The Potential Value of Agricultural Trade Options

Darren L. Frechette

Hedgers located far from organized commodity exchanges suffer a mismatch between their local prices and exchange prices. Futures and options traded on the exchange may still be valuable to distant hedgers, but only to the extent that basis risk is small. Forward contracting allows hedgers to manage risk using a local delivery price, but the Commodity Futures Trading Commission has long banned the sale of off-exchange options, limiting the opportunities available to hedgers. Recently, agricultural trade options (ATOs) have been introduced as over-the-counter option products designed specifically for hedgers. To date, ATOs have found little interest from potential sellers, but the potential demand for these options may be substantial. This study develops a methodology for measuring the potential value of ATOs. It describes and quantifies the demand for corn ATOs by dairy farms in Pennsylvania and estimates the value these farms might place on ATO contracts offered locally.

Key Words: agricultural trade options, dairy farms, futures, hedging, options, risk management

Futures, options, and forward contracts are traditional risk management tools for controlling price risk in agriculture. Futures eliminate upside and downside risk simultaneously, while options eliminate downside risk without eliminating upside potential, in exchange for a premium paid in advance. Futures and options are highly liquid but are traded only on organized exchanges, resulting in basis risk. Distant hedgers face especially significant basis risk that dissuades them from using futures and options to hedge. Forward contracts can be tailored to local conditions, but their liquidity is typically low or nonexistent. Hedgers must choose among these three risk management instruments or "goods" with different combinations of attributes: liquidity, upside potential, and basis risk.

If it were possible to provide hedgers with another alternative, their welfare might be increased. One such alternative is agricultural trade options (ATOs). ATOs are a risk management tool with the upside potential of exchange-traded options but with little or no basis risk. The result is to combine the positive aspects of options and forward contracts into a new product for hedgers.

For many years, the Commodity Futures Trading Commission (CFTC) has banned off-exchange contracts that involve option-like payoffs. The potential for fraud and misuse has seemed too great to allow option-like contracts to be traded outside of the heavily regulated exchanges. Only recently has serious pressure been mounting to deregulate and allow agricultural trade options contracts to be sold to agricultural producers and agribusinesses. Their notable proponents have included U.S. Senator Pat Roberts of Kansas (Associated Press, 1998), U.S. Senator Richard Lugar of Indiana, then-Treasury Secretary Lawrence Summers, and Federal Reserve Bank Chairman Alan Greenspan (Associated Press, 2000).

ATOs are option contracts sold by licensed merchants, such as banks and grain elevators, to hedgers who negotiate terms directly with the merchant. ATOs provide the upside potential of options contracts without significant basis risk. Another advantage of ATOs is that they do not mandate fixed contract sizes, so small farms and businesses can tailor ATOs to their individual needs.

ATOs have been available (in theory) since the CFTC began a three-year pilot program in June 1998,

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but the number of merchants licensed to trade them has been negligible. One possible reason for the dearth of merchants is that ATOs are still highly regulated. Capitalization requirements and other regulatory requirements have been dropped or substantially reduced in recent months to help promote the use of ATOs. Pressure to deregulate ATOs further has resulted in a continuing series of revisions to the program since its inception.

It is not yet clear what the eventual response will be to deregulating ATOs, but the tools exist for a serious analysis of the potential benefits from doing so. The literature on transaction costs faced by hedgers is relatively new. Hirshleifer (1988) showed that transaction costs drive hedgers from the market. Simaan (1993) and Lence (1995, 1996) found opportunity costs reduce optimal hedge ratios.

Frechette (2000) treated marginal transaction costs as prices in a demand system where the hedging products are treated as goods. He developed a methodology for computing the potential value of hedging opportunities using futures and forward contracts. In a related study, Frechette (2001) incorporated options using Lapan, Moschini, and Hanson's (1991) framework. The contribution of the present article is to extend this new methodology to a four-good system and assess the potential value of ATOs. The application is corn purchased by Pennsylvania dairy farms for cattle feed.

Pennsylvania dairy farms represent an especially interesting set of hedgers for study because they experience significant basis risk. Pennsylvania dairy farms are far enough east of Chicago and the large corn-producing states that the price they pay for corn to feed their cattle is often very different from the price at the Chicago Board of Trade. For example, during the 1997–98 study period examined here, the weekly average price of corn in Western Pennsylvania was 24¢ higher per bushel than the corresponding nearby Chicago futures price. The prices move differently, so the effectiveness of a hedge using futures and options on the Chicago Board of Trade is limited—e.g., the correlation coefficient between the Western Pennsylvania weekly corn price and the corresponding weekly Chicago futures price is only 0.31.

Correlation coefficients for four other regions of Pennsylvania range from 0.56 to 0.89. These values are low, indicating the hedging effectiveness of Chicago Board of Trade contracts in Pennsylvania is low due to basis risk. Basis risk may explain why so few Pennsylvania dairy farmers hedge their feed costs, and therefore Pennsylvania dairy farmers are likely to be among those producers helped most by ATOs.

It is hoped the real contribution of this work is much more important than just another normative optimal hedging study computing optimal hedge ratios under a new set of assumptions. ATOs are a new product designed to improve risk management in the agricultural sector. The results of this study will quantify the value of the opportunity to trade corn ATOs. End-users can review these results to determine whether they should consider ATOs, and in roughly what proportions. The analysis can be used by policy makers to determine whether the ATO program should continue or perhaps should be eliminated.

