Profit Margin Hedging

by

Hyun Seok Kim, B. Wade Brorsen, and Kim B. Anderson

Suggested citation format:

Profit Margin Hedging

Hyun Seok Kim,

B. Wade Brorsen,

and

Kim B. Anderson*

Chicago, Illinois, April 16-17, 2007

Copyright 2007 by Hyun Seok Kim, B. Wade Brorsen and Kim B. Anderson. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.

* Kim is a Ph.D. candidate (hyunseok.kim@okstate.edu), Brorsen is a regents professor and Jean & Patsy Neustadt Chair (wade.brorsen@okstate.edu), and Anderson is a Charles A. Breedlove professor and extension economist (kim.anderson@okstate.edu), Department of Agricultural Economics, Oklahoma State University.
Profit Margin Hedging

Some extension economists and others often recommend profit margin hedging in choosing the timing of crop sales. This paper determines producer’s utility function and price processes where profit margin hedging is optimal. Profit margin hedging is shown to be an optimal strategy under a highly restricted target utility function even in an efficient market. Although profit margin hedging is not the optimal rule in the presence of mean reversion, it can still be profitable if prices are mean reverting. Simulations are also conducted to compare the expected utility of profit margin hedging strategy with the expected utility of other strategy such as always hedging and selling at harvest strategies. A variance ratio test is conducted to test for the existence of mean reversion in agricultural futures prices process. The simulation results show that the expected utility of profit margin hedging strategy is highest. The paired difference tests for the profit margin hedging and other two strategies shows that the expected utilities of profit margin hedging strategies are not significantly different from those of always hedging strategy, but are significantly different from those of selling at harvest strategy except when the transaction cost is considered. The results of variance ratio test indicate that there is little evidence that futures price of wheat follows mean reverting process.

Keywords: expected utility, mean reversion, profit margin hedging, target

Introduction

Some extension economists and others often recommend profit margin hedging, which sells crop preharvest, whenever prices are above a target. However, this strategy recommendation is without a research base. The strategy is also included in undergraduate text books such as Purcell and Koontz (pp. 329-330). The theoretical assumptions that would justify such a strategy have never been developed. Some empirical studies have found that a profit margin hedging strategy is profitable for producers or investors.

Leuthold and Mokler (1980) calculate the implied profit margin of feeding cattle by subtracting the cost of producing live cattle estimated from futures prices of feeder cattle and corn with an allowance for non-feed cost from total income estimated from the futures price of live cattle. They analyze hedging results when the implied profit margin varies from one to fifteen dollars in one dollar increments and found the optimal trigger level to be five dollars per cwt. Returns for the five dollar trigger level were $3.11 per cwt compared to $0.86 cwt for cash returns with the hedge reducing variance by fifty-seven percent.

Kenyon and Clay (1987) proposed a variable trigger level based on the expected profit margin determined by expected pork production and the cost of corn and soybean meal. They conclude that a producer could increase profits and reduce risk when the futures market offered an implied profit margin that exceeded the expected profit margin by 70 percent.

Johnson et al. (1991) used the moving average of the gross crushing margin as a proxy for all costs of crushing soybeans. Producers place a crush trade when the implied crushing/profit margin is above the moving average. If implied crushing/profit margin is below the moving
average, a reverse crush trade is placed. They find that the profits from these trades increase as the implied profit margin moves further from the moving average. However, these studies do not provide any theory deriving the assumptions where profit margin hedging is optimal.

This research will focus on answering the question, “What assumptions for producer’s utility and price process can justify profit margin hedging?” The purpose of this paper is to determine producer’s utility function and price processes where profit margin hedging is optimal. This study conducts a statistical test of mean reversion in agricultural futures prices process. The simulations are also conducted to compare the expected utility of profit margin hedging strategy with the expected utility of other strategies such as always hedging and selling at harvest.

