Automation in the Hedge-Ratio Estimation Cottage Industry

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Practitioner's Abstract: *Futures markets can be used to minimize a firm's financial exposure to cash price fluctuations, but it's costly to determine the futures position size that minimizes this risk. We present survey results that indicate that finding the risk-minimizing futures position requires 160 hours of skilled market analysts' time spread over 60 days and costs between $15,000 and $25,000. This process can be automated so that optimal futures positions can be determined in minutes at a fraction of this cost.*

We introduce HedgeSmart, software that determines the optimal hedging strategy by combining user-supplied, business-specific data with the generally accepted price-risk minimization model and an up-to-date database containing more than 10 million records on commodity price movements. The user can incorporate his/her own historical commodity prices to insure that the analysis reflects specific location, grade, and pricing characteristics as appropriate to your firm. The time and cost savings that HedgeSmart achieves enables analysts to ask "what-if" questions, to explore alternative hedging approaches.

Key words: futures markets, hedging, hedge ratio, hedge ratio estimation.

Introduction

Futures markets provide a channel for hedging whereby price risk flows from firms that want to avoid it to speculators who are willing to accept it. This risk transfer function is one of the societal benefits provided by futures markets. Price risk for agricultural products is easy to envision. For example, when farmers plant a crop, they don't know the price they will receive for their harvest so they face risk with respect to the crop price. Cattle feeders, hog feeders, and dairy farmers likewise don't know the price they will receive for their products as they incur feeding costs. This problem is common to many of the sectors that produce the roughly $350 billion of U.S. agricultural products (figure 1).

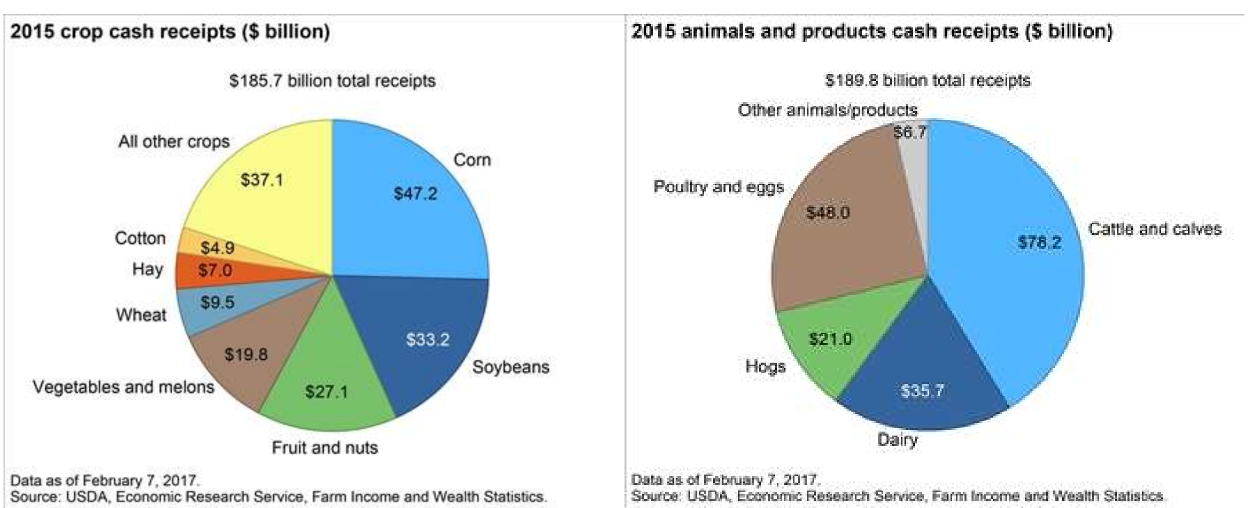

Figure 1. U.S. Agricultural Production ($ bill), 2015 (latest year, final ests available).

Price risk compounds beyond the farm gate price. In each subsequent transaction, commodity brokers, handlers, and processors face price risk because once commodities are purchased, price changes affect profit margins in storage, transportation, and processing. In addition, both the buyer and the seller in each transaction experience price risk. Hence, the $350 billion production value easily translates to over a trillion dollars of agricultural commodity transactions subject to price risk. Price risk arises elsewhere as fluctuations in interest rates, fuel prices, and exchange rates also affect agribusinesses' profitability.

