Appendix A. A Nonstochastic Comparison of Price- and Revenue-Based Support

Before planting, the producer can only guess at harvested yields and harvest-time prices due to their stochastic nature (that is, random variation). To simplify the discussion of the basic differences between program alternatives, this appendix uses a stylized, nonstochastic analysis. In other words, we abstract away from price and yield uncertainty by evaluating the differences in the programs at the end of the crop year. The section of this report entitled “Stochastic Evaluation of Commodity Support Program Alternatives,” implements an empirical analysis that explicitly addresses the stochastic component of prices and yield. This appendix examines two general classes of support payments—one with payments tied to current production and one to past production.

Price and Revenue-Based Marketing Loan Benefits

In simplified terms, the price-based marketing loan benefits (Price-MLB) are based on a payment rate determined by shortfalls in the market price with respect to the statutory loan rate, multiplied by quantity of the crop the producer places under the loan (see box, “Calculation of Price and Revenue-Based Marketing Loan Benefits”). In contrast, revenue-based marketing loan benefits (Revenue-MLB) are based on a payment rate determined by shortfalls in revenue per acre with respect to a statutory target revenue, multiplied by the producer’s planted acreage. For simple comparability with this Price-MLB, the stylized graphs in this section assume that the Revenue-MLB payment rates are determined by average national yield. Additional analysis for program scenarios based on lower levels of yield aggregation—in particular, a county-based program—is presented as part of the stochastic analysis in the main body of this report.

To demonstrate the relationship between prices, yields, and payments, we need to consider the relationship between price and yield. Figure A.1 shows price per bushel and gross revenue per acre as a function of harvested yield for the case of a stylized crop with a significantly negative correlation between price and yield (that is, a correlation approaching -1).[1] Note that the “price” curve should not be interpreted as a supply or demand function. Instead, each point along the curve represents the mean harvest-time price associated with a level of harvested yield, given the expected yield and price at planting time.[2] In the figure, price per bushel and gross revenue per acre are expressed as percentage changes from the expected price and revenue at planting time. As indicated in figure A.1, harvest-time price tends to fall as harvested yield increases. In this example, price decreases faster than yield increases, and hence gross revenue per acre falls as yields increase. The strongly negative relationship between price and yield means that, as yield increases, the decrease in revenue is smaller than the decrease in price, as shown by comparing the revenue and price deviation functions in equation A.1.

Figures A.2 and A.3 show the relationship between Price-MLB payments per acre and harvest-time revenue per acre for the stylized crop as a function of yield and price, respectively. Two target revenue choices are used in

[1]While we use a stylized crop for the sake of generality, Cooper (2008; 2009b) shows that the depictions in the figures in this section can hold for certain actual crops, like corn.

[2]This price-yield function does not imply a statistical probability associated with any point along the line, but is simply the mean harvest-time market price that an analysis of the historical data says would be associated with a realized harvest. The section of this report on the stochastic analysis of program payments, which predicts at the beginning of the crop year the possible costs of the support program, assigns probabilities of occurrence to price-yield pairs.

Calculation of Price and Revenue-Based Marketing Loan Benefits

For farmer *i* of a crop in region *j* in time *t*, the existing price-based loan deficiency payment, or the marketing loan benefit, is calculated as:

$$\text{Price-MLB}_{ijt} = \max\{0, LLR_{jt} - ALR_{jt})\} \cdot A_{ijt} \cdot Y_{ijt}\,, \qquad \text{(A.1)}$$

where the statutorily set local loan rate *(LLR)* is the national loan rate *(LR)* adjusted by various region-specific (county or other region) and quality factors. The alternative loan repayment rate, or *ALR*, is a USDA-determined market price that varies daily or weekly (depending on the crop) according to market conditions, and is adjusted to reflect quality of the product. Depending on the crop, the *ALR* may be a county (wheat, feed grains, oilseeds), national (peanuts), or world (upland cotton and rice) "posted" price. The term $max\{\, 0, (LLR_{jt} - ALR_{jt})\}$ in equation A.1 is a shorthand way of saying that the payment rate = $(LLR_{jt} - ALR_{jt})$ if $LLR_{jt} > ALR_{jt}$, or 0 if $LLR_{jt} \leq ALR_{jt}$. The payments are applied to current production on each farm, which equals harvested area, *A*, times yield, *Y*.

