Ledger Provision in Hog Marketing Contracts

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Abstract

Some long-term marketing contracts in the North American hog sector provide for price-dependent loan agreements at low rates. We show that these provisions linking pricing with financing are hybrids between forward rate agreements and commodity options. This observation presents approaches for valuing the stipulations. We suggest that the ledger arrangement is transaction-cost efficient, especially for a packer with a natural partial pass-through hedge from retail market positions.

Keywords: commodity option, contract production, forward rate agreement.

JEL classification: Q1, L2, G3

LEDGER PROVISION IN HOG MARKETING CONTRACTS

Tighter integration in the hog production sector in North America has given rise to unfamiliar risk sharing and financing arrangements. In some cases, marketing contracts of up to ten years duration specify that a downstream integrator, often a packing company, must share downside and upside market hog and feed price risk with the grower. In other cases, the integrator and grower agree to maintain a ledger account, whereby they lend to each other at specified rates. The extent of the transfers depends on how market hog and feed prices evolve over the duration of the contract.

These various provisions are not readily valued, and this has been a significant problem for the industry (Buhr 2000; Lawrence and Vontalge 2000; Martin 1998). Growers want to know if the proposals do reduce risk and if the terms are, in expectations, not unduly unfavorable. Integrators have the same concerns, but from their own perspective. Third-party lenders want to know the true nature of assets and liabilities of the entity they are financing. Even though third-party lenders generally prefer that hog producers enter into long-term contracts (Godley 1996), off-balance sheet and obscure liabilities always concern financiers.

It therefore comes as no surprise that price movements have caused financial problems for many participants in the North American hog sector. Indeed, even the most experienced livestock integrators have made miscalculations in contract design. In August 2002, Arkansas-based poultry and hog packer Tyson declared its intention to exit many stages of hog production because of liabilities arising from persistently low hog prices (Smith 2002a). Concerns have been raised that other pork packers may not be able to finance their way through price and lending assurances given to growers (Smith 2002b).

Quite apart from the implications for efficient planning, if and when contractual relations terminate early (as with Tyson), the valuation of assets and obligations will be an issue in settlement. Valuation may also be important when designing and

implementing public policy. The Livestock Mandatory Reporting Act of 1999 attests that promoting price transparency in agricultural markets is U.S. federal policy. Yet the loan terms of some ledger contracts cloud the true price to be paid. In addition, some policy setters offer ledger-style interventions to growers. Continuing an intervention mechanism used in 1998–99, the provincial government in Saskatchewan, Canada, made price-contingent loans available to hog growers in 2003–04. The rate (prime) was lower than commercial rates available to small businesses.

The issue addressed in this paper is the valuation of these contractually provided price-contingent loans. We show that these provisions are hybrids between forward (interest) rate agreements and commodity spot options. This allows an approximate, valuation using standard option pricing and interest rate arbitrage arguments. Our work here extends the observations in Gardner 1977, in Unterschultz et al. 1998, and in Shao and Roe 2003 (forthcoming). Gardner pointed out that price-contingent government support payments for agricultural commodities could be valued as put options. Unterschultz et al. decomposed a popular feature of a hog marketing contract, the market hog price window, into a combination of a put and a call at the same maturity but at different strike prices. Shao and Roe, focusing on price averaging provisions in marketing contracts, modeled the conditions as Asian-Basket options. None of these papers looked at the main theme of this article, the valuation of lending provisions in marketing contracts.

Valuing the Ledger Provision

We studied some relevant provisions of two ledger-style contracts offered by John Morrell and Company and posted on the Iowa Attorney General's web site (Iowa Attorney General 2003). In each, the true hog price paid is supplemented with a loan from the integrator to the grower when prices are below a reference price. The loan is paid off when prices are higher, and then a reserve balance also may be built up in anticipation of lower future spot prices.

Contract #1 settles the balance regardless of the sign of the ledger balance at contract termination, and we model this first. Contract #2 settles the balance only

when the grower owes Morrell. This provision is modeled at the conclusion of the section. In each contract, the interest rate is zero, but this is not the case in other ledger contracts. The relevant parts of the contracts are provided in the appendix.[1]

Two-Way Settlement

Let $t = 0$ denote the current time, with S_Δ as the time $t = \Delta$ spot price. A ledger contract expires at time $t = T$. Let $T = N\Delta$ such that deliveries take place at $t = n\Delta$, $n \in \{1, 2, \dots, N\}$. The risk-sharing price floor F in the ledger contract generates the payoff for the producer as follows: $\pi = S_\Delta$ if $S_\Delta > F$ and $\pi = F + \beta(S_\Delta - F), 0 \le \beta \le 1$, otherwise at time $t = \Delta$. However, the producer is required to pay back the difference, $F + \beta(S_\Delta - F) - S_\Delta = (1 - \beta)(F - S_\Delta)$, at $t = T$ with an instantaneous interest rate $\bar{r}(t)$ set by the integrator that is predetermined, finite, and continuously compounded.[2] Rate $\bar{r}(t)$ is typically set at a number between zero and the prime rate.