Hedging Demand

Consider the choice facing a dairy farmer in Pennsylvania who wants to hedge his feed corn purchases. The farmer must choose an optimal hedge ratio for each of four price risk management tools: (*a*) Chicago futures contracts, (*b*) Chicago options contracts, (*c*) Pennsylvania forward contracts, and (*d*) Pennsylvania ATOs. The local contracts are assumed to have no basis risk, although there may be a small basis risk in practice. Each tool is used within a risk management strategy to some extent, or possibly to no extent.

The hedger is assumed to maximize the expected utility of profits by choosing four static hedge ratios: x_{CH} represents the portion of output hedged in the futures market in Chicago, x_{PA} represents the portion hedged using forward contracts in Pennsylvania, z_{CH} represents the portion of output hedged in the options market in Chicago, and z_{PA} represents the portion hedged using over-the-counter options in Pennsylvania. Futures and forward hedging are accomplished using long contracts, so an input hedger will typically have positive x_i. Because options hedging is accomplished by buying calls, an output hedger will typically have positive z_i. Only an at-the-money option strike price, k_i, is considered in each market.

There are two time periods, with the current futures or forward price denoted f_i and the terminal futures or spot price denoted p_i when realized, or $\tilde{p}_i$ when treated as a random variable. The option premium is denoted r_i, and the terminal call option value is denoted v_i, or $\tilde{v}_i$ when treated as a random variable: $v_i = 0$ if $p_i < k_i$, and $v_i = k_i - p_i$ if $p_i \$ k_i$. The two-period assumption with static hedge ratios is not restrictive because ATOs are not fungible.

The application is corn purchased by Pennsylvania dairy farms for cattle feed, which allows the quantity hedged to be treated as fixed and predetermined.

The hedger faces additional costs beyond f_i and r_i, the unbiased expectations of $\tilde{p}_i$ and $\tilde{v}_i$. Call these extra costs $t_{x,i}$ per unit hedged with futures, and $t_{z,i}$ per unit hedged with options. Utility is a function of profits, π, treated as a random variable:

$$(1)\quad \begin{aligned}\tilde{\pi} = {} & -\tilde{p}_{PA} + (\tilde{p}_{CH} - f_{CH})x_{CH} + (\tilde{v}_{CH} - r_{CH})z_{CH} \\ & + (\tilde{p}_{PA} - f_{PA})x_{PA} + (\tilde{v}_{PA} - r_{PA})z_{PA} \\ & - t_{x,CH}|x_{CH}| - t_{z,CH}|z_{CH}| - t_{x,PA}|x_{PA}| \\ & - t_{z,PA}|z_{PA}| - c,\end{aligned}$$

where c represents other net costs, per unit, and $|\cdot|$ is the absolute value operator. All money values are adjusted by appropriate discount rates, suitably defined. The use of unit values does not sacrifice any generality because the quantity hedged is assumed to be predetermined by the hedger.

The utility function $u(\cdot)$ is assumed to be continuous, monotonic increasing, and strictly concave: $u' > 0$, and $u'' < 0$. The hedger's optimization problem is written as:

$$(2)\quad \max_{\{x_i, z_i\}} \mathrm{E}[u(\tilde{\pi})],$$

with $\mathrm{E}[\cdot]$ representing the expectations operator over all sources of uncertainty. The four first-order conditions are:

$$(3a)\quad \mathrm{E}\left[u'(\tilde{\pi})\left(f_i - \tilde{p}_i - t_{x,i}\,\mathrm{sgn}(x_i)\right)\right] = 0,$$

and

$$(3b)\quad \mathrm{E}\left[u'(\tilde{\pi})\left(r_i - \tilde{v}_i - t_{z,i}\,\mathrm{sgn}(z_i)\right)\right] = 0,$$

with $i = CH$ or PA, and $\mathrm{sgn}(x) = |x|/x$. The second-order conditions are satisfied because of the conditions imposed on $u(\cdot)$.

The marginal transaction costs are the prices faced by the hedger. These prices include broker's fees, opportunity costs, and learning costs associated with futures and options hedging. They also include the hidden costs of illiquidity, which are sure to be higher in the local market than they will be in the centralized exchange. Therefore, basis risk can be reduced or eliminated only at an extra cost. There will be a substitution effect between exchange-traded and local hedging instruments, leading to four positive hedge ratios in the most general case.

This approach allows us to compute the potential value of ATOs using the hedger's surplus, as in Frechette (2000). The hedger's surplus is the hedger's willingness to pay for the opportunity to trade ATOs. The hedger's surplus, therefore, can be interpreted as the value that would be gained by the hedger if ATOs were available. If

$$(4)\quad u^* = \max_{\{x_i, z_i\}} \mathrm{E}[u(\tilde{\pi})],$$

then the hedger's surplus for ATOs is represented by $e_{z,PA}$, which is defined implicitly by

$$(5)\quad u^* = \max_{\{x_i, z_{CH} | z_{PA} = 0\}} \mathrm{E}[u(\tilde{\pi} + e_{z,PA})].$$

The value of $e_{z,PA}$ will depend on the marginal transaction costs ($t_{x,i}$ and $t_{z,i}$) and the other parameters.

In equation (4), the x_i and z_i are chosen optimally to maximize expected utility. The result is the optimal set of hedge ratios when all four hedging goods are available. In equation (5), the x_i and z_{CH} are chosen optimally, but z_{PA} is restricted to be zero. The result is the optimal set of hedge ratios when only three hedging goods are available, when ATOs are unavailable. The hedger's surplus for ATOs is the extra value that would be required to make the hedger as well off choosing among three hedging goods as the hedger would be if all four goods were available. As soon as equation (4) is solved for u^*, then equation (5) can be solved for $e_{z,PA}$, the hedger's surplus for ATOs.