Futures markets provide a low-cost channel for shifting price risk from commodity owners to professional speculators. In futures markets, buyers and sellers trade standardized contracts that clearly specify conditions for the future delivery of a commodity. The contract's price is known at the time of the transaction so that the futures transaction effectively determines today the price for a commodity delivered in the future. Price risk is eliminated because future prices are established before production begins. Hedging is the practice of using a current futures market transaction as a substitute for a pending commodity transaction in an attempt to reduce the risk attached to the ultimate price. Commodity buyers and sellers can both hedge because commodity can be either bought or sold through futures contracts. Individual commodity buyer's and commodity seller's hedging activities are not connected because each transacts with the futures market rather than with the counterparty.

The fundamental hedging questions are (1) "Which contracts should I use for my hedge?" (2) "How many of these contracts should I buy or sell?" and (3) "How much price risk can I avoid by hedging?" The answers to these questions constitute a hedging strategy defined by the hedge ratio (HR) or number of units held in a particular futures contract (commodity and maturity) per unit of the pending physical commodity transaction, and the hedge effectiveness (HE) defined as the proportion of the price risk eliminated by hedging. The simplest hedging strategy is to sell (buy) a unit of the commodity in the futures market for each unit of the physical commodity in the pending sale (purchase). The contract maturity selected is the one that occurs immediately after the pending physical commodity transaction. This strategy is variously referred to as a one-to-one (1:1) direct hedge, or a naïve hedge.

A more sophisticated strategy is to offset the pending physical commodity transaction with a futures market transaction that is proportional to the pending physical commodity transaction. This proportion is the hedge ratio. The advantage of this more general approach is (1) the hedge ratio is selected to minimize price risk, and (2) this approach can be used for physical commodities that don't have futures contracts (for example sorghum, corn syrup, or distillers dried grains). The disadvantage of this approach is that determining the hedge ratio is time consuming even for skilled analysts with access to comprehensive datasets. For those not currently versed in hedging theory, it requires a considerable investment in learning. As a result, most practitioners either rely on "rules of thumb", or other naive strategies, or contract with consultants to obtain appropriate hedging strategies. This paper considers the hedge ratio estimation (HRE) generally and as a process and considers automation as means to drastically reduce the cost of finding the empirical optimal hedge ratio.

This paper lays the foundation for an algorithm that automates hedge ratio estimation. The algorithm relies on user supplied input that describes the process to be hedged, the hedge horizon, hedge frequency, and hedge vehicles. One design goal is to encompass the widest possible variety of hedging scenarios. Based on the user-provided input, the algorithm queries a comprehensive price database and passes the data to the hedge ratio estimation component. Hedge ratios are computed in accordance with the standard portfolio theory of hedging.

We proceed as follows. First, the current hedging literature will be surveyed with an eye toward understanding hedging applications, then the state of the art for hedge ratio estimation will be distilled from the literature. Costs of hedge ratio estimation will be presented and discussed followed by the potential for automation in hedge ratio estimation and a description of our solution to the problem.

Background

Carter (1999), Williams (2001) and Lien and Tse (2002) survey the futures market literature. Carter segments the literature into five areas: (1) the evolution of futures trading, (2) hedging, (3) price behavior, (4) pricing efficiency, and (5) futures pools. Our interest is in hedging and more specifically, hedge ratio determination. Current thinking is that hedge ratio determination derives from the portfolio theory of hedging. Williams (2001, p. 779) observes "The portfolio theory of hedging has become a spectacular growth industry." Our interest is in automating this industry so we review of the terminology and concepts we wish to automate.

<u>Direct Hedging: Production, Storage, and Acquisition</u>

Ideally, hedging "locks in" the price for a future transaction. Sometimes the "lock" is imperfect. Given this imperfection, hedging is an attempt to reduce the price risk on a pending transaction. In our context, hedging involves futures markets for the commodity involved in the pending transaction. There are only two ways to participate in futures markets: either to buy before you sell resulting in a long futures position in the interim, or to sell before you buy resulting in a short position in the interim. Accordingly, a short hedge involves selling futures contracts in anticipation of selling the physical commodity, and a long hedge involves buying futures contracts in anticipation of buying the physical commodity. Additional classifications exist within this dichotomy.

Hedges can be classified by the futures contracts used (the hedge vehicles). With direct hedging, futures contracts exist for the commodity hedged (the hedge target), so one strategy is to have one futures market unit offset each unit of spot market commitment. Cross hedging uses futures contracts that are only related to the hedging target (for example, grain sorghum might be the hedge target and corn futures are used as the hedge vehicle). Cross hedging requires the hedger to select both the hedge vehicle and the size of the position in the hedge vehicle. We consider direct hedging prior to cross hedging.