For a revenue-based version of equation A.1, the payment would be the difference between a target revenue and actual revenue per acre, or

$$\text{Revenue-MLB}_{ijt} = \max\{\, 0, (LTR_{jt} - ALR_{jt} \cdot Y_{jt})\} \cdot \; Y_{ij}^{APH} \,/\, E(Y_{jt}) \cdot A_{ijt}\,, \qquad \text{(A.2)}$$

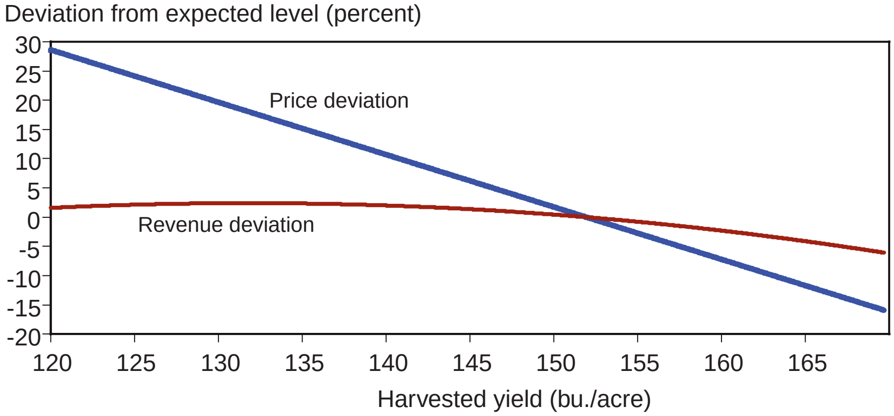
where the statutorily set local target revenue per acre rate, or *LTR*, is the national target revenue rate *LR* adjusted by various county-specific and quality factors (e.g., Miranda and Glauber, 1991). Actual, or realized, yield for the region is Y_{jt}. To account for the difference in productivity of producer *i* with respect to regional productivity, the payment is multiplied by the ratio of the producer's actual production history, Y_{ij}^{APH}, and expected yield for the region in time *t*, or $E(Y_{jt})$.

Figure A.1

Crop price and revenue deviations as a function of crop yield

Stylized crop with a significantly negative correlation between price and yield

Deviation from expected level (percent)



Note: The price deviation is defined as the percentage difference between the realized price at harvest time and the expected price at pre-planting time. A positive value means that the harvest-time price is higher than the pre-planting price. The revenue-per-acre deviation is defined similarly.

the figure: one in which the target revenue is set slightly above the expected revenue (Example I), and one in which the target revenue is set below the expected revenue per acre (Example II).

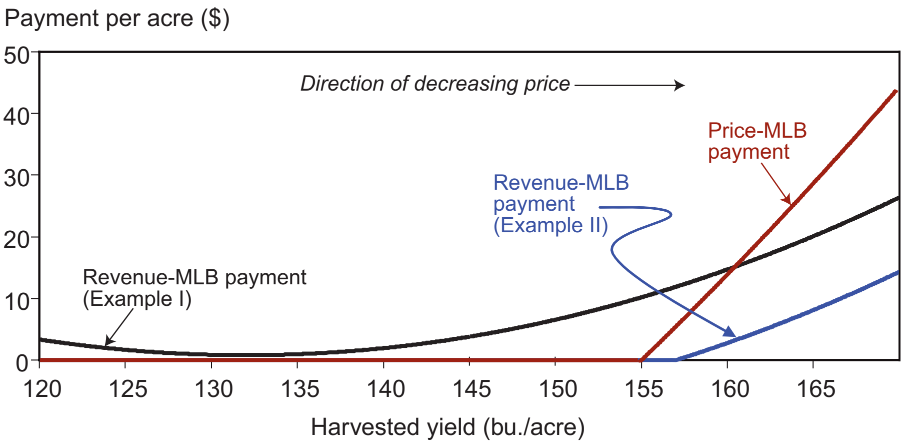
In figures A.2 and A.3, the shape of the Revenue-MLB line inversely mirrors the shape of the revenue line in figure A.1. The kink in the Price-MLB line occurs at the loan rate, and the payment rate falls to zero for prices in excess of the loan rate. The Revenue-MLB payment rate for Example II is zero when actual revenue per acre is below the target value.

