MARYLAND COOPERATIVE EXTENSION
UNIVERSITY OF MARYLAND
COLLEGE PARK•EASTERN SHORE

Fact Sheet

Fact Sheet 714

Using Options: Insuring Corn Production Costs

Kevin McNew
Extension economist
Department of Agricultural and Resource Economics

Corn producers face significant risks in farming. The vagaries of weather and insects can lead to large crop-yield losses. At the same time, small changes in global supplies and domestic export demand can result in sharp price swings. When these forces of yield and price variability are combined, producers have little way of knowing what their farm revenue will be. Most importantly, they do not know how likely it is that revenue will be high enough to cover their production costs.

One way to measure the variability of revenue is through probabilities. Probabilities allow us to quantify the uncertainty in a particular outcome. For example, weather forecasts are stated in probabilistic terms. A 20 percent chance of rain informs us that if current conditions were repeated 100 times, rain would result 20 times.

Unlike the probability of rain, however, producers can change the probability of revenue outcomes. Put options on futures give producers a means of altering the risk they face from low prices and the resulting low revenue levels. Put options are an insurance policy for low prices. Farmers who buy put options would pay a premium and, in return, receive a minimum price guarantee for their crop. If prices are higher, for example at harvest time, the farmer could still get a higher price. This fact sheet presents probability estimates for corn revenue per acre in two Maryland counties. Using this information, Maryland corn producers can determine the probability that their corn revenue will be greater than the cost of production. This study also presents revenue probabilities for nine put options strategies. By comparing the probability of break-even for the nine options strategies and the no-options case, producers can select a strategy most likely to cover their production costs.

Producers may have other financial goals. For example, instead of minimizing the probability that revenue will fall below production costs, a producer may instead pick a strategy that gives the highest probability of revenue being at a high level. Another financial goal may be to secure a bank loan. The information in this study should be useful on this account. Lending institutions are quite wary of the risks of farming and quantifying these risks as well as taking steps to reduce them should be useful for securing operating loans. While it may seem of little significance to a farmer that using options reduces the probability of falling below break-even levels by 4 to 6 percent, for example, this may be important to a bank.

It should be emphasized that the probability calculations that follow are net of premium costs for the options. The producer using any of the options strategies that are analyzed is

changing the probability of low revenue **after** paying these costs. However, the calculations do not account for transaction costs like interest expense and brokerage fees on the options transaction.

Another important factor is that the probabilities will change from year-to-year depending on the expected price. For example, if the December futures price at planting is $2.85 one year and $2.35 the following year, it follows that the producer would expect revenue to be significantly higher in the first year compared to the second. Thus, the probability of revenue exceeding costs in the first year is much higher when compared to the second year. Although the tables in this study can be used for both of these years, producers must update their expected revenue estimate each year to get the appropriate probability values.

PROBABILITY OF REVENUE

Simply stated, probabilities of revenue provide a measure of the chance or likelihood that the revenue earned in a given year is less than a critical value. For example, suppose the probability that revenue <$210 per acre is 0.25 and the probability that revenue <$250 per acre is 0.50. The first of these expressions states that 25 percent of the time corn revenue per acre will be less than $210. Of course, this implies that 75 percent of the time revenue will exceed $210. The second statement says that 50 percent of the time revenue will be less than $250. The higher the revenue level, the higher the probability that actual revenue will fall below it.

To see how options can be used to change the probability function, nine different options strategies are explored. The calculations treat price and yield as random and take into account the cost of the options premiums and the effect of basis risk (i.e., the variability between the local cash price and the Chicago Board of Trade price). For each options strategy the calculations allow the user to see the probability of revenue falling below particular levels, such as $250 or $260 per acre.

ANALYSIS AND STRATEGIES

Data on average county yields were collected from 1972-1994 for Carroll, Frederick, Kent, and Queen Anne's counties. In addition, regional cash corn prices at harvest time were used to estimate per-acre revenue levels and the probability distribution of revenue. Because there is negligible difference between Frederick and Carroll counties and Kent and Queen Anne's counties, only Carroll and Queen Anne's counties are presented in this report.