Let $r(t)$ denote the finite, instantaneous market interest (and discount) rate to the grower at time t when quoted at the current time period. The time $t = \Delta$ discounted value of $(1 - \beta)(F - S_\Delta)$ paid at $t = T$ is $\exp\{\int_\Delta^T [\bar{r}(t) - r(t)]dt\}(1 - \beta)(F - S_\Delta)$. Thus, the actual present discounted payoff (at $t = \Delta$) to the grower is

$$\pi_f^* = \begin{cases} S_\Delta & \text{if } S_\Delta > F, \\ F + \beta(S_\Delta - F) - \exp\{\int_\Delta^T [\bar{r}(t) - r(t)]dt\}(1 - \beta)(F - S_\Delta), & \text{otherwise.} \end{cases} \tag{1}$$

The gain from a price floor is $\pi_f^* - S_\Delta = Z(\Delta, T)(1 - \beta)\max(F - S_\Delta, 0)$, with $Z(\Delta, T) = 1 - \exp\{\int_\Delta^T [\bar{r}(t) - r(t)]dt\}$. The latter represents the payoff from $Z(\Delta, T)$ put options with strike price F and maturity date $t = \Delta$. The value of the price floor at $t = 0$ is $Z(\Delta, T)(1 - \beta)p(F, \Delta)$, where $p(F, \Delta)$ is the premium for a put option with strike price F and maturity date $t = \Delta$. Similar considerations apply to all the future periods.

As a result, the total value of the price floor to the grower is

$$V_f(t=0) = \sum_{n=1}^{N} Z(n\Delta,T)(1-\beta)p(F,n\Delta). \qquad (2)$$

Notice that if $\bar{r}(t) = r(t) \ \forall t \in [\Delta,T]$ then $V_f(t=0) = 0$ because the interest rate differential neither subsidizes nor penalizes the grower. As $\bar{r}(t) < r(t)$ in most contracts, we then have $V_f > 0$ to the grower. The agreement to provide loans in the future (a forward rate agreement) at rate $\bar{r}(t)$, rather than $r(t)$, is to the grower's advantage because the state-contingent loans previously modeled can be awarded only to the grower.[3]

On the other hand, a risk-sharing price ceiling provides the following payoff to the producer: $\pi = S_\Delta$ if $S_\Delta < K$ and $\pi = K + \alpha(S_\Delta - K), 0 \le \alpha \le 1$, otherwise at time $t = \Delta$. Once again, the difference, positive or negative, returns to the producer at $t = T$. The actual payoff is

$$\pi_c^* = \begin{cases} S_\Delta & \text{if } S_\Delta < K, \\ K + \alpha(S_\Delta - K) + \exp\{\int_\Delta^T [\bar{r}(t) - r(t)]dt\}(1-\alpha)(S_\Delta - K), & \text{otherwise.} \end{cases} \qquad (3)$$

Calculating the difference, the loss to the grower from a price ceiling amounts to $\pi_c^* - S_\Delta = -Z(\Delta,T)(1-\alpha)\max(S_\Delta - K, 0)$.

The latter represents the payoff from $Z(\Delta,T)(1-\alpha)$ written call options with strike price K and maturity date $t = \Delta$. The value of the price ceiling at $t = 0$ is $-Z(\Delta,T)(1-\alpha)c(K,\Delta)$, where $c(K,\Delta)$ is the premium for a call option with strike price K and maturity date $t = \Delta$. Similar considerations apply to all the future periods. The total value of the price ceiling to the grower is

$$V_c(t=0) = -\sum_{n=1}^{N} Z(n\Delta,T)(1-\alpha)c(K,n\Delta). \qquad (4)$$

Finally, the value of a ledger contract is $V_l = V_f + V_c$; that is,

$$V_l(t=0) = \sum_{n=1}^{N} Z(n\Delta,T)\big[(1-\beta)p(F,n\Delta) - (1-\alpha)c(K,n\Delta)\big]. \qquad (5)$$

