COTTON MARKET INTEGRATION: ACROSS COUNTRIES, AMONG QUALITIES, & THROUGH TIME

Jon Devine
Cotton Incorporated
Cary, NC

Abstract

Cotton is among the most internationally traded agricultural commodities. The global nature of the cotton market, as well as the existence of dominant geographical import market (Asia), could support expectations that world cotton prices would be integrated. The last know study of cotton market integration examined price relationships in the late 1980s and the late 1990s. There has been important structural change in the world cotton market since these study periods. Another significant event in world cotton markets was the volatility that occurred in 2010/11. Given structural change and recent volatility, the objective of this research is to examine recent relationships among world cotton prices. This analysis implements stationarity tests on price pair differences. Each price pair compares a published price against New York futures. The reason that analysis is centered on New York futures is because New York (InterContinental Exchange) futures are the most widely used for hedging purposes. Correspondingly, an applied take-away from this study could be a comparison of the ability to hedge a collection of different varieties and qualities of cotton using New York futures. Other prices that are included in the analysis are global benchmarks, including the China Cotton (CC) Index, the A Index, and spot prices from India and Pakistan. In addition, a series of prices for specific varieties and qualities quoted by Cotlook (e.g., higher grade Australian cotton), publishers of the A Index, are examined.

Introduction

Cotton is among the most internationally traded agricultural commodities. Considering the degree of globalization in cotton markets, prices for cotton from around the world could be expected to be integrated. However, the record volatility in cotton prices during the 2010/11 crop year could have altered the strength and nature of existing co-integrative relationships. To investigate potential changes in relationships among cotton prices over time, this research examines a range of cotton prices. The prices examined could be classified into two basic sets. One contains a series global benchmarks, including the China Cotton (CC 328) Index, the A Index, and spot prices from India and Pakistan. A second set of prices are from Cotlook Ltd. (Cotlook), a cotton trade group and publisher of the A Index. The A Index is widely regarded as representative of a world price for cotton and is derived as an average of individual prices for specific varieties and qualities. These individual prices could inform discussion regarding the relationship among cotton qualities. Rather than attempt to analyze each possible price pair

The general approach is the same as that used by Baffes and Ajwad (2001), which examines the stationarity of price pair differences (e.g., the CC Index less the NY Nearby). The reason that this approach is adopted is twofold. First, it offers a means of comparison with the 2001 study. Second, it facilitates results that have a direct applied interpretation. As many commodities, cotton can be hedged using futures markets. By far, the most common market that is used to hedge futures is in New York. In addition to U.S. cottons, a variety of international growths are also hedge using New York futures. Many of the world's cotton merchants claim they are basis traders, implying that their profit is derived from the stability of the difference between the price they buy/sell cotton relative to NY futures.

This research offer several contributions. The first is the identification of explicit representations regarding relationships among the world's major cotton producing countries' cotton prices, which should be relevant to participants in the global cotton trade. Results from the benchmark prices support these findings. Supplementing these results are descriptions of relationships for different qualities of cotton fiber. An additional contribution of this analysis may be methodological and derived from how time is treated as a variable. Price-pair relationships are examined through two different approaches. One is in terms of discrete periods (entire sample from August 2004 to December 2012, before the price spike from August 2004 to July 2010, and inclusive of the spike from August 2010 to the present). The second temporal approach is continuous relative to time and implements rolling windows. These rolling windows represent time periods of a fixed length (e.g., 48 months) that a advanced through the sample one month at a time. This continuous treatment of time may inform discussion regarding changes in price relationships relative to the 2010/11 spike.

Conceptual Model

The methods for examining market integration across countries, among qualities, and through time are adopted from that implemented by Baffes and Ajwad (2001). This approach can be introduced using the following general equation.

$$p_t^1 = \mu + \beta_1 p_t^2 + \varepsilon_t \qquad (1)$$

In this formulation, p_t^1 and p_t^2 represent prices from different markets, μ and β_1 represent parameters to be estimated, and ε_t is an error term assumed to be identically and independently distributed $(0, \sigma^2)$. When directly applied, this approach investigates a rather strict definition of market integration, typically testing a null hypothesis that the slope β_1 is equal to one and the intercept μ equals zero. More formally, this null hypothesis can be written

$$H_0 = \mu + 1 = \beta_1 = 1 \qquad (2)$$

After identifying non-stationarity in prices as a potential issue with this approach to market integration, Baffes and Ajwad (2001) also recognized that differences among qualities and transaction costs would likely prevent the intercept μ from being equal to zero. As a result, the authors proposed an alternate approach for determining market integration.

An intermediate step in this process was that which examined whether the price-pair difference

$$p_t^1 - p_t^2 \sim I(0) \qquad (3)$$

If the price-pair difference is stationary, then it is possible to conclude that price signals are transmitted from one market to another in the long run. This process was identified as being intermediate since it requires either the assumption that $\beta_{1=}1$ or the test result that $\beta_{1=}1$. This assumption/finding that $\beta_{1=}1$ is necessary since a non-stationary price difference could be the result of an omitted non-stationary variable. Including such a variable in a formulation such as than in Equation 1 could render a non-stationary difference stationary.

