coefficients of the price series.

$$S_j = \frac{\psi_j^2 \Omega_{jj}}{\psi\Omega\psi'} \quad (5)$$

The term $\psi\Omega\psi'$ corresponds to the variance of the component of price variation that is permanently impounded on the price of an asset due to new information. The information share of market *j* (*j* = 1, …, n) is defined as the proportion of $\psi\Omega\psi'$ from market *j* in relation to total variance. That is, the information share corresponds to the proportion of the total variance of the common factor contributed by a specific market.

Hasbrouck's information shares start from the estimation of an error correction model then decomposes the impact of a perturbation and allocates this impact to the markets. This procedure implies that information shares can yield different results depending on the order of the prices in the system. In order to avoid this problem, Lien and Shrestha (2009) proposed a new technique which relies on decomposing the covariance matrix based on the correlations between the series. Their procedure adopts a transformation of the orthogonalized matrix used by Hasbrouck (1995), which is calculated as: $F^* = [G\Lambda^{-1/2}G^T V^{-1}]^{-1}$. In summary, Λ represents a diagonal matrix whose non-zero elements are the eigenvalues of a matrix that corresponds to the innovation correlation matrix. The corresponding eigenvectors are grouped in the columns of matrix G, while V refers to a diagonal matrix that contains the innovation standard deviation in its principal diagonal. Lien and Shrestha (2009) approach provides a single information share for each market that is independent in terms of the ordering of price series, improving the technique proposed by Hasbrouck (1995).

DATA

Daily soybean futures prices were obtained from Barchart and the websites of the futures exchanges in Brazil (BM&FBovespa), Argentina (Matba) and China (Dalian Commodity Exchange). They are all closing prices and were converted to US$/bu. The sample period goes from 10/11/2002 to 12/29/2011 (2,004 observations). The data set is split into three sub-periods in order to explore how recent changes in international trade and in futures trading volume may have impacted price and volatility relationships between the four markets. The first sub-period goes from October 11th, 2002 to September 29th, 2006 and is characterized by rising Chinese imports of soybeans but still low trading volume of soybean futures contracts at the DCE. The second sub-period goes from October 9th, 2006 to December 30th, 2008, when Chinese imports of soybeans continued rising and there was large increases in the trading volume of the DCE soybean futures contract. The third sub-period goes from January 5th, 2009 to December 29th, 2011, during which Chinese imports kept a strong growth but the futures trading volume at the DCE dropped sharply.

An important point in this study is the difference in trading hours across the four futures exchanges. Trading sessions in local time run from 9:30 am to 1:15 pm in the U.S. (CME Group), 9 am to 11:30 am and 1:30pm to 3pm in China (DCE), 9am to 2:15 pm in Brazil (BM&FBovespa), and 11:30 am to 3:15 pm in Argentina (Matba). Brazil and Argentina are in the same time zone, which is three hours ahead of the U.S. However, the time difference varies during the year according to daylight savings time in each of the three countries. China is fourteen hours ahead of the U.S. and eleven hours ahead of Brazil and Argentina. Time differences between China and the other countries also vary during the year because of daylight savings time in Brazil, Argentina and U.S. (China does not adopt daylight savings time). Table I (Appendix) illustrates the time differences between trading sessions.

RESULTS

The stationarity and cointegration tests showed that the four price series are first-order integrated and cointegrated for the whole period and also for each sub-period. In fact, Johansen's test indicated the presence of two cointegrating vectors for the whole period and one cointegrating vector for each of the sub-periods. Graphs with the four prices series in level (Figure II) and in first-difference (Figure III) are presented in the Appendix.

First an error correction model (ECM) was estimated for the whole period and estimated coefficients are presented in Table 2[2]. Results show that the estimated coefficients of the error correction term (ECT) are statistically distinguishable from zero for all countries but Argentina, indicating that U.S., Brazil and China participate in the adjustments to shocks in their long-run equilibrium relationship. The magnitudes of the estimated coefficients of the ECT suggest that U.S. prices adjust more rapidly than Brazilian and Chinese prices, but the differences in the speed of adjustment appear to be small. The estimated coefficient of lagged price changes show mixed results. There appears to be more interaction between U.S., Brazil and China, but Argentine prices do not appear to interact with the other three markets. Thus ECM results suggest relatively stronger short-run dynamics between U.S., Brazil and China, with little participation of Argentina.