The meaning of hedger's surplus can be understood best by considering consumer's surplus, a familiar microeconomic concept. The consumer's surplus measures the total excess value accruing to the consumer due to the opportunity to purchase and consume a good or set of goods. Similarly, the hedger's surplus measures the total excess value accruing to the hedger due to the opportunity to hedge with a specific hedging good or set of hedging goods. The hedger's surplus for ATOs is the total excess value accruing to the hedger due to the opportunity to hedge with ATOs, above and beyond the value already accruing due to the opportunity to hedge with futures, options, and forward contracts.

Previous literature on hedger's surplus has been restricted to futures, options, and forward contracts. Hedger's surplus values calculated by Frechette (2000) pertained to forward contracts or a hypothetical local futures exchange. Hedger's surplus estimates ranged from 2.7¢ to 24.5¢ per bushel for highly risk-averse hedgers with only futures available. Estimates ranged from 4.1¢ to 25.9¢ per bushel for the second market. Less risk-averse hedgers exhibited lower surplus estimates.

Table 1. Conditional Covariance Structure for Regional Prices, Nominal Cents/Bushel, 1997–98

Pennsylvania Region	N	Price Mean	Price Variance	Basis Variance	Basis-Futures Covariance	Price-Futures Covariance
Southeastern	104	291.40	31.31	14.26	!21.59	38.66
Central	104	287.40	8.91	37.33	!44.22	15.93
South Central	104	284.80	15.14	41.69	!43.29	16.86
Western	104	279.50	28.90	63.41	!47.27	12.88
Lehigh Valley	85	274.70	30.61	19.16	!25.30	35.86
CBOT Futures	104	255.22	60.27			

Note: Data collection for Lehigh Valley began May 1997; all other data are for January 1997 through December 1998.

Frechette (2001) calculated hedger's surplus values with only futures and options available. Estimates ranged from 2.5¢ per bushel to 23¢ per bushel for highly risk-averse hedgers, and fell for less risk-averse hedgers, considering both markets together. Estimates of the portion of the surplus due to the options market were less than 0.01¢ per bushel for highly risk-averse hedgers, and rose for less risk-averse hedgers. It was shown that options can be treated as a luxury good and futures as a necessary good.

The two articles cited above provided analyses of the hedger's surplus, but considered only two goods at a time. The major conclusions were that the optimal combination of hedge ratios and the hedger's surplus depend critically on the marginal transaction costs of hedging and the level of risk aversion. The results offer insights into actual hedging behavior and attach pecuniary values to optimal hedging portfolios. The next step is to combine the two previous models and extend the analysis to a fourth good: ATOs. The primary objective of this analysis is to quantify the demand side of the ATOs market for policy makers and end-users. The incremental value of this study over Frechette (2000, 2001) lies primarily in the empirical application.

Empirical Application

In this section, the hedging demand theory from the previous section is applied to the hedging decisions made by dairy producers in five regions of Pennsylvania. Dairy producers may hedge their purchases of corn using long futures and by purchasing call options traded at the Chicago Board of Trade, and by using forward contracts and ATOs locally. The negative exponential (constant absolute risk aversion) utility function is assumed, which results in a convenient way to compare results for different levels of risk aversion.

Basis is specified as local price minus Chicago price. Expected utility is computed as a numerical integral over price and basis risk, which were modeled using a bivariate normal distribution. Price means were modeled using an autoregressive specification, as in Frechette (2000, 2001). Expected utility was then maximized numerically with respect to the four choice variables: x_i and z_i, with $i = CH$ or PA. The integrals were calculated by the trapezoidal method, and optimization was achieved by the simplex method.

Data

The data set is the same one used by Frechette (2000, 2001) and consists of (*a*) weekly corn cash prices collected by the Pennsylvania Department of Agriculture (PDA), and (*b*) the nearby corn futures price in Chicago. Local cash prices were collected through surveys and phone calls for five Pennsylvania regions: Southeastern, Central, South Central, Western, and the Lehigh Valley.

The prices were collected and reported by PDA on Monday mornings before the market opened, and the futures price that corresponds most closely is the previous Friday's settlement price for the nearby futures contract. If the Chicago Board of Trade was closed due to a holiday, then the closest day was used, matching the information sets as closely as possible in each case. All prices are reported in cents per bushel, from January 1997 through December 1998.

Table 1 displays summary statistics and the covariance structure used in this analysis. The table shows that the covariances are negative and relatively large in magnitude between the Chicago price and each regional basis, indicating the hedge ratios for exchange-traded futures and options may be quite low in these regions. These statistics represent actual results for the sample period, and therefore the results represent optimal ex post behavior in the sense that hedgers are assumed to have known the covariance matrix before the sample period began. Individual hedgers' expectations will depend on the sample period and available information.

At the suggestion of a reviewer, several alternative sample periods were investigated. The variance-covariance matrix of the price appears to have been very different from 1997–1998 compared to 1996, when corn prices surged to over $5 per bushel with high volatility. The 1990–1995 period contrasted as a period of lower volatility. For example, the futures price variance was estimated at 60.27 from the 1997–1998 data, but it was 68.49 when using data from the 1990–1998 period. The covariance was affected the most, and the correlation coefficient estimate from the larger sample dropped from 0.89 to 0.14 for the Southeastern Pennsylvania region.