For the purposes of this analysis, which is exploratory, a coefficient equal to one is assumed. The reason that this assumption is made is related to the application. In the global cotton market, many of the world's largest traders operate as basis traders. In other words, many cotton merchants rely on differences in global prices as a means for hedging and generating profits. Since the cotton market experienced unprecedented volatility during the 2010/11 crop year, it could be expected that relationships among different qualities of cotton grown in different countries could have been affected by recent volatility.

By making the assumption that $\beta_{1=}1$ it is possible to determine whether previous basis levels were maintained during the period of volatility. While the stationarity of these differences can inform discussion regarding the stability of price-pair differences over time, they may not be sufficient to make determinations regarding market integration. Rather, with respect to market integration, these findings could be considered an intermediate step in identifying omitted variables and supporting less restrictive investigations of price relationships.

Empirical Model

Unit root tests typically serve only as a precursor in the development of time series models that describe market integration. As opposed to their typical application, this investigation directly applies unit root tests to make inferences regarding inter-price relationships. These inferences are rooted in the assumption that the coefficient in equation 1 is equal to one. While inferences resulting from this approach are somewhat limited by this relatively strong assumption, especially considering the potential for excluded variable bias, the examination of the stationarity of price-pair differences may be warranted by the application to the cotton market. Given the volatility in global cotton markets experienced during the 2010/11 crop year, it could be expected that market participants may ask the question whether existing inter-price relationships were altered.

This research attempts to address these questions by testing the stationarity of price-pair differences. A focus of this research is to determine how inter-price relationships may have changed over time, this investigation examines the consistency of price-pair differences using rolling windows (i.e., rolling periods of 36, 48, and 60 months) which could generate different results depending on when the particular is positioned in time relative to the volatility in 2010/11. In addition to the timing of different rolling windows, the duration of the window may also inferences regarding the presence of a unit root. As a result, stationarity tests based on rolling windows of 36, 48, and 60 months are examined alongside those for two discrete time periods, one exclusive of the volatility of the 2010/11 crop year (prior to 2010/11, the 72 months between the start of the sample in August 2004 and July 2010) and one inclusive of the volatility of the 2010/11 crop year (from August 2004 to September 2012, representing all of the months in the sample at the time when this publication was completed).

This approach, which investigates the potential influence of sample size on unit root test results, may have relevance beyond the cotton market. In addition, this research implements three separate unit root tests. The purpose of examining these different tests is to determine whether the choice of a particular test over another and to quantify any potential differences. The tests that are considered are the Augmented-Dickey Fuller (ADF) test, the Phillips-Perron (PP) test, and the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test. Each of these tests, as well as the key differences among them that may lead to differences in results, are briefly introduced below.

Augmented Dickey-Fuller (ADF) and Phillips-Perron Tests

A unit root process could be defined by the following autoregressive process

$$y_t = \rho y_{t-1} + \delta x_t + u_t \qquad (4)$$

where x_t is an optional exogenous term that can be defined either as a constant or as a constant and a trend and ρ and δ are parameters to be estimated. If $|\rho| > 1$ then the variance of y_t increases over time and the series is non-stationary. If $|\rho| < 1$ then the series is considered stationary. To enable more efficient testing, Equation 4 can be re-written by subtracting y_{t-1} from both sides. This results in the following formulation

$$\Delta y_t = \alpha y_{t-1} + \delta x_t + u_t. \qquad (5)$$

With this equation, tests examining whether $\alpha = 0$ are equivalent to tests of whether $|\rho| < 1$. Correspondingly, tests of the null hypothesis H_0: $\alpha = 0$ against the alternative H_1: $\alpha < 0$ which is equivalent to testing if $|\rho| < 1$. The above specifications are only valid if the underlying process is AR(1). The augmented Dickey-Fuller tests a less restrictive formulation which compensates for higher order correlations in the disturbance term. It can be written

$$\Delta y_t = \alpha y_{t-1} + \delta x_t + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + \ldots + \beta_p \Delta y_{t-p} + v_t \qquad (6)$$

Even though the above specifications are all based on autoregressive processes, (Said & Dickey, 1984) demonstrated that the ADF approach is valid in the presence of moving average component if sufficient lags are included in the specification. Rather than rely on a series of lags, the PP test is based on Equation 6 and implements and alternate test statistic to accommodate serial correlation (Phillips & Perron, 1988).

Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) Test

A common criticism of both the ADF and PP tests is their lack of power (e.g., Kremers et al., 1992). In the context of statistics, power, also known as Type II error, refers to the probability that a test will reject the null hypothesis when the null hypothesis is not true. Correspondingly, tests suffering from a lack of power are not able to generate insufficient evidence for rejection. Both the ADF and PP tests involve the null hypothesis of a unit root. As a result, the tests require significant evidence to disprove the presence of a unit root. In relatively situations the burden of proof rests on disproving the null hypothesis of a unit root. Correspondingly, there can be a tendency to over-identify non-stationarity. In response to the lack of power in ADF and PP tests, Kwaitkowski et al. (1992) developed a complementary approach which tests the null hypothesis of stationarity relative to an alternate hypothesis of non-stationarity.

Data

Price data were collected from several sources and can be classified into two general categories. The first category is that of benchmark prices. For different cotton producing countries, there is commonly one price that is most commonly referred to when speaking about that individual market. For example, in the U.S., most market participants follow New York futures. Other benchmark prices that are investigated in this study include the A Index, which is the most widely accepted representation for a world price, the CC Index (328), which is mill-delivered price for Chinese cotton, and spot prices from India (Shankar-6 variety) and Pakistan (values published by the Karachi Cotton Association for grade 3 1-1/32" staple fiber).