Over this period, nine different options strategies were explored in terms of their impact on the probability of revenue per acre. The nine strategies are combinations of two different strike prices and three different percentages of hedging. The two-strike prices considered are at-the-money and 20 cents out-of-the-money. An out-of-the-money put option has a strike price below the current futures price. The specific strike price that a producer would use depends on the futures price when the option is purchased. For example, if the December futures price is $2.50, then the at-the-money option has a $2.50 strike price and a $2.30 put option would signify the 20-cent out-of-the-money option.

Along with varying strike prices, variations in hedged production are also considered. Three different levels of hedging are considered: 33 percent, 66 percent, and 100 percent of total expected production. If a farmer anticipates producing 15,000 bushels, these percentages of hedging would correspond to 1-, 2-, or 3-options contracts, respectively. A complete list of the strategies studied can be found below in Table 1.

TABLE STRUCTURE

There are two revenue probability tables: one for Queen Anne's County (Table 2) and one for Carroll County (Table 3). In addition, Table 4 corresponds to the example given at the end of this report. Although the tables are county-specific, producers on the Eastern Shore of Maryland should use the tables for Queen Anne's County, while Western Shore producers should select the Carroll County table.

In each table, the left-most column represents the normalized revenue. Normalized revenue is revenue per acre ($250, $255, $260, etc.) divided by the average historic revenue per acre for each county. It can be interpreted as a percentage of average or expected corn revenue. Normalizing the rev-

enue scale allows individual farmers to use these tables with their own historic average revenue, which may differ from the specific county data used. The second column (labeled Strategy 0) in each table represents the probability if no hedge is used, while the remaining nine columns show the probability for one of the nine options strategies. The column headings go from 0-9, where 0 refers to unhedged revenue and 1 through 9 are in order from top to bottom of Table 1.

USING THE TABLES

Step 1: Estimating revenue per acre

To use the tables, a farmer must first estimate expected revenue per acre. In estimating yield, producers usually have a good indication based on their individual yield history, with recent years of particular importance. Price can be estimated at planting time by using the December Corn Futures price and adding on the historic average basis for the region (see Fact Sheet 495 for corn basis estimates in Maryland). The product of the estimate for yield and price gives the producer's estimate of revenue per acre.

Step 2: Choosing the appropriate table

Producers with farms on the Western Shore should use the Carroll County table, while Eastern Shore farmers should use the Queen Anne's County table.

Step 3: Transforming the normalized revenue scale

A producer must next transform the normalized revenue scale to make it specific to his or her farm. With the selected table, multiply the normalized scale by expected per-acre revenue. The outcome is a scale relevant to the producer's farm.

Step 4: Evaluating strategies

With the table specific to the producer's farm, the producer can begin to compare the probabilities of low revenue using different options strategies. Using an objective of minimizing the chance of falling below production costs, the producer should find the table row that corresponds to this level. Then, reading across rows, select the strategy (column) that has the lowest probability.

Step 5: Calculating how many contracts to use

Once a strategy is selected, the number of options contracts must be computed:

- multiply the total expected production by the desired percentage hedge (0.33, 0.67, or 1.00);
- divide by 5,000;
- round up or down to the nearest integer.

This produces the number of options contracts to purchase.

Step 6: Selecting the appropriate options

Once a strategy has been chosen, select the options strike price to use. The at-the-money option will be the option with the strike price closest to the futures price at any given time. The 20-cent out-of-the-money put option will be the option with a strike price that is 20 cents below the at-the-money option. For example, if the December corn futures price is at $2.64, then a $2.60 option would be considered at-the-money while the $2.40 put option would coincide with the 20-cent out-of-the-money option.

Example

Suppose a farmer in Kent County grows 465 acres of corn and has $215 per acre in production costs.

Step 1: Estimating revenue per acre

Total production for the last 3 years has been 40,000, 36,000, and 50,000 bushels, respectively.

Average these to estimate total production at 42,000 bushels.

Average per acre yield is then 42,000/465 = 90.32 bushels per acre.

At planting time, the December Corn Futures is quoting $2.81.

Historic average basis for Kent County at harvest time is -0.01.

Thus, the estimated selling price is $2.80.

Estimated revenue per acre is 90.32 x $2.80 = $252.90.

Step 2: Selecting the appropriate county

The producer's farm is in Kent County, so he/she uses the Queen Anne's County table.

Step 3: Transforming the normalized revenue scale

The producer multiplies the normalized revenue scale by $252.90.

