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Evaluating the Saskatchewan Short-Term Hog Loan Program

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Abstract

The Saskatchewan short-term hog loan program of 2002 provided a non-market credit line to participating hog producers. The repayment conditions for cash advances committed to by the provincial government depend on later hog prices, and so the program has derivative contract attributes. We model the contracts and use an estimated spot price stochastic process to establish summary statistics for producer benefits from the program.

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JEL classification: Q1, G3

EVALUATING THE SASKATCHEWAN SHORT-TERM HOG LOAN PROGRAM

Introduction

From time to time, some governments have seen a need to intervene in agricultural credit markets as a means of providing financial relief for commodity producers faced with unusually low product prices. This was the case in the Saskatchewan hog sector in 1999, and again in 2002. The Saskatchewan short-term hog loan program of 2002 involved government-originated credit lines at prime interest rates to eligible hog producers.

Domestic agricultural support has come under increased scrutiny since the middle 1990s in Canada and elsewhere because of provisions in international trade agreements. On April 14, 2004, eight state-level producer associations and 119 individual United States hog producers petitioned the U.S. Commerce Department to investigate whether suppliers in the Canadian hog industry received countervailable subsidies within the meaning of the Uruguay Round Agreements Act of 1995. Were the U.S. Commerce Department to find in favor of the U.S. producers, then duties could be imposed on sector imports from Canada. Among complaints by the U.S. producers was the assertion that the Canadian hog industry was receiving subsidized loans. The loans at issue, and also ones formally investigated by the U.S. Commerce Department, included Farm Credit Canada's Flexi-Hog Loan Program; guaranteed loans through marketing cooperatives; as well as loan arrangements in the provinces of Alberta, Manitoba, Quebec, Saskatchewan, New Brunswick, and Prince Edward Island.

The U.S. Commerce Department issued a preliminary finding on August 23, 2004, to the effect that many of these loan programs did provide subsidies. But the subsidies were not countervailable under law. Because of the tight timeline, the broad nature of the petition, and the emphasis on finding the existence rather than extent of a subsidy, the U.S. Commerce Department used a cursory procedure to value producer benefits from the loan programs (see Jochum 2004). Excluded provisions were repayment schedules that are triggered by commodity spot prices, that is, that would require specification of spot market dynamics. We know of no other endeavor seeking to value any of these commodity-price-contingent loan programs.

An understanding of the cost of loans in which repayment is conditional on commodity spot market conditions is important for at least two reasons. First, careful valuation should assist government personnel when designing and implementing a program. Second, in the event that a program is challenged under the conditions of a trade agreement, an objective valuation algorithm will assist all parties in coming to a resolution. The intent of this paper is to assess the value of one such program.

The valuation procedure proposed in this paper appeals to an observation made in Hennessy and Lien (2003) that ledger stipulations in hog marketing contracts amount to a hybrid between a portfolio of commodity options and a portfolio of interest rate forward agreements. The state-contingent cash flows in the Saskatchewan loan agreements are similar. We provide a valuation analysis of the 2002 Saskatchewan hog loan program based on cash flow. We then estimate the stochastic process for determining the spot market price for the underlying commodity. This allows us to integrate numerically our cash flow formulas over spot price realizations and so to provide summary statistics on the loan program's value to producers.[1]

Loan Amounts

The loan program may be viewed at http://www.agr.gov.sk.ca/docs/finance/rebate_and_assistance_programs/hogloan2002.pdf with instructions and examples at http://www.agr.gov.sk.ca/docs/finance/rebate_and_assistance_programs/hogloaninstructions2002.pdf.[2] Loans were available for matured hogs and weanling hogs, and we provide program timelines in the appendix.