Supplementing the analysis of these benchmark prices is an examination of data from Cotlook. Along with the A Index, Cotlook has been publishing export offers for specific varieties and qualities of cotton from international merchants since 1966. These quotes are included in the trade group's weekly publication, Cotton Outlook. The variety/quality prices used in the analysis are monthly averages of these weekly values. Over its nearly 50-year history, there have been several important definitional changes to the prices that are published by Cotlook. The most significant recent revision occurred in August 2004 (the onset of the 2004/05 northern hemisphere crop year), when the geographical basis for all of Cotlook's quotes shifted from Northern Europe to the Far East. For consistency, the time period considered for this analysis is from August 2004 through December 2012 (latest data available when this draft of the research was completed).

Descriptive statistics for benchmark and Cotlook variety/quality prices appear in Tables 4.1 and 4.2. Given variation in availability that can occur due to changes in acreage and weather conditions, prices for specific qualities from specific countries are not always available. The percent coverage data indicate the proportion of months when price data were published. Since certain varieties had less data available, only those varieties/qualities with at least 85% coverage between August 2004 and the present were considered for this analysis. Coverage is lowest for lower quality varieties and 85% was selected as a cut-off since it allowed for at least one set of lower quality prices to be analyzed.

Table 1. Descriptive Statistics for Benchmark Cotton Prices

	Averages (percent coverage)			**Coefficients of Variation**		
	Entire sample (8/04-12/12)	Pre-spike (8/04-7/10)	Since spike (8/10-12/12)	Entire sample (8/04-12/12)	Pre-spike (8/04-7/10)	Since spike (8/10-12/12)
NY Futures	72.6 (100%)	57.6 (100%)	71.0 (100%)	44.9%	18.6%	35.2%
A Index	79.8 (98.0%)	63.0 (98.6%)	80.9 (98.6%)	46.3%	17.0%	37.0%
CC Index	102.7 (100%)	82.4 (100%)	121.4 (100%)	35.7%	14.6%	17.6%
Shankar-6	85.5 (55.4%)	67.2 (96.6%)	75.2 (96.6%)	31.1%	15.0%	25.2%
Pakistan	67.0 (100%)	54.8 (100%)	69.9 (100%)	41.0%	21.3%	32.9%

Note: Percent coverage refers to the number of months with data in each of time period.

Table 2. Descriptive Statistics for Cotlook Variety Quotes

	Averages (percent coverage)			Coefficients of Variation		
	Entire sample (8/04-12/12)	Pre-spike (8/04-7/10)	Since spike (8/10-12/12)	Entire sample (8/04-12/12)	Pre-spike (8/04-7/10)	Since spike (8/10-12/12)
Higher Grades						
U.S.	85.2 (86.1%)	73.9 (91.7%)	120.67 (72.4%)	28.3%	13.5%	17.4%
Uzbekistan	86.5 (99.0%)	67.6 (98.6%)	132.6 (100%)	46.5%	16.3%	36.1%
W. Africa	79.9 (96.3%)	65.7 (97.9%)	117.4 (92.2%)	40.3%	15.8%	33.8%
Australia	89.8 (92.1%)	71.3 (88.9%)	130.4 (100%)	41.2%	14.7%	32.2%
Medium Grades						
U.S.	82.0 (97.5%)	64.8 (97.9%)	124.8 (96.6%)	45.0%	16.4%	35.2%
Uzbekistan	83.7 (48.0%)	65.0 (98.6%)	129.4 (100%)	48.0%	17.1%	37.5%
W. Africa	77.6 (96.5%)	64.2 (98.3%)	115.1 (92.2%)	40.6%	16.7%	34.2%
Brazilian	75.4 (31.4%)	64.4 (14.6%)	106.8 (22.6%)	31.4%	14.6%	22.6%
Lower Grades						
U.S.	67.6 (86.6%)	61.3 (97.9%)	93.6 (58.6%)	25.3%	17.6%	14.4%

Note: Percent coverage refers to the number of months with data in each time period. Higher grade U.S. refers to California Acala. Higher and medium grade West African quotes are an average from Benin, Burkina Faso, Ivory Coast, and Mali. Medium and lower-grade U.S. quotes are an average of Memphis/Eastern and Memphis/Orleans/Texas quotes. The component prices for each average are highly co-linear. Please contact the author if you are interested in seeing data for the components used to derive the averages.

A focus of this analysis is to examine cotton prices to determine if relationships among prices may have significantly changed with the volatility introduced by the 2010/11 price spike. Informal analysis is possible using the descriptive statistics provided in this section. By examining the coefficients of variation (COV), it appears that Cotlook quotes tended to deviate farther from their means than benchmark prices. For most variety/quality quotes, the COV was between 40% and 50% over the entire sample, between 15% and 20% prior to 2010/11, and between 30% and 40% since the 2010/11 crop year. For each time period, the COV for prices for both higher and lower grades U.S. cotton were less than the COV's for other qualities/varieties. The COV's for benchmark prices followed a similar pattern, although the value for the CC Index since the 2010/11 crop year was lower. This is likely due to the stabilizing effect of China's reserve purchases.