Step 4: Evaluating strategies

Now the farmer can consider which strategy ensures the lowest probability that revenue falls below $212 per acre. Looking across the highlighted row in Table 3, we can see that Strategy 6 ensures the lowest probability of revenue falling below $215. From the list of strategies in Table 1, we can see that this strategy corresponds to a 100 percent hedge with an at-the-money put option.

With Strategy 6, the producer has a 28 percent chance (i.e., 0.2816 probability) of corn revenue being less than the production costs of $215 per acre. By comparison, using no options (i.e., Strategy 0) would imply a 35 percent chance of not meeting the same level of production costs. Thus, using options in this case has decreased the risk level by roughly 20 percent (i.e., going from 35 percent risk to 28 percent risk).

Alternatively, another way to look at it is by examining the equivalent probability from the no-options strategy and determining the revenue level. From using options, the producer can expect revenue to be less than production costs of $215 roughly 28 percent of the time. For the no-options strategy (from Strategy 0 in Table 3) this same probability level has a revenue level of $202.32. Thus, for the same risk (i.e., probability value) a no-options strategy has a lower revenue level than the use of Strategy 6.

As an example, if given the opportunity to select between two investments where investment A pays $10 with a probability of 80 percent and investment B pays $50 with an 80 percent chance, most would prefer investment B because it offers a higher payout with the same risk as investment A. The same holds true here. By using options in this case, the producer has a downside risk of 28 percent. This level of risk coincides with $215 in revenue, while if the producer does not use options, this same level of risk coincides with only $202 in revenue.

Step 5: Calculating how many contracts to use

Divide total production by 5,000 bushels: 42,000/5,000 = 8.4
Round up or down to the nearest integer: 8.0

So our producer should purchase eight contracts of the at-the-money December put option. His/her actual hedge will be only 95.2 percent of expected production. However, if he/she is very bearish and believes prices may fall by harvest time, he/she may wish to overhedge and buy nine contracts, corresponding to 45,000 bushels or 107 percent of expected production.

Step 6: Selecting the appropriate options

With the December Corn Futures at $2.81, the $2.80 strike price put option is at-the-money and the $2.60 put option is 20 cents out-of-the-money.

Table 1. Put Option Strategies.

Strategy Number	Total Hedged[1] (%)	Option Strike Prices	
		At-the-Money (%)	20 Cents Out-of-the Money (%)
1	33	33	0
2	33	0	33
3	67	67	0
4	67	0	67
5	67	33	33
6	100	100	0
7	100	0	100
8	100	67	33
9	100	33	67

[1] Each row represents a different strategy. If a producer expects to produce 15,000 bushels then a 33 percent hedge would be one contract, a 67 percent hedge would be two contracts, and a 100 percent hedge would be three contracts. Specific strike prices used will depend on the planting date futures price. For example, if the December futures price is $295 in March (at planting time), then the strike prices will be $300 and $280.