Table 1: Estimated error correction models for the whole period.

Independent variables	Dependent variables			
	$\Delta Pusa_t$	$\Delta Pchn_t$	$\Delta Pbra_t$	$\Delta Parg_t$
Constant	-0.0083***	0.010	-0.059***	0.021
	(-3.35)	(0.501)	(-2.731)	(1.599)
$ECT_{1,t-1}$	-0.036***	0.021**	0.020**	-0.001
	(-3.275)	(2.255)	(2.063)	(-0.296)
$ECT_{2,\,t-1}$	0.012***	-0.002	0.005*	-0.001
	(3.823)	(-0.845)	(1.875)	(-1.153)
$\Delta Pusa_{t-1}$	0.090***	0.229***	0.200***	0.019
	(2.617)	(7.734)	(6.613)	(1.052)
$\Delta Pchn_{t-1}$	-0.006	-0.110***	0.048**	0.017
	(-0.256)	(-5.059)	(2.148)	(1.232)
$\Delta Pbra_{t-1}$	-0.031	-0.019	-0.103***	-0.025
	(-0.963)	(-0.715)	(-3.622)	(-1.447)
$\Delta Parg_{t-1}$	-0.072	0.194***	-0.039	0.006
	(-1.229)	(3.869)	(-0.773)	(0.204)

Note: t statistics in parentheses; significance level: *** 1%; **5%; *10%.

ECMs were further estimated for three sub-periods determined by participation of China in international trade and Chinese futures trading activity. Results for each sub-period are presented in Table 2. In the first sub-period the estimated coefficients of the ECTs are statistically distinguishable from zero in the U.S., Brazil and Argentina equations, but not in the China equation. In the second and third sub-periods, statistical significance of the ECT emerges only in the China and Brazil equations. This finding indicates that Chinese prices started participating in the long-run adjustment process only in the second sub-period, suggesting a stronger interaction between China and the other markets has developed since 2006. This closer connection between Chinese prices and other prices might be a consequence of China's growing volumes of soybean imports and the stronger development of futures trading at DCE since the mid-2000's. The estimated coefficients of lagged price

[2]The lag structure was selected based on the SBC.

changes offer mixed results again, but appear to suggest limited short-run interaction between prices. The U.S. and Argentina equations show little statistical significance of lagged price changes in all sub-periods. In the China and Brazil equations, U.S. price changes are statistically distinguishable from zero in all sub-periods, but there is little to no significance in the other variables.

Table 2: Estimated error correction models for the three sub-periods

Independent variables	Dependent variables $\Delta Pusa_t$	$\Delta Pchn_t$	$\Delta Pbra_t$	$\Delta Parg_t$
First sub-period				
Constant	-0.093**	0.031	0.094***	-0.042*
	(-3.211)	(1.393)	(3.200)	(-2.280)
$ECT_{1,t-1}$	-0.037**	0.011	0.037***	-0.017*
	(-3.260)	(1.341)	(3.187)	(-2.334)
$\Delta Pusa_{t-1}$	0.116*	0.219***	0.104**	-0.042
	(2.405)	(4.736)	(2.218)	(-0.163)
$\Delta Pchn_{t-1}$	0.009	-0.151***	0.114***	0.025
	(0.415)	(-4.074)	(3.577)	(1.102)
$\Delta Pbra_{t-1}$	-0.058	0.030	-0.164***	0.025*
	(-1.264)	(1.224)	(-3.698)	(-1.895)
$\Delta Parg_{t-1}$	-0.052	0.220**	0.114*	0.025
	(-0.459)	(3.129)	(1.805)	(0.740)
Second sub-period				
Constant	0.001	-0.040*	-0.040*	-0.001
	(1.429)	(-3.240)	(-4.897)	(-1.529)
$ECT_{1,t-1}$	0.014	0.093***	0.081***	0.007
	(1.395)	(3.235)	(4.882)	(1.575)
$\Delta Pusa_{t-1}$	0.033	0.295***	0.268***	-0.021
	(0.048)	(2.874)	(2.556)	(-0.673)
$\Delta Pchn_{t-1}$	-0.018	-0.155***	0.015	0.019
	(-0.454)	(-3.062)	(0.026)	(0.368)
$\Delta Pbra_{t-1}$	0.039	-0.032	-0.094	0.015
	(0.302)	(-0.149)	(-1.116)	(0.571)
$\Delta Parg_{t-1}$	-0.097	0.287*	-0.211	0.016
	(-0.798)	(2.588)	(-1.492)	(0.123)
Third sub-period				
Constant	0.103	0.699***	0.787***	0.200
	(1.429)	(3.240)	(4.897)	(1.375)
$ECT_{1,t-1}$	0.009	0.064***	0.073***	0.018
	(1.395)	(3.235)	(4.882)	(1.229)
$\Delta Pusa_{t-1}$	0.088	0.108*	0.125*	0.050
	(0.048)	(2.874)	(2.556)	(0.673)
$\Delta Pchn_{t-1}$	0.012	-0.070*	0.065	0.005
	(0.454)	(-2.862)	(0.026)	(0.368)
$\Delta Pbra_{t-1}$	-0.113*	-0.029	-0.092*	-0.045
	(-2.302)	(-0.149)	(-3.116)	(-0.571)
$\Delta Parg_{t-1}$	-0.006	0.105	0.017	-0.019
	(-0.798)	(1.588)	(1.492)	(-0.123)