While the descriptive statistics allow for some discussion of the patterns of price movement, they do not facilitate formal examination of the evolution of relationships of cotton prices. With examination of the stability of cotton price relationships being the motivation for this research, results from the stationarity tests of price pair differences are presented in the following section.

Results

In Tables 3-8, it is possible to examine the stationarity of price pairs in three discrete time periods. The time periods are the entire sample (August 2004 to December 2012 – the latest month available), the time period before the 2010/11 spike (August 2004 to July 2010), and the time period inclusive of the spike (August 2010 to December 2012). It is not possible to investigate stationarity after the spike since there were insufficient observations at the time of publication. In these data, it possible to see that there is a clear difference in results according to the test used, with the KPSS test indicating far more stationary results that either the ADF or PP tests. In addition, there appears to be a difference over time, with the time periods that were either before or inclusive of the spike having the most stationary price pairs. This may be due to a tendency for a transition between two price pair difference levels with the 2010/11 volatility.

To further investigate the role of time, stationarity tests are also applied in continuous time using rolling windows. These rolling windows refer to time periods of fixed length that progress through time. Windows of 60, 48, and 36-months were produced. Due to space considerations (15-page limit), however, only the results from 48-month windows are presented. If you might be interested in results for windows of other sizes, please contact the author. The gray lines in each chart represent the average difference between a given price and the NY Nearby throughout a 48-month period and therefore are a smoothed representation of price difference. The volatility within each of the windows is described by the stationarity tests. The distinction is important for interpretation. For example, even if prices in one in one window were nearly equal to those in a preceding window; they might not have a constant mean throughout the sample or may exhibit a random walk. Correspondingly, a flat difference described by the gray lines may mask underlying unit roots. Conversely, a gray line that has a trend over time may have stationary price pair differences within individual windows. When examining these charts, there is some evidence that the 2010/11 price spike impacted stationarity. This is most obvious in the examples of KPSS test results for the CC Index 328, Indian Shankar-6 prices, higher grade U.S. and Uzbek prices, as well as medium grade U.S. and Uzbek prices. Results from the ADF and PP test results did not indicate stationarity to inform such discussion. An interesting finding may be that the difference for each of the prices for the three qualities of U.S. cotton increased over time.

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Table 3. Stationarity Test Results: Benchmark Prices less the NY Nearby (whole sample, 8/04 to 12/12 n=101)

	Avg. Difference in	ADF	PP	KPSS

	cents/lb	test result (p-value)	test result (p-value)	test result (KPSS-stat)
CC Index (328)	30.1	non-stationary (0.5126)	non-stationary (0.5140)	non-stationary (0.7814)
A Index	7.7	non-stationary (0.1576)	stationary (0.0499)	non-stationary (0.6235)
Indian Shankar-6	-2.1	non-stationary (0.3666)	non-stationary (0.2414)	stationary (0.2526)
Pakistan	-5.7	non-stationary (0.1267)	non-stationary (0.0646)	stationary (0.2649)

Note: All test results based on 5% significance level. Critical value for KPSS test is 0.4630.

Table 4. Stationarity Test Results: Benchmark Prices less the NY Nearby (pre-spike, 8/04 to 7/10 n=72)

	Avg. Difference in cents/lb	ADF test result (p-value)	PP test result (p-value)	KPSS test result (KPSS-stat)
CC Index (328)	24.7	non-stationary (0.5289)	non-stationary (0.4601)	stationary (0.3860)
A Index	5.7	non-stationary (0.1910)	non-stationary (0.1391)	stationary (0.4433)
Indian Shankar-6	3.2	non-stationary (0.2557)	non-stationary (0.1380)	stationary (0.2206)
Pakistan	-2.8	non-stationary (0.8145)	non-stationary (0.8145)	stationary (0.3016)

Note: All test results based on 5% significance level. Critical value for KPSS test is 0.4630.

Table 5. Stationarity Test Results: Benchmark Prices less the NY Nearby (includes spike, 8/10 to 12/12 n=29)

	Avg. Difference in cents/lb	ADF test result (p-value)	PP test result (p-value)	KPSS test result (KPSS-stat)
CC Index (328)	43.4	non-stationary (0.5901)	non-stationary (0.5860)	stationary (0.4146)
A Index	12.8	non-stationary (0.4204)	non-stationary (0.2960)	stationary (0.2654)
Indian Shankar-6	-7.6	non-stationary (0.6152)	non-stationary (0.4985)	stationary (0.3345)
Pakistan	-13.0	non-stationary (0.1828)	non-stationary (0.1494)	stationary (0.2984)

Note: All test results based on 5% significance level. Critical value for KPSS test is 0.4630.

Table 6. Stationarity Test Results: Cotlook Variety Quotes less the NY Nearby (8/04 to 12/12 n=101)

	Avg. Difference	ADF	PP	KPSS

		test result (p-value)	test result (p-value)	test result (KPSS-stat)
		Higher Grade Quotes		
U.S.	20.3	non-stationary (0.6951)	non-stationary (0.5990)	non-stationary (0.8596)
Uzbekistan	13.9	non-stationary (0.1942)	non-stationary (0.0926)	non-stationary (0.5781)
W. Africa	10.2	non-stationary (0.8932)	non-stationary (0.6382)	non-stationary (0.7195)
Australia	16.6	stationary (0.0163)	stationary (0.0007)	non-stationary (0.6613)
Medium Grade Quotes				
U.S.	7.4	stationary (0.0203)	stationary (0.0153)	non-stationary (0.5042)
Uzbekistan	7.7	non-stationary (0.0892)	non-stationary (0.1793)	stationary (0.4435)
W. Africa	6.7	non-stationary (0.0682)	stationary (0.0489)	stationary (0.4023)
Brazilian	8.8	non-stationary (0.1322)	non-stationary (0.1511)	stationary (0.0921)
Lower Grade Quotes				
U.S.	8.1	non-stationary (0.1539)	non-stationary (0.1575)	stationary (0.1861)

Note: All test results based on 5% significance level. Critical value for KPSS test is 0.4630.

