Australasian Agribusiness Review – Vol. 21 - 2013

Paper 6

ISSN 1442-6951

Wheat and corn price skewness and volatility: Risk management implications for farmers and end users

J. Williams [A]

Abstract

Little has been documented as to how price skewness and volatility can influence decision making regarding agribusiness risk taking and managing risk in a dynamic environment. Price volatility introduces opportunities for farmers and end users, but it also introduces new risks, which can then require management. Volatility-skewness matrices are developed using CME wheat and corn prices to tactically determine when pricing and hedging might be more successful for farmers and end users. Volatility and skewness may still favour the end user, but the matrices changed considerably during 2007 to 2012. Farmers need realistic pricing targets and hedging triggers in price risk management decision making with timing becoming increasingly important, but production-product risk still remains an important consideration, as does basis and currency risk for international transactions and hedging.

Key words: Price volatility, skewness, pricing, hedging, timing, risk management

Background

Grain prices have been falling gradually relative to general prices for many centuries (Glamann, 1977), which increases the propensity for positive price skewness by stealth. In contrast, agricultural supply uncertainty and price have been an historical preoccupation for economists (Anderson, 1938), with price volatility being the bane of regulators in times of war and fiscal uncertainty (Keynes, 1938).

[A] Senior Researcher at the Australian Commodity Research Institute, PO Box 603 Werribee, Victoria. 3030. Email: comm.trade@bigpond.com

Empires and governments traditionally have attempted to use granaries as buffer stocks (Davies, 1938) to control supply and restrict price volatility (Williams and Wright, 1991). This is despite product withdrawal and hoarding impacting on end users during accumulation (Peck, 1977), and despite the demand-price devastation to new crop farmers in the offloading phase (Williams, 2012). The link between price stabilization and welfare benefits is weak (Waugh, 1944; Massell, 1969; Gilbert, 1986), and it is not always apparent who is the recipient of such benefits (Roy, 1984: Singh, 1999).

Market deregulation has the effect of switching the focus of stability from buffer stocks to price hedging (Peck, 1975; Gordon and Rausser, 1984). McKinnon (1967) argued that government buffer-price stabilization schemes focused on spot price and ignored the contribution of forward prices to commercial inventory and supply chain stability (Working, 1949). There was a shift towards farmers managing their price risk despite production uncertainty, provided that regular price volatility rendered sufficient pricing opportunities (Williams and Schroder, 1999).

Speculators and US fund managers have recently borne the brunt of criticism from G20 summit leaders in 2011 over perceived price volatility (Cordier, 2012), without adequate justification (Sanders, Irwin, and Merrin, 2010), and despite the 2008 wheat and corn spikes being a confluence of rising crude oil prices, the 2006-07 Australian drought, eastern Europe winter thawing problems, excessive wet conditions affecting 2008 US corn planting, and the adoption of an ethanol-related US energy policy in the 2008 US Presidential election which created new demand potential for corn (Tokgoz, Elobeid, Fabiosa, Hayes, Babcock, Yu, Dong, and Hart, 2008). As well, the balance between large fund speculation and hedgers may be more important in price movement than speculative position size (Peck, 1981; Streeter and Tomek, 1992). Agricultural markets often only exist via futures markets because speculators span the periods when seasonal physical market inactivity occurs (Rutledge, 1979).

The drivers of price volatility can be diverse (Radetzki, 2006) and unique to a particular year (Cooper and Lawrence, 1975), whilst there is continual debate over the impact of each specific end usage on price volatility (Perrin, 2008). Annual patterns of commodity price volatility change (Voituriez, 2001; Sumner, 2009) because of the dynamics of production, supply, trade, currency exchange, investment fund policy, end usage demand (Anderson, 1985), macroeconomic policy (Awokuse, 2005), and government policies (Boehlje and Griffin, 1979; Crain and Lee, 1996; Lence and Hayes, 2002). However, contrary evidence suggests that price volatility has not significantly changed over 50 years even using nominal data, except for wheat and rice in specific years (Huchet-Bourdon, 2011).

Any policy to increase global agricultural production and productivity to stabilize price can be considered deficient if subsequent price suppression results in farm prices below costs of production. Farm subsidies have traditionally been used to offset the consequences of suppressing price. However, many governments are unwilling or unable to devote up to one-third of their budget to farm subsidies, such as in the food bowl countries of EU, USA, China, and, increasingly, India (Gupta, 2000). As an alternative to subsidies, price volatility can create opportunities for risk management for farmers, which can support profitability.

The objective of this paper is to examine 30 year price skewness and volatility data with the aim to identify conditions that could motivate or hinder price risk management decisions by farmers and end users. Prolonged positive price skewness and low volatility might be expected to result in a lack of opportunity for target pricing or hedging for farmers, whereas end users may not perceive sufficient risk to be motivated to manage price risk. Alternatively, decreasing positive price skewness and regular occurrences of price volatility might increase opportunities for target pricing or hedging for farmers, with end users perceiving sufficient risk to be motivated to manage price risk.

There are two contributions of this paper. The first is that price skewness and volatility are examined in matrices based on market position, with the aim to tactically determine when target pricing and triggers for hedging might be more successful for farmers and end users. The second contribution lies with the change in price skewness and volatility over time, and assessing how this could impact tactically on pricing and hedging for farmers and end users.

Whilst both product and price are the keys to managing price risk, this paper assumes no production or product risk which would otherwise distract from pricing decision making. It also ignores basis and currency risk in international transactions and hedging.

Target pricing and trigger hedging decisions

Farmers mostly have downside price risk (long position) in contrast to an end user who mostly has upside price risk (short position). Managing price risk can occur through a spot transaction if the product is available, or through a forward transaction if the product is not available, either with a physical forward contract or hedging price through a futures market.

Target pricing is often important for farmers (Williams and Malcolm, 2012), whereas end users are more likely to use maximum limit pricing in procurement budgets or as a trigger to initiate price hedging (Collins, 1997). The willingness to transact or hedge often depends on the opportunity or risk of reaching a particular price.

Choosing subjective price targets or triggers depends on the individual risk attitude and circumstance of the decision maker (Williams, 2009). One example of a totally unrealistic target price is adding a profit margin to the current price in a bearish market, when commodity markets intrinsically ignore the operational costs of a farmer or end user (Williams and Schroder, 1999). Farmers may sometimes be forced to accept prices below their cost of production, whereas end users may sometimes be forced to buy above their break-even limit. The alternative for farmers is to withhold product from the supply chain either by hoarding or pooling, whereas the alternative for end users is a switch to substitute products or alternate operating methods.