The choice of sample period is difficult because the prices up through 1996 appear to have been generated by a different variance structure than those from 1997–1998. Consequently, 1997–1998 was chosen as the sample period for this analysis. If the true correlation coefficient is closer to 0.14 than to 0.89, then the demand for ATOs in Southeastern Pennsylvania may be understated in the analysis to follow. Regardless, the five regions display a variety of covariance scenarios that serve as representative cases for farmers in different parts of Pennsylvania.

Unbiased markets are assumed. Thus, the futures price is given by f_i, and r_i is the expected value of $\max\{\tilde{p}_i - k_i, 0\}$, where k_i is the strike price at-the-money. There is no time value from ATOs because they are not tradable. The farmer gains no time value from the exchange-traded options either, because he/she does not trade them. The time-value component of the exchange-traded options is important to the extent that it increases the price to the farmer. The farmer must pay a marginal time cost, which is included in the marginal cost of hedging, $t_{z,i}$, and for which no real benefit accrues to the hedger.

The estimates of basis risk and expected basis depend on the structural forecasting model chosen by the hedger. There are many such models in use, such as naïve expectations, adaptive expectations, and rational expectations. The results depend on the model chosen, and yet there is no clear consensus in the literature to guide this choice. Fortunately, the results often are robust to any reasonable choice of forecasting method.

Moschini and Hennessy (2001) consider this issue and conclude that a constant covariance matrix "may not be a bad approximation," and that "conditional variance does not do much better than unconditional variance" for use in estimating producers' responses to price risk. Each hedger has a unique perception of market structure, and no single model has come to dominate the literature.

To proceed, a time-series forecasting model is selected, as in Frechette (2000). An autoregressive moving average model was estimated with the following form:

$$(6) \quad p_t = \alpha_0 + \sum_{i=1}^{I} \alpha_i p_{t-i} + \sum_{j=1}^{J} \beta_j \varepsilon_{t-j} + \varepsilon_t .$$

In practice, (6) is truncated at a lag length sufficient to balance accuracy against degrees of freedom. If the error term satisfies standard assumptions, then ordinary least squares (OLS) can be used to obtain estimates of the α_i and β_j, which generate corresponding estimates of $E_{t-1} p_t$. The lag length is chosen by minimizing the Akaike Information Criterion statistic and testing the standard OLS assumptions. The conditional covariance matrix is estimated by substituting expected local price minus expected futures price for expected basis. The conditional covariance matrix is assumed to be constant and to represent a bivariate normal distribution.

A range of coefficients of absolute risk aversion was selected to span a range of possible farmer risk preferences. Lapan and Moschini (1994) and Lence (1995) were used as a guide to select values for the coefficient of absolute risk aversion after converting the units following Raskin and Cochran (1986). The relative risk aversion parameter in these studies ranged from 0 to 20 per year for a soybean farm. Adjusting to a weekly value (multiply by 52) in cents (divide by 100), adjusting from an output-based quantity to a much smaller input quantity (divide by roughly 5) requires a final scaling factor of roughly 0.1. The range from 0 to 20 corresponds to an approximate range for the coefficient of absolute risk aversion of 0 to 2%. Reasonable values to span this range were chosen as 2.00 for high risk aversion, 0.20 for moderate risk aversion, and 0.02 for low risk aversion.

Results

Figure 1 illustrates a typical demand curve for ATOs in the Southeastern Pennsylvania region using a specific combination of hedging costs for the alternate goods, x_i and z_{CH}.

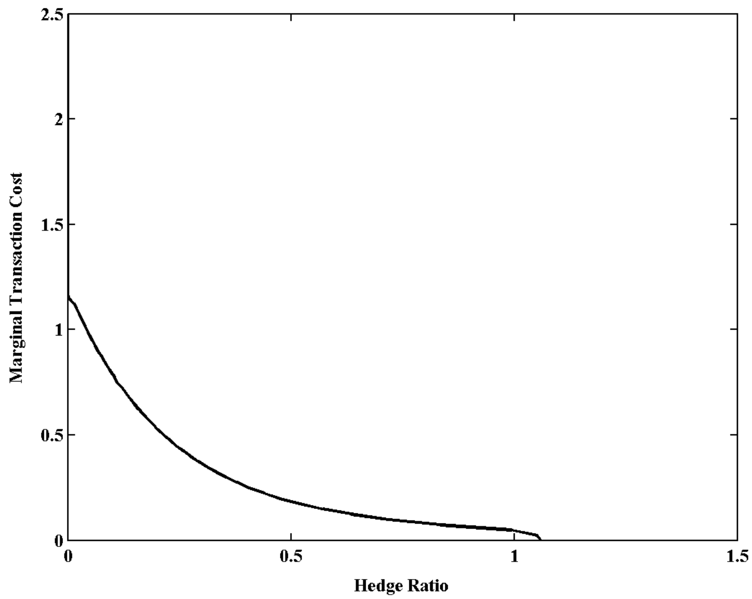

Figure 1. Demand curve for ATO corn calls, Southeastern Pennsylvania dairy farms

In figure 1, $t_{x,PA} = 2.00$, $t_{x,CH} = 1.50$, and $t_{z,CH} = 0.75$, all measured in cents per bushel, and the coefficient of absolute risk aversion (CARA) is 2.0. Figure 1 shows that a high marginal transaction cost of over-the-counter (OTC) options hedging will drive hedgers out of the market. The critical transaction cost is approximately 1.20¢ per bushel. In contrast, if OTC options were costless, the optimal hedge ratio would rise to approximately 1.06.

