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COTTON: PHYSICAL PRICES BECOMING MORE RESPONSIVE TO FUTURES PRICES[1]

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Introduction

The ICAC Coordinating Agency of Argentina noted that the direction of inter-daily change in the Cotlook A Index was becoming easier to predict than in the past based only on the observed change on the settlement price of the nearby cotton futures contract (NCFC) in the Intercontinental Exchange (ICE), and asked the Secretariat to analyze the statistical relationship between those two series of prices. This article summarizes the results of two analyses: a correlation analysis of monthly average prices over the period August 1991-May 2009, and a regression analysis of daily prices over the period January 2000-May 2009.

Correlation Analysis with Monthly Data

The mean and the standard deviation of the A Index and the price of the NCFC between August 1991 and May 2009 amounted, respectively, to 66.88 US cents/lb and 13.80 US cents/lb, and 61.38 US cents/lb and 13.81 US cents per pound. The annual correlation coefficients are generally greater than 0.85, indicating that the series are highly correlated (Table 1).

In seasons 1995/96 through 1998/99, the correlation among spot and futures prices was lower than in other seasons. In particular, the correlation coefficients for 1996/97 and 1997/98 are not significantly different from zero at the 5% significance level.

The seasons in which the correlation between spot and futures prices was low coincided with the seasons in which ending stocks in China (Mainland) amounted to at least 90% of Chinese mill use (Figure 1). The Chinese government built substantial cotton stockpiles during those years (Goreaux et. al. 2007), and one of the side-effects was the disruption of the price discovery process in the futures market. The stocks-to-mill use ratio in China (Mainland) explains 59% of the variability in the annual correlation coefficient.[3]

Since 2000/01, the correlation has been relatively stable at around 0.94, ranging from 0.91 (in 2001/02) to 0.98 (in 2000/01). These results suggest that the correlation between monthly average spot and futures cotton prices has remained high and relatively stable, except for those years in which the stocks-to-mill use ratio in China (Mainland) exceeded the 90% threshold.

Regression Analysis with Daily Data

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[3] The R-square of a regression of the correlation coefficients on a constant and a variable with the stock-to-mill use ratio in China (Mainland) for seasons when this ratio exceeds 95% and zeroes in all other seasons is 0.5878.

The Cotlook A Index is released at 2:30 pm London time, or 9:30 am New York time. The settlement price for the cotton futures contract in the Intercontinental Exchange (ICE) is announced at 2:30 pm New York time. Therefore, close attention must be paid to the dates of the series under study. Since the focus of this analysis is on the effect of the price of the NCFC on the A Index, the A Index is compared against the settlement price for the NCFC in the preceding trading day. The logic behind this comparison is that physical cotton traders inform their trading decisions with the most recent settlement price from the ICE, which is the settlement price from the previous day.

The A Index and the nearby cotton futures prices are non-stationary and integrated of order 1, i.e. for each series, the mean of the series in levels shifts through time, but not the mean of the inter-daily changes.

In order to avoid spurious regression[4] results, the stability of the long run relationship between the non-stationary series is tested with the Engle-Granger methodology: (a) an ordinary least squares regression of the A Index on a constant and the price of the NCFC on the previous day is run; (b) the residuals in first differences are regressed against lagged residuals in levels and lagged residuals in first differences;[5] (c) the t-value of the coefficient for the lagged residuals equals -5.38 and is higher in absolute value than the (extrapolated) critical value for two variables and 2231 observations at the 1% significance level, -3.73. Therefore, it can be concluded that a unique and stable long-run relationship between the A Index and the previous day's price of the NCFC exists.

The existence of a stable long-run relationship between the series validates the use of traditional regression methods, despite the non-stationarity of the series in levels. Following the general-to-specific methodology, a full model is first estimated and then alternative restrictions are sequentially tested to arrive at the final restricted and parsimonious model.