**Theory of Expected Target Utility**

The mean-variance (E-V) model is a risk-return model which is the most commonly used to analyze choices under uncertainty. However, some previous studies argue that E-V analysis has several well-known theoretical shortcomings (Fishburn; Holthausen). Fishburn (1977) proposed a mean-risk model which generalized mean-target semivariance model (Markowitz; Mao; Hogan and Warren; Porter) to address the shortcomings of the E-V model which is that variance is not a suitable measure of risk. Fishburn’s model measured return as the mean of the outcomes, but defined risk as weighted deviations of outcomes below target and the model assumes risk neutrality above the target. Holthausen (1981) adapted Fishburn’s model by using the same measure of risk but defining return as weighted deviations above the target to avoid the risk neutrality restriction. To measure producer’s expected utility, this study adopts Holthausen’s model in which the utility function is:

\[
U(\pi) = \begin{cases} 
(\pi - t)^\beta & \text{for all } \pi \geq t \\
-k(t - \pi)^\alpha & \text{for all } \pi \leq t.
\end{cases}
\]

where \( \pi \) indicates profit, \( t \) represents the target, \( k \) is a positive constant, and \( \alpha \) and \( \beta \) reflect the risk preferences. If \( \alpha < 1 \) (\( \alpha > 1 \)), then the producer is risk seeking (averse) below target. Then, the expected target utility can be written as

\[
EU(\pi) = \int_{-\infty}^{\infty} (\pi - t)^\beta f(\pi) d\pi - k \int_{-\infty}^{t} (t - \pi)^\alpha f(\pi) d\pi
\]

where \( f(\pi) \) is probability density function of \( \pi \) which is normally distributed with mean \( \pi \) and variance \( \sigma_\pi^2 \). If producers place hedge, then the profit is

\[
\pi = p(1 - F) + p^0 \int_0^1 F
\]

\(^1\) The variance of profit, \( \sigma_\pi^2 \), equals \( (1 - F)^2 \sigma_p^2 \) where \( \sigma_p^2 \) is variance of \( p \).
where \( p \) is the price of crop, \( F \) is a hedge ratio, and \( p^0_f \) indicates the futures price at the placing point of hedge. Then, equation (2) is rewritten as

\[
EU(\pi) = \int_{-\infty}^{\infty} \{ p(1 - F) + p^0_f F - t \}^\beta f(\pi)dp - k\int_{-\infty}^{\infty} \{ t - p(1 - F) - p^0_f F \}^\alpha f(\pi)dp
\]

where

\[
A = \frac{t - p^0_f F}{1 - F},
\]

and \( F \) is a choice variable. Equation (4) will be optimized when the first derivative with respect to \( F \) equals to zero. The first order condition of equation (4) is

\[
EU'(\pi) = -\int_{-\infty}^{\infty} \beta \{ p(1 - F) + p^0_f F - t \}^{\beta-1} (p - p^0_f) f(\pi)dp
\]

\[
-\int_{-\infty}^{\infty} \{ p(1 - F) + p^0_f F - t \}^\beta \frac{df(\pi)}{d\sigma^2} 2(1 - F)\sigma^2 dp
\]

\[
-\{ A(1 - F) + p^0_f F - t \}^\beta f(\pi) \frac{t - p^0_f}{(1 - F)^2}
\]

\[
-k\int_{-\infty}^{\infty} \alpha \{ t - p(1 - F) - p^0_f F \}^{\alpha-1} (p - p^0_f) f(\pi)dp
\]

\[
+k\int_{-\infty}^{\infty} \{ t - p(1 - F) - p^0_f F \}^\alpha \frac{df(\pi)}{d\sigma^2} 2(1 - F)\sigma^2 dp
\]

\[
+k\{ t - A(1 - F) - p^0_f F \}^\alpha f(\pi) \frac{t - p^0_f}{(1 - F)^2}
\]

If \( \alpha \) and \( \beta \) are equal, and \( k \) is one, then equation (5) can be rewritten as

\[
EU'(\pi) = -\int_{-\infty}^{\infty} \alpha \{ p(1 - F) + p^0_f F - t \}^{\alpha-1} (p - p^0_f) f(\pi)dp
\]

\[
-\int_{-\infty}^{\infty} \{ p(1 - F) + p^0_f F - t \}^\alpha \frac{df(\pi)}{d\sigma^2} 2(1 - F)\sigma^2 dp
\]

\[
-\int_{-\infty}^{\infty} \alpha \{ t - p(1 - F) - p^0_f F \}^{\alpha-1} (p - p^0_f) f(\pi)dp
\]

\[
+k\int_{-\infty}^{\infty} \{ t - p(1 - F) - p^0_f F \}^\alpha \frac{df(\pi)}{d\sigma^2} 2(1 - F)\sigma^2 dp.
\]

Then, the first and the third term in equation (6) cancel out. If the hedge ratio, \( F \), equals one, then the second and the last term are deleted and equation (6) will be zero. Therefore, when a producer has the same level of risk preferences above and below target, and \( k \) equals to one, the expected target utility will be optimized if the producer places a hedge on all amount of a crop.
If the hedge ratio, \( F \), is less than 1, then there is no interior solution and the optimum is the lower bound of zero. In case of dropping assumptions, \( \alpha \) and \( \beta \) are equal and \( k \) equals one are dropped, we do not obtain analytical solution yet.