Price volatility can enable more realistic pricing targets and hedging triggers for farmers and end users, particularly if there is price signal transmission. Increased frequency in reaching a target or trigger price creates more opportunities for decision making (Oi, 1961), and is more likely to create the uncertainty required for market liquidity as expressed through volume being traded (Malliaris and Urrutia, 1998; Bessembinder and Seguin, 1993).

Decreasing positive skewness is another factor that can influence price targets and trigger decision making. The greater the frequency of higher prices which is associated with the median price shifting towards higher prices, the more likely will the target prices of farmers be realized (Anderson and Danthine, 1983), and motivate end users into pricing or hedging decisions (Collins, 1997).

Issues with price volatility

Volatility is multi-dimensional in price range-amplitude as well as the frequency and duration of price movement. Strong price trends may extend the price range but have no frequency and duration, hence price spikes occur (Gilbert, 2010). Large speculator activity may continue the trend, while large hedgers can reverse the trend (Wang, 2001).

The certainty associated with an uptrend can decrease seller activity because of the belief that prices will be higher tomorrow, whereas downtrend certainty can decrease buyer activity because of the belief that prices will be lower tomorrow (Williams and Schroder, 1999). End users and farmers might be anxious over prices and perceive the need for early transactional pricing or hedging, but not simultaneously. Therefore, market illiquidity can occur and prevent the management of price risk. The ability to transact and hedge are more likely to occur when uncertainty creates price volatility and market liquidity.

However, price movement frequency by itself is often not a good guide to pricing and hedging. If high frequency of price movement occurred when there was strong positive skewness favouring low prices, farmers might be unwilling to lock in low profitability. As well, end users might perceive insufficient uncertainty to motivate them to manage price.

Skewness characteristics

Positive skewed data with a convex frequency distribution characterized by the mean > median > mode (MacGillivray, 1981) was identified in many physical, economic, and biological investigations during the late 19th century (Pearson, 1895). Of the seven different types of skewed frequency curves identified through Pearson's non-random data examination (Pearson, 1895, Figure 5), three were positively skewed and none were negatively skewed. Pearson's application of skewness testing to non-random homogeneous price data makes it very relevant to this paper.

Many studies indicate non-random price data has time-varying non-stationarity that changes mean-median-mode relativity and skewness (Dark, 2010; Cuddy and Della Valle, 1978), which are influenced by similar factors that affect volatility. However, whilst volatility and skewness can be inter-connected, they remain separate variables. As an example, if decreasing price volatility was not offset by the frequency-duration of high prices, the more likely would positive skewness increase. This could lessen pricing-hedging opportunities for farmers, and decrease the price risk for end users.

Long memory that might support the theory of autocorrelation and price range formation has been found in agricultural commodity price data by identifying fractional integration (Chang, McAleer, and Tansuchat, 2012; Elder and Jin, 2007), volatility clustering as measured by autoregressive conditional heteroscedasticity (Baillie and Myers, 1991), and slow volatility decay (Crato and Ray, 2000; Jin and Frechette, 2004). Persistent long memory of increased volatility might be expected to decrease positive skewness and perhaps increase negative skewness. This will be examined in this paper.

Wheat and corn price analysis

CME (Chicago Mercantile Exchange) soft wheat and corn prices were selected for this study because many countries use Chicago for benchmarking and hedging due to the large volumes being transacted (liquidity). Therefore, this paper is not country specific and can apply to most global farmers or end users. Inter-commodity comparison between wheat and corn is justified by differences in agronomic and seasonal factors, as well as end usage. Corn is used for food, feed, starch, bourbon alcohol, syrup, and ethanol, whereas wheat generally is used for flour, feed, and starch.

Historical spot daily continuous spliced wheat and corn futures prices from the (CME) were selected for comparison because of similarity of the data source and denomination to remove local basis variability (Castelino, 1989), as well as international basis and currency variables (Yang, Balyeat, and Leatham, 2005). De-trended data was not used in this study because of the important implications of nominal price in target pricing and trigger decision making during price risk management. Daily closing-settlement prices were selected instead of intra-day data because of simplicity and alignment with other studies. Spot prices were used throughout to remove carry and backwardation variances in the forward market. The impact of inflation was minimized by analysing the data in annualized sets.

Figure 1 graphs Chicago Mercantile Exchange (CME) nominal daily spot prices for both soft wheat and corn for 30 years from 1983 to 2012. Historically, US corn prices have generally been at a discount to soft wheat prices.

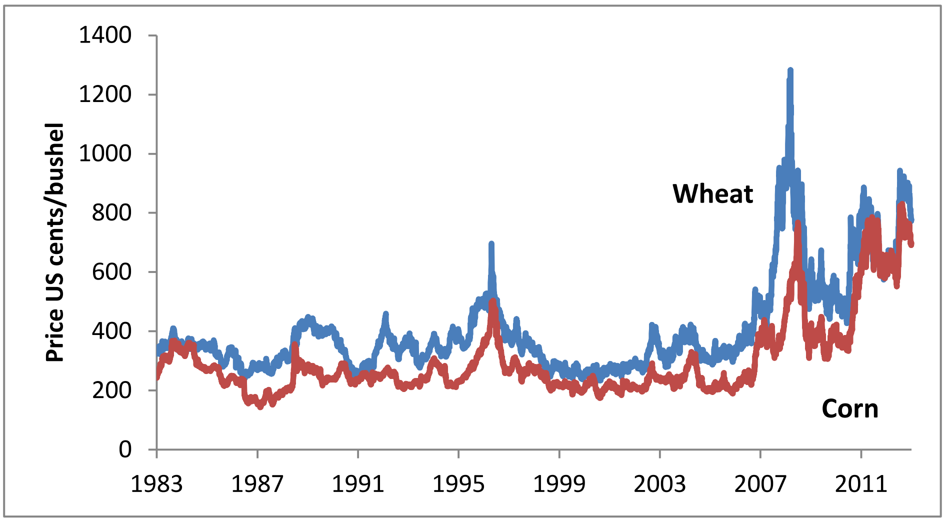

Figure 1. CME spot month soft wheat and corn daily prices: 1983-2012

Source: John Williams using PremiumData

This paper does not purport to predict the future movement of prices, volatility, or skewness. Autoregressive Conditional Heteroscedasicity (ARCH) and Generalized Autoregressive Conditional Heteroscedasicity (GARCH) were therefore excluded because of unrealistic assumptions and subjective interpretation of outcomes (Gilbert and Morgan, 2010).