In the full model, the value of the A Index is explained by its previous 14 realizations, the previous 15 realizations of the price of the NCFC prices and a constant. According to the restricted model, the A Index depends positively on the value of the A Index and the price of the NCFC in the previous day, and negatively on the value of the price of the NCFC 2 days before, and the A Index 8 days before.[6] The magnitude of the effect of the lagged A Index is the greatest, followed by the effect of the NCFC price in the previous day, the effect of the NCFC price 2 days before, and finally the effect of the A Index 8 days before. The restricted model explains 99.8% of the variability in the A Index (Table 2).

In general terms, today's A Index can be approximated by yesterday's A Index plus an adjustment term that reflects the impact of daily changes in the NCFC prices on the A Index.[7] This adjustment term indicates that a sufficient condition for today's A Index to increase is that the settlement price of NCFC in the previous day be at least 96% of the value of the NCFC two days before. The forecasting ability of the model over the period January 3, 2009 to May 5, 2009 is very good (Figure 2).[8]

Based on this restricted model, the stability of the relationship between spot and futures prices through time is analyzed in an augmented version of the restricted model. The augmented model includes interaction terms between indicator variables for each season and prices: if the interaction terms are statistically significant, the relationships have not been stable through time. The null

[4] Spurious regression results might indicate that two series are highly correlated when in fact they bear little relation with each other, but instead are following some common trend.
[5] The Akaike and the Schwartz Information Criteria suggested that 2 lags in levels (i.e. 1 lag in first differences) better represented the data from lags 0 through 31 on a vector autoregressive model in levels.
[6] Alternatively, error correction models were estimated but none could outperform the final model presented here in terms of the accuracy of the forecasts of the A Index, as measured by the Theil Inequality Coefficient.
[7] The null hypothesis that the coefficients of the price of the NCFC in the previous day and 2 days before add up to zero is rejected at the 1% significance level (Wald test=30.36).
[8] Theil Inequality Coefficient=0.004; Covariance proportion=0.995.

hypothesis that all the interaction terms for the lagged A Index are jointly null cannot be rejected at the 10% significance level (Wald test=0.1441, df=9). Furthermore, the interaction terms for the season 2000/01 are not significant, indicating that short-run price relationships remained stable between 1999/00 and 2000/01 (Table 3).

A final model, omitting all the non-significant variables in the augmented model, is estimated (Table 4). The interaction terms for seasons 2001/02 through 2008/09 are significantly different from zero at the 5% significance level. The implication of the latter is that the impact of changes in the price of the NCFC on the A Index (the "pass-through") has changed through time. According to this final model, the value of the A Index can be forecast as 97% of the value of the A Index[9] in the previous day plus 0.61 cents per pound, plus an adjustment term. The A Index tends to increase (decreased) from its previous day's value if the adjustment term is higher (lower) than the threshold of 3% of the value of the A Index in the previous day plus 0.61 cents.

The adjustment term for each season is composed of 5 impact coefficients, 4 of which indicate the pass-through effect of nearby futures contract prices to the A Index according to the season, and 1 reflects an observed regularity with no direct explanation: that the value of the A Index in any given day is negatively related to its own value 8 business days before. The pass-through effect of futures prices is calculated as the summation of the coefficients for the price of the NCFC in levels and the corresponding interaction term for each season, and it indicates the effect of the price of the NCFC on a specific date on the A Index (Table 5).

In 1999/00 and 2000/01, the pass-through of the most recent NCFC price and the pass-through of the NCFC price 2 days before were, respectively, 0.17 and -0.14. The A Index tended to decrease when the price of the NCFC in the previous day was lower than 81.6% of the price of the NCFC 2 days before or when the ratio exceeded 81.6%, but the weighted change in NCFC prices (the weights being the pass-through coefficients) was lower than the above cited threshold.[10] Using season-average prices to simulate the required decline in futures prices to induce a decline in the A Index in 2000/01, the analysis suggest that the A Index tended to decline when the inter-daily decline in futures prices exceeded -5.53%. For example, if the inter-daily change in futures prices was -5% then the A Index would likely increase; but if the inter-daily change in futures prices was -7% then the A Index would likely decline.