Under the program, the loan amount is determined by the price and hog numbers sold between September 3, 2002, and April 30, 2003. The repayment schedule is determined by spot prices after May 1, 2003. Let $t = 0$ denote April 30, 2003. Also, let $D_{m,0}$ and $D_{w,0}$ denote, respectively, the loan amounts for matured hogs and weanling hogs as determined by the program formula. Specifically,

$$D_{m,0} = \sum_s q_{m,s} \times \max\{0, \min[50, 0.9 \times (145 - p_s)]\} \tag{1}$$

for matured hogs, where s denotes that a sale of matured hogs occurred between September 3, 2002, and April 30, 2003; p_s is the Saskatchewan market price per 100 kg for a 108 index hog corresponding to the period when the sales occurred; and $q_{m,s}$ is the quantity of matured hogs sold. That is, if the 108 index price is less than \$145 per 100 kg, the advance for the sold matured hog equals 90 percent of the difference, provided it is less than \$50. When it is larger than \$50, the advance is set to \$50.

On the other hand, $D_{w,0} = 10\sum_{s'} q_{w,s'}\chi_{s'}$ where s' denotes that a sale of weanling hogs occurred between September 3, 2002, and April 30, 2003; $p_{s'}$ is the Saskatchewan market price per 100 kg for a 108 index hog corresponding to the period when the sales occurred; $q_{w,s'}$ is the quantity of weanling hogs sold; and $\chi_{s'} = 1$ if $p_{s'} < 145$ and zero otherwise. That is, the advance is \$10 per 100 kg if the 108 index price is less than \$145.

Repayments

For both matured and weanling hogs, the repayment may start as early as May 1, 2003. In the case of matured hogs, if the weekly 108 index price is greater than \$150 per 100 kg, then a third of the difference is repaid. Let $D_{m,t}$ denote the unconsolidated loan at time t for matured hogs and let r denote the weekly interest rate charged by the loan agreement.[3] The loan payment at time t + 1 (which is a week after t) is as follows: $I_{m,t+1} = 0$ if $p_{t+1} < 150$; $I_{m,t+1} = (1/3)[p_{t+1} - 150]$ if $150 \le p_{t+1} \le 150 + 3(1+r)D_{mt}$; and $I_{m,t+1} = (1+r)D_{mt}$ if $p_{t+1} > 150 + 3(1+r)D_{mt}$. Consequently, $D_{m,t+1} = (1+r)D_{mt} - I_{m,t+1}$. Alternatively, we have

$$D_{m,t+1} = \max\{0, (1+r)D_{m,t} - (1/3)\max[p_{t+1} - 150, 0]\}. \quad (2)$$

Note that $D_{m,t+1} = 0$ if $D_{m,t} = 0$. In fact, the loan payment represents the payoff from writing a one-third unit of a capped call option in which the strike price is \$150 and the cap is $3(1+r)D_{m,t}$ (McDonald 2003). For any given $D_{m,t}$, the valuation of the capped call option can be estimated. However, as time changes so does $D_{m,t}$.

Let T denote April 30, 2004, the loan consolidation day. For the repayment after T, the hog producer will pay back the maximum between one-third of the excess of the monthly price over \$150 per 100 kg and the sum of 1/36 of the remaining consolidated payment and the accumulated interests over the month. Let m_T denote the monthly price at T. The repayment at T is then

$$K_T = \min[(1+r)^4 D_{m,T-1}, \max\{(m_T - 150)/3, [(1+r)^4 - 1]D_{m,T-1} + (D_{m,T-1}/36)\}]. \quad (3)$$

As a result, $D_{m,T} = (1+r)^4 D_{m,T-1} - K_T$ is the debt at the $T+1$ month. The repayment at the $T+1$ month is then

$$K_{T+1} = \min[(1+r)^4 D_{m,T}, \max\{(m_{T+1} - 150)/3, [(1+r)^4 - 1]D_{m,T} + (D_{m,T-1}/36)\}], \quad (4)$$

and the remaining debt after the $T+1$ month is

$$D_{m,T+1} = (1+r)^4 D_{m,T} - K_{T+1}. \quad (5)$$

For the general case, the repayment at the $T+i$ month is

$$K_{T+i} = \min[(1+r)^4 D_{m,T+i-1}, \max\{(m_{T+i} - 150)/3, [(1+r)^4 - 1]D_{m,T+i-1} + (D_{m,T-1}/36)\}], (6)$$