The *direct production hedge* is the easiest to envision. Imagine a farmer at planting (time 0) knows his costs (c_0) but not the cash price (s_t) that he will receive for his crop at harvest (time 1). The farmer's profit per unit of production is

(1a) $\pi_u = s_1 - c_0 = s_0 - c_0 + (s_1 - s_0)$

where s_t is the spot price for the crop at time t and c_0 is the known cost of production at planting (t = 0). Profit so defined is equal to its current level ($s_0 - c_0$) plus a term due to price change ($s_1 - s_0$). Risk is due to the unknown s_1 or the price change and is measured by the variance of the outcome, $V_u(\pi_u) = V_u [s_0 - c_0 + (s_1 - s_0)]$.

With hedging, the farmer (a) sells the post-harvest contract at planting, (b) buys the post-harvest futures at harvest to close the futures position, and (c) sells the harvested crop locally simultaneously with (b). With events (a) and (b) added to (1a) the gain or loss becomes

(1b) $\pi_h = s_1 - c_0 + f_{10} - f_{11} + s_0 - s_0 = s_0 - c_0 + b_{11} - b_{10}$

where f_{Mt} represents the price of the futures contract that matures at time M (M = 1, harvest) observed at time t (t=0, planting; t=1, harvest), and $b_{Mt} = (s_t - f_{Mt})$ is the basis for the futures contract that matures at time M observed at time t. At planting time, the harvest time spot and futures prices are unknown while c_0 and s_0 are known so price risk is due to $b_{11} - b_{10}$. Comparison of (1a) to (1b) indicates that the farmer has substituted the risk of a basis change for the risk of a price risk change. With hedging, risk is measured as $V_h [s_0 - c_0 + (b_{11} - b_{10})$.

Equations (1a) and (1b) apply a *storage hedge* if we change our story to commodity bought at time 0 for c_0, stored, and sold at time 1. Both the production hedge and the storage hedge are short hedges as futures contracts are sold at time 0.

With reconfiguration, (1a) and (1b) can depict an *anticipatory hedge* where futures contracts are bought at the known price f_{10} at time 0 in anticipation of the future (time 1) purchase of a commodity. In this case, π represents the cost of the input where

(1c) $\pi_u = - s_1 = - s_0 - (s_1 - s_0)$

(1d) $\pi_h = - f_{10} + f_{11} - s_1 + s_0 - s_0 = -s_0 - (b_{11} - b_{10})$

Again hedging substitutes the risk of a basis change for the risk of a price change. The signs on the basis are reversed in (1b) versus (1d) because purchasing agents incur economic losses (gains) when spot prices increase (decrease). The variance is unaffected by this sign reversal. Production, storage and anticipatory direct hedging are widely practiced.

Commodity processing hedging combines production and anticipatory hedges with different hedge horizons. The result is a *complex hedge.*[1] For example, to hedge crushing a 60-pound bushel of soybeans with a yield of 48 pounds of soymeal and 11 pounds of soybean oil, a soybean crusher should purchase 1 bushel of soybean futures as an anticipatory hedge at time 0, and sell 11 pounds of soybean oil futures and 48 pounds of soybean meal futures in a production hedge. When soybeans are purchased (time 1), the soybean futures contracts are sold to close the anticipatory hedge, and when the soybean meal and soybean oil futures are sold (time 2) their respective futures contracts are bought to close the production hedge. Soy complex hedges have

[1] This terminology refers to hedging in a commodity complex and is not meant to indicate a higher degree of complexity.

been analyzed by Dahlgran (2005); Fackler and McNew; Garcia, Roh, and Leuthold; and Tzang and Leuthold.

The unhedged processing margin is

$$(2a)\qquad \pi_u = -(s_1^B - s_0^B) + 48(s_2^M - s_0^M) + 11(s_2^O - s_0^O)$$

where the time periods are 0, the beginning of the anticipatory period; 1, the beginning of the production period; and 2, the termination of the hedge; and the superscripts indicate commodities beans (B), soymeal (M) and soyoil (O).