In 2001/02, the pass-through of the most recent NFCF price and the pass-through of the NCFC price 2 days before were, respectively, 0.27 and -0.24. The A Index tended to decrease when the price of the NCFC in the previous day was lower than 89.1% of the price of the NCFC 2 days before or when the ratio was higher than 89.1% but the weighted change in NCFC prices was lower than the above cited threshold. Simulation results suggest that the A Index tended to decline when the inter-daily decline in futures prices exceeded -3.93%.

In 2002/03, the pass-through of the most recent NFCF price and the pass-through of the NCFC price 2 days before were, respectively, 0.25 and -0.22. The A Index tended to decrease when the price of the NCFC in the previous day was lower than 86.7% of the price of the NCFC 2 days before or when the ratio was higher than 86.7% but the weighted change in NCFC prices was lower than the above cited threshold. Simulation results suggest that the A Index tended to decline when the inter-daily decline in futures prices exceeded -4.3%.

In 2003/04, the pass-through of the most recent NFCF price and the pass-through of the NCFC price 2 days before were, respectively, 0.46 and -0.43. The A Index tended to decrease when the price of the NCFC in the previous day was lower than 92.6% of the price of the NCFC 2 days before or when the ratio was higher than 92.6% but the weighted change in NCFC prices was lower than

[9] The null hypothesis that the coefficient of the lagged A Index equals 1 is rejected at the 1% significance level (Wald test=19.87, df=1).
[10] All calculations hereon were made ignoring the effect of the A Index lagged 8 days.

the above cited threshold. Simulation results suggest that the A Index tended to decline when the inter-daily decline in futures prices exceeded -2.2%.

In 2004/05, the pass-through of the most recent NFCF price and the pass-through of the NCFC price 2 days before were, respectively, 0.47 and -0.43. The A Index tended to decrease when the price of the NCFC in the previous day was lower than 93.3% of the price of the NCFC 2 days before or when the ratio was higher than 93.3% but the weighted change in NCFC prices was lower than the above cited threshold. Simulation results suggest that the A Index tended to decline when the inter-daily decline in futures prices exceeded -2.1%.

In 2005/06, the pass-through of the most recent NFCF price and the pass-through of the NCFC price 2 days before were, respectively, 0.52 and -0.44. The A Index tended to decrease when the price of the NCFC in the previous day was lower than 86.2% of the price of the NCFC 2 days before or when the ratio was higher than 86.2% but the weighted change in NCFC prices was lower than the above cited threshold. Simulation results suggest that the A Index tended to decline when the inter-daily decline in futures prices exceeded -2.02%.

In 2006/07, the pass-through of the most recent NFCF price and the pass-through of the NCFC price 2 days before were, respectively, 0.52 and -0.49. The A Index tended to decrease when the price of the NCFC in the previous day was lower than 93.3% of the price of the NCFC 2 days before, or when the ratio was higher than 93.3% but the weighted change in NCFC prices was lower than the above cited threshold. Simulation results suggest that the A Index tended to decline when the inter-daily decline in futures prices exceeded -2.12%.

In 2007/08, the pass-through of the most recent NFCF price and the pass-through of the NCFC price 2 days before were, respectively, 0.63 and -0.59. The A Index tended to decrease when the price of the NCFC in the previous day was lower than 94.4% of the price of the NCFC 2 days before, or when the ratio was higher than 94.4% but the weighted change in NCFC prices was lower than the above cited threshold. Simulation results suggest that the A Index tended to decline when the inter-daily decline in futures prices exceeded -1.64%.

In 2008/09 (until May), the pass-through of the most recent NFCF price and the pass-through of the NCFC price 2 days before were, respectively, 0.65 and -0.62. The A Index tended to decrease when the price of the NCFC in the previous day was lower than 94.4% of the price of the NCFC 2 days before, or when the ratio was higher than 94.4% but the weighted change in NCFC prices was lower than the above cited threshold. Simulation results suggest that the A Index tended to decline when the inter-daily decline in futures prices exceeded -1.69%.