such that the remaining debt after the $T+i$ month is

$$D_{m,T+i} = (1+r)^4 D_{m,T+i-1} - K_{T+i}, \quad (7)$$

where $i = 0,\ldots, 35$. Finally, we have

$$I_{m,T} = \sum_{i=0}^{35} (1+\delta)^{-i} K_{T+i}, \quad (8)$$

where δ is the monthly rate the producer would face in commercial lending markets. The present value of the payment at time $t = 0$ is $R_m = \sum_{t=1}^{T} [1 + (\delta/4)]^{-t} I_{m,t}$ for a loan of $D_{m,0}$. The difference between $D_{m,0}$ and $E_0(R_m)$, the time 0 expected present value of repayments, is the expected benefit of the loan program to matured hog producers.

For weanling hogs, the loan is consolidated when the 108 index price exceeds $150 per 100 kg. Thus, $D_{w,t+1} = (1+r)D_{w,t}$ if $p_{t+1} < 150$. Otherwise, the loan is consolidated. As was the case with matured hogs, repayment must commence by April 30, 2004. The repayment is a monthly installment of the principal and accrued interest over three years. That is, the monthly payment is $(1+r)^{156} D_{w,t} / 36$. The discounted value of the installment schedule at t is $I_{w,t+1} = \sum_{i=0}^{35} (1+\delta)^{-i} (1+r)^{156} D_{w,t} / 36$. Thus the payment represents $I_{w,t+1}$ units of digital call option with the strike price being $150 (Hull 2003). Similarly, the payment schedule at $t+2$ represents the payoff from $I_{w,t+2} = \sum_{t=0}^{35} (1+\delta)^{-i} (1+r)^{156} D_{w,t+1} / 36$ units of a digital call option with the strike price being $150 per 100 kg. At time 0, the discounted payment is as follows:

$$\begin{aligned} R_w &= [1+(\delta/4)]^{-1} I_{w,1} \chi(p_1 \geq 150) + [1+(\delta/4)]^{-52} I_{w,52} \chi(\max(p_1,...,p_{51}) < 150) \\ &+ \sum_{t=2}^{51} [1+(\delta/4)]^{-t} I_{w,t} \chi(p_t \geq 150, \max(p_1,...,p_{t-1}) < 150), \end{aligned} \tag{9}$$

where, for an event A, $\chi(A) = 1$ if A occurs and zero otherwise. The loan amount is $D_{w,0}$. The difference between $D_{w,0}$ and $E_0(R_w)$, the time 0 expected payment, is the expected benefit of the loan program for weanling hog producers.

Generating Future Weekly and Monthly Prices

Weekly simple average index 100 price data for Saskatchewan slaughter hogs from January 1999 to April 2003 are collected from various issues of *Weekly Livestock and Meat Report*.[4] Allowing for four lags with intercept and trend, the Phillips-Perron unit root statistics for the 108 index price series[5] (in logarithms) is 4.0913, barely exceeding the 1 percent significance level critical value, 4.0012. On the other hand, the Phillips-Perron unit root statistics for the differenced 108 index price series (in logarithms) is 13.047. In fact, the statistics are 3.2093 and 12.369 for price (in level) and differenced price (in level). That is, the price level is non-stationary. With these test results, we decide to model the differenced logarithmic price series for forecasting purposes.

Based upon the AIC (Akaike Information Criteria), we choose the AR(1) model. When examining the residual series, we detect autoregressive conditional heteroskedasticity (ARCH) effects. The final model we adopt is therefore an AR(1)-GARCH(1,1) specification as follows:

$$\underset{}{\Delta \log p_t} = \underset{(0.06861)}{0.142404}\Delta \log p_{t-1} + \varepsilon_t \tag{10}$$

$$\sigma_t^2 = \underset{(0.00016)}{0.00032} + \underset{(0.06548)}{0.21561}\varepsilon_{t-1}^2 + \underset{(0.09550)}{0.67102}\sigma_{t-1}^2 \tag{11}$$

The numbers within the parentheses are the corresponding standard errors.