Table 2 shows the optimal hedge ratios for all four hedging instruments under different combinations of marginal transaction costs and different CARA values for the Southeastern region of Pennsylvania. Some results in the table are straightforward and act as expected. For example, when all marginal transaction costs are zero (Case 1), hedging is dominated by local forward contracts, and price risk is eliminated completely at no cost. When costs rise (Cases 2 and 3), the hedge ratios fall. As futures and forward contracts become more expensive than options (Cases 4 and 5), options and ATOs tend to be chosen in higher proportions. All these results follow from neoclassical demand theory and previous analyses of risk-averse behavior.

More noteworthy are the cases where multiple hedge ratios are positive. For example, in Cases 7 and 8, Chicago futures, forward contracts, and ATOs all exhibit positive hedge ratios under high risk aversion (CARA = 2.00). As shown by panel B of table 2, the respective values are 0.04, 0.76, and 0.21 under Case 7 with CARA = 2.00. There are several cases in which ATOs are used together in a portfolio with traditional hedging instruments to form the optimal hedging strategy.

This revelation leads to several logical questions. How much welfare have hedgers been losing due to the ban on ATOs? How much might they stand to gain under deregulation? How valuable might ATOs be to hedgers if sufficient numbers of ATO merchants are registered? These questions can be answered by estimating the hedger's surplus for ATOs.

Table 2 displays the hedger's surplus estimates for hedgers in Southeastern Pennsylvania under various combinations of marginal transaction costs and CARA values. The maximum estimate is 2.55¢ per bushel ($127.50 per 5,000-bushel contract), which occurs when CARA = 0.20 (panel C) in Case 6, with $t_{x,PA} = 2.00$, $t_{x,CH} = 1.50$, $t_{z,CH} = 0.75$, and $t_{z,PA} = 0$. The minimum is zero, which occurs whenever $z_{PA} = 0$. The potential value of ATOs in Southeastern Pennsylvania was less than 1¢ per bushel in all other cases.

Case-by-case, the surplus values vary greatly. In Case 1, all transaction costs are zero. Forward contracts eliminate all price risk for no cost, and are always favored with a hedge ratio of 1.00. No other hedging products are demanded at all. The potential value of ATOs is zero as a consequence because none are demanded.

Table 2. Optimal Hedge Ratios and Hedger's Surplus (cents/bushel) for Southeastern Pennsylvania Dairy Farms

A. Transaction Costs									
Hedging Instruments	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Futures Contracts	0.00	1.00	2.00	1.00	2.00	1.50	1.50	1.50	1.50
Options Contracts	0.00	1.00	2.00	0.00	0.00	0.75	0.75	0.75	0.75
Forward Contracts	0.00	1.00	2.00	1.00	2.00	2.00	2.00	2.00	2.00
ATOs	0.00	1.00	2.00	0.00	0.00	0.00	0.50	1.00	1.25
B. Optimal Hedge Ratios for High Risk Aversion (CARA = 2.00)									
Hedging Instruments	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Futures Contracts	0.00	0.01	0.02	0.01	0.02	0.04	0.04	0.04	0.04
Options Contracts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forward Contracts	1.00	0.98	0.95	0.89	0.00	0.00	0.76	0.89	0.92
ATOs	0.00	0.00	0.00	0.13	1.09	1.06	0.21	0.04	0.00
Value of ATOs	*0.00*	*0.00*	*0.00*	*0.04*	*0.31*	*0.30*	*0.06*	*0.00*	*0.00*
C. Optimal Hedge Ratios for Moderate Risk Aversion (CARA = 0.20)									
Hedging Instruments	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Futures Contracts	0.00	0.09	0.19	0.00	0.00	0.00	0.15	0.36	0.47
Options Contracts	0.00	0.00	0.00	0.07	0.07	0.00	0.00	0.00	0.07
Forward Contracts	1.00	0.72	0.45	0.00	0.00	0.00	0.00	0.00	0.00
ATOs	0.00	0.00	0.00	1.26	1.26	1.34	0.87	0.36	0.00
Value of ATOs	*0.00*	*0.00*	*0.00*	*0.22*	*0.56*	*2.55*	*0.34*	*0.07*	*0.00*
D. Optimal Hedge Ratios for Low Risk Aversion (CARA = 0.02)									
Hedging Instruments	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Futures Contracts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Options Contracts	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0.00
Forward Contracts	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ATOs	0.00	0.00	0.00	1.30	1.30	1.42	0.00	0.00	0.00
Value of ATOs	*0.00*	*0.00*	*0.00*	*0.05*	*0.05*	*0.24*	*0.00*	*0.00*	*0.00*

In Cases 2 and 3, all transaction costs are equal and positive. All price risk can still be eliminated using forward contracts, but there is a cost to hedging. In these cases, forward contracts are still favored at the high level of risk aversion (CARA = 2.00) with hedge ratios equal to 0.98 and 0.94 when transaction costs are 1¢ and 2¢ per bushel. At the moderate level of risk aversion (CARA = 0.20), some futures contracts are also demanded, but the optimal hedger relies primarily on forward contracts. At the lowest level of risk aversion (CARA = 0.02), the optimal solution is not to hedge at all. No ATOs or exchange-traded options are demanded, so the potential value of ATOs is zero.