The increase in the magnitude of the futures prices pass-through through the seasons indicates that spot prices have become more responsive to daily changes in futures prices. However, the difference between the pass-through coefficients for the previous day's NCFC price and the NCFC price 2 days before has remained stable through time, at around 0.032. This is consistent with the findings from the previous section, that the correlation between monthly spot and futures has remained stable over the period 2000/01-2008/09. Therefore, while the immediate response of spot prices to futures prices has become more sensitive in recent seasons, the medium-term relationship has remained stable.

The ratio of futures prices in the adjustment term below which spot prices tend to decline has followed an increasing tendency through time, suggesting that a smaller decline in futures prices is required today to trigger a decline in the A Index than in previous seasons (Figure 4). For example, a decline of -1.7% in futures prices would trigger a decline in the A Index in 2008/09, but it would not necessarily have done so in seasons 1999/00 through 2006/07.

Finally, these findings coincide with the observed evolution of the proportion of days in which the A Index moved in the same direction as the price of the NCFC in the previous day. The number of

such days divided by the total number of days in which the A Index was quoted followed an increasing trend from 1999/00 to 2008/09 (Figure 6).

Conclusion

The results of the analyses summarized in this article suggest that the Cotlook A Index is mainly determined by its value on the previous day, and the latest inter-daily change in the price of the nearby cotton futures contract. Furthermore, the analyses indicate that daily spot prices have become more responsive to changes in futures prices in recent seasons, and a smaller decline in futures prices is required to trigger a decline in the Cotlook A Index today than in previous seasons. One possible driver of this change is the increase in the representativeness of global cotton prices of the Cotlook A Index after changing its basis from Northern Europe to Far East in August 2004. The change reflected the increased relevance of the Far East in world cotton trade. Therefore, the increase in the responsiveness of the A Index to futures prices since 2003/04 might reflect the fact that the A Index had lost representativeness of spot prices by the late 1990s, rather than a change in the way cotton is traded.

A correlation analysis on monthly average prices indicates that the correlation between spot and futures prices has remained stable since 2000/01.

Therefore, while the short-term relation between spot and futures prices has changed through time, the medium-term relation –which is less influenced by day-to-day changes in prices- has remained stable.

Table 1. Correlation between the A Index and the Price of the NCFC, based on monthly data.

Season	Correlation	t-statistic	p-value	N
1991/92	0.95	9.99	0.000	12
1992/93	0.87	5.65	0.000	12
1993/94	0.96	11.44	0.000	12
1994/95	0.99	21.48	0.000	10
1995/96	0.66	2.81	0.019	12
1996/97	0.21	0.69	0.507	12
1997/98	0.51	1.88	0.089	12
1998/99	0.80	4.19	0.002	12
1999/00	0.85	5.15	0.000	12
2000/01	0.98	14.10	0.000	12
2001/02	0.90	6.60	0.000	12
2002/03	0.95	10.06	0.000	12
2003/04	0.92	7.48	0.000	12
2004/05	0.92	7.66	0.000	12
2005/06	0.95	10.07	0.000	12
2006/07	0.92	7.39	0.000	12
2007/08	0.97	12.37	0.000	12
2008/09	0.96	10.21	0.000	10
1991/92-2007/08	0.95	43.78	0.000	202

Table 2. Restricted Model

Dependent Variable: AINDEX
Method: Least Squares
Sample (adjusted): 1/14/2000 5/29/2009
Included observations: 2209 after adjustments
White Heteroskedasticity-Consistent Standard Errors & Covariance

	Coefficient	Std. Error	t-Statistic	Prob.
C	0.128895	0.070106	1.838572	0.0661
AINDEX(-1)	1.000392	0.010846	92.23603	0.0000
AINDEX(-8)	-0.018455	0.008978	-2.055684	0.0399
NBF1	0.453931	0.019920	22.78781	0.0000
NBF1(-1)	-0.436630	0.020820	-20.97133	0.0000

R-squared	0.998176	Mean dependent var	58.06227
Adjusted R-squared	0.998172	S.D. dependent var	9.682387
S.E. of regression	0.413946	Akaike info criterion	1.076099
Sum squared resid	377.6583	Schwarz criterion	1.089001
Log likelihood	-1183.551	Hannan-Quinn criter.	1.080812
F-statistic	301455.7	Durbin-Watson stat	2.029207
Prob(F-statistic)	0.000000		

Note: AINDEX is the A Index, NBF1 is the previous day's price of the nearby cotton futures contract, numbers in parenthesis indicate lags.

