Payments under the Average Crop Revenue Program: Implications for Government Costs and Producer Preferences

Joseph Cooper

This paper develops a stochastic model for comparing payments to U.S. corn producers under the U.S. Senate's Average Crop Revenue Program (ACR) versus payments under the price-based marketing loan benefit and countercyclical payment programs. Using this model, the paper examines the sensitivity of the density function for payments to changes in expected price levels. We also assess the impact of the choice of yield aggregation used in the ACR payment rate on the mean and variance of farm returns. We find that ACR payments lower the producer's coefficient of variation of total revenue more than does the price-based support, although ACR may not raise mean revenue as much. While corn farmers in the heartland states might still prefer to receive the traditional forms of support when prices are low relative to statutory loan rates and target prices, this outcome is not necessarily the case for farmers in peripheral production regions.

Key Words: domestic support, counter-cyclical payments, revenue, price, corn, yield, pairs bootstrap, kernel density, combinatorial optimization

Two U.S. domestic commodity support programs make payments when market prices fall below statutory price levels, the latter defined as target prices and loan rates. One such support mechanism is the counter-cyclical payment (CCP) program (Farm Services Agency 2006b), where the price-varying payment is tied to the farm's historical production levels. Since their inception under the 2002 Farm Act, total annual CCP payments across all eligible crops have ranged from a low of $809 million in fiscal year 2003 to $4.36 billion in 2006. The other is marketing loan benefits, such as those taken in the form of loan deficiency payments (LDPs) tied to the farm's current production.

In early 2008, the U.S. Senate proposed a farm bill (the "Food and Energy Security Act of 2007") that would allow the producer the choice of receiving the traditional suite of Title I commodity supports or an alternative, the Average Crop Revenue Program (ACR), which provides a payment tied to losses in revenue.[1] The revenue payment rate would be based on the difference between a target revenue and actual revenue as measured at the state level. In principle, the ACR revenue payment would provide producers protection against an unexpected decline in revenues, whether due to low yields, low prices, or some combination thereof. Protection against low yield is provided at least to the extent that the farmer's yield is correlated with state yield. This ACR revenue payment would be provided in lieu of CCPs, marketing loan benefits, and direct payments (the

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[1] Average Crop Revenue Election (ACRE), a revenue-based program similar to ACR but with some revisions aimed at lowering potential program costs, passed into law (the "Food, Conservation and Energy Act of 2008") in May 2008.

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latter of which is a lump sum payment). In addition to the revenue payment, the ACR would provide the producer with a flat \$15 per "base" acre (a fixed, historical measure of farm acres), regardless of crop, current prices, or current yields. In addition to making payments based on revenue loss, the ACR would be novel for permitting the producer a choice between two suites of Title I programs. One would expect producers to choose the program that maximizes their expected utility (assuming that one accepts this model of farm behavior).

While a fair number of studies have been published that empirically examine the impacts of commodity support on production (e.g., Sckokai and Moro 2006, Goodwin and Mishra 2006, Anton and Le Mouel 2004, and Hennessy 1998), the academic literature is thin on examinations of the implication of the empirical distribution of commodity support payments for both government policy and producer preferences.

However, there are a variety of reasons to examine the probability density function of commodity support payment. For example, since farmers are generally considered to be risk-averse, farmer preference for payment programs should be expressed over at least the first two moments of the payment distribution, i.e., the mean and variability of revenue. In addition, of relevance to the U.S. government are the higher moments of the payment distribution. For example, multilateral agreements may place ceilings on certain types of U.S. domestic agricultural support. As such, higher moments of the distribution can be suggestive of the probability that such ceilings may be exceeded by a proposed support program.

The goal of this paper is to develop a stochastic model for estimating potential ACR revenue support payments to U.S. corn producers that can be used to address policy issues, such as the two above, that relate to the empirical distribution of federal commodity support. Before turning to the model, we provide a brief background on the ACR as well as the traditional price-based programs.

Background

Under Section 1401 of the 2007 Senate Farm Bill, the qualifying producer would be allowed a one-time election in any one of the 2010 through 2012 crop years to receive the ACR revenue and fixed payments starting in the year of election, in lieu of receiving direct payments, marketing loan benefits, and counter-cyclical payments (CCPs). The fixed payment component of the ACR is \$15 per acre times 100 percent of the base acres on the farm for all covered crops.