To generate the simulated price paths from $t = 0$ to $t = T$, we adopt the following procedures.

1. Let $e_1, e_2, ..., e_{225}$ be the standardized residuals (i.e., each with unit variance) from the AR(1)-GARCH(1,1) estimation. The price at April 30, 2003, is denoted as p_0. The predicted variance for May 3, 2003, is denoted as $\hat{\sigma}_1^2$.
2. Draw 52 samples from the standardized residuals with replacement and denote them by $u_1, u_2, ..., u_{52}$.
3. Let $v_1 = u_1\hat{\sigma}_1$ and calculate $p_1 = \exp[1.42404\log(p_0) - 0.42404\log(p_{-1}) + v_1]$. Also, calculate $\hat{\sigma}_2^2 = 0.00032 + 0.21561v_1^2 + 0.67102\hat{\sigma}_1^2$.
4. Let $v_2 = u_2\hat{\sigma}_2$ and calculate $p_2 = \exp[1.42404\log(p_1) - 0.42404\log(p_0) + v_2]$. Also, calculate $\hat{\sigma}_3^2 = 0.00032 + 0.21561v_2^2 + 0.67102\hat{\sigma}_2^2$.
5. Continue the above procedure until $v_{52} = u_{52}\hat{\sigma}_{52}$ and calculate $p_{52} =$ $\exp[1.42404\log(p_{51}) - 0.42404\log(p_{50}) + v_{52}]$.

As a result, we generate a price path $\{p_1, p_2, ..., p_{52}\}$ from which we can calculate the cost of the loan agreement for matured and weanling hogs. We repeat steps 1-5 five hundred times to generate five hundred paths from which we derive five hundred observations for R_m and R_w, respectively.

In the case of matured hogs, to calculate repayment after the consolidation date, we need forecasts of monthly prices. We first construct monthly data by averaging over four consecutive weeks. The resulting monthly price series exhibit a unit root. The Phillips-

Perron unit root statistics for the 108 index price series (in logarithms) is 2.4647, and is less than the 10 percent significance level critical value, 3.1782. Upon taking the difference, we find that the resulting series is best described by a random walk, that is, $\log m_t - \log m_{t-1} = \eta_t$, where m_t is the monthly average price at time *t*, and η_t is a white noise with standard deviation 0.186202. The Jacques-Bera statistic is 1.1273, implying that the normality assumption of η_t cannot be rejected. Moreover, we detected no ARCH effects in the data.

We adopted the above model to generate 48 future monthly prices. First, we generate 48 random samples from standard normal distributions: $\{w_1, w_2, ..., w_{48}\}$. From these we generate 48 samples of z_i such that $z_i = 0.186202 w_i$. The last month in the estimation sample is March 2003, and the corresponding price is \$141.6 per 100 kg. Thus, the one-month-ahead forecast of the monthly price is $f_1 = 141.6 \exp(z_1)$. Similarly, the two-month-ahead forecast is $f_2 = f_1 \exp(z_2) = 141.6 \exp(z_1 + z_2)$ and the *k*-month-ahead forecast is $f_k = f_{k-1} \exp(z_k) = 141.6 \exp\left(\sum_{i=1}^{k} z_i\right)$, where $1 \le k \le T$.

Empirical Estimates of the Benefits

To derive the loan amount, we assume that $q_{m,s} = q_{w,s} = 1$ for every *s*. Based upon the price data between September 3, 2002, and April 30, 2003, the loans are \$653.18 and \$340 per 100 kg for matured hogs and weanling hogs, respectively. We consider three parameter configurations for *r* and *δ:* (i) $r = 0.05/52 = 0.096\%$, $\delta = 0.10/12 = 0.83\%$; (ii) $r = 0.05/52 = 0.096\%$, $\delta = 0.15/12 = 1.25\%$; (iii) $r = 0.075/52 = 0.144\%$, $\delta = 0.15/12 = 1.25\%$. Table 1 provides summary statistics for the present value of the aggregate loan repayments for both types of hog producers, that is, R_m and R_w.