Table 3. Augmented Model
Dependent Variable: AINDEX
Method: Least Squares
Sample (adjusted): 1/14/2000 5/29/2009
Included observations: 2209 after adjustments

	Coefficient	Std. Error	t-Statistic	Prob.
C	0.630400	0.115167	5.473807	0.0000
AINDEX(-1)	0.970403	0.011019	88.06667	0.0000
AINDEX(-8)	-0.007124	0.004756	-1.497996	0.1343
NBF1	0.190288	0.031356	6.068673	0.0000
NBF1(-1)	-0.163479	0.032244	-5.069992	0.0000
AINDEX(-1)*D1	-0.010379	0.012229	-0.848720	0.3961
AINDEX(-1)*D2	-0.009478	0.014202	-0.667392	0.5046
AINDEX(-1)*D3	0.010633	0.013478	0.788948	0.4302
AINDEX(-1)*D4	-0.014254	0.011232	-1.269074	0.2046
AINDEX(-1)*D5	-0.013160	0.015347	-0.857489	0.3913
AINDEX(-1)*D6	-0.041529	0.021963	-1.890871	0.0588
AINDEX(-1)*D7	0.001898	0.014759	0.128572	0.8977
AINDEX(-1)*D8	0.010600	0.013086	0.809997	0.4180
AINDEX(-1)*D9	-0.011246	0.014175	-0.793388	0.4276
NBF1*D1	-0.037430	0.041973	-0.891774	0.3726
NBF1*D2	0.085591	0.041702	2.052466	0.0402
NBF1*D3	0.054428	0.039650	1.372702	0.1700
NBF1*D4	0.270463	0.035925	7.528493	0.0000
NBF1*D5	0.277870	0.039115	7.103831	0.0000
NBF1*D6	0.326049	0.041839	7.792942	0.0000
NBF1*D7	0.333059	0.044131	7.547006	0.0000
NBF1*D8	0.435082	0.036030	12.07548	0.0000
NBF1*D9	0.465749	0.037405	12.45144	0.0000
NBF1(-1)*D1	0.047429	0.043220	1.097393	0.2726
NBF1(-1)*D2	-0.077281	0.043440	-1.779028	0.0754
NBF1(-1)*D3	-0.064529	0.040594	-1.589616	0.1121
NBF1(-1)*D4	-0.252733	0.037586	-6.724153	0.0000
NBF1(-1)*D5	-0.264504	0.040587	-6.516901	0.0000
NBF1(-1)*D6	-0.280360	0.045815	-6.119387	0.0000
NBF1(-1)*D7	-0.332267	0.045642	-7.279782	0.0000
NBF1(-1)*D8	-0.442961	0.037319	-11.86968	0.0000
NBF1(-1)*D9	-0.448450	0.039523	-11.34661	0.0000

R-squared	0.998556	Mean dependent var	58.06227
Adjusted R-squared	0.998535	S.D. dependent var	9.682387
S.E. of regression	0.370598	Akaike info criterion	0.866984
Sum squared resid	298.9959	Schwarz criterion	0.949560
Log likelihood	-925.5838	Hannan-Quinn criter.	0.897152
F-statistic	48547.60	Durbin-Watson stat	2.015061
Prob(F-statistic)	0.000000		

Note: AINDEX is the A Index, NBF1 is the previous day's price of the nearby cotton futures contract, numbers in parenthesis indicate lags.