With hedging (2a) becomes

$$(2b)\qquad \pi_h = -(s_1^B - s_0^B) + 48(s_2^M - s_0^M) + 11(s_2^O - s_0^O) + (f_{11}^B - f_{10}^B) - 48(f_{22}^M - f_{20}^M) - 11(f_{22}^O - f_{20}^O)$$

or in terms of bases

$$(2c)\qquad \pi_h = -(b_{11}^B - b_{10}^B) + 48(b_{22}^M - b_{20}^M) + 11(b_{22}^O - b_{20}^O)$$

This demonstrates (a) the substitution of basis risk for price risk for each of the three commodities, and (b) the mix of the anticipatory hedge for the soybeans purchase as indicated by the negative sign and the production hedge for the soyoil and soymeal as represented by the positive coefficients.

Other direct complex hedges include cattle feeding (Schafer, Griffin and Johnson; CME Group) and hog feeding (Kenyon and Clay). Other applications are also possible with the selection of various commodity bundles and the specification of input/output coefficients.

Cross Hedging

A c*ross hedge* uses a futures contract for a commodity that is related to the target commodity. For example, the corn futures might be used to hedge distillers dried grains or grain sorghum transactions, or cattle futures might be used to hedge buffalo growing (Movafaghi, 2014), or breweries might search for a futures contract to hedge hops purchases (Prera, Fortenbery, and Marsh. 2016). The equal and offsetting logic of a direct hedge is lost in a cross hedge so the gain or loss on the hedged position becomes

$$(3a)\qquad \pi_h = s_1 - c_0 + \beta\,(f_{10} - f_{11})$$

where β is the *hedge ratio* defined as number of units futures market units held per spot market unit. Risk is defined as

$$(3b)\qquad V(\pi_h) = V(s_1 - c_0) + \beta^2 V(f_{10} - f_{11}) + 2\beta \,\mathrm{Cov}\,[(s_1 - c_0)(f_{10} - f_{11})]$$

and is minimized at

(3c) $\beta^* = - \text{Cov} [(s_1 - s_0) (f_{10} - f_{11})] / V(f_{10} - f_{11})$.

This assumes that f represents the price of the best hedge vehicle.

Using the cross hedging approach when direct hedging is possible results in a proportional direct hedge. Rolfo (1980; cocoa, Brazil), Grant (1989, corn, soybeans), Grant and Eaker (1985, wheat, corn, oats), Ederington (1979, wheat, corn), Carter (1984, barley, corn) and Carter and Lyons (1985, beef) all find proportional hedges to be superior to direct hedges as price risk management strategies.

Proportional hedging has also been applied in processing environments where direct hedging was possible. This permits the hedge ratios for each commodity in the complex to take advantage of the correlations that exist among the commodities in the complex and depart from the underlying input-output coefficient. Proportional processing hedges have been studied in the soybean sector (Tzang and Leuthold 1990; Fackler and McNew 1993) and more recently in the corn-based ethanol refining (a.k.a. corn crushing) sector (Dahlgran, 2009; Franken and Parcell, 2003).

True cross hedging in the commodity processing can be practiced when direct hedging is not available as in cottonseed crushing (Dahlgran, 2000; Rahman, Turner, and Costa, 2001) and in the early days of ethanol refining before the ethanol futures contract was available (Franken and Parcell, 2003), and fishmeal production (Franken and Parcell, 2011). While the cited hedging examples come from agricultural commodity markets, applications in energy, metals, securities, equities, or currency markets are also abundant.

Portfolio Theory of Hedging

The portfolio theory of hedging unifies the hedging applications that we have considered. The theory assumes that an agent holds a necessary spot (or cash) market position, x_f, and can also hold an attendant futures market position, x_f (Johnson, Stein). The profit outcome (π) of these combined positions is

(4a) $\pi = x_s (s_1 - s_0) + x_f (f_{M1} - f_{M0})$,

where s_t is the commodity's spot price at time t, f_{Mt} is the M-maturity futures contract's price at time t, and time subscripts 0 and 1 indicate initiating and terminating transaction times. The manager's choice variable, x_f, is selected to maximize utility in the mean-variance utility function

(4b) $U(\pi) = E(\pi) - \phi/2 \; V(\pi)$

Johnson and Stein provide the solution

(4c) $x_f^* = [\phi^{-1} E (\Delta f_M) - x_s \text{Cov} (\Delta f_M \, \Delta s)] \, V (\Delta f_M)^{-1}$

where $\Delta s = s_1 - s_0$ and $\Delta f_M = f_{M1} - f_{M0}$.