Standard deviation (SD) is used to indicate price volatility as measured by the average price dispersion from the mean. It does not measure the actual range, amplitude, frequency, or duration.

$$SD = \sqrt{\frac{\sum (x - \bar{x})^2}{(n-1)}}$$

where $\bar{x}$ is the mean of price data.

There are many measures to quantify the degree of skewness in a distribution of data (Arnold and Groeneveld, 1995; Dark, 2010). Depicting skewness in price data can vary from a frequency distribution in a histogram, percent rank ((100 – percent rank) measures skewness), or Cumulative Distribution Function. Tabor (2010) tested 11 different methods for measuring skewness with the results varying between the methods according to the amount of skewness. However, provide that the skewness measurement method is kept consistent, comparative analysis between years has validity in time series analysis (Dark, 2010).

The Edgeworth (1904) Skew[x] function was selected to measure skewness because of its widespread adoption in analysis as well as its sample focus with relevant degrees of freedom.

$$\text{Skew}[x] = \frac{n}{(n-1)(n-2)} \sum \left[\left(\frac{X - \mu}{\sigma} \right)^3 \right]$$

It is argued that because each individual year was examined within three 10-year periods (1983-92; 1993-2002; 2003-2012), the data sets are samples of a bigger price data population.

Agricultural skewness problem

Using Figure 1 as an example of seemingly low prices for most of the time (Jacks, O'Rourke, and Williamson, 2009), if a wheat grower had a pricing target of US$4 per bushel during the 24-year period from 1983 to 2006, then there would be a 58 percent probability (1983, 1988, 1989, 1990, 1991, 1992, 1994, 1995, 1996, 1997, 2002, 2003, 2004, and 2006) of achieving that target price and minimizing subsequent losses. Any more unrealistic higher target price to maximize profit may have decreased the frequency of achieving that target.

Assuming that the pricing target was then increased to US$6 per bushel during the 6 years 2007 to 2012 because of increased costs, lower profitability, and higher price volatility, then the target price would have been reached in each of the years (100 percent probability). It might be concluded that the farmer benefited from the increased price volatility by improving the potential to be profitable, despite historical positive price skewness.

In contrast, a wheat end user with a trigger to hedge at US$4 per bushel during 1983 to 2006 would have speculated for 42 percent of the time by buying wheat opportunistically in the spot physical market. However, if the trigger to hedge price was raised to US$6 per bushel and operations adjusted, the end user would have had to hedge 100 percent of the time during 2007 to 2012 because of the increased price volatility.

Again using Figure 1, if a corn grower had a pricing target of US$3 per bushel during the 24-year period from 1983 to 2006, there would be a 38 percent probability (1983, 1984, 1988, 1993, 1995, 1996, 1997, 2004, and 2006) that the target price could be achieved. Assuming that the pricing target was then increased to US$5 per bushel because of increased costs and lower profitability, then during the 6 years 2007 to 2012, the probability of reaching the target price increased to 50 percent (2008, 2011, and 2012). It might again be concluded that the farmer benefited from the increased price volatility by improving the potential to be profitable, despite historical positive price skewness, but not as much as for wheat.

In contrast, a corn end user with a trigger to hedge at US$3 per bushel during 1983 to 2006 would have speculated for 62 percent of the time by buying corn opportunistically in the spot physical market. However, if the trigger to hedge price was raised to US$5 per bushel, the corn end user would have had to hedge 50 percent of the time during 2007 to 2012.

Positive price skewness in agricultural supply chains generally favours the end user to the detriment of farmers whenever there is a lack of sufficient price volatility. In terms of corn growers with the aforesaid target prices, and assuming some constancy of other variables, they were disadvantaged in15 years out of 24 when there was little price volatility during 1983 to 2006, and 3 out of 6 years when there was price volatility and a 67 percent increase in target prices during 2007 to 2012. End users were disadvantaged in only 9 years during the 24 years from 1983 to 2006, and even when price volatility increased and their targeted purchase price rose by 67 percent, they were only disadvantaged in 3 out of the next 6 years.

The wheat outcome was better for growers but worse for end users. On the assumption that farmers were willing and able to avail themselves of the pricing and hedging opportunities when they arose, wheat growers were disadvantaged in only 10 out of 30 years, even with a 50 percent increase in target prices during the last 6 years. In contrast, end users were disadvantaged in 14 years during 1983 to 2006, but 100 percent in the 6 years from 2007 to 2012 when price volatility increased and their targeted purchase price rose by 50 percent.

Historical skewness verses volatility

Figure 2 indicates the annualized price skewness for CME soft wheat based on daily spot prices for each year over the 30 year period during 1983 to 2012. There were five occurrences of negative skewness in 1984, 1985, 1988, 2000, and 2001 with none during the period 2002 to 2012, which represented 17 percent of the 30 year sample period.

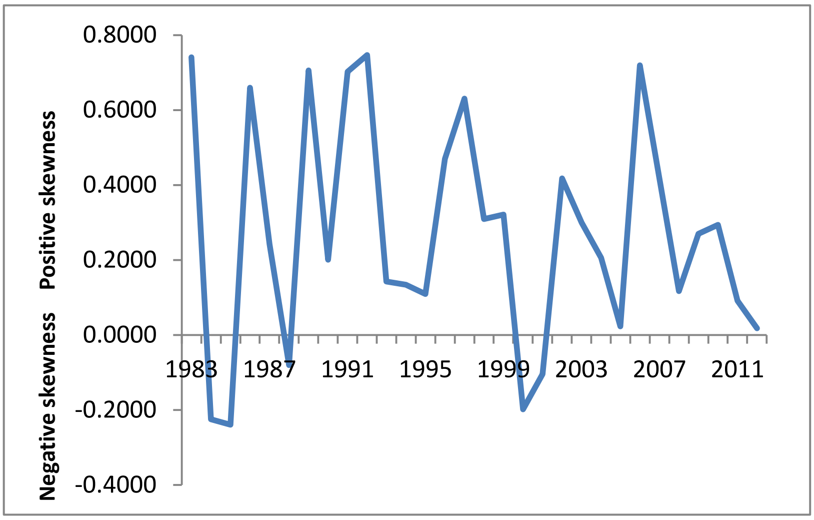

Figure 2. CME soft wheat annualized spot price skewness: 1983 - 2012

Only one of the years of negative skewness for wheat (1988) aligned with the 20 years in which the previously discussed price targets and triggers for farmers were achieved. Negative skewness may be a poor indicator of the ability to achieve wheat price targets and triggers.