If the provision, when considered by itself, is fair, then $V_l(t=0)=0$. If $\overline{r}(t)\leq r(t)\ \forall t\in\ [\Delta,T]$, then $Z(n\Delta,T)\geq 0\ \forall n\in\{1,2,\ ...\ ,N\}$. In that case, condition $(1-\beta)p(F,n\Delta)\geq\ (1-\alpha)c(K,n\Delta)\ \forall n\in\{1,2,\ ...\ ,N\}$ ensures that the ledger provision has positive financial value to the grower at $t=0$. This inequality on put and call value relations holds whenever the integrator assumes most of the downside risk (i.e., β is close to zero or F is high), or the grower reverts only a small fraction of upside price movements (i.e., α is close to unity or K is high). Contract terms are then more generous than price parameters alone would suggest. After $t=0$, the provision likely will assume positive or negative value as spot prices decrease or increase.

We have yet to place values on the options. Subject to acknowledging the true nature of the options, standard procedures may be applied. The options are on spot prices and it is important to model future commodity spot prices carefully, especially with distant maturities. Equilibrium adjustments suggest that mean reversion, rather than standard geometric Brownian motion, is appropriate as a characterization of price stochastics. Hilliard and Reis (1998), and also Miltersen and Schwartz (1998), provide valuation procedures that accommodate commodity price mean reversion.

A more problematic issue is that readily traded price contract markets of any kind are thin beyond three years forward. The integrator may have difficulty in setting off assumed risks because of low liquidity in spot and near-term forward markets. Grimes and Plain (2003) report that sales in hog spot markets have fallen to account for less than 14 percent of total market hogs in early 2003. In this light, the assumption of risk-free arbitrage with spot markets is quite tenuous, although imperfect substitutes (processed meats) may be available. Valuation will depend upon the asset positions and risk preferences of the contract holder. The latter is not readily elicited. Work by Hall and Murphy (2002), for example, suggests ways of accounting for valuation when it is costly or impossible to eliminate risk.

A further issue we have not considered is default risk. The literature on measuring and mitigating exposure is large (see Duffie and Singleton 2003 on methodologies). Some integrators require that a reserve be built up as a ledger balance due the grower when prices are high; see Contract #1 in the appendix. This provision, which we have not modeled, performs like a futures market margin

account in reducing integrator credit risk exposure. Including feed prices as a factor in determining loans also should help in reducing the risk of grower default, but may increase the risk of integrator default.

One-Way Settlement

We now turn to the contract provision whereby the integrator receives any balance owed in the ledger account but does not pay any balance owing at termination. In this case, the value of the ledger contract to the grower is equal to

$$V_l(t=0) = V_a + \sum_{n=1}^{N} Z(n\Delta, T)\left[(1-\beta)p(F, n\Delta) - (1-\alpha)c(K, n\Delta)\right]. \tag{6}$$

where V_a is the value of a compound Asian option that provides the following payoff at $t = T$: $\pi_a = -\max\{\sum_{n=1}^{N}[(1-\beta)\max(F - S_{n\Delta}, 0) - (1-\alpha)\max(S_{n\Delta} - K, 0)], 0\}$. This equation is arrived at by first assuming that the two-way ledger account provision applies. After repaying any outstanding loans, the grower may also have to repay an amount at contract termination. If and only if the undiscounted accumulation of loans received in low-price spot markets, $(1-\beta)\max(F - S_{n\Delta}, 0)$, exceeds the undiscounted accumulation of loan reversions in high-price spot markets, $(1-\alpha)\max(S_{n\Delta} - K, 0)$, then the difference is due to the integrator at maturity. Standard procedures to value Asian options involve Monte Carlo simulation because closed-form solutions are generally not possible. Procedures are outlined in Hull 2002 and in McDonald 2003.

Discussion

We have provided a means of valuing an important provision in hog marketing contracts. We did not address why integrators finance growers, and a motive is not immediate. The market problem likely concerns liquidity, although tax and other motives may have secondary significance. Integrators may have access to capital markets at more favorable rates because of the comparative size of their financial operations. This, according to Fudenberg, Holmstrom, and Milgrom (1990), is one prerequisite for the efficiency of longer-term contracts over less-committed relationships. Still, if a bank has an existing relationship with the grower and is

prepared to provide risky longer-term loans for the infrastructure underpinning a production operation, then why not use shorter-term loans that stabilize the operation? When hog prices are low, integrators may be able to procure hogs elsewhere at better terms than those in the contract, and so a grower's default is not necessarily bad in this regard.