This solution contains a speculative component based on the expected futures price change $E(\Delta f_M)$ and a hedging component based on the covariance of price changes in the spot and futures markets. If we adopt the assumption that futures markets are efficient[2], then $E(\Delta f_M) = 0$ and (5) reduces to

(5d) $x_f^* = - x_s \text{Cov}(\Delta f_M \Delta s) V(\Delta f_M)^{-1}$

so the optimal hedge ratio, x_f^*/x_s, is $- \text{Cov}(\Delta f_M \Delta s) V(\Delta f_M)^{-1}$.[3] This optimal hedge ratio is estimated by $\hat{\beta}_1$ in the regression

(5c) $\Delta s_t = \beta_0 + \beta_1 \Delta f_{Mt} + \varepsilon_t$, $t = 1, 2, \ldots T$

where Δ represents differencing over the hedging horizon, ε_t represents stochastic error at time t, and T represents the number of observations used in estimating of β_0 and β_1. The risk minimizing futures position is $x_f^* = -\hat{\beta}_1 x_s$. Ederington shows that hedge effectiveness or the risk reduction achieved by taking the futures position is estimated by the regression R^2.

Anderson and Danthine (1980, 1981) generalized this approach to accommodate multiple futures positions. In this case, x_f, f_{M1}, and f_{M0} represent vectors of length k and hedge ratios are the parameters in the multiple regression

(5d) $\Delta s_t = \beta_0 + \sum_{j=1}^{k} \beta_j \Delta f_{jt} + \varepsilon_t$, $t = 1, 2, 3, \ldots T$,

where Δf_{jt} is the change in the price of futures contract j over the hedge period, and $\hat{\beta}_j$ is the estimated hedge ratio indicating the units in futures contract j per unit of spot position.

Commodity processors have both an anticipatory hedge and a production hedge so their profit outcome is

(5e) $\pi = - x_1 \Delta_1 s_1 + x_2 \Delta_2 s_2 + x^1_f \Delta_1 f_1 + x^2_f \Delta_2 f_2$.

where input purchases (x_1) and output sales (x_2) are temporally separated by $t_2 - t_1$ but connected by product transformation with $[\lambda_1 : \lambda_2][x_1 : x_2]^T = 0$ where λ_1 and x_1 are row vectors of input coefficients and quantities, respectively and λ_2 and x_2 are row vectors of output coefficients and quantities. λ is scaled so that one element equals 1. This allows the hedge to be expressed as per unit of the corresponding input output.

Hedge ratios are estimated by fitting

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[2] We are obviously making this assumption as we employ our database to provide hedging rather than speculative strategies.

[3] This solution is also the solution obtained under a simple variance minimization objective.

(5f) $\lambda_1 \Delta_1 s_1 = \alpha_1 + \Delta_1 f_1 \beta_1 + \varepsilon_1$ and

(5g) $\lambda_2 \Delta_2 s_2 = \alpha_2 + \Delta_2 f_2 \beta_2 + \varepsilon_2$

where (5f) represents the anticipatory hedge and (fg) represent the production hedge.

This specification has been applied to soybean processing (Dahlgran, 2005; Fackler and McNew; Garcia, Roh, and Leuthold; and Tzang and Leuthold), cattle feeding (Schafer, Griffin and Johnson), hog feeding (Kenyon and Clay), and cottonseed crushing (Dahlgran, 2000; Rahman, Turner, and Costa).

Hedge Ratio Estimation

The two primary statistics in hedging strategies, the hedge ratios and hedge effectiveness, are estimated with the regression

(6a) $\Delta_H S \lambda = X \alpha + \Delta_H F \beta + \varepsilon$

where S and F are matrices of spot and futures prices respectively, λ is a vector of input/output coefficients, and X is the set of conditioning variables, α is the set of parameters corresponding to X, β is the hedge ratios and ε is the stochastic error term. The β estimates are the sought-after hedge ratios.

Hedge effectiveness (e) is defined by Ederington as the proportionate price-risk reduction achieved through hedging, or

(6b) $e = [\ V(\pi_u) - V(\pi_h)\ ] / V(\pi_u)$

where V is the variance operator, π_u the agent's unhedged outcome ($x_f = 0$) and π_h is the agent's hedged outcome ($x_f = -\hat{\beta}_1 x_s$). Lindahl observes, "The most popular measure of hedging effectiveness is commonly called R^2 … ". In terms of (6b), hedge effectiveness is

(6c) $e = [\ SSE(\alpha) - SSE(\alpha, \beta)\ ] / SSE(\alpha)$

The effectiveness estimator is the R^2 only if α is the simple intercept for the regression. Otherwise, X α represents the systematic behavior of the hedge target that would have occurred regardless of hedging. The variance of the unhedged outcomes is conditional on these systematic effects.