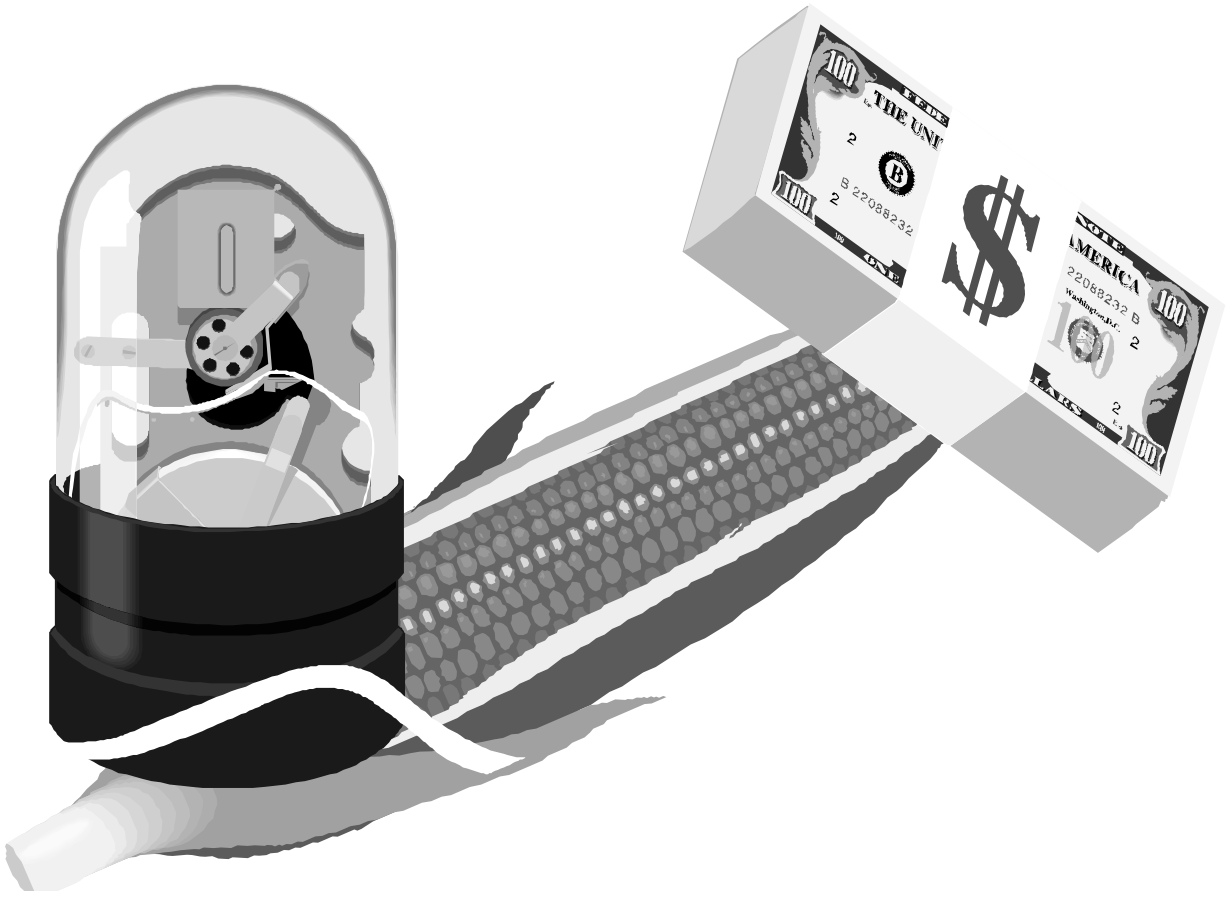

Table 2. Queen Anne's County Revenue Probabilities.

Normalized Revenue[2]	Strategy[1] 0[3]	1	2	3	4	5	6	7	8	9
0.50	0.0309	0.0287	0.0283	0.0308	0.0288	0.0298	0.0355	0.0309	0.0337	0.0320
0.55	0.0482	0.0440	0.0439	0.0459	0.0436	0.0446	0.0512	0.0460	0.0489	0.0473
0.60	0.0734	0.0663	0.0666	0.0669	0.0649	0.0657	0.0730	0.0674	0.0708	0.0688
0.65	0.1078	0.0979	0.0988	0.0958	0.0948	0.0949	0.1011	0.0958	0.0987	0.0971
0.70	0.1518	0.1393	0.1422	0.1347	0.1351	0.1342	0.1388	0.1346	0.1370	0.1355
0.75	0.2065	0.1932	0.1964	0.1844	0.1884	0.1859	0.1862	0.1845	0.1847	0.1838
0.80	0.2722	0.2588	0.2632	0.2477	0.2540	0.2508	0.2442	0.2475	0.2449	0.2457
0.85	0.3457	0.3353	0.3397	0.3229	0.3310	0.3269	0.3157	0.3232	0.3171	0.3198
0.90	0.4247	0.4174	0.4215	0.4062	0.4151	0.4106	0.3952	0.4069	0.3980	0.4023
0.95	0.5049	0.5030	0.5054	0.4928	0.5017	0.4973	0.4805	0.4928	0.4836	0.4882
1.00	0.5837	0.5849	0.5863	0.5789	0.5865	0.5834	0.5665	0.5814	0.5717	0.5762
1.05	0.6573	0.6625	0.6631	0.6620	0.6653	0.6641	0.6523	0.6635	0.6568	0.6610
1.10	0.7248	0.7321	0.7311	0.7343	0.7352	0.7352	0.7289	0.7354	0.7322	0.7341
1.15	0.7837	0.7924	0.7911	0.7968	0.7962	0.7969	0.7951	0.7980	0.7971	0.7977
1.20	0.8334	0.8437	0.8410	0.8497	0.8473	0.8487	0.8496	0.8506	0.8512	0.8516
1.25	0.8756	0.8848	0.8822	0.8908	0.8875	0.8894	0.8928	0.8912	0.8930	0.8924
1.30	0.9079	0.9162	0.9136	0.9224	0.9185	0.9208	0.9260	0.9222	0.9253	0.9239
1.35	0.9335	0.9411	0.9385	0.9466	0.9427	0.9449	0.9500	0.9460	0.9491	0.9480
1.40	0.9535	0.9591	0.9569	0.9638	0.9602	0.9623	0.9671	0.9630	0.9661	0.9648
1.45	0.9679	0.9723	0.9705	0.9759	0.9729	0.9747	0.9786	0.9753	0.9777	0.9765
1.50	0.9784	0.9816	0.9804	0.9840	0.9820	0.9831	0.9856	0.9835	0.9851	0.9844