The ACR revenue payment for the producer of a program commodity in year t is triggered when 90 percent of the average crop revenue program guarantee (RPG) is greater than the actual state revenue (ASR) for that commodity. The ACR revenue payment (denoted as ACR) to producer i of crop j in period t is

$$\text{(1a)}\quad \mathrm{ACR}_{ijt} = \max\{\,0, (0.90 \cdot RPG_{tj} - ASR_{tj})\} \cdot \frac{Y_{ij}^{APH}}{E(YS_{jt})} \cdot 0.90 \cdot (\,\overline{A}_{ij}^{B} \cdot 0.85),$$

where RPG_{tj} is the product of the average crop revenue pre-planting price, P_{tj}^{R}, and the state expected yield, $E(YS_{tj})$. This latter value is estimated using a linear trend yield regression for the state yield data over the period 1980 to 2006.[2] Actual state revenue ASR_{tj} is the product of the Federal Crop Insurance harvest price, P_{tj}, and the actual state yield per planted acre, YS_{tj}.

The value $\overline{A}_{ij}^{B}$ is the farm-specific "base" acreage for the program crop, i.e., a historical value calculated as per government rules (Farm Services Agency 2006a). In another departure from what one might expect in a traditional insurance instrument, the average crop revenue planting price, P_{tj}^{R}, is the average of the current as well as the past two years' Federal Crop Insurance pre-planting prices. Furthermore, in the case of each of the 2011 through 2012 crop years, the legislation bounds the maximum percentage changes in P_{tj}^{R} at not more than +/-15 percent from $P_{t-1,j}^{R}$.

The Y_{ij}^{APH} is either (i) the actual production history (production/acre) of the producer as used to calculate the producer's crop insurance under the Federal Crop Insurance Program, or (ii) a "comparable yield" determined by USDA in the case

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[2] The legislation contains provisions for substituting alternative values for expected state yield in the cases where the USDA cannot "establish" the expected yield using the trend regression, or where the expected yield based on the trend regression is negative.

where the actual production history is not available. The latter provision may be necessary to make a payment calculation in the case where *i* has not produced the crop in recent years. Hence, receiving the ACR revenue payment does not necessarily require current production, but recent production history can affect the payment level. The ratio $Y_{ij}^{APH} / E(YS_{ij})$ can be interpreted as moral hazard adjustment, albeit one regarding past actions.

In contrast to the ACR revenue payment, counter-cyclical payments (CCP) are established using a payment rate determined by shortfalls in an "effective" price with respect to a statutory target price, multiplied by the fixed base acreage and base yield. In other words, current production of the commodity is not required for the producer to receive a CCP payment. The total CCP option for a producer *i* of crop *j* in year *t* would be calculated over 2008 to 2012 as

$$\text{(1b)}\quad \text{P-CCP}_{ijt} = 0.85 \cdot \max\{\,0, (TP_j - [\text{Max}\,(NP_{jt}, LR_j)] - Dj)\,\} \cdot (\,\bar{A}_{ij}^{B} \cdot \bar{Y}_{ij}^{B}\,),$$

where TP_j, LR_j, and Dj are the statutory per bushel target price, national average loan rate, and direct payment rate, respectively, for a covered crop as specified in the farm legislation.[3] For each covered crop, NP_{jt} is a national market price (season average price for the marketing year), and $\bar{A}_{ij}^{B}$ and $\bar{Y}_{ij}^{B}$ are farm-specific base acreage and yield, respectively, i.e., where the latter is calculated as per government rules (Farm Services Agency 2006a) as with the base acres discussed earlier. While the acreage and yield values in equation (1b) are fixed, the payment rate itself is a function of contemporary season prices.

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

$$\text{(1c)}\quad \text{LDP}_{ijt} = \max\{0, (LLR_{jt} - ALR_{jt})\} \cdot A_{ijt} \cdot Y_{ijt},$$

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. Under the 2002 Farm Act, the alternative loan repayment rate, or *ALR*, is essentially 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 payments are applied to current production on each farm, which equals harvested area, *A*, times yield, *Y*.