Variations of this model in the academic literature include alternative error specifications such as serially correlated residuals, ARCH and GARCH error behaviors. ARCH-based models allow time varying error distributions. As variances and covariances change, the optimal hedge ratios also change through time. Models that account for this dynamic behavior are expected to offer improved hedge effectiveness as compared to OLS.

Hatemi and Roca (2006) examine time varying optimal hedge ratios by applying the Kahlman filter expressed as

(6d) $\lambda \, \Delta_H S_t = \alpha \, X_t + \Delta_H F_t \;\; \beta_t + \varepsilon_t$

(6e) $\beta_t = \beta_{t-1} + v_t$

The empirical findings with regard to time varying hedge ratios has been mixed. Some researchers have found improved hedge effectiveness (see, for instance Baillie and Myers, 1991; Park and Switzer, 1995; Lien et al., 2014; Prokopczuk, 2011; Tejeda and Goodwin, 2014) while others have found the improvement to be minimal (Garcia, Roh, and Leuthold, 1995; Wang, Wu, and Yang, 2015, Lien and Tse, 2002). Moschini and Myers (2002, p 590) state ".. no existing study has provided compelling evidence that such time varying hedge ratios are statistically different from a constant hedge ratio."

Other model specifications (Wang, Wu, and Yang, 2015) include the vector error correction model

(6d) $\Delta s_t = \alpha_s + \beta_{11} \, \Delta s_{t-1} + \beta_{12} \, \Delta f_{t-1} + \theta \, z_{t-1} + \varepsilon_{st}$

(6e) $\Delta f_t = \alpha_s + \beta_{21} \, \Delta s_{t-1} + \beta_{22} \, \Delta f_{t-1} + \theta \, z_{t-1} + \varepsilon_{st}$

(6f) $z_t = s_t - \psi \, f_t$

Again, some ECM models have been found to yield better performance over those derived from OLS methods (Ghosh, 1995; Chou et al., 1996; Ghosh and Clayton, 1996; Lien and Tse, 1999; Sim and Zurbruegg, 2001) while others (Wang, Wu, and Yang 2015; Moosa, 2003; Lien and Shrestha, 2008) find that more sophisticated estimation techniques do not necessarily result in hedge ratios that produce more effective hedges.

These studies seem to indicate that the ordinary regression model is the "gold standard" for hedge ratio estimation. Alternative model specifications might offer slight improvements in hedge effectiveness but at a cost of more complex modelling. These studies also indicate that while time-varying hedge ratios might offer improved hedge effectiveness they too have an increased computational burden.

Hedge Ratio Estimation Costs

A gap exists between hedging and practice. While the academic literature reports increasingly sophisticated hedge ratio estimation techniques, practitioners rely on basic methods. For example, ethanol plant managers and grain merchandisers indicate in personal interviews that they use one-to-one hedging or apply other heuristic rules.

In one sense, this gap is inexplicable as price-risk minimization theory is elegant and straightforward and regression analysis, the standard for hedge-ratio estimation, is a widely used analytical technique. On the other hand, this gap is rational if hedge ratio estimation is costly and the benefits of employing the analysis are minimal. To estimate the cost of hedge ratio estimation, we conducted a thought experiment with the audience at the 2017 NCCC-134 Conference on Commodity Price Analysis, Forecasting, and Market Risk Management. Given the conference title, we assumed the audience was knowledgeable about hedging, hedging strategies, and hedge ratio estimation. The instructions and problem description for the thought experiment read as follow and our survey instrument is shown in table 1.