In Cases 4 and 5, the transaction costs for futures and forward contracts are assumed to be equal and positive, but the transaction costs for exchange-traded options and ATOs are zero. Options and ATOs have zero marginal transaction costs, aside from the option premium, so they tend to be favored in these cases. Under high risk aversion in Case 4, the forward hedge ratio drops to 0.89, the ATOs hedge ratio rises to 0.13, and the futures hedge ratio is just 0.01. The hedger's surplus due to ATOs is only 0.04¢ per bushel. Under moderate risk aversion, the effect is more evident as the forward hedge ratio drops all the way to zero and the ATOs hedge ratio rises to 1.26. The hedger's surplus is 0.22¢ per bushel. Under low risk aversion, the hedge ratios change to 1.30 for ATOs, zero for futures and forward contracts, and 0.10 for options. The hedger's surplus drops back down to just 0.05¢ per bushel. Case 5 is very similar to Case 4, except even the highly risk-averse hedger now moves away from forward contracts into ATOs with a hedge ratio of 1.09. Surplus is higher because the alternative goods are more expensive.

Cases 4 and 5 demonstrate a general result for the Southeastern region—ATOs are most valuable to moderately risk-averse hedgers. Highly risk-averse hedgers prefer the sure security of forward contracts, while barely risk-averse hedgers place little value on any hedging instrument. It is the moderately risk-averse hedgers in this region who exhibit a strong preference for ATOs.

In Cases 6–9, the transaction costs for futures, forward contracts, and exchange-traded options are set, respectively, at 1.50¢, 2.00¢, and 0.75¢ per bushel. The transaction costs for ATOs vary between zero and 1.25¢ per bushel. In all cases, the potential value of ATOs declines with their cost for all levels of risk aversion. Case 6 is like Case 5 because ATO transactions are costless, and therefore Case 6 exhibits the largest potential surplus. For the high level of risk aversion, the maximum surplus is 0.30¢ per bushel, which declines to 0.06¢ per bushel when ATO transaction costs rise to 0.50¢ per bushel, and then to zero for the higher values of transaction costs. For the moderate level of risk aversion, the potential value of ATOs peaks at 2.55¢ per bushel and declines to 0.34¢ per bushel, then to 0.07¢ per bushel, and finally, under Case 9, to zero. For the low level of risk aversion, the surplus starts at 0.24¢ per bushel and immediately drops to zero.

The potential value of ATOs is highest at moderate levels of risk aversion because ATOs do not limit the upside potential of hedgers' profits. Extremely risk-averse hedgers prefer forward contracts to ATOs because they are not willing to forego the ATO premium in exchange for an uncertain return. Moderately risk-averse hedgers are willing to take such a gamble if the transaction costs are low enough because a small amount of risk is still acceptable to them. Nearly risk-neutral hedgers act similarly to moderately risk-averse hedgers, but place less value on the opportunity. They prefer ATOs and options to forward contracts and futures contracts because their upside potential is not limited.

The results also indicate forward contracts can be considered a normal good, and futures and ATOs can be considered inferior goods. For example, in Case 7 for the highly risk-averse hedger in the Southeastern region, the own-price elasticities of hedging demand are –1.117 for futures contracts, –1.083 for forward contracts, and –1.203 for ATOs. There are no meaningful elasticities involving options because none are purchased in Case 7. The cross-price elasticities can also be calculated, and a synthetic expenditure elasticity constructed as the sum of the price elasticities for each hedging instrument times –1. The synthetic elasticity emulates a positive marginal change in expenditures via an equivalent negative marginal change in all prices. The synthetic expenditure elasticity for futures is –1.445, for forward contracts +0.717, and for ATOs –2.572. The negative elasticities for futures and ATOs imply that an equal percentage reduction in marginal transactions costs across goods would induce hedgers to substitute forward contracts for futures and ATOs.[1]

Tables 3–6 provide a detailed accounting of the optimal hedge ratios and hedger's surpluses for each of the other four regions of Pennsylvania for which data were available. In two of the other regions, the highest surplus was found to accrue to highly risk-averse hedgers. These values are 7.88¢ per bushel in Central PA (table 3, Case 6), and 12.25¢ per bushel in South Central PA (table 4, Case 5). In Western PA (table 5) and Lehigh Valley (table 6), the highest surpluses were 2.23¢ per bushel (Cases 5 and 6) and 2.40¢ per bushel (Case 6), respectively, which accrued to moderately risk-averse hedgers. The highest surplus always occurred in Cases 5 and 6, in which ATO transactions were costless and the other hedging instruments were most costly.

Discussion and Conclusions

The contribution of this study lies primarily in the estimation of the value of deregulating ATO contracts tailored to local conditions. The methodology for calculating hedger's surplus was extended to treat ATOs as a hedging good which exists as part of a hedging demand system. The hedger's surplus is the natural extension of the consumer's surplus from neoclassical demand theory. The potential value of ATOs was calculated as the hedger's surplus gained by hedgers when ATOs become available.

Our calculations show that ATOs may have relatively small potential value to dairy farmers in Southeastern Pennsylvania on a per bushel scale, but from an annual perspective the value seems much larger. A firm procuring 5,000 bushels of corn per week could see a potential value as high as $6,630 per year from ATOs. Still, $6,630 would likely seem small for such a large firm in practice.

[1] Elasticities were calculated numerically using arc increments of 0.0001¢ per bushel. The specific results vary depending on the case and region under study.