[1] Strategy 0 is the case of no options, while strategies 1-9 use options. Refer to Table 1 for identification of the strategies.
[2] Normalized revenue is the percentage of expected revenue. It can be used to convert to a dollar value scale relevant for a particular producer. Multiply the normalized revenue column by an estimate of expected revenue (price times yield).
[3] Probabilities refer to how likely it is that actual revenue will fall below the normalized revenue. For example, with no options (i.e., Strategy 0) there is a 27 percent chance (i.e., 0.2722 probability) of falling below 80 percent of expected revenue.

Table 3. Carroll County Revenue Probabilities.

Normalized Revenue[2]	Strategy[1] 0[3]	1	2	3	4	5	6	7	8	9
0.50	0.0065	0.0031	0.0033	0.0034	0.0031	0.0032	0.0043	0.0034	0.0039	0.0037
0.55	0.0141	0.0075	0.0082	0.0073	0.0070	0.0070	0.0092	0.0075	0.0084	0.0078
0.60	0.0281	0.0174	0.0187	0.0155	0.0156	0.0153	0.0185	0.0165	0.0174	0.0166
0.65	0.0512	0.0365	0.0392	0.0317	0.0335	0.0321	0.0353	0.0335	0.0340	0.0333
0.70	0.0869	0.0681	0.0726	0.0595	0.0629	0.0605	0.0625	0.0613	0.0608	0.0604
0.75	0.1364	0.1166	0.1222	0.1037	0.1104	0.1059	0.1044	0.1056	0.1040	0.1041
0.80	0.2028	0.1830	0.1902	0.1674	0.1774	0.1716	0.1637	0.1691	0.1636	0.1654
0.85	0.2817	0.2674	0.2738	0.2517	0.2632	0.2570	0.2436	0.2535	0.2458	0.2484
0.90	0.3721	0.3655	0.3708	0.3538	0.3638	0.3587	0.3419	0.3553	0.3454	0.3501
0.95	0.4687	0.4698	0.4723	0.4632	0.4713	0.4681	0.4510	0.4639	0.4550	0.4599
1.00	0.5644	0.5724	0.5721	0.5731	0.5761	0.5748	0.5621	0.5735	0.5667	0.5703
1.05	0.6539	0.6673	0.6644	0.6729	0.6717	0.6730	0.6674	0.6733	0.6707	0.6723
1.10	0.7327	0.7481	0.7444	0.7573	0.7528	0.7560	0.7583	0.7571	0.7591	0.7581
1.15	0.7999	0.8167	0.8112	0.8290	0.8211	0.8254	0.8325	0.8279	0.8320	0.8308
1.20	0.8567	0.8719	0.8667	0.8827	0.8752	0.8792	0.8877	0.8810	0.8866	0.8846
1.25	0.8998	0.9120	0.9074	0.9224	0.9143	0.9187	0.9282	0.9202	0.9264	0.9236
1.30	0.9317	0.9420	0.9381	0.9498	0.9435	0.9469	0.9556	0.9479	0.9535	0.9508
1.35	0.9552	0.9627	0.9597	0.9687	0.9636	0.9663	0.9728	0.9670	0.9711	0.9692
1.40	0.9716	0.9767	0.9743	0.9808	0.9771	0.9790	0.9838	0.9794	0.9826	0.9812
1.45	0.9824	0.9857	0.9843	0.9885	0.9861	0.9873	0.9903	0.9875	0.9895	0.9887
1.50	0.9892	0.9914	0.9905	0.9932	0.9916	0.9925	0.9945	0.9926	0.9939	0.9933

[1] Strategy 0 is the case of no options, while strategies 1-9 use options. Refer to Table 1 for identification of the strategies.