Figure 3 indicates the annualized price skewness for CME corn based on daily spot prices over the same 30 year period during 1983 to 2012. The major characteristic is the much weaker movement of positive skewness relative to wheat during the whole time period (Figure 2). There were more occurrences and greater strength of negative skewness in 13 years (1983, 1984, 1985, 1986, 1987, 1991, 1997, 1999, 2000, 2001, 2003, 2008, and 2009).

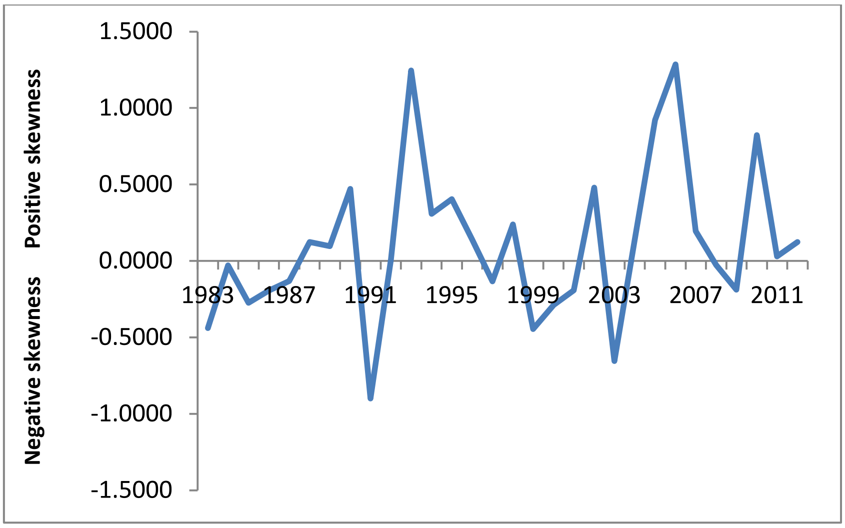

Figure 3. CME corn annualized spot price skewness: 1983 - 2012

Even though the occurrence of negative skewness for corn was 43 percent of the 30 year sample period, only four of the years of negative skewness align with those in which the previously discussed price targets and triggers were achieved (1983, 1984, 1997 and 2008). Again it might be concluded that the occurrence of negative skewness for corn is a poor indicator of the probability of achieving price targets and triggers in price risk management.

Whilst the opportunities for target pricing and hedging may have increased for corn farmers relative to wheat because of negative skewness, it decreased for end users. Timing in pricing and hedging decision making may have been crucial for both corn growers and end users.

Figure 4 compares the price volatility of US soft wheat and corn using annualized standard deviation on daily spot prices over the same 30 year period from 1983 to 2012.

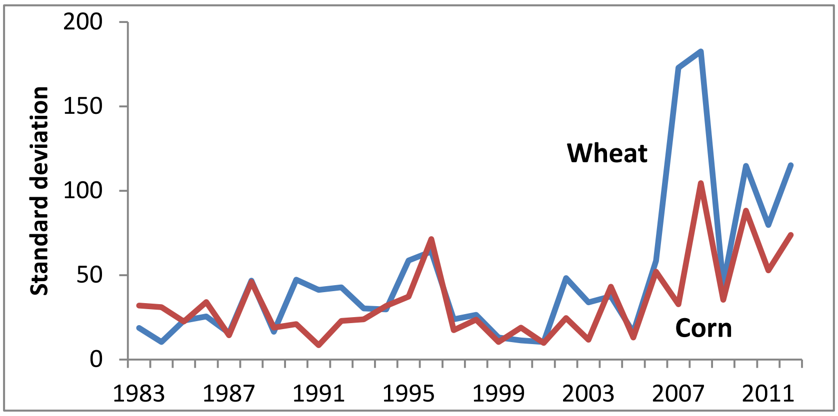

Figure 4. CME wheat & corn annualized spot price standard deviation: 1983 - 2012

The price volatilities for both wheat and corn were relatively subdued until 2006, after which both wheat and corn prices incurred higher volatility from 2007 to 2012. This enabled growers to increase their target prices after 24 years of relative low volatility, with increased price risk for end users, moreso for corn end users because of the higher negative skewness.

Using the previous target pricing example, wheat growers during 2007 to 2012 were able to increase their target price from US$4 to $6 per bushel and corn growers from US$3 to $5 per bushel, and yet the probability of achieving that new target price increased from 58 to 100 per cent for wheat and from 38 to 50 percent for corn.

The increased price volatility after 2007 was perplexing for corn end users because it occurred when negative skewness was encountered (2008, 2009), albeit mildly. In contrast, the increased price volatility for wheat occurred at a time of positive skewness.

Skewness and volatility matrix development

A quadrilateral was established based on the following four segment criteria:

High price volatility	A Positive skewness and standard deviation above 50	B Negative skewness and standard deviation above 50
Low price volatility	D Positive skewness and standard deviation below 50	C Negative skewness and standard deviation below 50
	Positive skewness	Negative skewness

Annual average prices, skewness, and standard deviation were then compared for wheat and corn in Table 1 between 1983 and 1992 and categorized according to the selected criteria.

Product	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**
Wheat	3.64 0.7411 (19) D	3.48 - 0.2249 (10) C	3.43 - 0.2394 (23) C	2.75 0.6593 (25) D	3.11 0.2431 (16) D	4.40 - 0.0799 (47) C	4.09 0.7058 (17) D	2.61 0.2009 (47) D	4.05 0.7026 (41) D	3.54 0.7464 (43) D
Corn	3.37 - 0.4404 (32) C	2.69 - 0.0300 (31) C	2.48 - 0.2751 (22) C	1.60 - 0.1938 (34) C	1.85 - 0.1312 (14) C	2.85 0.1233 (46) D	2.40 0.0963 (19) D	2.32 0.4721 (21) D	2.52 - 0.8996 (8) C	2.17 0.0107 (23) D

Note: Top is annual price in US$/bushel, 2nd row is price skewness, 3rd row is standard deviation, bottom is volatility-skewness category.

Table 1. CME annualized wheat and corn prices, skewness, and volatility: 1983-1992

Table 2 summarizes the volatility-skewness category by outcome for 1983 to 1992.