Revenue-MLB payments go to zero when realized gross revenue is above the target revenue level. With the high inverse correlation between crop

Figure A.2

Possible relationships between two types of marketing loan benefits and yield

Stylized crop with a significantly negative correlation between price and yield

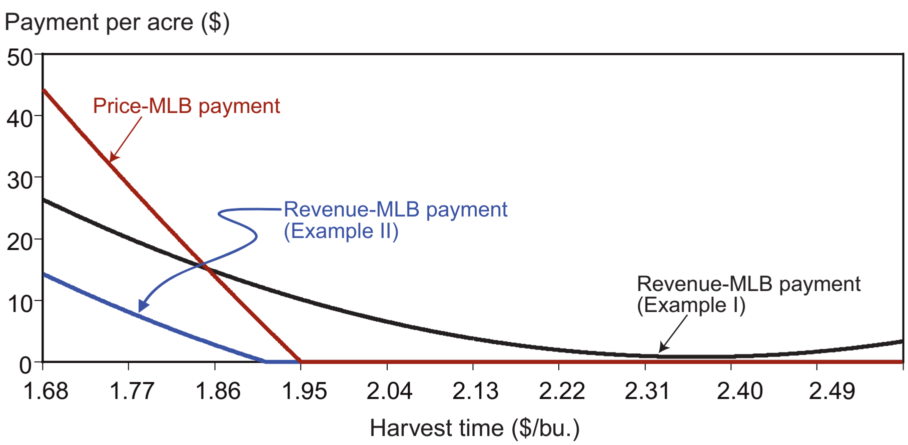


Note: For Revenue-MLB (Example I), the target revenue is set to be slightly higher than the expected revenue. In Revenue-MLB (Example II), the target revenue is set to be lower than the expected revenue.

Figure A.3

Possible relationships between two types of marketing loan benefits and price

Stylized crop with a significantly negative correlation between price and yield



Note: For Revenue-MLB (Example I), the target revenue is set to be slightly higher than the expected revenue. In Revenue-MLB (Example II), the target revenue is set to be lower than the expected revenue.

price and yield, the Revenue-MLB line changes more slowly with respect to revenue change than does the Price-MLB line, suggesting greater predictability for the revenue-based MLB than the price-based MLB under this price-yield scenario.

The general shape of the Price-MLB function per acre as a function of yield or price will be the same regardless of crop, as long as the price-yield correlation is less than zero. That is, the Price-MLB function per acre will be increasing in yield, as increasing yield will always cause some decrease in price (as long as price-yield correlation is less than zero). By design, the Price-MLB per acre will increase as price decreases, even in cases where the price decrease is less than the yield increase (that is, revenue per acre increases).

For the Revenue-MLB, the stylized graphs in figures A.1-A.3 should generally hold for a crop with a price-yield correlation that is relatively negative (that is, closer to -1). For a crop where the price-yield correlation is low (that is closer to 0), however, the general shapes of some of the relationships between payments, prices, and yields can differ from those in figures A.1-A.3, bearing in mind that the Revenue-MLB payment per acre always decreases as revenue per acre increases.