[2] Normalized revenue is the percentage of expected revenue. It can be used to convert to a dollar value scale relevant for a particular producer. Multiply the normalized revenue column by an estimate of expected revenue (price times yield).

[3] Probabilities refer to how likely it is that actual revenue will fall below the normalized revenue. For example, with no options (i.e., Strategy 0) there is a 20 per-

Table 4. Example with Expected Revenue of $252.90 per acre.

Producer Revenue[2]	Normalized Revenue	Strategy[1] 0[3]	1	2	3	4	5	6	7	8	9
126.45	0.50	0.0309	0.0287	0.0283	0.0308	0.0288	0.0298	0.0160	0.0309	0.0337	0.0320
139.1	0.55	0.0482	0.0440	0.0439	0.0459	0.0436	0.0446	0.0261	0.0460	0.0489	0.0473
151.74	0.60	0.0734	0.0663	0.0666	0.0669	0.0649	0.0657	0.0416	0.0674	0.0708	0.0688
164.39	0.65	0.1078	0.0979	0.0988	0.0958	0.0948	0.0949	0.0646	0.0958	0.0987	0.0971
177.03	0.70	0.1518	0.1393	0.1422	0.1347	0.1351	0.1342	0.0972	0.1346	0.1370	0.1355
189.68	0.75	0.2065	0.1932	0.1964	0.1844	0.1884	0.1859	0.1428	0.1845	0.1847	0.1838
202.32	0.80	0.2722	0.2588	0.2632	0.2477	0.2540	0.2508	0.2031	0.2475	0.2449	0.2457
214.97	0.85	0.3457	0.3353	0.3397	0.3229	0.3310	0.3269	0.2816	0.3232	0.3171	0.3198
227.61	0.90	0.4247	0.4174	0.4215	0.4062	0.4151	0.4106	0.3743	0.4069	0.3980	0.4023
240.26	0.95	0.5049	0.5030	0.5054	0.4928	0.5017	0.4973	0.4772	0.4928	0.4836	0.4882
252.90	1.00	0.5837	0.5849	0.5863	0.5789	0.5865	0.5834	0.5815	0.5814	0.5717	0.5762
265.55	1.05	0.6573	0.6625	0.6631	0.6620	0.6653	0.6641	0.6826	0.6635	0.6568	0.6610
278.19	1.10	0.7248	0.7321	0.7311	0.7343	0.7352	0.7352	0.7708	0.7354	0.7322	0.7341
290.84	1.15	0.7837	0.7924	0.7911	0.7968	0.7962	0.7969	0.8414	0.7980	0.7971	0.7977
303.48	1.20	0.8334	0.8437	0.8410	0.8497	0.8473	0.8487	0.8950	0.8506	0.8512	0.8516
316.13	1.25	0.8756	0.8848	0.8822	0.8908	0.8875	0.8894	0.9341	0.8912	0.8930	0.8924
328.77	1.30	0.9079	0.9162	0.9136	0.9224	0.9185	0.9208	0.9599	0.9222	0.9253	0.9239
341.42	1.35	0.9335	0.9411	0.9385	0.9466	0.9427	0.9449	0.9761	0.9460	0.9491	0.9480
354.06	1.40	0.9535	0.9591	0.9569	0.9638	0.9602	0.9623	0.9861	0.9630	0.9661	0.9648
366.71	1.45	0.9679	0.9723	0.9705	0.9759	0.9729	0.9747	0.9921	0.9753	0.9777	0.9765
379.35	1.50	0.9784	0.9816	0.9804	0.9840	0.9820	0.9831	0.9955	0.9835	0.9851	0.9844

[1] Strategy 0 is the case of no options, while strategies 1-9 use options. Refer to Table 1 for identification of the strategies.

[2] Normalized revenue is the percentage of expected revenue. It can be used to convert to a dollar value scale relevant for a particular producer. Multiply the normalized revenue column by an estimate of expected revenue (price times yield).

[3] The probabilities refer to how likely it is that actual revenue will fall below the normalized revenue. For example, with no options (i.e., Strategy 0) there is a 27 percent chance (i.e., 0.2722 probability) of falling below 80 percent of expected revenue or $202.32 per acre for this example.