	Positive skewness	Negative skewness
High price volatility	A Wheat 0% Corn 0%	B Wheat 0% Corn 0%
Low price volatility	D Wheat 70% Corn 40%	C Wheat 30% Corn 60%

Table 2. Volatility and skewness category allocation: 1983-1992

Table 3 categorizes the selected criteria between 1993 and 2002.

Product	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Wheat	3.78 0.1426 (30) D	4.02 0.1346 (30) D	5.12 0.1094 (59) A	3.81 0.4701 (64) A	3.26 0.6304 (24) D	2.76 0.3097 (26) D	2.49 0.3216 (13) D	2.80 - 0.1980 (11) C	2.89 - 0.1037 (10) C	3.25 0.4177 (48) D
Corn	3.06 1.2454 (24) D	2.31 0.3089 (32) D	3.69 0.4037 (37) D	2.58 0.1378 (71) A	2.65 - 0.1330 (17) C	2.14 0.2383 (24) D	2.05 - 0.4456 (10) C	2.32 - 0.2881 (19) C	2.09 - 0.1934 (10) C	2.36 0.4801 (24) D

Note: Top is annual price in US$/bushel, 2^{nd} row is price skewness, 3^{rd} row is standard deviation, bottom is volatility-skewness category.

Table 3. CME annualized wheat and corn prices, skewness, and volatility: 1993-2002

Table 4 summarizes the volatility-skewness category by outcome for 1993 to 2002.

	Positive skewness	Negative skewness
High price volatility	A Wheat 20% Corn 10%	B Wheat 0% Corn 0%
Low price volatility	D Wheat 60% Corn 50%	C Wheat 20% Corn 40%

Table 4. Volatility and skewness category allocation: 1993-2002

Table 5 categorizes the selected criteria between 2003 and 2012.

Product	2003	2004	2005	2006	2007	2008	2009	2010	20111	2012
Wheat	3.77 0.3000 (34) D	3.08 0.2060 (38) D	339 0.0232 (16) D	5.01 0.7189 (59) A	8.85 0.4181 (173) A	6.11 0.1169 (183) A	5.42 0.2701 (44) D	7.94 0.2937 (115) A	6.53 0.0911 (80) A	7.78 0.0178 (115) A
Corn	2.46 - 0.6543 (12) C	2.05 0.1448 (43) D	2.16 0.9211 (13) D	3.90 1.2845 (52) A	4.56 0.1955 (33) D	4.07 - 0.0264 (104) B	4.15 - 0.1889 (35) C	6.29 0.8219 (88) A	6.47 0.0288 (53) A	6.98 0.1243 (74) A

Note: Top is annual price in US$/bushel, 2nd row is price skewness, 3rd row is standard deviation, bottom is volatility-skewness category.

Table 5. CME annualized wheat and corn prices, skewness, and volatility: 2003-2012

Table 6 summarizes the volatility-skewness category by outcome for 2003 to 2012.

High price volatility	A Wheat 60% Corn 40%	B Wheat 0% Corn 10%
Low price volatility	D Wheat 40% Corn 30%	C Wheat 0% Corn 20%
	Positive skewness	Negative skewness

Table 6. Volatility and skewness category allocation: 2003-2012

Tactical development

Pricing and hedging scenarios for categories A, B, C, and D were developed in Tables 7 and 12 on the assumption that positive skewness indicates less time for high prices for farmers and more time for low prices for end users, whereas negative skewness indicates more time for high prices for farmers and less time for low prices for end users.

Farmers. Category B in Table 7 was the best scenario for farmers because there was negative skewness (more time for high prices to occur) combined with high volatility (more opportunities for high prices to occur). Speculative spot transactions might be expected to rise and price hedging activity to decrease for farmers when the probability of high prices increases. However, the probability of best case scenarios (category B) was non-existent for wheat during 1983 to 2012, and only occurred once (2008) for corn.

	Positive skewness	Negative skewness
High price volatility	**A. Better outcome** Less time for high prices High motivation for hedging (Wheat 27%, Corn 17%)	**B. Best outcome** More time for high prices Little motivation for hedging (Wheat 0%, Corn 3%)
Low price volatility	**D. Worst outcome** Less time for high prices Some motivation for hedging (Wheat 56%, Corn 40%)	**C. Good outcome** More time for high prices Some motivation for hedging (Wheat 17%, Corn 40%)

Table 7. Farmer price risk management - volatility and skewness scenarios: 1983-2012

The worst scenario for farmers was category D because there was less time for high prices to occur combined with less opportunity for pricing or hedging due to low volatility. Speculative spot transactions or deferment of sales through hoarding or pooling might be expected to be high because of the lack of pricing or hedging opportunities. The worst case scenario probability was 56 percent for wheat during 1983 to 2012, and 40 percent for corn.

Whilst increased price volatility in category A provided more opportunities for farmers to meet pricing and hedging targets, the occurrence of ever reaching those targets was minimal unless they were established at low prices. The probability of occurrence of category A was 27 percent for wheat during 1983 to 2012, but only 17 percent for corn. Price volatility may therefore be more important for wheat growers than for corn growers.

Category C was a relative good situation for farmers because while there was decreased price volatility, the occurrence of reaching pricing and hedging targets was higher due to negative skewness, with the possible opportunity to raise the target price. However, the probability of category C was only 17 percent for wheat during 1983 to 2012, and 40 percent for corn.

Category change directions might be considered important in tactical pricing and hedging. Table 8 indicates the category directional change for wheat farmers during 1983 to 2012.

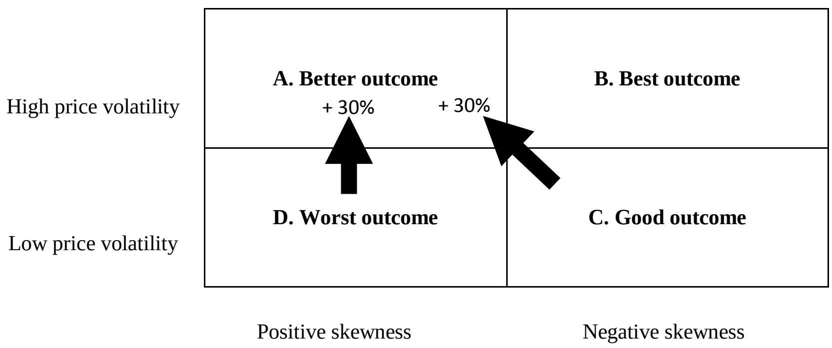

Table 8. Wheat farmer volatility and skewness category change: 1983-2012

Whilst the occurrence of the worst outcome lessened considerably for wheat growers during 1983 to 2012, the other directional change was away from negative skewness in category C and towards positive skewness in category A. The combination of more frequent high prices (high volatility) but of less time duration (positive skewness) suggests that the motivation for pricing and hedging in risk management should be high. However, timing through tactical management would be crucial.