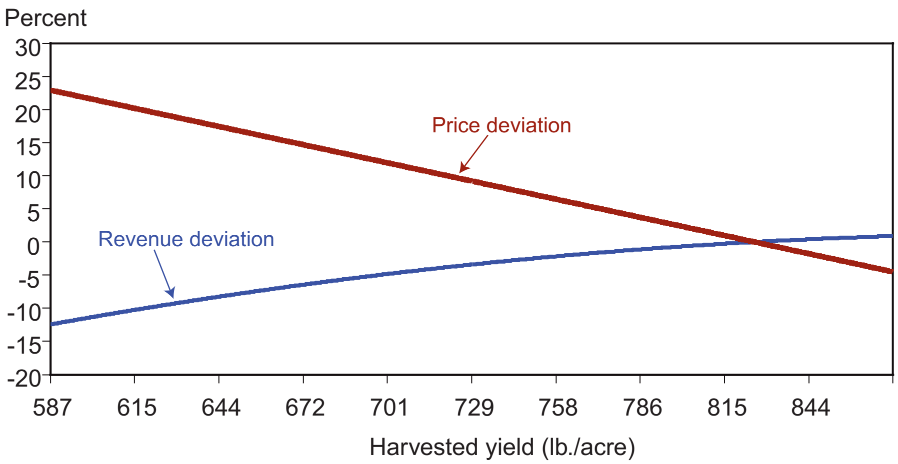
Now consider a crop with a price-yield correlation closer to 0 (but still negative), say a crop for which U.S. production is not a significant driver of world price changes for that crop. Here, price changes as a result of yield changes are muted relative to the scenario in figure A.1, and consequently, so are changes in the Price-CCP. As depicted in figure A.4, the price deviation line for such a crop would be less steep than that depicted in figure A.1, and the revenue per acre deviation line can actually be increasing in yield.

In this case with the relatively low price-yield correlation, the Revenue-MLB payment may actually be seen as decreasing in yield or increasing in price (over a feasible ranges of prices and yields). For instance, decreasing yield may not be fully offset by increasing price, causing gross revenue per acre to fall.

Figure A.4

Crop price and revenue deviations as a function of crop yield

Stylized crop with a price-yield correlation close to zero



Price and Revenue-Based Countercyclical Payments

Price-based countercyclical payments (Price-CCP) are based on a payment rate determined by shortfalls in an "effective" price with respect to a statutory target price, multiplied by a fixed base acreage and yield. In contrast, revenue-based countercyclical payments (Revenue-CCP) are based on a payment rate determined by shortfalls in "effective" revenue (effective price times season-average yield) with respect to a statutory target revenue, multiplied by the fixed base acreage and the ratio of the producer's base yield to national average base yield (see box, "Calculation of Price and Revenue-Based CCPs"). While the base acreage and yield values are calculated from historic period(s) and are fixed, the payment rate itself is a function of contemporary season prices. USDA's Farm Service Agency (2006a) specifies how the Price-CCP program determines the base acreage and yield.

For the sake of creating a direct analogy to the current price-based CCP, this appendix considers the revenue CCP program to operate at the national level. That is, the payment rate for this revenue-CCP program is determined using national average yield in addition to national average price. A benefit of this approach is that its administrative costs should be no higher than for the price-based CCP. A disadvantage—depending on one's point of view—of using a national payment rate in the revenue-CCP payment rate is that the correlation between the revenue support payments and farm level revenue is likely to be lower than if the payment rate were based on more regionalized expected and actual yield. Cooper (2008) finds little difference in the impact of the Price-CCP and Revenue-CCP on the variability of total revenue. As such, a national-level implementation of revenue-based support would not necessarily reduce or eliminate calls for ad hoc disaster assistance. A revenue-CCP based on regional yield averages is considered in the stochastic simulation in the next section.

As an aid in contrasting the properties of Price-CCP and Revenue-CCP, figures A.5 and A.6 depict an average relationship between payments per base acre and harvested yield, price, or gross revenue for the same stylized crop with a significantly negative price-yield correlation depicted in figure A.1. In figures A.5 and A.6, the Price-CCP curve has kinks at the loan rate and at the effective target price, which is the target price less the direct payment rate. The Price-CCP is linear between the kinks given that the payment rate varies in price only. The Revenue-CCP curve slopes up to the point where price equals the loan rate, given that the minimum price used in the formula is the loan rate; after that, the price point slopes down. Lest the reader be perturbed by this seemingly idiosyncratic kink in the Revenue-CCP, this characteristic is simply a result of the program not permitting the effective price to fall below the loan rate—effective farm price falls as yield increases, but only down to the loan rate. The dashed line shows what the Revenue-CCP payment would be if the effective market price in the payment calculation were allowed to fall below the loan rate.