> ***Instructions:*** *As this presentation proceeds, you will be asked to fill out the attached survey questionnaire. It will be collected at the completion of this presentation.*
>
> ***Problem Description:*** *An alum of your program from 10 years ago is employed as a manager for a firm that owns five ethanol refineries in west-central Nebraska. The plants are widely dispersed and use sorghum as the feedstock.*
>
> *He contacted your department in hopes of obtaining advice on how to manage price risk. Your department head passed the request to you because of our interest and expertise in futures markets. If handled correctly, this request could become a consulting contract.*
>
> *Before we get back to the client we want to give some thought to a contract that we might propose. At this stage we need only preliminary estimates of the time involved and the timeline for the study.*

Table 2 summarizes the survey responses. Sixty two percent of the respondents had PhDs and most of the remainder had Masters Degrees. As expected, the audience was familiar with consulting studies and hedging ratio estimation with the median values of 1 and 1.5 studies respectively. Most significantly, table 2 indicates that the audience estimated that hedge ratio estimation requires a median of 160 hours to perform, 60 days to complete, and are priced at \$15,000 to \$25,000. The median consulting wage rate was roughly \$100 per hour. All of these results were within the bounds of our initial expectations.

Table 2. Thought experiment survey results.

	Resp	Avg	Min	Max	Median
PhD degree	10				
Non PhD degree	6				
Consulting studies performed	16	7.5	0	50	1
Hedging studies perfomed	16	4.75	0	25	1.5
Billable hrs (most likely)	16	168	24	426	159.3
Days to complete	16	61	16	132	60
Cost – academic study	15	\$16,417	\$2,500	\$35,000	\$15,000
Cost – consulting firm	12	\$33,750	\$4,000	\$125,000	\$23,750

Table 1. A Hedging Thought Experiment *Questionnaire*

	Billable Hours Min	Max	Most likely	Days to step Compl'n
1. Conceptualize project	______	______	______	______
a. Is this something I can do?				
b. Is it worth doing?				
c. Grasp portfolio theory of hedging?				
d. Review literature?				
2. Initial meeting with client	______	______	______	______
a. Preparation?				
b. Travel?				
c. Meeting?				
3. Data search	______	______	______	______
a. What data are you looking for?				
b. Where will you look?				
c. Data acquisition cost? $________				
4. Compile data	______	______	______	______
5. Analyze data	______	______	______	______
a. Discover quirks, discontinuities, missing values?				
b. Collect additional data?				
c. Code and run regressions?				
6. Prepare report	______	______	______	______
a. How many pages? ________				
7. Prepare for and meet with client	______	______	______	______
a. Preparation?				
b. Travel?				
c. Meeting?				
8. Follow-up with client	______	______	______	______

Demographic information

a. Highest degree attained (round) B.S. M.S PhD

b. How many consulting studies have you performed? _____

c. How many hedging studies have you done? _____

d. Roughly how much would you charge for this work? $______ to $______

e. How much would a consulting firm charge for this project? $______ to $______

Suggestions for other items to include / consider (use other side if needed):

Some of the 160 hours required to obtain hedge ratio estimates is allocated to model building. Each of the three components of the regression's dependent variable, $\lambda\ \Delta S_t$, must be specified. In some applications, the input/output parameters (λ) are well known, while in other cases (hog and cattle feeding) these coefficients may vary by firm, season, or location. The hedge horizon (Δ), and the cash prices for the commodities (S_t) are subject to the same considerations. Higher quality hedge ratios result from cash prices that are geographically and product form specific to the firm.

A sampling strategy must be adopted. This determines the beginning and end of the sampling period and the frequency of sampling within the sample period. In practice, it relates time t to a specific date. For the regression's independent variables the futures contract commodities and maturities must be selected. An exclusion buffer for imminently maturing contracts might be employed in the computation of the futures price changes. The conditioning variables in X must be supplied (quarterly or monthly dummies for example) and the behavior of the error terms must be specified. The possible combinations compound and the data selection effort compounds accordingly.

The Potential for Automation

The difference between commercial and academic hedge ratio estimation practice signals the potential for automation. The differing approaches are due to costs and incentives which differ between the sectors. The academic enterprise seeks new and better hedge ratio estimation techniques while the commercial enterprise seeks cost effective risk reduction. While the academic sector is subject to opportunity costs of time, research findings are the valued product. Slight but insignificant hedge effectiveness increments are valuable. In contrast, the commercial enterprise is more pragmatic about the costs of hedge rate ratio estimates versus the amount of risk reduction achieved. Case in point, HRE research shows that hedge ratios are time-varying but these results have little value to a practitioner because of the time that elapses between the last sample observation and the publication date.

Second, table 2 reports that hedge ratio estimation requires a significant amount of time, whether measured as an input or as elapsed time. Our survey subjects were skilled in the theory and practice of econometrics. In contrast, most managers in the commercial enterprise do not have the ready access to this knowledge base and its acquisition will require large additional time investments. Similar considerations apply with regards to the skills to use econometric software and data management tools. The academic researcher may also have access to a cadre of skilled research assistants with freshly acquired econometric skills.