Table 4. Final Model
Dependent Variable: AINDEX
Method: Least Squares
Sample (adjusted): 1/14/2000 5/29/2009
Included observations: 2209 after adjustments

	Coefficient	Std. Error	t-Statistic	Prob.
C	0.613368	0.105597	5.808574	0.0000
AINDEX(-1)	0.968262	0.007119	136.0052	0.0000
AINDEX(-8)	-0.009484	0.004604	-2.059900	0.0395
NBF1	0.169728	0.020831	8.147773	0.0000
NBF1(-1)	-0.138487	0.021054	-6.577706	0.0000
AINDEX(-1)*D6	-0.035631	0.019886	-1.791751	0.0733
NBF1*D2	0.105145	0.034449	3.052201	0.0023
NBF1*D3	0.082011	0.031703	2.586832	0.0098
NBF1*D4	0.292909	0.027233	10.75565	0.0000
NBF1*D5	0.295907	0.031053	9.529142	0.0000
NBF1*D6	0.346563	0.034669	9.996220	0.0000
NBF1*D7	0.355032	0.037260	9.528560	0.0000
NBF1*D8	0.460176	0.027218	16.90721	0.0000
NBF1*D9	0.484925	0.029109	16.65905	0.0000
NBF1(-1)*D2	-0.106411	0.034457	-3.088203	0.0020
NBF1(-1)*D3	-0.079770	0.031709	-2.515703	0.0120
NBF1(-1)*D4	-0.289686	0.027227	-10.63968	0.0000
NBF1(-1)*D5	-0.295911	0.031037	-9.534243	0.0000
NBF1(-1)*D6	-0.306493	0.038656	-7.928683	0.0000
NBF1(-1)*D7	-0.351208	0.037265	-9.424569	0.0000
NBF1(-1)*D8	-0.456133	0.027204	-16.76700	0.0000
NBF1(-1)*D9	-0.479639	0.029075	-16.49663	0.0000

R-squared	0.998548	Mean dependent var	58.06227
Adjusted R-squared	0.998534	S.D. dependent var	9.682387
S.E. of regression	0.370716	Akaike info criterion	0.863149
Sum squared resid	300.5604	Schwarz criterion	0.919920
Log likelihood	-931.3484	Hannan-Quinn criter.	0.883890
F-statistic	71619.39	Durbin-Watson stat	2.006268
Prob(F-statistic)	0.000000		

Note: AINDEX is the A Index, NBF1 is the previous day's price of the nearby cotton futures contract, numbers in parenthesis indicate lags.

Table 5. Final model. Effects of each variable on the A Index, by season.

Season	Constant (US cents/lb)	aindex(-1)	aindex(-8)	nbf1	nfb1(-1)
1999/00	0.613	0.968	-0.009	0.170	-0.138
2000/01	0.613	0.968	-0.009	0.170	-0.138
2001/02	0.613	0.968	-0.009	0.275	-0.245
2002/03	0.613	0.968	-0.009	0.252	-0.218
2003/04	0.613	0.968	-0.009	0.463	-0.428
2004/05	0.613	0.968	-0.009	0.466	-0.434
2005/06	0.613	0.933	-0.009	0.516	-0.445
2006/07	0.613	0.968	-0.009	0.525	-0.490
2007/08	0.613	0.968	-0.009	0.630	-0.595
2008/09	0.613	0.968	-0.009	0.655	-0.618

Figure 1. Correlation between the A Index and NCFC Prices, and Stocks-to-Mill Use Ratio in China (Mainland).