**Theory of Mean Reversion**

The dominant paradigm of the behavior of financial and commodity markets is the efficient market hypothesis which is that the market adjusts so quickly to new information that there exist no trading rules which consistently outperform the market in terms of expected returns. Therefore, under the efficient market hypothesis, buying and holding a diversified market portfolio rather than attempting to time investments to beat the market is best for investors in the stock market. In contrast to the efficient market hypothesis, some researchers suggested that asset prices are somewhat predictable. For example, stock market prices tend to follow a mean reversion process which is a tendency for a stochastic process to return over time to a long-run average value. The mean reverting price process can be written as

\[
P_{t+1} - P_t = \lambda (\bar{P} - P_t) + \epsilon_{t+1}
\]

where \( P_t \) is stock price at time \( t \), \( \bar{P} \) is the long-run average price, \( P_t \) always goes towards level \( \bar{P} \) with mean-reversion speed \( \lambda \) which is greater than zero, and \( \epsilon_{t+1} \) is an error term with mean zero and variance \( \sigma^2 \). Producers’ expected profit function can be defined as

\[
E(\pi) = E\left[ pq - C + (p_f^0 - p_f)F \right]
\]

where \( p_f \) represents random futures price at the terminal point of hedge, and \( p_f^0 \) is the known futures price at the time of the hedge, and \( F \) is futures contracts. If futures random price follows mean reversion process, then equation (8) will be rewritten as

\[
E(\pi) = E\left[ pq - C + \lambda (p_f^0 - \bar{P})F \right]
\]

Since \( p_f^0 \) is greater than \( \bar{P} \) under profit margin hedging rule, and \( \lambda \) is a positive value, the profit margin hedging is profitable with mean reverting futures price process.

**Data**

The chosen agricultural commodity is hard red winter wheat. This study uses July futures contract prices from the Kansas City Board of Trade (KCBT). The sample period extends from June 2\(^{nd}\) 1975 through May 26\(^{th}\) 2006. In contrast to previous studies (Irwin, Zulauf, and Jackson; Yoon and Brorsen) which used a monthly or weekly data set to conduct mean reversion test for commodity price, this study uses daily data.
To test mean reversion in wheat futures prices, return horizons of 5, 20 days are examined. July observations are deleted since these observations are for delivery period. Markets are thin during this time and can be quite volatile.

To conduct simulation, Oklahoma monthly June average wheat cash prices and price for July futures contract at September 20th from 1975 to 2005 are used. The economic costs of wheat production from 1975 to 2005 are obtained from Economic Research Services (ERS), U.S. Department of Agriculture (USDA) website and targets are calculated as 70% of these economic costs. The data of wheat yield from 1975 to 2005 at Garfield County, Oklahoma, are obtained from the website of National Agricultural Statistic Service (NASS), USDA. To make hedging decision with price risk and yield risk, 5 year moving average of revenue are used.

**Procedures**

This paper has two main procedures – simulation to compare the expected utility of profit margin hedging strategy with the always hedging and the selling at harvest strategies, and mean reversion testing for wheat July futures price. The expected utility is measured by taking the average utility across 31 years. To test mean reversion, the variance ratio test is employed.

**Measure of Expected Utility**

To measure producers’ expected utility, this study employs Holthausen’s (1981) target utility function which is defined as

\[
U(\pi) = \begin{cases} 
(\pi - t)\beta & \text{for all } \pi \geq t \\
-k(t - \pi)^\alpha & \text{for all } \pi \leq t.
\end{cases}
\]

where terms are the same as in equation (1). This study considers four cases which are no risk, basis risk, transaction cost, and yield risk for three hedging strategies. To measure the utility without any risk, this study used perfect foresight model which assumes actual harvest basis is known at the time of the decision. In this case, under profit margin hedging strategy, if the sum of futures price at the time of the decision and foresighted basis is greater than the target return then producers place hedge, otherwise they do not place hedge and sell the crop at harvest. If the basis risk were considered, producers place hedge when the sum of futures price at the time of the decision and average basis is greater than the target return. When the yield risk were considered, producers place hedge if the product of average yield and the sum of futures price at the time of the decision and the foresighted basis are greater than the target returns.