Note: t statistics in parentheses; significance level: *** 1%; **5%; *10%.

In terms of information shares (IS), the original measure proposed by Hasbrouck (1995) leads to upper and lower bounds, implying IS are ordering dependent. However, the measure proposed by Lien and Shrestha (2009) provides a unique value for information share, which they called ‘modified information share’ (MIS). The MIS were calculated for the whole sample period defined in this study and are presented in Table 3. Overall the MIS indicates that China was responsible for 50.86% of the price discovery process, followed by U.S. with 32.59%. Argentina and Brazil presented small percentages. These findings suggest that Chinese prices are responsible for approximately half of the variance of the common factor between the four markets, i.e. the price discovery process in the soybean market is dominated by China. These findings are consistent to those reported by Liu and An (2009) for Chinese and U.S. markets.

Table 3. Modified Information Share – MIS

Market	MIS (%)
U.S.	32.59
China	50.86
Brazil	5.55
Argentina	11.00

CONCLUSIONS

This paper aimed to investigate soybean futures price linkages between China, U.S, Brazil and Argentina over the past ten years. In particular, this research wants to explore how the increasing participation of China in the soybean international trade and the growing trading volume in Chinese futures market might have impacted price relationships between the four main players in the soybean market.

Results of the cointegration analysis and error correction model estimation suggest that Chinese prices participate in the adjustment to the long-run equilibrium between the four markets and also in the short-run dynamics. There is also evidence of stronger linkages between Chinese prices and prices in the other three markets after 2006. The findings appear consistent with the idea that the growing Chinese participation in international trade and the development of its soybean futures contract might have created a closer connection between prices in China and other markets.

One challenge in this research lies in different time zones where soybean futures prices are traded (Table I, Appendix). Results presented in this paper were obtained with closing prices in each futures exchange taken on the same day. However, Chinese closing prices on a given calendar day are known before futures trading start in U.S., Brazil and Argentina on the same calendar day. It remains to be explored whether price linkages could differ from the current results if Chinese closing prices are taken on the next calendar day compared to the other three prices, or if Chinese open prices are used. Therefore, one of the next steps of this research is to consider other combinations of open and closing prices in order to address the large time differences between the four futures markets.

Finally, a further step in this research will be the investigation of correlations and volatility spillovers between the four major players, which will rely on the dynamic conditional correlation - GARCH framework proposed by Engle (2002).