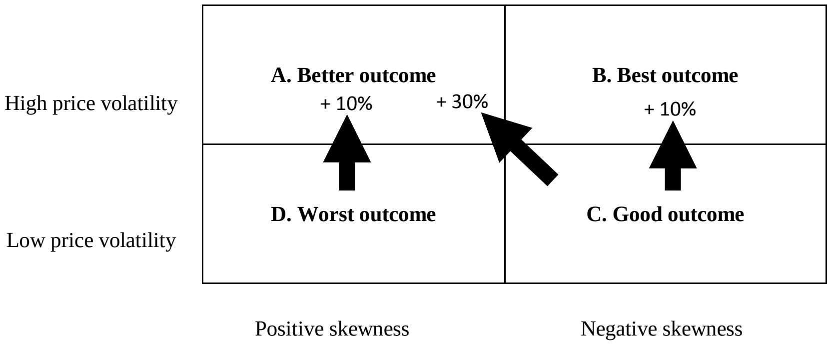

Table 9. Corn farmer volatility and skewness category change: 1983-2002

Whilst the occurrence of the worst outcome firstly increased then decreased for corn growers during 1983 to 2012, the percentage of years in worst outcome was lower than for wheat. A small percentage (10 percent) shifted from category D to A. Another 10 percent shifted from category C into the best outcome category B. The majority of the change during the 30 year period occurred from category C to category A. Again more frequent high prices (high volatility) but of less time duration (positive skewness) suggests that the motivation for pricing and hedging should be high, albeit with good timing through tactical management.

End user. The category outcomes for an end user are not the exact opposite for a farmer (Table 10). Category D with positive skewness (long periods of low prices) and low volatility (relative price stability) becomes the best outcome for the end user, and the more likely to encourage opportunistic spot purchases with little motivation for forward pricing or hedging.

	Positive skewness	Negative skewness
High price volatility	**A. Good outcome** More time for low prices Some motivation for hedging (Wheat 27%, Corn 17%)	**B. Better outcome** Less time for low prices High motivation for hedging (Wheat 0%, Corn 3%)
Low price volatility	**D. Best outcome** More time for low prices Little motivation for hedging (Wheat 56%, Corn 40%)	**C. Worst outcome** Less time for low prices Some motivation for hedging (Wheat 17%, Corn 40%)

Table 10. End user price risk management – volatility & skewness scenarios: 1983-2012

Category C has the worst outcome for an end user with negative skewness (longer periods of high prices) and low volatility (little opportunity for forward pricing or hedging). There may be some product substitution and alternate operation switching by end users rather than waiting for pricing or hedging opportunities to occur. The probability for category C was only 17 percent for wheat during 1983 to 2012, but 40 percent for corn.

Whilst category B had increased price volatility that provided more opportunities to meet low pricing targets and hedging triggers, the occurrence of ever reaching those low targets was minimal unless they were established at higher prices due to the negative skewness. Timing might be critical when pricing or hedging within this category. However, the occurrence of category B was zero for wheat during 1983 to 2012, and it only occurred in one year for corn.

Category A had a higher occurrence of low prices (positive skewness) combined with volatility (more opportunity to meet pricing targets and hedging triggers). Therefore, some motivation for end users to forward price or to hedge might be expected whenever such opportunities arise, albeit with good timing through tactical management. The probability of category A was 27 percent for wheat during 1983 to 2012, and 17 percent for corn.

Category change directions might also be considered important in tactical pricing and hedging for end users. Table 8 indicates the category directional change during 1983 to 2012.

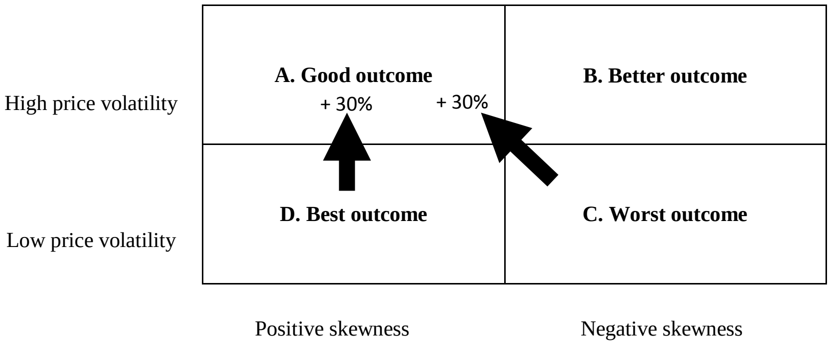

Table 11. Wheat end user volatility and skewness category change: 1983-2012

The occurrence of the worst outcome lessened considerably for wheat end users during 1983 to 2012, however, the best outcome occurrence lessened as well. Category A increased the most for end users. The combination of more frequent high prices (high volatility) and of more time duration (positive skewness) suggests that the motivation for pricing and hedging might be high with timing being important, but not as high as might occur for category B.

In contrast, the best outcome (category D) decreased for corn end users in Table 12, but only by 10 percent. The biggest change was the lessening of worst outcome category C by 40 percent, with 10 percent going to category B, and 30 percent to category A.

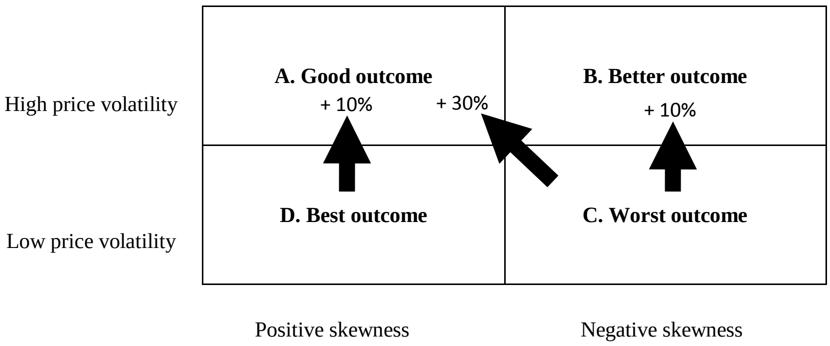

Table 12. Corn end user volatility and skewness category change: 1983-2002

This directional change for corn during 1983 to 2012 again supports the premise that end users have a more favourable outcome for more of the time. More frequent high prices (high volatility) but of less time duration (positive skewness) might suggest that low price opportunities for forward pricing and hedging may occur, however timing is important.