Table 3. Optimal Hedge Ratios and Hedger's Surplus (cents/bushel) for Central Pennsylvania Dairy Farms

A. Optimal Hedge Ratios for High Risk Aversion (CARA = 2.00)

Hedging Instruments	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Futures Contracts	0.00	0.01	0.02	0.00	0.00	0.00	0.02	0.00	0.00
Options Contracts	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.03	0.04
Forward Contracts	1.00	0.94	0.84	0.00	0.00	0.00	0.00	0.00	0.78
ATOs	0.00	0.00	0.00	1.14	1.14	1.15	1.02	0.95	0.08
Value of ATOs	*0.00*	*0.00*	*0.00*	*0.27*	*1.12*	*7.88*	*0.61*	*0.12*	*0.00*

B. Optimal Hedge Ratios for Moderate Risk Aversion (CARA = 0.20)

Hedging Instruments	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Futures Contracts	0.00	0.12	0.10	0.00	0.00	0.00	0.00	0.10	0.10
Options Contracts	0.00	0.00	0.00	0.04	0.04	0.00	0.03	0.07	0.07
Forward Contracts	1.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ATOs	0.00	0.00	0.00	1.29	1.29	1.35	0.63	0.00	0.00
Value of ATOs	*0.00*	*0.00*	*0.00*	*0.39*	*0.40*	*0.61*	*0.10*	*0.00*	*0.00*

C. Optimal Hedge Ratios for Low Risk Aversion (CARA = 0.02)

Hedging Instruments	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Futures Contracts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Options Contracts	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.00	0.00
Forward Contracts	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ATOs	0.00	0.00	0.00	1.33	1.33	1.39	0.00	0.00	0.00
Value of ATOs	*0.00*	*0.00*	*0.00*	*0.04*	*0.04*	*0.07*	*0.00*	*0.00*	*0.00*

Table 4. Optimal Hedge Ratios and Hedger's Surplus (cents/bushel) for South Central Pennsylvania Dairy Farms

A. Optimal Hedge Ratios for High Risk Aversion (CARA = 2.00)

Hedging Instruments	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Futures Contracts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Options Contracts	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
Forward Contracts	1.00	0.97	0.93	0.96	0.00	0.00	0.40	0.87	0.92
ATOs	0.00	0.00	0.00	0.00	1.17	1.17	0.66	0.08	0.00
Value of ATOs	*0.00*	*0.00*	*0.00*	*0.00*	*12.25*	*0.69*	*0.15*	*0.01*	*0.00*

B. Optimal Hedge Ratios for Moderate Risk Aversion (CARA = 0.20)

Hedging Instruments	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Futures Contracts	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.07	0.05
Options Contracts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.07
Forward Contracts	1.00	0.67	0.31	0.00	0.00	0.00	0.00	0.00	0.24
ATOs	0.00	0.00	0.00	1.42	1.42	1.42	0.91	0.43	0.00
Value of ATOs	*0.00*	*0.00*	*0.00*	*1.16*	*1.16*	*1.16*	*0.58*	*0.11*	*0.00*

C. Optimal Hedge Ratios for Low Risk Aversion (CARA = 0.02)

Hedging Instruments	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Futures Contracts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Options Contracts	0.00	0.00	0.00	0.08	0.08	0.00	0.00	0.00	0.00
Forward Contracts	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ATOs	0.00	0.00	0.00	1.41	1.41	1.49	0.00	0.00	0.00
Value of ATOs	*0.00*	*0.00*	*0.00*	*0.08*	*0.08*	*0.11*	*0.00*	*0.00*	*0.00*

Table 5. Optimal Hedge Ratios and Hedger's Surplus (cents/bushel) for Western Pennsylvania Dairy Farms

A. Optimal Hedge Ratios for High Risk Aversion (CARA = 2.00)

Hedging Instruments	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Futures Contracts	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Options Contracts	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Forward Contracts	1.00	0.98	0.97	0.98	0.66	0.66	0.97	0.96	0.97
ATOs	0.00	0.00	0.00	0.00	0.43	0.43	0.00	0.02	0.00
Value of ATOs	*0.00*	*0.00*	*0.00*	*0.00*	*0.17*	*0.17*	*0.00*	*0.00*	*0.00*

B. Optimal Hedge Ratios for Moderate Risk Aversion (CARA = 0.20)

Hedging Instruments	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Futures Contracts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Options Contracts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forward Contracts	1.00	0.83	0.65	0.20	0.00	0.00	0.00	0.56	0.65
ATOs	0.00	0.00	0.00	1.15	1.42	1.42	1.11	0.15	0.00
Value of ATOs	*0.00*	*0.00*	*0.00*	*0.26*	*2.23*	*2.23*	*1.60*	*0.01*	*0.00*

C. Optimal Hedge Ratios for Low Risk Aversion (CARA = 0.02)

Hedging Instruments	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Futures Contracts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Options Contracts	0.00	0.00	0.00	0.07	0.07	0.00	0.00	0.00	0.00
Forward Contracts	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ATOs	0.00	0.00	0.00	1.48	1.48	1.51	0.00	0.00	0.00
Value of ATOs	*0.00*	*0.00*	*0.00*	*0.19*	*0.19*	*0.21*	*0.00*	*0.00*	*0.00*

Table 6. Optimal Hedge Ratios and Hedger's Surplus (cents/bushel) for Lehigh Valley Pennsylvania Dairy Farms