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APPENDIX

Figure I. Volume of soybean futures contracts at the Dalian Commodity Exchange – DCE (China)

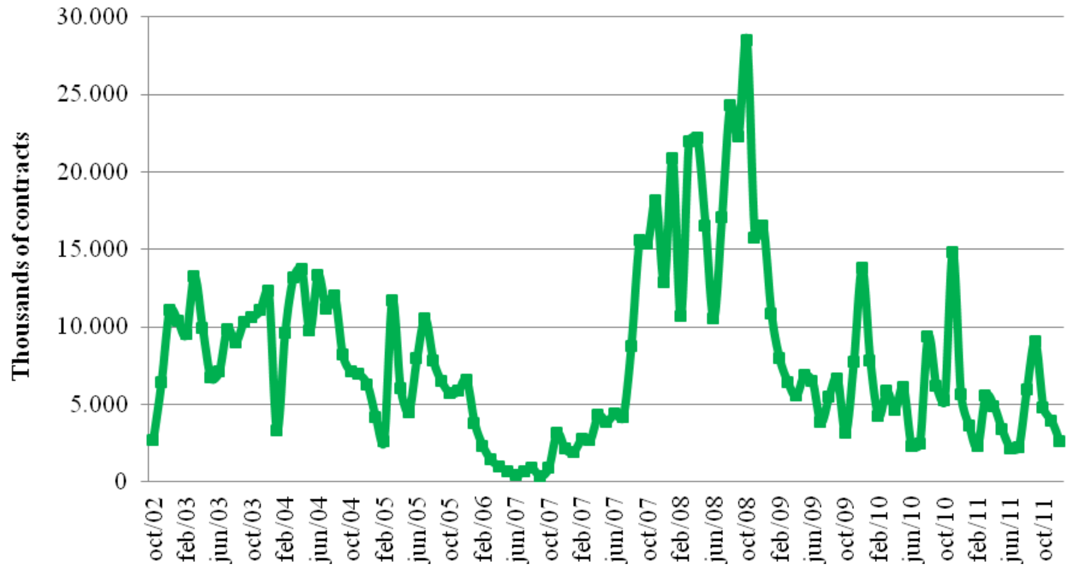

Figure II. Daily soybean futures prices over time (US$/bu)

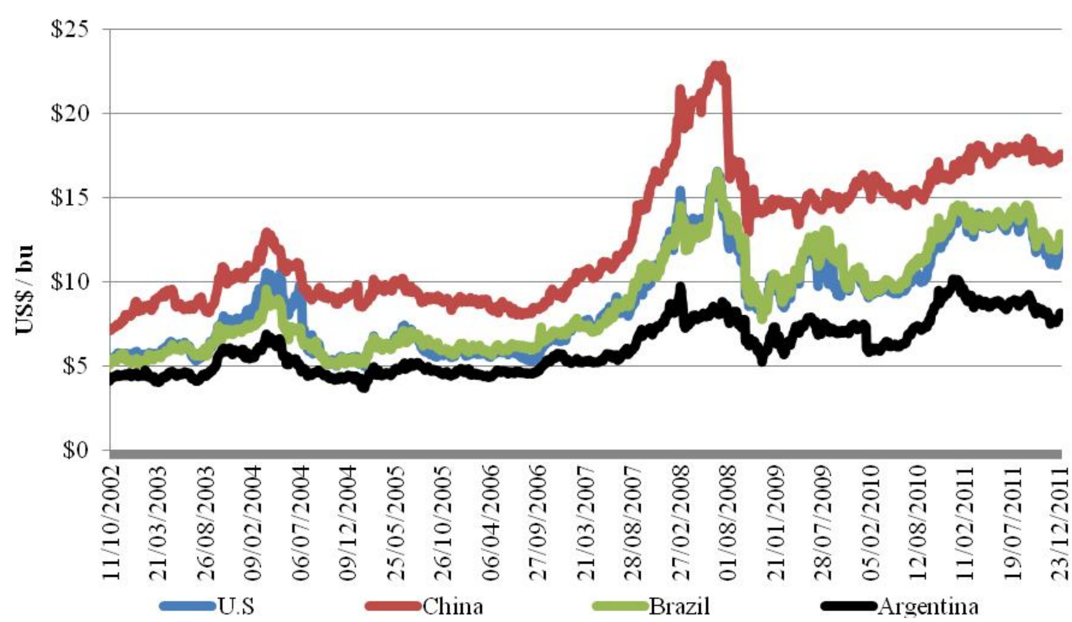

Figure III. Daily soybean futures price changes (%)