If producers place hedge, the July contract futures price at September 20th is used as profit to calculate utilities. If producers do not place hedge, June cash price is used as profit. Table 1 shows that how producers make decisions to place hedge and measure their utilities. In this study, we assume producers are risk averse above target and risk seeking below target and pick 0.5 as risk preferences \( \alpha \) and \( \beta \). Also, the study assumes the transaction cost is 1.2 cents per bushel. July futures contract prices at September 20th are used to calculated utilities. After
measure producer’s utility, the study calculate the expected utility by taking an average of utilities such as

\begin{equation}
EU(\pi) = \frac{1}{n} \sum_{i=1}^{n} U_i(\pi).
\end{equation}

**Variance Ratio Test**

The idea behind the variance ratio test is that if the natural logarithm of a price series \( P_t \) is a random walk, then the variance of \( k \)-period returns should equal \( k \) times the variance of one-period returns (Cochrane; Kim, et al.; Lo and MacKinlay; Poterba and Summers). The general \( k \)-period variance ratio, \( VR(k) \) is defined as

\begin{equation}
VR(k) = \frac{\sigma^2(k)}{k \sigma^2(1)}
\end{equation}

where \( \sigma^2(k) \) is the variance of the \( k \) differences and \( \sigma^2(1) \) is the variance of the first differences. The null hypothesis of interest is that \( VR(k) \) equals one. That is, \( VR(k) \) equal to one implies that futures price follows a random walk process, whereas a variance ratio of less than one implies a mean reversion process. Lo and MacKinlay (1988) show that the variance ratio estimator can be calculated as

\begin{equation}
\sigma^2(k) = \frac{1}{m} \sum_{r=k}^{nk} (P_t - P_{t-k} - k\hat{\mu})^2,
\end{equation}

where

\[ m = k(nk - k + 1) \left(1 - \frac{k}{nk}\right) \]

and

\begin{equation}
\sigma^2(1) = \frac{1}{(nk - 1)} \sum_{r=1}^{nk} (P_t - P_{t-1} - \hat{\mu})^2,
\end{equation}

in which

\[ \hat{\mu} = \frac{1}{nk} \sum_{i=1}^{nk} (P_t - P_{t-1}) = \frac{1}{nk} (P_{nk} - P_0), \]

where \( P_0 \) and \( P_{nk} \) are the first and last observations of the price series. Lo and MacKinlay (1988) also derive asymptotic standard normal test statistic for their variance ratio.

\begin{equation}
z(k) = \frac{VR(k) - 1}{\left[\phi(k)\right]^{1/2}} \rightarrow N(0, 1)
\end{equation}
where
\[
\phi(k) = \frac{2(2k-1)(k-1)}{3k(nk)}
\]

**Results**

Table 2 denotes that, for all cases, the average prices of profit margin hedging strategy are the highest, following always hedging and selling at harvest strategy, respectively.

Table 3 shows the expected utilities for hedging strategies. The expected utility of profit margin hedging strategy is higher than with the other two strategies. Especially, the expected utility of profit margin hedging without any risk or cost has the highest value, which confirms the theoretical findings. The expected utility of always hedging strategy is greater than that of selling at harvest strategy except with the case of transaction cost. Adding yield risk greatly reduces the advantage of profit margin hedging.

The results of the paired difference tests for the profit margin hedging and other two strategies are presented in Table 4. All of the expected utilities of paired profit margin hedging and selling at harvest strategies are significantly different from zero at 5% significance level except for the case of considering transaction cost. This implies that the expected utilities of profit margin hedging strategies are significantly different from those of selling at harvest strategies except for the case considering transaction cost. None of the expected utilities of paired profit margin hedging and always hedging strategies are significantly different from zero at 5% significance level. That is, the expected utilities of profit margin hedging strategies are not significantly different from those of always hedging strategies.