A. Optimal Hedge Ratios for High Risk Aversion (CARA = 2.00)

Hedging Instruments	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Futures Contracts	0.00	0.00	0.01	0.00	0.00	0.02	0.02	0.02	0.00
Options Contracts	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.03
Forward Contracts	1.00	0.98	0.97	0.92	0.93	0.62	0.84	0.93	0.95
ATOs	0.00	0.00	0.00	0.11	0.00	0.44	0.15	0.02	0.00
Value of ATOs	*0.00*	*0.00*	*0.00*	*0.03*	*0.00*	*0.18*	*0.04*	*0.00*	*0.00*

B. Optimal Hedge Ratios for Moderate Risk Aversion (CARA = 0.20)

Hedging Instruments	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Futures Contracts	0.00	0.05	0.09	0.05	0.00	0.00	0.00	0.23	0.23
Options Contracts	0.00	0.00	0.00	0.06	0.12	0.00	0.01	0.00	0.00
Forward Contracts	1.00	0.78	0.56	0.00	0.00	0.00	0.00	0.28	0.40
ATOs	0.00	0.00	0.00	1.26	1.27	1.40	1.11	0.20	0.00
Value of ATOs	*0.00*	*0.00*	*0.00*	*0.18*	*0.63*	*2.40*	*0.28*	*0.01*	*0.00*

C. Optimal Hedge Ratios for Low Risk Aversion (CARA = 0.02)

Hedging Instruments	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Futures Contracts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Options Contracts	0.00	0.00	0.00	0.16	0.16	0.00	0.00	0.00	0.00
Forward Contracts	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ATOs	0.00	0.00	0.00	1.30	1.30	1.49	0.00	0.00	0.00
Value of ATOs	*0.00*	*0.00*	*0.00*	*0.06*	*0.06*	*0.22*	*0.00*	*0.00*	*0.00*

A large firm may not find it worthwhile even to learn about ATOs when other risk management instruments are such close substitutes.

Firms in other regions of Pennsylvania could gain substantially more. The maximum annual surplus values in the other regions are $20,488 for Central PA, $31,850 for South Central PA, $5,798 for Western PA, and $6,240 for Lehigh Valley. These numbers are equivalent to a range from zero to $612.50 per 5,000 bushels hedged. Certainly the potential exists for ATOs to be used effectively and profitably in these regions. However, these surpluses are maximum values over all cases computed, and in most cases the values are much lower. Values are highest when ATOs are costless and alternatives are costly.

The reported values vary greatly because it is impossible to know the effective marginal transaction costs faced by specific hedgers in specific circumstances. Several of the cases in tables 2–6 involve very low marginal costs for ATOs. The true costs of using ATOs may be substantially higher due to learning costs, liquidity costs, and costs involved with writing the contracts and marketing them to new users. These costs are likely to be high initially. If these costs cannot be reduced enough to compete with the other risk management goods available to producers, then the ATOs program is unlikely to succeed.

The values also depend on individual hedgers' risk preferences. More fundamentally, the form of the hedger's objective function plays an important role in the determination of optimal hedge ratios and hedger's surplus. Alternative objective functions, such as found in Chavas and Holt (1996) or Lence (2000), may be more appropriate for studies of this sort.

The values also are dependent on the markets involved and the type of hedger, which were restricted here to corn input hedgers on dairy farms in five local regions of Pennsylvania. However, we may be able to use these estimates as indicators of the general magnitude of the potential value of ATOs even if the specific numerical result is only applicable to a narrowly defined population. Some general implications of the results can be drawn.

First, the potential value of ATOs varies widely depending on local basis risk, individual risk aversion preferences, and the cost of alternatives. The study of hedging demand is no different in this way to the study of consumer demand wherein demand depends on location, individual utility functions, and the prices of complementary and substitute goods. Further research should continue to investigate the symmetry between portfolio analysis and consumer demand.

Second, the potential value of ATOs is nonmonotonic in the risk-aversion level in some locations. Highly risk-averse hedgers may prefer forward contracts, and nearly risk-neutral hedgers place little value on any hedging tool. In some locations, the moderately risk-averse hedgers value ATOs most.

Third, the potential value of ATOs depends critically on transaction costs. As little as 1¢ per bushel in cost can make the difference between exclusive demand for ATOs and no demand at all. There are many consumer goods in the marketplace for which a small increase in price would cause demand to shift entirely to substitutes. This reality underlies the concept of perfect competition. There are three substitutes for ATOs in the model, and therefore some substitution is expected as the price of ATOs rises. Any future work distinguishing preferences for hedging products must focus on transaction costs.

Future work also might address actual farmer preferences for risk management tools. Farmer surveys might yield data that could be used to estimate actual farmer preferences empirically. A demand system could be estimated based on inferred prices and basis risks across survey respondents, including various demographic variables to model risk aversion. A study incorporating observed behavior into the model described here would be a valuable contribution to the economics of hedging demand.

Finally, the most important implication of these results is that ATOs embody real value to some hedgers. In the end, it may not be possible for merchants to supply ATOs at a low enough cost to make the program succeed, but this study shows that a potential demand exists for the product. The analysis can be interpreted as providing an indication of how high the costs could be and still stimulate demand. If ATO regulations can be adjusted so that more ATO merchants are available to serve hedgers at reasonable cost, then almost certainly some hedgers will use ATOs to their advantage. Those hedgers who are moderately or highly risk averse will be most likely to benefit from ATOs, especially those with the largest basis risk. The demand side of the market exists, and further efforts may be warranted to develop the supply side by refining and revising the registration requirements for ATO merchants.

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