Table 7. Stationarity Test Results: Cotlook Variety Quotes less the NY Nearby (8/04 to 07/10 n=72)

	Avg. Difference	ADF test result (p-value)	PP test result (p-value)	KPSS test result (KPSS-stat)
		Higher Grade Quotes		
U.S.	16.9	non-stationary (0.1982)	non-stationary (0.0866)	stationary (0.2760)
Uzbekistan	10.3	stationary (0.0262)	non-stationary (0.1683)	stationary (0.4191)
W. Africa	8.3	non-stationary (0.0604)	stationary (0.0352)	stationary (0.4113)
Australia	14.8	stationary (0.0058)	stationary (0.0058)	stationary (0.1069)
Medium Grade Quotes				
U.S.	7.4	stationary (0.0203)	stationary (0.0153)	non-stationary (0.5042)
Uzbekistan	7.7	non-stationary (0.0892)	non-stationary (0.1793)	stationary (0.4435)
W. Africa	6.7	non-stationary (0.0682)	stationary (0.0489)	stationary (0.4023)
Brazilian	8.8	non-stationary (0.1322)	non-stationary (0.1511)	stationary (0.0921)
Lower Grade Quotes				
U.S.	3.9	stationary (0.0392)	stationary (0.0290)	non-stationary (0.6593)

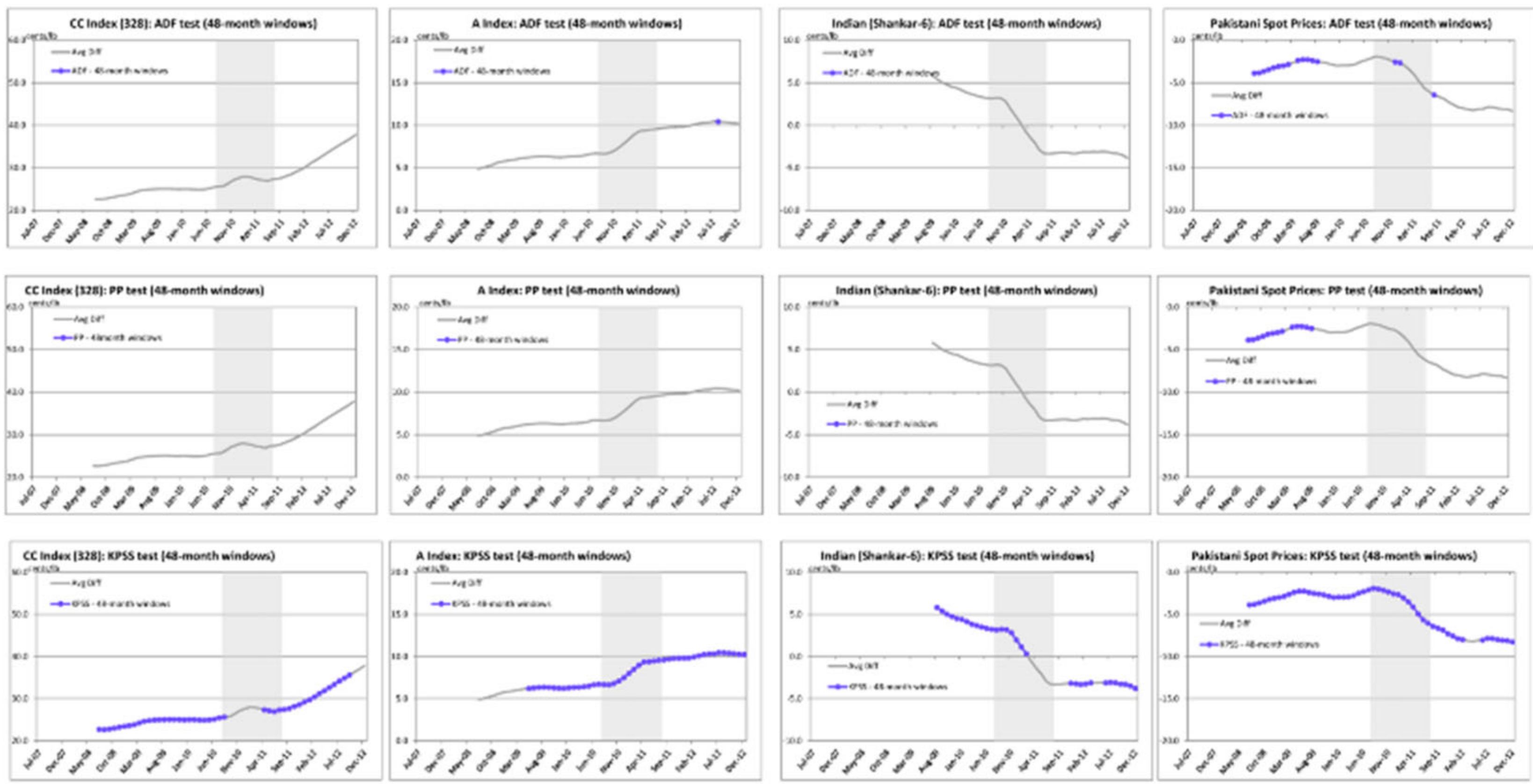
Note: All test results based on 5% significance level. Critical value for KPSS test is 0.4630.