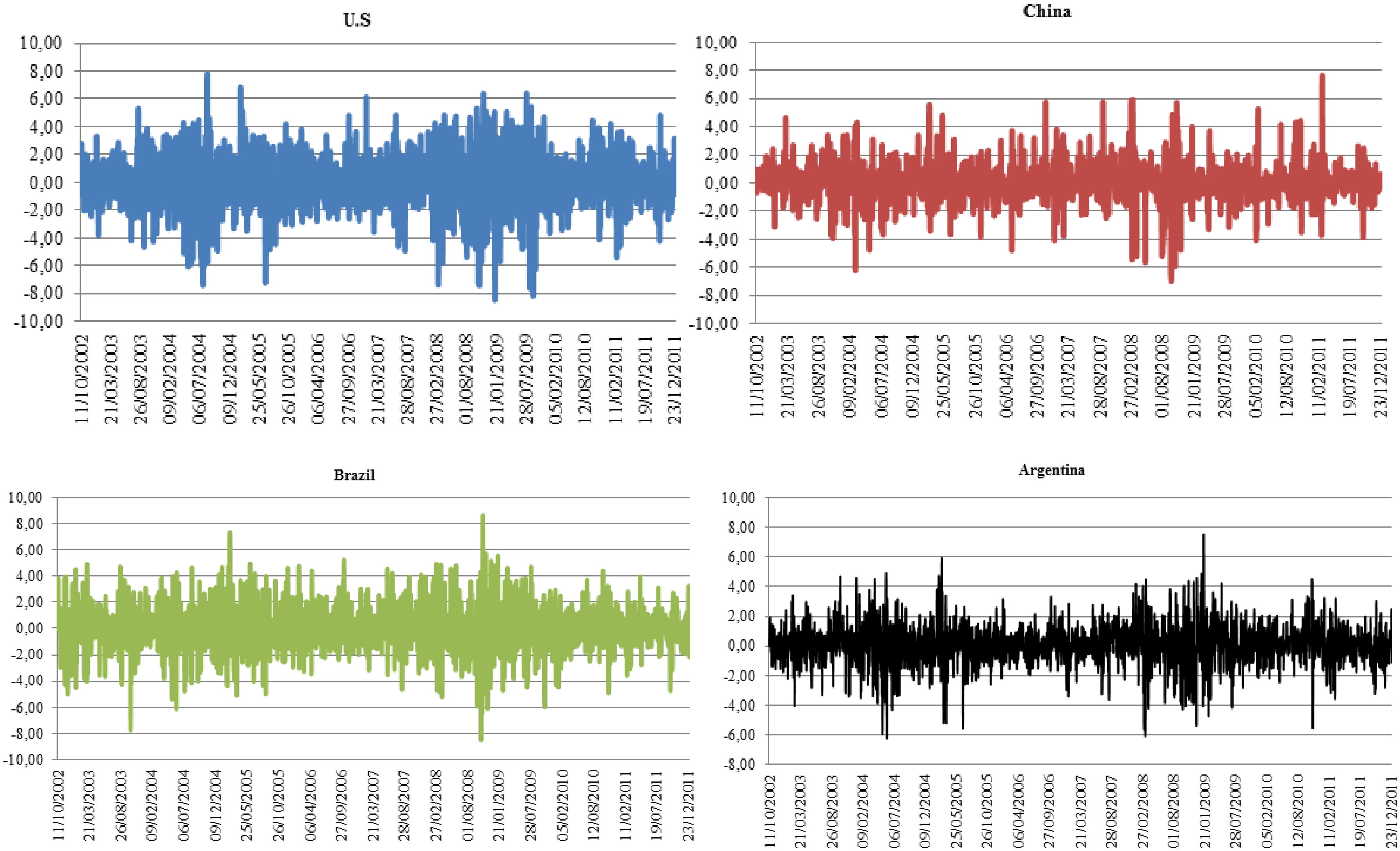

Table I. Differences in Time Zones

	Brazil	Argentina	U.S.	China
Brazil	-	Same time zone (+/- 1 h, DST)	+ 3hs (+/- 1h, DST)	-11 hs (+ 1 h, DST)
Argentina		-	+ 3hs (+/- 1h, DST)	-11 hs (+ 1 h, DST)
U.S.			-	-14 hs (+1 h, DST)
China				-

*DST = daylight saving time.