Third, the academic and commercial hedge ratio estimation enterprises have differing data access. The academic enterprise must work with publicly available data including purchased data from Bloomberg or Reuters data services. These data are generally aggregated geographically and the sampling mechanisms are opaque. The data are then analyzed under hypothetical scenarios with regard to hedge horizons, sampling, and input/output coefficients. In contrast, commercial firms want analyses of location-specific firm-level price data, as these are the prices that apply to the transactions the firm is trying to hedge. To the extent these data exist, the firm will have access to them. The commercial firm may be able to justify a commercial real-time data service that generates copious data. The firm may have ample specific data available yet the skill and inclination to manipulate these data may be absent and learning techniques to manipulate these data will be beyond the typical hedging manager's job description.

The gulf between the academic and the commercial hedge ratio estimation enterprises is due to these differing incentives and production technologies. When two markets have differing incentives and differing production technologies the optimal solution is for each to seek its comparative advantage and then trade. In this case, the opportunities for trade are limited because academic results are out-of-date from the commercial's perspective because the time requirements of the peer review process require many months to pass between analysis and publication. In addition, academic results are too general. A firm wants firm and location specific results but are reluctant to provide proprietary data to academics. On the other side, the methodology used by academics is not accessible to most commercial analysts. As a result, hedge ratio estimation is a costly prospect performed mostly by consultants..

Automated Hedge Ratio Estimation

The process of hedge ratio estimation involves specifying the nature of the hedge, querying large databases of publicly recorded prices, then running a standard hedge-ratio regression model. Automation is economically feasible because the process is common across all hedges in all commodities. Automation allows parties in the academic and commercial sectors to trade non-propriety assets while retaining control over proprietary information. Automation brings together the academic enterprise's econometric capital and research knowledge and the commercial enterprise's proprietary price data and knowledge of the intricate workings of the local, firm-level transactions.

The standardized process has been coded into HedgeSmart©, web-based app. A prototype is available at http://HedgeSmart.net. This app is designed to accommodate any type of hedging (production, storage, anticipatory, complex) and compute hedge ratios in accordance with the portfolio theory of hedging. The flexibility of the app allows the user to incorporate aspects critical to his/her hedging scenario. User controlled inputs include

- The ***cash commodities*** as represented by the cash prices, S_t.
- The ***input and output relationships*** between physical commodities, λ.
- The ***hedge horizon***, Δ.
- The ***sample period***, *i.e.*, the beginning and ending dates corresponding to t=1 and t=T.
- The ***sampling frequency***, *i.e.*, the dates corresponding to the intermediate values of t.
- The ***conditioning variables***, i.e., dummies, lagged variables and other data contained in X.
- The ***hedge vehicles***, *i.e.*, futures contracts and maturities (M) used for hedging.
- The error term's (ε_t) behavior.

For firm-level hedging decisions, location- and grade-specific cash prices are more appropriate than central market prices. HedgeSmart allows users to incorporate their own prices.

Alternatively, the user can select from the cash prices in our database. The user's assumptions govern the selection of the appropriate data from our 10.25 million record database spanning 1990 to the present. Our database is updated daily after the markets close. The input specification and sampling algorithms permit the user to perform highly individualized hedge ratio and hedge effectiveness analyses.

Hedge ratios and hedge effectiveness are computed and reported in a matter of seconds. The program also graphically depicts hedged, unhedged, and one-to-one hedging outcomes over the sample period. If unused data are available, the program simulates hedged, unhedged and one-to-one hedged outcomes over the post sample period to validate the results.

This app substantially automates hedge ratio estimation significantly reducing the cost of developing price-risk management solutions. This automation will benefit academic researchers, hedge strategy teachers, hedging consultants, hedgers.

As more hedging strategies are constructed and analyzed, better-informed hedging decisions ultimately result. Cost reduction will increase the number of agents engaged in minimizing price-risk exposure, will increase the frequency of price-risk management strategy formulations, and will create opportunities to easily examine strategies formulated under alternative assumptions about transaction timing and planning horizons. More finely-tuned hedging strategies will lead to better-informed hedging decisions throughout the agricultural sector. Enhanced price-risk management in the aggregate economy will result in fewer business bankruptcies and greater financial stability for firms that engage in this practice.

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