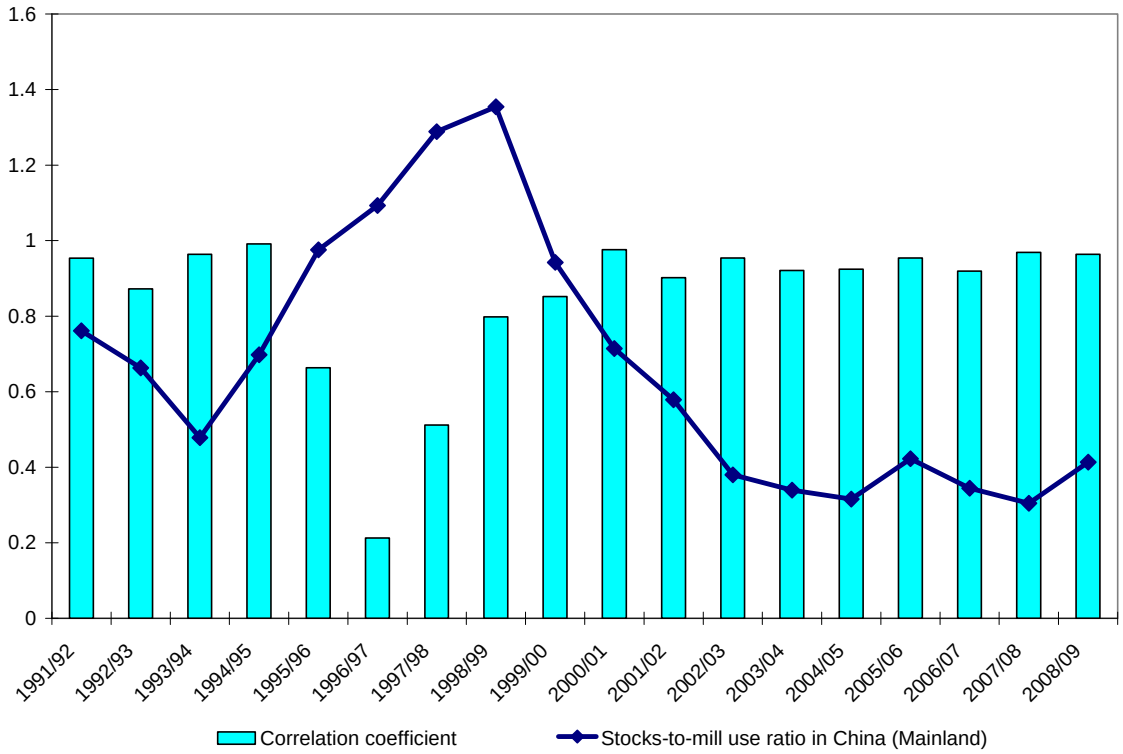
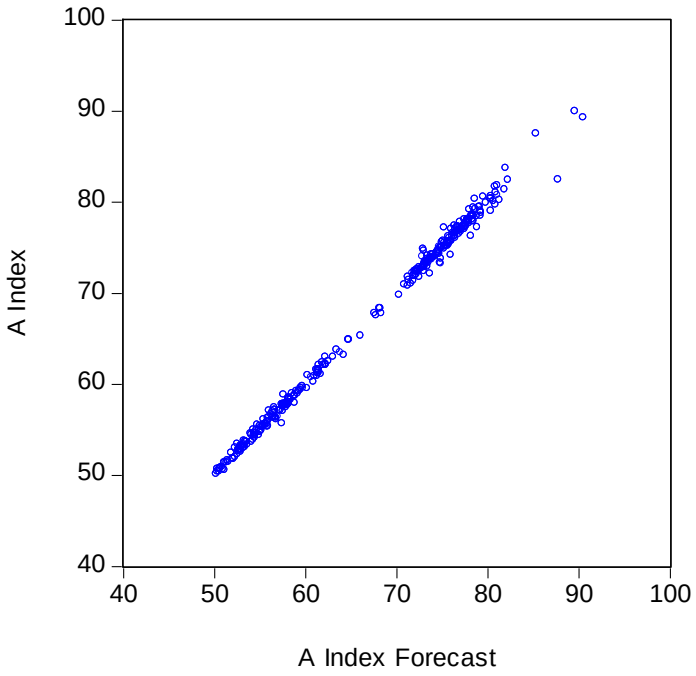


Figure 2. Observed versus Forecast A Index.
Panel a.



Panel b.