In the case of a price-yield correlation closer to 0 (figure A.4), the Price-CCP payment per acre would be increasing as yield increases, given low but still negative price-yield correlation. However, for such a crop, the price decrease

Calculation of Price- and Revenue-Based CCPs

The total Price-CCP option for a CCP recipient in year t is calculated as:

$$\text{Price - CCP}_{it} = 0.85 \cdot \max\{0, (TP - (\text{Max}(NP_t, LR)) - D)\} \cdot (\overline{A}_i^B \cdot \overline{Y}_i^B), \quad \text{(A.3)}$$

where *TP*, *LR*, and *D* are the statutory per bushel target price, national average loan rate, and direct payment rate, respectively, for a covered crop for which the recipient is eligible to receive a CCP payment. For each covered crop, *NP* is a national market price (season-average price for the marketing year). The "base" acreage and yield for recipient *i* are $\overline{A}_i^B$ and $\overline{Y}_i^B$, respectively.

In contrast, a target revenue-based CCP (Rev-CCP) payment is

$$\text{Revenue - CCP}_{it} = 0.85 \cdot \max\{0, TR - Y_t \cdot \max(NP_t, LR_j)\} \cdot \left(\frac{\overline{Y}_i^B}{\overline{Y}^B} \cdot \overline{A}_i^B \right), \quad \text{(A.4)}$$

where TR and $\overline{Y}^B$ are the statutory national target revenue per acre and statutory national program yield (bu/acre), respectively, for the crop. In particular, $\overline{Y}^B$ is the national average payment yield per base acre under the countercyclical payment program. The product $Y_t \cdot \max(NP_t, LR)$ is the national "effective" revenue per acre for year *t*, where Y_t is national average yield.

The rationale for calculating actual revenue using the "effective price" of $\max(NP_t, LR)$ is to lower the payment rate as prices fall below the loan rate *LR*, given that CCP recipients can receive marketing loan benefits if they produce the program crop in time *t*.

in response to the yield increase is smaller than the yield increase. As such, gross revenue can be increasing as yield increases.

One difference of the Revenue-CCP examined in this section relative to the Price-CCP is that the former does not exhibit the same hard cap on the payment rate that the Price-CCP does. Namely, the payment rate in the Price-CPP has a ceiling equal to the target price (less the direct payment rate) minus the loan rate. In contrast, while the effective price in the Revenue-CCP is restricted from falling below the loan rate, national yield is not subject to a program floor. Hence, the ceiling on the Revenue-CCP payment rate is the target revenue per acre itself (times 0.85), although to achieve this payment rate would be highly improbable as it would require national average actual yield to be zero. Hence, it is possible for the variability of Price-CCP payments to be lower than for the Revenue-CCP payment rate. This result is not due to the general principle of targeting revenue rather than price, but simply to the hard ceiling on the payment rate in the Price-CCP.

In contrast, with the Price-LDP, the payment rate per unit of production continues increasing as price decreases, at least in principle. For the same mean level of payments then, and if the coefficient of variation of revenue is less than that of price, the Revenue-LDP should have a lower variability of payments than the Price-LDP.

At the same time, depending on what the target revenue is set at, revenue-based payments can be significantly lower than price-based payments for