Table 8. Stationarity Test Results: Cotlook Variety Quotes less the NY Nearby (8/10 to 12/12 n=29)

	Avg. Difference	ADF test result (p-value)	PP test result (p-value)	KPSS test result (KPSS-stat)
Higher Grade Quotes				
U.S.	31.0	non-stationary (0.5823)	non-stationary (0.4246)	stationary (0.2353)
Uzbekistan	22.9	non-stationary (0.3634)	non-stationary (0.3140)	stationary (0.3281)
W. Africa	15.2	non-stationary (0.9024)	non-stationary (0.7644)	stationary (0.2269)
Australia	20.7	stationary (0.0241)	stationary (0.0189)	stationary (0.0764)
Medium Grade Quotes				
U.S.	7.4	stationary (0.0203)	stationary (0.0153)	non-stationary (0.5042)
Uzbekistan	7.7	non-stationary (0.0892)	non-stationary (0.1793)	stationary (0.4435)
W. Africa	6.7	non-stationary (0.0682)	stationary (0.0489)	stationary (0.4023)
Brazilian	8.8	non-stationary (0.1322)	non-stationary (0.1511)	stationary (0.0921)
Lower Grade Quotes				
U.S.	8.1	non-stationary (0.1539)	non-stationary (0.1575)	stationary (0.1861)

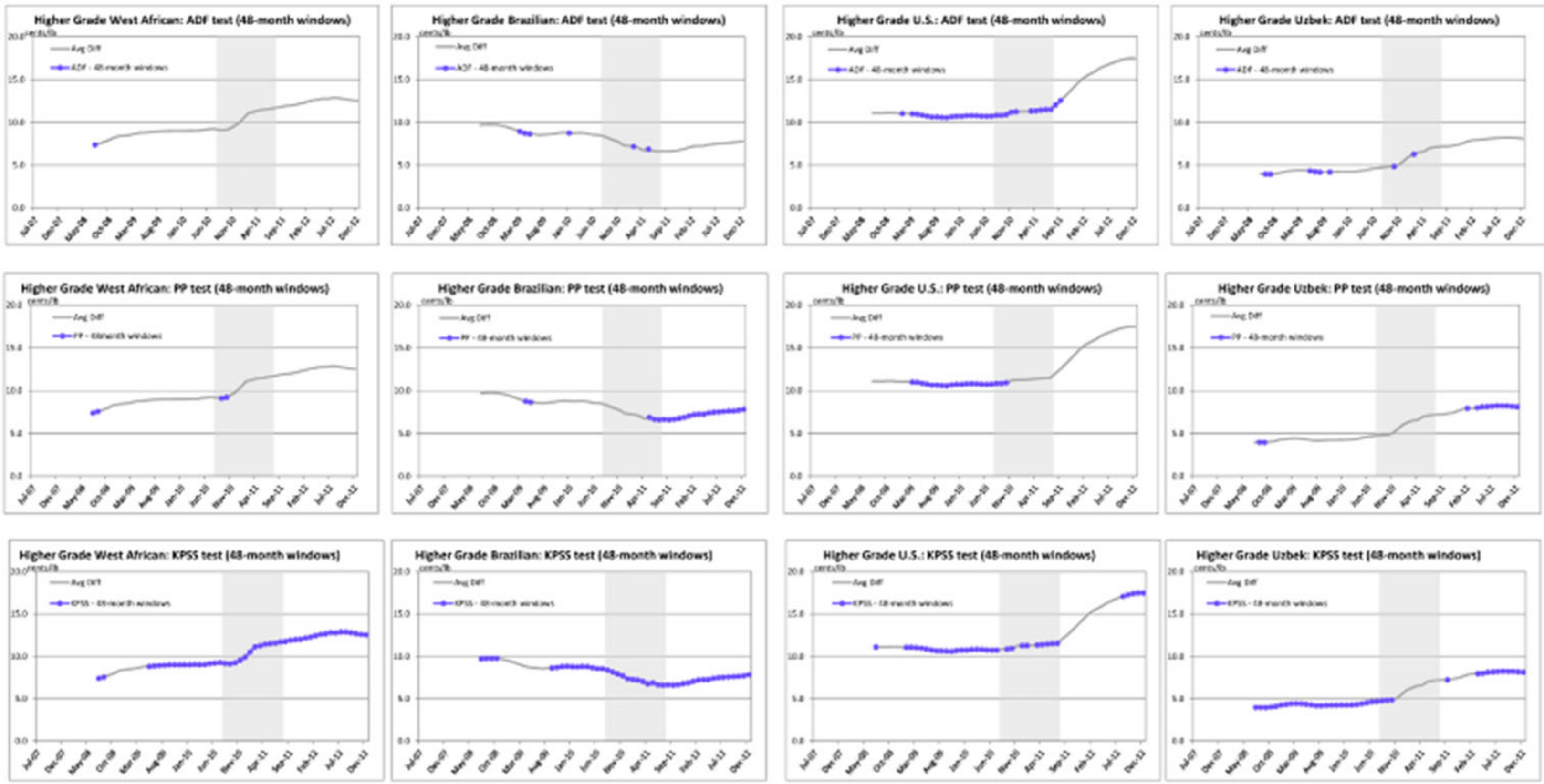
Note: All test results based on 5% significance level. Critical value for KPSS test is 0.4630.