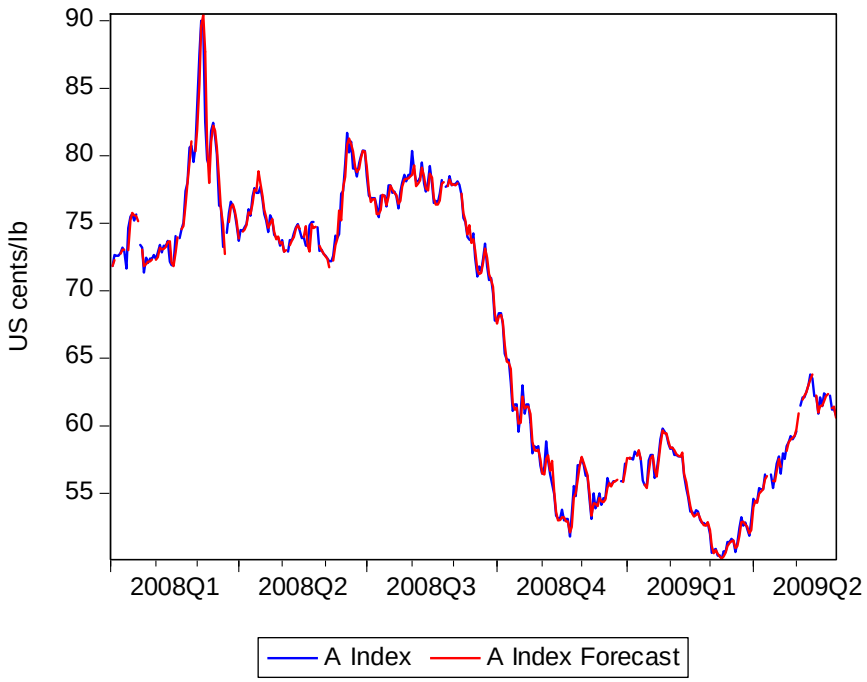


Figure 3. Ratio of NCFC prices in the Adjustment Term.

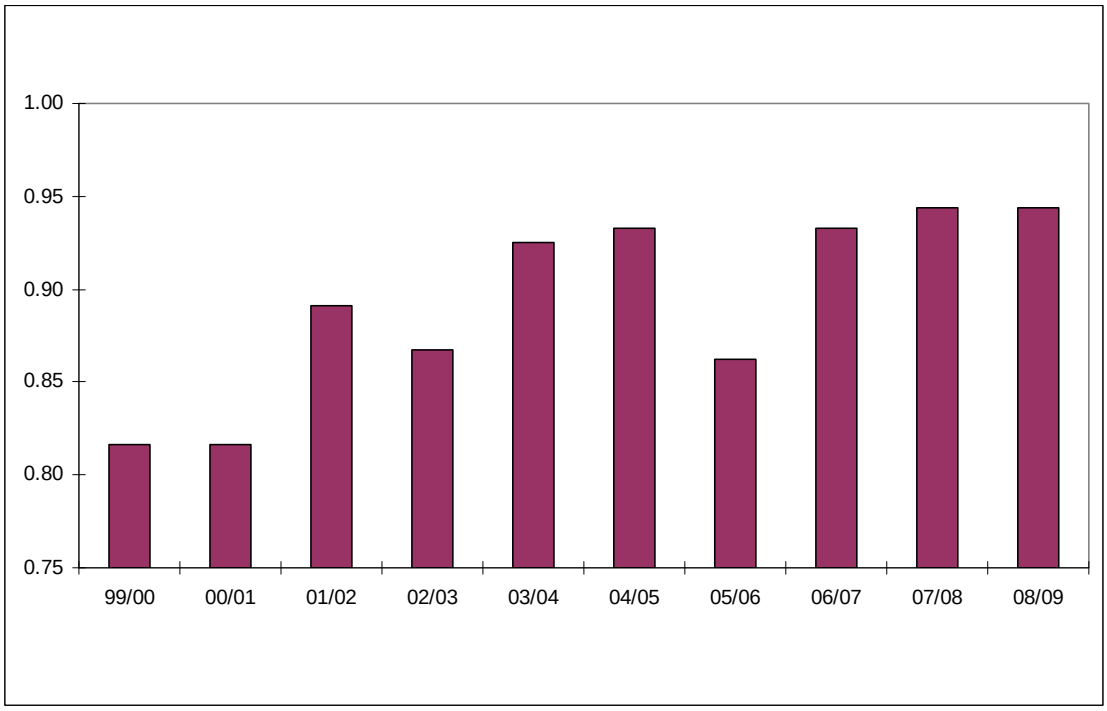


Figure 4. Proportion of days in which the A Index moved in the same direction as the price of the NCFC in the previous day, by season.