Figure A.5

Relationship between two CCP payment types and yield

Stylized crop with a significantly negative correlation between price and yield

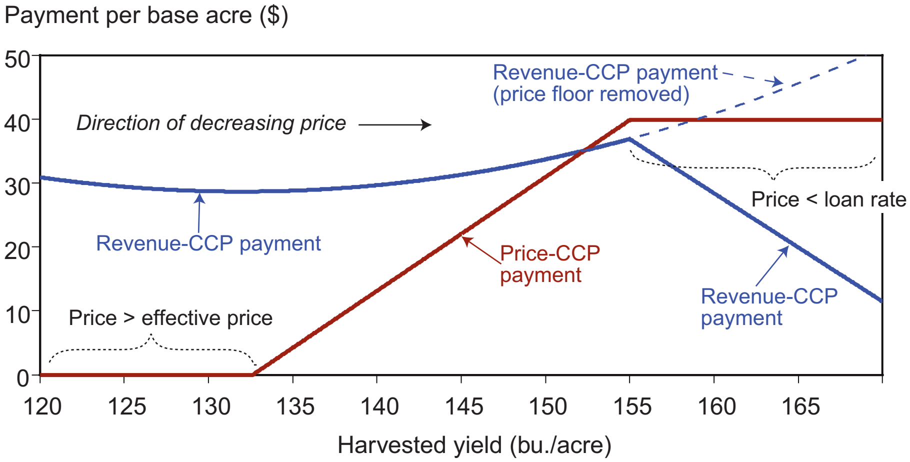
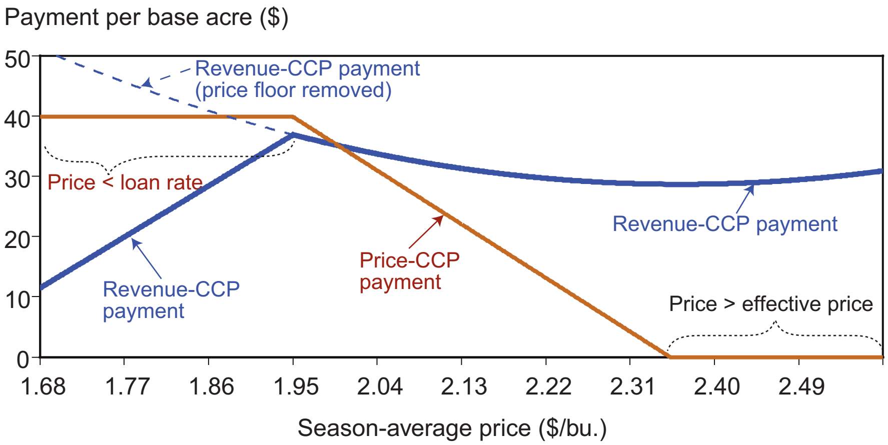


Figure A.6

Relationship between two CCP payment types and price

Stylized crop with a significantly negative correlation between price and yield



a given market price, yield, loan rate, direct payment rate, and target price (figs. A-2, A-3). One potential drawback of setting the target revenue low enough that, on average, the revenue-based support would produce a significantly lower payment rate than the price-based support is that it could lead producers receiving the revenue-based support to request additional forms of domestic support, such as disaster assistance. One way to reduce the probability of such a scenario occurring would be for the Government to set the target revenue to a level that would return, on average across a span of years, the same payment level as the price-based program. Even in such a case, the benefits to producers and the Government of a revenue-based program would be evident in payments that more accurately compensate for revenue decreases and (generally) reduce variability in payments from year to year.

However, to set the parameters of the payment programs so that they produce, on average, the same level of payments across time requires a statistical analysis of the relationship between price and yield. Figures A.2, A.3, A.5, and A.6 demonstrate how the programs differ in their response to revenue changes over an average price-yield relationship estimated from historic data. The goal of these charts is to illustrate general properties of these payment schemes. To simplify this evaluation, the program payments are evaluated at harvest time—that is, prices and yield are realized, not expected, prices.

However, yields and price are stochastic when evaluated at the time planting decisions are made. As such, payments are viewed as being drawn from a probability distribution. In other words, each price-yield point along the price-yield lines in figures A.1 and A.4 has an unequal probability of occurring. As such, each payment rate defined over the payment graphs in this section does not have an equal probability of occurrence. Hence, a statistical analysis is necessary to predict at the beginning of the crop season how payments under a revenue-based commodity support system might differ from those under a traditional commodity support structure. The main body of this report presents the results of such an analysis for a county-based payment approach, demonstrating how the mean, variability, and other characteristics of the statistical distribution of payments can be estimated, and how different types of payment programs compare to each other on this basis.