Where the goals of the integrator and the bank do align is the procurement of a steady flow of uniform and high-quality hogs. Key and McBride (2003) provide evidence to suggest that contract production is more efficient (as measured by volume of output relative to input use), although whether the grower retains more of the surplus to service loans is another issue. The move toward value-added pork production, with emphasis on food safety, has generated a need for stronger vertical links, and, again, the banker may wish to avoid a grower who is closed out of a premium that is paid for downstream confidence in product quality.[4]

While it generally provides higher prices, marketing through a committed relationship leaves the grower vulnerable. The grower must make two sorts of investments. Resources, typically with a significant fraction borrowed, are invested in site-specific infrastructure with imperfectly substitutable alternative uses. In addition, the grower must make human capital investments in producing the categories of hogs, and often under the desired procedures, the integrator wants. The investments are vulnerable to hold-up if alternative outlets for market hogs are imperfect substitutes. Default on a contract due to liquidity problems would leave the grower vulnerable to renegotiations. Growers, in foreseeing renegotiations, may seek either a bank credit line guarantee or a contract design with measures to avoid a liquidity crunch.

Quite apart from entry, liquidity concerns also affect incentives for the grower. This may be particularly true of noncontractible grower investments in producing quality hogs in which direct means of control are not possible. Theories on the role of debt and liquidity on incentives exist, as in Aghion and Bolton 1992 and also in Hart 1995 and 2001, but we cannot find any that explains why the contractor should in effect provide the credit line. Sunk cost investments in buildings and human capital should be made to work until obsolescence, yet a cash-poor company may have to idle its assets, and this may not (it should not) be in the interests of any party. The

integrator will know the industry better and may know the grower better than would a third-party lender.

Most likely it is more transaction-cost efficient for the integrator to provide liquidity for growers rather than for a bank to open a line of credit. The integrator, too, may be well-placed to hedge price risk (especially near-term) as a part of daily operations. When a packer contracts, then, to the extent that retail-level and farm-level prices covary, there may be little need to hedge. However, packers would be wise to apprise when correlations fail and to regularly re-estimate the consequences of a failure. The effect of liquidity on incentives needs scrutiny too. Removing the risk of near-term default and/or renegotiation may strengthen incentives to make value-enhancing investments. But ledger contracts may just postpone a business failure. In addition, the integrator may face the soft-budget constraint syndrome, as discussed in Maskin and Xu 2001, and ultimately may roll over or forgive some debts of a valued grower at contract maturity.

Endnotes

1. We do not model all of the many features in the ledger provisions of these contracts.

2. By this we mean that \$1 compounds to $\exp\{\int_0^T \bar{r}(t)dt\}$ over the interval $[0,T]$.

3. On forward rate agreements, see Hull 2002 or McDonald 2003.

4. See Dickinson and Bailey 2002 on a consumer premium for traceability in pork and beef red meats. Kilmer, Andre, and Stevens (2001) provide related information in the fruit and vegetables sector.

Appendix

Extract from Morrell Contract #1

"Whenever the market price of live hogs is less than or equal to the floor price, Morrell will pay the producer based on the $40.00/cwt floor price, and will reduce the balance of the producer's ledger account by the difference, if any, between the market price and the floor price per hundred weight of delivered hogs. Conversely, whenever the market price of live hogs is greater than the floor price, Morrell will first apply 100% of the difference between the market price and the floor price per hundred weight of delivered hogs to reduce or eliminate a negative balance, if any, in the producer's ledger account. If the ledger account does not have a negative balance (or as soon as the negative balance has been reduced to zero), Morrell will pay the balance of the market price to the producer, except that, whenever the balance of the market price payable to the producer (after reducing any negative balance in the producer's ledger account to zero) exceeds $43.00/cwt, Morrell will first apply 20% of the difference between the market price and $43.00/cwt to build up a reserve (i.e., a positive balance) in the producer's ledger account. The positive balance in the producer's ledger account will never be allowed to exceed an amount equal to $5.00 times the number of market hogs the producer has projected to produce over the contract period."

"At the end of the contract period, if the producer's ledger account shows a positive balance, then Morrell will pay this amount to the producer in cash, without interest, within 30 days; or, if the producer's ledger account shows a negative balance, then the producer will pay this amount to Morrell in cash, without interest, within 30 days."

Extract from Morrell Contract #2

This contract was represented as FOR DISCUSSION ONLY: SAMPLE FORMAT.

"At the beginning of the contract period, the producer's ledger account may have a balance of zero but at any time during the contract period, the account may only reflect a balance due Morrell or zero. It will not reflect a balance due the producer from Morrell."

"At the end of the contract period, if the producer's ledger account shows a negative balance, then the producer will pay this amount to Morrell in cash, without interest, within 30 days."

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