The result of the variance ratio test in table 5 shows little evidence of mean reversion in futures prices. None of the variance ratios, \( VR(k) \), are significantly different from 1.0 at the 5% significance level. Both variance ratios are greater than 1.0, which would indicate positive correlation rather than mean reversion.

**Summary and Conclusions**

Some extension economists and others often recommend profit margin hedging in choosing the timing of crop sales. This paper determines producer’s utility function and price processes where profit margin hedging is optimal. Profit margin hedging is shown to be an optimal strategy under a highly restricted target utility function even in an efficient market. Although profit margin hedging is not the optimal rule in the presence of mean reversion, it can still be profitable if prices are mean reverting.

Simulations are also conducted to compare the expected utility of profit margin hedging strategy with the expected utility of other strategy such as always hedging and selling at harvest strategies. A variance ratio test is conducted to test for the existence of mean reversion in agricultural futures prices process. The simulation results show that the expected utility of profit margin
hedging strategy is higher than selling at harvest and selling at harvest strategies. Therefore, this result suggests that the profit margin hedging gives the highest expected utility to producers. The paired difference tests for the profit margin hedging and other two strategies shows that the expected utilities of profit margin hedging strategies are not significantly different from those of always hedging strategy, but are significantly different from those of selling at harvest strategy except when the transaction cost is considered. With the variance ratio test, there is little evidence that futures price of wheat follows mean reverting process.
References


Kansas City Board of Trade (KCBT). Available at http://www.kcbt.com/historical_data.asp


U.S. Department of Agriculture (USDA), National Agricultural Statistic Service (NASS). Available at http://www.nass.usda.gov/QuickStats/Create_County_All.jsp

Table 1. The Method of Producer’s Decision Making and Utility Measure for Each Strategy

<table>
<thead>
<tr>
<th>Method</th>
<th>Risk</th>
<th>Profit Margin Hedging</th>
<th>Always Hedging</th>
<th>Selling at Harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decision Making</td>
<td>No risk or cost</td>
<td>If $\pi = p^0 + B \geq t$ then $F=1$</td>
<td>Always $F=1$</td>
<td>Always $F=0$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If $\pi = p^0 + B \leq t$ then $F=0$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basis risk</td>
<td></td>
<td>If $\pi = p^0 + \overline{B} \geq t$ then $F=1$</td>
<td>Always $F=1$</td>
<td>Always $F=0$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If $\pi = p^0 + \overline{B} \leq t$ then $F=0$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transaction cost</td>
<td></td>
<td>If $\pi = p^0 + B \geq t$ then $F=1$</td>
<td>Always $F=1$</td>
<td>Always $F=0$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If $\pi = p^0 + B \leq t$ then $F=0$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yield risk</td>
<td></td>
<td>If $\pi = (p^0 + B)\overline{q} \geq \overline{q}$ then $F=1$</td>
<td>Always $F=1$</td>
<td>Always $F=0$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If $\pi = (p^0 + B)\overline{q} \leq \overline{q}$ then $F=0$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utility Measure</td>
<td>No risk or cost</td>
<td>For $\pi \geq t$ , $U(\pi) = [(p^0 + B) - t]^0$</td>
<td>For $p \geq t$ , $U(\pi) = [p - t]^0$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>For $\pi \leq t$ , $U(\pi) = [p - t]^0$ when $p \geq t$</td>
<td>For $p \leq t$ , $U(\pi) = -k[t - (p^0 + B)]^a$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$U(\pi) = -k[t - p]^a$ when $p \leq t$</td>
<td>$U(\pi) = -k[t - p]^a$</td>
<td></td>
</tr>
<tr>
<td>Basis risk</td>
<td></td>
<td>For $\pi \geq t$ , $U(\pi) = [(p^0 + B) - t]^0$</td>
<td>For $p \geq t$ , $U(\pi) = [p - t]^0$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>For $\pi \leq t$ , $U(\pi) = [p - t]^0$ when $p \geq t$</td>
<td>For $p \leq t$ , $U(\pi) = -k[t - (p^0 + B)]^a$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$U(\pi) = -k[t - p]^a$ when $p \leq t$</td>
<td>$U(\pi) = -k[t - p]^a$</td>
<td></td>
</tr>
<tr>
<td>Transaction cost</td>
<td></td>
<td>For $\pi \geq t$ , $U(\pi) = [(p^0 + B) - t]^0 - TC$</td>
<td>For $p \geq t$ , $U(\pi) = [p - t]^0$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>For $\pi \leq t$ , $U(\pi) = [p - t]^0$ when $p \geq t$</td>
<td>For $p \leq t$ , $U(\pi) = -k[t - (p^0 + B)]^a - TC$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$U(\pi) = -k[t - p]^a$ when $p \leq t$</td>
<td>$U(\pi) = -k[t - p]^a$</td>
<td></td>
</tr>
<tr>
<td>Yield risk</td>
<td></td>
<td>For $\pi \geq t$ , $U(\pi) = [(p^0 + B) - t]^0$</td>
<td>For $pq \geq tq$ , $U(\pi) = [pq - tq]^0$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>For $\pi \leq t$ , $U(\pi) = [pq - tq]^0$ when $p \geq t$</td>
<td>For $p \leq t$ , $U(\pi) = -k[tq - pq]^a$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$U(\pi) = -k[tq - pq]^a$ when $p \leq t$</td>
<td>$U(\pi) = -k[tq - pq]^a$</td>
<td></td>
</tr>
</tbody>
</table>