Exhibit 1. Stationarity Tests for Benchmark Prices (48-month rolling windows)



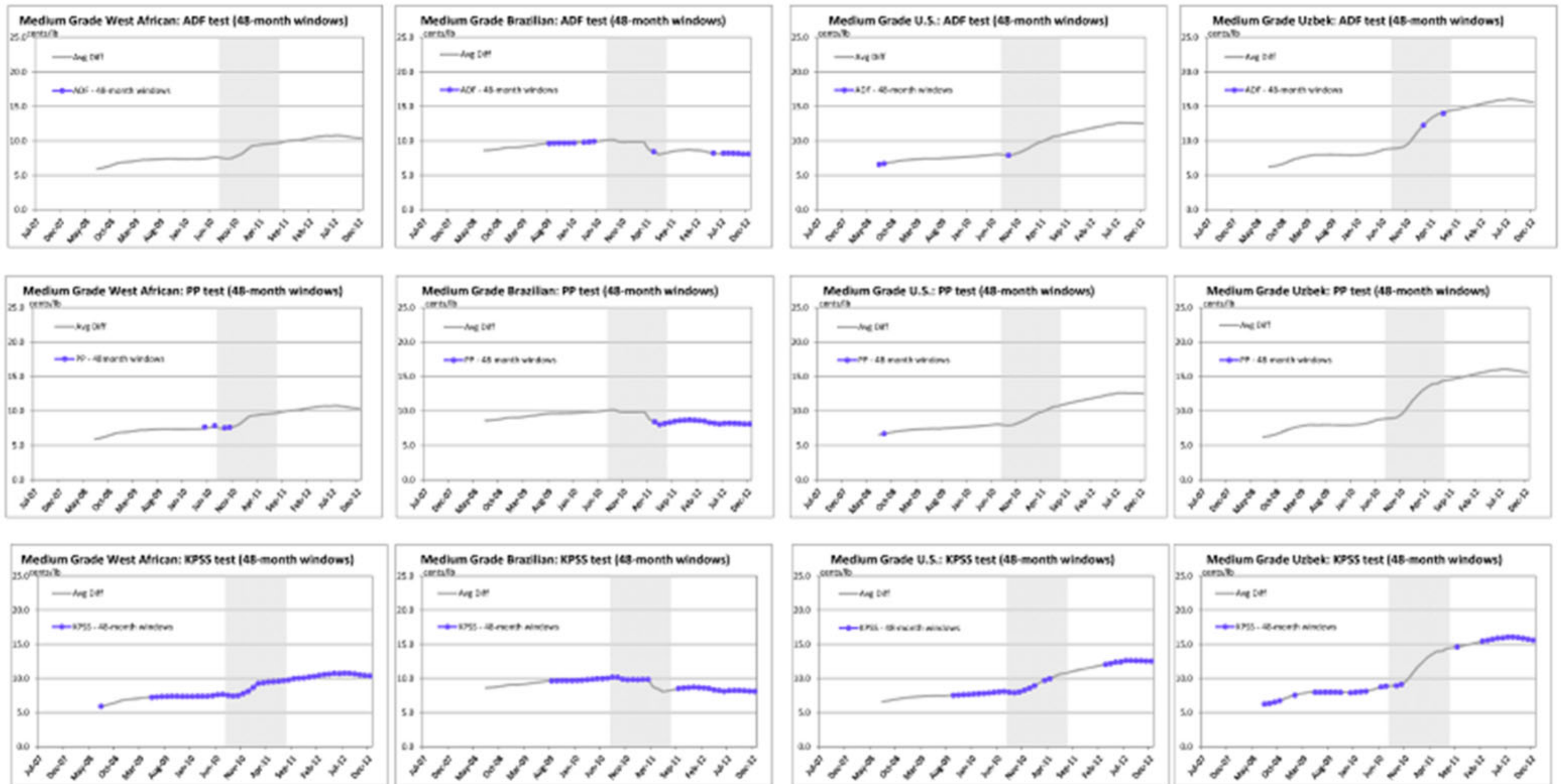
Notes:
The gray lines indicate the average price pair difference over rolling windows of 60 months. For example, the average described by the point at July 2008 for the West Africa less A Index difference is the average difference between these two prices during the 60-month time period between August 2004 and July 2009.
Blue points/lines indicate time periods (rolling windows) where the price difference was stationary (5% significance level).
The shaded region highlight the time period since the onset of the 2010/11 crop year. This region is highlighted in order to facilitate discussion of the potential impact of price volatility on the relationships among different cotton prices.