Conclusions

Both farmer (long) and end user (short) market positions were contrasted through the use of volatility-skewness matrices to identify how price volatility and skewness can affect target pricing and hedging triggers in decision making. Sufficient end usage differences between CME wheat and corn enabled a contrast to be made between wheat and corn farmers and wheat and corn end users. Whilst standard deviation and skewness measures both have their weaknesses, the combination does provide a useful tool in management decision making.

The study found persistent and increasing positive skewness for both CME soft wheat and corn which favoured end users over farmers regarding pricing opportunities and risks. Positive skewness was found in 25 out of 30 years for wheat during 1983 to 2012, and 17 out of the same 30 year period for corn. Some increase in price volatility was found during 2007 to 2012, but this may have been inadequate to compensate farmers for the major increase in positive skewness. Any attempts to suppress prices and volatility by governments can worsen the dilemma for farmers, which may not always be ameliorated by farm subsidies.

Farmers have the best outcome when negative skewness is combined with high volatility, but this only occurred once in the 30 year study period (2008 for corn and never for wheat). Their worst outcome occurred when positive skewness was combined with low volatility, with the problem that this usually occurred in the majority of years (17 out of 30 years for wheat, and 12 years for corn).

End users had the best outcome when positive skewness was combined with low volatility, with the advantage that this occurred in 17 years for wheat during the 30 year period and 12 years for corn. Their worst outcome occurred when negative skewness was combined with low volatility, but this only occurred in 5 out of the 30 years for wheat, and 12 years for corn. The advantage for end users was that this worst case occurrence decreased substantially during 1983 to 2012 (30 percent for both wheat and corn).

The increase in price volatility during 2007 to 2012 was countered by the decrease in the time duration of high prices as measured by the increase in positive skewness. Therefore, tactics such as timing have become increasingly important when implementing and executing price targets and hedging triggers for both farmers and end users. Tactics and risk management are not the exact opposite between farmers and end users as might be expected.

There was some evidence of long memory in recent volatility for wheat and corn price data as indicated by the increasing occurrence of category A. However, this was not sufficient to prevent the erosion of negative skewness towards more positively skewed prices. If long memory of price volatility had been sufficiently high, then a shift from positive to negative skewness would have been expected, but the exact opposite occurred.

This then creates an enormous dilemma for farmers. There may be more opportunities for target prices or hedging triggers to be reached, but the duration of time for these occurrences has decreased. As well, whilst tactics such as timing of decision making are important, pre-harvest decisions have to be made against a background of production risk, whereas postharvest decisions have to be made against a background of product risk. This contrasts with an end user who is more certain of quantity and quality required, and therefore has better alignment with pricing or hedging.

Market liquidity might be expected to increase with greater price volatility. However, the increase in price volatility during the 30 year period has occurred with a shift from negative to positive skewness, which might neutralize any impact on market liquidity. If farmers are to avail themselves of limited pricing and hedging opportunities through price volatility, then speculators are required to fill the vacuum caused by inactive and little motivated end users. Market liquidity and production-product risks must be considered by farmers in price risk management decision making, as well as currency and basis risk for those who are reliant on international price benchmarks and hedging.

References

Anderson, D. S. (1938), Prices and the agricultural problem. *Journal of Farm Economics* 20(1): 58-68.

Anderson, R. W. (1985), Some determinants of the volatility of futures prices. *Journal of Futures Markets* 5:3, 331-348.

Anderson, R.W. and Danthine, J.P. (1983), The time pattern of hedging and the volatility of futures prices. *Review of Economic Studies* 50(2): 249-266.

Arnold, B. C. and Groeneveld, R. A.. (1995), Measuring skewness with respect to the mode. *The American Statistician* 49(1): 34-38.

Awokuse, T. O. (2005), Impact of macroeconomic policies on agricultural prices. *Agricultural and Resource Economics Review* 34(2): 226-237.

Baillie, R.T., and R.J. Myers. (1991), Bivariate GARCH estimation of the optimal commodity futures hedge. *Journal of Applied Econometrics* 6: 109-124.

Bessembinder, H. and Seguin, P. J. (1993), Price volatility, trading volume, and market depth: Evidence from futures markets. *Journal of Financial and Quantitative Analysis* 28(1): 21-39.

Boehlje, M. and Griffin, S. (1979), Financial impacts of government support price programs. *American Journal of Agricultural Economics* 61(2): 285-296.

Castelino, M.G. (1989), Basis volatility: Implications for hedging. *Journal of Financial Research* 12: 157-172.

Chang, C., McAleer, M., and Tansuchat, R. (2012), Modelling long memory volatility in agricultural commodity futures returns. Unpublished Working Paper 15093:10, Complutense University of Madrid.

Collins, R.A., 1997, Toward a positive economic theory of hedging. *American Journal of Agricultural Economics* 79: 488 - 499.

Cooper, R.N. and Lawrence, R.Z. (1975), The 1972-75 Commodity boom, *Brookings Papers on Economic Activity* 3: 671-723.

Cordier, Jean. (2012), What is the impact of the G20 2011 on agricultural prices volatility - the declared source of global food insecurity. *Farm Policy Journal* 9(1): 1-11.

Crain, S.J., and Lee, J.H. (1996), Volatility in wheat spot and futures markets, 1950 - 1993: government farm programs, seasonality and causality. *Journal of Finance* 51: 325 - 343.

Crato, N., and Ray, B.K. (2000), Memory in returns and volatilities of futures contracts. *Journal of Futures Markets* 20(6): 525-543.

Cuddy, J.D., and. Della Valle, P.A. (1978), Measuring the instability of time series data. *Oxford Bulletin of Economics and Statistics* 40(1): 79-85.

Dark, J. G. (2010), Estimation of time varying skewness and kurtosis with an application to value at risk. *Studies in Nonlinear Dynamics and Econometrics* 14(2): 1-48.

Davies, J. S. (1938), The economics of the ever-normal granary. *Journal of Farm Economics* 20(1): 8-21.

Edgeworth, F.Y. (1904), The law of error. *Translations of the Cambridge Philosophical Society* 20: 36-65 & 113-114.