When comparing column 3 to column 4 and column 6 to column 7, we see that as the loan interest rate, *r*, increases, the present value of the repayments increases and the benefit of the loan program decreases for both hog producers. On the other hand, the variability of the benefit decreases, implying that both producers incur less risk. From comparisons between column 2 and column 3 (and column 5 and column 6), we see that

TABLE 1. Summary statistics for the present value of the loan repayments

Parameters/ Statistics	Matured Hogs			Weanling Hogs		
r (%)	0.096	0.096	0.144	0.096	0.096	0.144
δ (%)	0.83	1.25	1.25	0.83	1.25	1.25
Mean	594.62	548.58	572.29	333.35	303.50	331.33
Median	589.08	537.58	564.91	336.46	308.63	335.20
Standard deviation	19.66	36.01	29.28	7.41	13.13	10.90
Minimum	565.27	505.27	540.27	323.16	286.16	316.07
25%-tile	576.28	516.36	544.13	323.16	286.16	316.07
75%-tile	610.36	574.96	594.28	339.87	316.04	341.45
Maximum	642.81	636.49	642.19	342.16	319.47	344.32

Note: Based upon the price data between September 3, 2002, and April 30, 2003, the loans are $653.18 and $340 per 100 kg for matured hogs and weanling hogs, respectively. The loans are paid within three years.

when the market interest rate increases, the present value of the repayments decreases and the benefit of the loan program increases for both hog producers. On the other hand, the variability of the benefit increases and hence becomes more risky for both weanling hog producers.

In each scenario, the weanling hog producer has on average a negative interest on his or her loans. For example, in case (i), a producer borrows $340 and pays back $333 per 100 kg within three years later. Case (ii) is the most beneficial to the weanling hog producer as the present value of the repayment is always smaller than the loan amount. The distribution of the present value is skewed to the right such that the median is larger than the mean in each case. On the other hand, the standard deviation is quite small, indicating that the benefit of the loan program is rather stable.

Matured hog producers enjoy more benefits than do weanling hog producers. In no case will the present value of the repayment exceed the loan amount. On average, the producers receive a 10 percent or larger negative interest. The coefficient of variation, that is, standard deviation over mean, of the prepayment is a bit larger than that for weanling hog producers. The present value distribution is skewed to the left such that the median is smaller than the mean, implying that the producers are more likely to incur small loan repayments. The effects of the loan and market interest rates are qualitatively similar to the weanling hog case.

Conclusion

The intent of this paper has been to reason through the cash flow consequences of a credit policy intervention in a commodity market, and then to estimate the policy's value to producers. We have done so with reference to the Saskatchewan short-term hog loan program of 2002. Other programs will likely have some distinguishing provisions, and so modifications to the algorithm will likely be necessary.

Endnotes

1. Related work on valuing hog contract provisions includes Unterschultz et al. 1998 and Shao and Roe 2003.
2. Available online to February 3, 2005, or later.
3. The rate is the prime rate charged by the Bank of Montreal on commercial loans made in Canada to its most creditworthy customers.
4. The Web site address is http://www.agr.gc.ca/misb/aisd/redmeat/wlmr20030104.htm.
5. The index 108 price equals the index 100 price multiplied by 1.08.

Appendix

Timeline for Mature Hog Loans

September 3, 2002: the beginning date when mature hogs delivered can apply for advances
April 30, 2003: the last date when mature hogs delivered can apply for advances
June 15, 2003: the last date for loan application
April 30, 2004: the mandatory date for loan consolidation
April 30, 2007: the last date for full loan repayment
Note: Loan repayment starts when the index price exceeds $150 per 100 kg, but no later than the mandatory date for loan consolidation, April 30, 2004. For example, if on the first week of December 2003, the index price exceeds $150, then a loan repayment is required. Suppose that the next week the index price falls below $150, there is no need for loan repayment.

Timeline for Weanling Hog Loans

The time parameters are the same as those for the mature hogs program.

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