Exhibit 2. Stationarity Tests for Higher Grade Cotlook Quotes (48-month rolling windows)



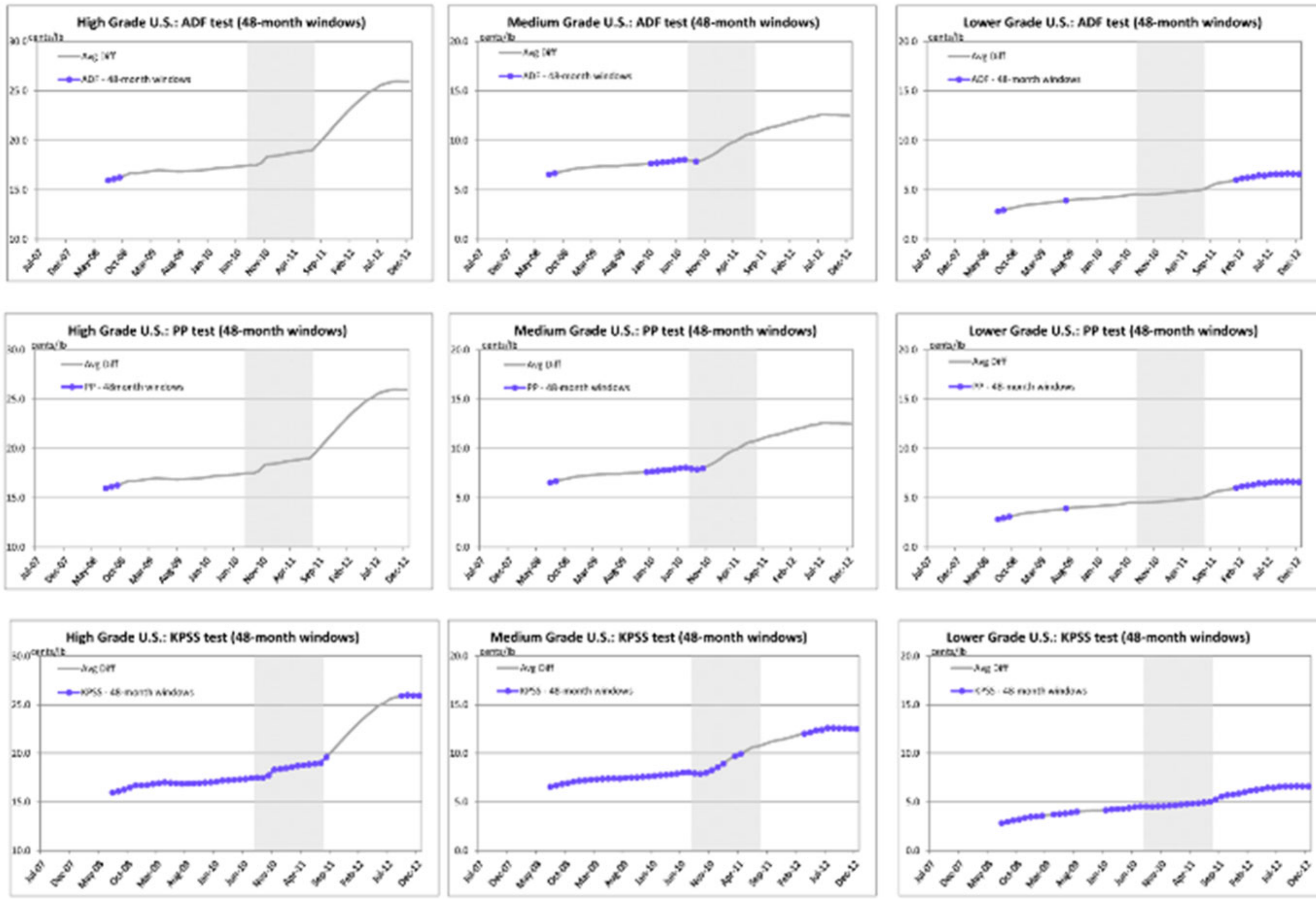
Notes:
The gray lines indicate the average price pair difference over rolling windows of 60 months. For example, the average described by the point at December 2012 is the average difference between two prices during the 60-month time period between August 2008 and December 2012.
Blue points/lines indicate time periods (rolling windows) where the price difference was stationary (5% significance level).
The shaded region highlight the time period since the onset of the 2010/11 crop year. This region is highlighted in order to facilitate discussion of the potential impact of price volatility on the relationships among different cotton prices.

Exhibit 3. Stationarity Tests for Medium Grade Cotlook Quotes (rolling 48-month windows)



Notes:
The gray lines indicate the average price pair difference over rolling windows of 60 months. For example, the average described by the point at December 2012 is the average difference between two prices during the 60-month time period between August 2008 and December 2012.
Blue points/lines indicate time periods (rolling windows) where the price difference was stationary (5% significance level).
The shaded region highlight the time period since the onset of the 2010/11 crop year. This region is highlighted in order to facilitate discussion of the potential impact of price volatility on the relationships among different cotton prices.

Exhibit 4. Stationarity Tests for U.S. Cotton Qualities (rolling 48-month windows)



Notes:

The gray lines indicate the average price pair difference over rolling windows of 60 months. For example, the average described by the point at December 2012 is the average difference between two prices during the 60-month time period between August 2008 and December 2012.

Blue points/lines indicate time periods (rolling windows) where the price difference was stationary (5% significance level).

The shaded region highlight the time period since the onset of the 2010/11 crop year. This region is highlighted in order to facilitate discussion of the potential impact of price volatility on the relationships among different cotton prices.