Elder, J. and Jin, H. (2007), Long memory in commodity futures volatility: A wavelet perspective. *The Journal of Futures Markets* 27: 411-437.

Gilbert, C. L. (1986), Commodity price stabilization: The Massell Model and the multiplicative disturbances. *The Quarterly Journal of Economics* 101(3): 635-640.

Gilbert, C.L. (2010), How to understand high food prices, *Journal of Agricultural Economics* 61(2): 398-425.

Gilbert, C.L. and C.W. Morgan. 2010. Food price volatility. *Philosophical Transactions of the Royal Society B: Biological Sciences* 365:1554, 3023-3034.

Glamann, K. (1977), The changing patterns of trade. *Cambridge Economic History of Europe* 5: 185-289.

Gordon, K. M., and Rausser, G. C. (1981), Country hedging for real income stabilization: A case study of South Korea and Egypt. *Journal of Futures Markets* 4(4): 449-464.

Gupta, S. (2000), Equity and efficiency in the reform of price subsidies: A guide for policymakers. International Monetary Fund.

Huchet-Bourdon, M. (2011), Agricultural commodity price volatility: An overview. *OECD Food, Agriculture and Fisheries Working Papers* 52: 1-51.

Jacks, D. S, O'Rourke, K. H., and Williamson, J. G. (2009), Commodity price volatility and world market integration since 1700. National Bureau of Economic Research, Working Paper 14748, Washington.

Jin, H.J., and Frechette, D.L. (2004), Fractional integration in agricultural futures price volatilities. *American Journal of Agricultural Economics* 86(2): 432-443.

Keynes, J.M. (1938), The policy of government storage of food-stuffs and raw materials. *The Economic Journal* 48(191): 449-460.

Lence S. H. and Hayes, D.J. (2002), U.S. farm policy and the volatility of commodity prices and farm revenues, *American Journal of Agricultural Economics*, 84(2): 335-351.

McKinnon, R.I. (1967), Futures markets, buffer stocks, and income stability for primary producers. *Journal of Political Economy* 75(6): 844-861.

MacGillivray, H.L. (1981), The mean, median, mode inequality and skewness for a class of densities. *Australian Journal of Statistics* 23(2): 247-250.

Malliaris, A.G. and Urrutia, J. L. (1998), Volume and price relationships: Hypotheses and testing for agricultural futures. *Journal of Futures Markets* 18: 53-72.

Massell, B. F. (1969), Price stabilization and welfare. *The Quarterly Journal of Economics* 83(2): 284-298.

Oi, W. Y. (1961), The desirability of price instability under perfect competition. *Econometrica* 29(1): 58-64.

Pearson, K. (1895), Contributions to the mathematical theory of evolution, II: Skew variation in homogeneous material, *Transactions of the Royal Philosophical Society, Series A* 186: 343-414.

Peck, A. E. (1975), Hedging and Income Stability: Concepts, Implications, and Example, *American Journal of Agricultural Economics* 57(3): 410-419.

Peck, A. E. (1977), Implications of private storage of grains for buffer stock schemes to stabilize prices. *Food Research Institute Studies* 16:125-140.

Peck, A. E. (1981), Measures and price effects of changes in speculation on the wheat, corn, and soybean futures markets, CBOT Seminar Report on Research on Speculation, 138-149.

Perrin, R.K., 2008, Ethanol production and food prices: a preliminary assessment. working paper 03/08, Agricultural Economics Department, University of Nebraska-Lincoln, May.

Radetzki, M. (2006), The anatomy of three commodity booms. *Resources Policy* 31(1): 56-64.

Rutledge, D.J. (1979), Trading volume and price variability: New evidence on the price effects of speculation. In the Proceedings of the Futures Trading Seminar, Volume V, Chicago Board of Trade, Chicago.

Roy, S. (1984), Pricing, planning, and politics: a study of economic distortions in India. Institute of Economic Affairs, London.

Sanders, D. R., Irwin, S. H., and Merrin, R. P. (2010), The adequacy of speculation in agricultural futures markets: Too much of a good thing? *Applied Economic Perspectives and Policy* 32(1): 77-94.

Singh, B. (1999), India: Procurement frauds. *Journal of Financial Crime* 7(2): 183-185.

Streeter, D.H. and Tomek, W.G. (1992), Variability in soybean futures prices: An integrated framework. *Journal of Futures Markets* 12(6): 705-728.

Sumner, D.A. (2009), Recent commodity price movements in historical perspective. *American Journal of Agricultural Economics*, 91(5): 1250-1256.

Tabor, J. (2010), Investigating the investigative task: Testing for skewness – An investigation of different test statistics and their power to detect skewness. *Journal of Statistics Education* 18: 1-13.

Tokgoz, S., Elobeid, A., Fabiosa, J., Hayes, D.J., Babcock, B.A., Yu, T., Fengxia, D., and Hart, C. E. (2008), Bottlenecks, drought, and oil price spikes: Impact on U.S. ethanol and agricultural sectors. *Review of Agricultural Economics* 30(4): 604-622.

Vittal, N. (2003), Corruption in India. Academic Foundation, New Delhi.

Voituriez, T. (2001), What explains price volatility changes in commodity markets? Answers from the world palm-oil market. *Journal of Agricultural Economics* 25: 295 - 301.

Wang, C. (2001), Investor sentiment and return predictability in agricultural futures markets, *The Journal of Futures Markets* 21(10): 929-952.

Waugh, F. V. (1944), Does the consumer benefit from price instability? *The Quarterly Journal of Economics* 58(4): 602-614.

Williams, J. (2009), Decision-Making in Australian Wheat Marketing and Price Risk Management. Doctorate Thesis, School of Land and Environment, University of Melbourne.

Williams, J. (2012), Competition and efficiency in international food supply chains: Improving food security. Earthscan-Routledge, UK.

Williams, J. and Malcolm, B. (2012), Farmer decisions about selling wheat and managing price risk in Australia. *Australasian Agribusiness Review* 20, Paper 1, 1-10.

Williams, J. and Schroder, W. (1999), Agricultural price risk management - The principles of commodity trading. Oxford University Press, Melbourne.

Williams, J.C. and Wright, B.D. (1991), Storage and commodity markets. Cambridge University Press, Cambridge.

Working, H. (1949), The theory of price of storage. *The American Economic Review* 39(6): 1254-1262.

Yang, J., Balyeat, B.R., and Leatham, D.J. (2005), Futures trading activity and commodity cash price volatility. *Journal of Business Finance Accounting* 32(1-2): 297-323.