Note: $B$ represents perfect foresighted basis, $\overline{B}$ is average basis, $\overline{q}$ indicates average yield, $TC$ denotes transaction cost, and other terms are same as equations (1) and (3).
Table 2. Average Prices for Hedging Strategies at September 20\textsuperscript{th} (1975-2005)

<table>
<thead>
<tr>
<th>Risk</th>
<th>Profit Margin Hedging</th>
<th>Always Hedging</th>
<th>Selling at Harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>No risk or cost</td>
<td>330.72</td>
<td>320.98</td>
<td>311.03</td>
</tr>
<tr>
<td>Basis risk</td>
<td>327.86</td>
<td>320.98</td>
<td>311.03</td>
</tr>
<tr>
<td>Transaction cost</td>
<td>330.10</td>
<td>319.78</td>
<td>311.03</td>
</tr>
<tr>
<td>Yield risk</td>
<td>329.23</td>
<td>320.98</td>
<td>311.03</td>
</tr>
</tbody>
</table>

Note: Unit is cents per bushel.
Table 3. The Expected Utilities for Hedging Strategies at September 20\textsuperscript{th} (1975-2005)

<table>
<thead>
<tr>
<th>Risk</th>
<th>Profit Margin Hedging</th>
<th>Always Hedging</th>
<th>Selling at Harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>No risk or cost</td>
<td>1.81</td>
<td>0.60</td>
<td>0.57</td>
</tr>
<tr>
<td>Basis risk</td>
<td>1.29</td>
<td>0.60</td>
<td>0.57</td>
</tr>
<tr>
<td>Transaction cost</td>
<td>1.76</td>
<td>0.50</td>
<td>0.57</td>
</tr>
<tr>
<td>Yield risk</td>
<td>1.08</td>
<td>0.60</td>
<td>0.57</td>
</tr>
</tbody>
</table>
Table 4. Results of Paired Differences Test, $t$-Ratio (1975-2005)

<table>
<thead>
<tr>
<th>Risk</th>
<th>Profit Margin Hedging vs. Always Hedging</th>
<th>Profit Margin Hedging vs. Selling at Harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>No risk or cost</td>
<td>1.58</td>
<td>2.57*</td>
</tr>
<tr>
<td>Basis risk</td>
<td>1.17</td>
<td>1.36</td>
</tr>
<tr>
<td>Transaction cost</td>
<td>1.64</td>
<td>2.52*</td>
</tr>
<tr>
<td>Yield risk</td>
<td>0.48</td>
<td>2.78*</td>
</tr>
</tbody>
</table>

Note: $t$-critical value with 29 degree of freedom at 5% significance level is 1.699. * indicates that it is significant at 5% level.
<table>
<thead>
<tr>
<th>Commodity</th>
<th>Return Horizon (k days)</th>
<th>No. of Observations</th>
<th>Variance Ratio [VR(k)]</th>
<th>Z-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>5</td>
<td>7070</td>
<td>1.01</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>6633</td>
<td>1.06</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Note: July Contract futures prices are used and July observations are deleted.