From the producer's perspective, a potential benefit, or liability, of the ACR over the LDP and the CCP is that the ACR's target revenue automatically rebalances itself to recent market prices. Therefore, it can provide payments in situations in which market prices are well above statutory loan rates and target prices. Of course, when market prices are low relative to loan rates and target prices, the ACR can be expected to provide lower mean benefits than the LDP plus the CCP (albeit leaving differences in the fixed payments out of the analysis).

Methodology for Estimating the Density Function for Program Payments

The only two stochastic variables that we explicitly need for calculating program payments at the national level are realized yield and season average price, although other variables can usefully feed into the econometric analysis, both to reduce omitted variable bias, and as intercept-shifting terms that can be useful for policy simulations. For the simulation of payments, then, we need to generate the distributions of price and yield. However, the procedure for doing so is considerably complicated by the fact that price and yield are correlated, and hence the estimated distributions must take this correlation into account. We estimate the density function for payments given (i) econometric estimates of the historical relationship between national price and national average yield, (ii) estimates of the distribution of yield density for a particular base year, and (iii) a bootstrap approach that links (i) and (ii).

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[3] An exception to the average national loan rates for the purposes of CCP is made for rice and barley, for which the Secretary of Agriculture would determine the average loan rates.

Modeling the Price-Yield Relationship Using Price and Yield Deviates

Our focus is on estimating the distribution of payments for a given reference crop year t, given that at pre-planting time in t, season average prices and realized yield are stochastic. As such, sector-level modeling that separately identifies supply, demand, and storage is unnecessarily complex to serve our needs and diverts attention away from the focus of this paper. A convenient way to address our questions is to model prices and yield as percentage deviations of realized prices and yields at the end of the season from the expected values at the beginning of the season when planting decisions are made. If one accepts that the observed distribution of percentage changes in price and yield between pre-planting and harvest are representative of their future distribution, then our econometric specification of the price-yield relationship can be reduced to one equation.

While the academic literature is rich with papers on price estimation for commodities [e.g., see Goodwin (2002) for an overview], few express prices in deviation form. One example that does is Lapp and Smith (1992), albeit as the difference in price between crop years rather than between pre-planting time and harvest within the same crop year. As price deviation in their paper was measured between years, yield change was not included in that analysis. Paulson and Babcock (2007) provide a rare example of the examination of the price-yield relationship within a season in an examination of crop insurance. Like them, for the purposes of estimating the relationship between price and yield, we re-express the historical price and yield data as proportional changes between expected and realized price and expected and realized yield within each period, respectively. We can then apply this history of proportional changes in yield and price to 2005 data to develop the distribution of payments. However, among the differences in our approach from that in Babcock and Paulson (2007) is that ours uses a modeling approach that easily permits multiple explanatory variables, thereby decreasing the chance of misspecification of the price-yield relationship, and permitting sensitivity analysis with respect to parameters of policy interest.

For the model, the realized national average yield, Y_t, is transformed to the yield deviation ΔY_t according to $\Delta Y_t = [Y_t - E(Y_t)] / E(Y_t)$. The expected value of Y_t, or $E(Y_t)$, is calculated from an estimated trend equation (as described below). To generate a distribution for Y_{2005} based on historical yield shocks, the historical yields must be detrended to reflect the proportional change in the state of technology between that in 2005 and that in time t, i.e., Y_{it} is detrended to 2005 terms as

$$(2)\quad Y_{it}^{d} = E(Y_{i2005})\,(\Delta Y_{it} + 1)\,,\ \forall\ i \text{ counties},\ t \text{ periods},\ t \neq 2005.$$

It is convenient to specify the yield deviate as the deviation of detrended yield from expected yield in the base year used for detrending, which we denote as ΔY_t^d. We detrend yield based on the standard practice of using a linear trend regression for yield.

As with yield, price is transformed into deviation form, i.e., the realized price at harvest, P_t, is the difference between the expected and realized price, or $\Delta P_t = [P_t - E(P_t)] / E(P_t)$. The derivation of $E(P_t)$ is discussed further in the data section.

Given the estimated trend yields as the predictions of $E(Y_t)$, we can construct ΔY_t^d and estimate the relationship between ΔP_t and ΔY_t^d. In particular, we assume that ΔP_t can only be partially explained by ΔY_t^d, and that the uncertainty in this relationship can be incorporated into the empirical distribution. We do so by specifying ΔP_t as

$$(3)\qquad \Delta P_t = g(\Delta Y_t^d, z_t) + \varepsilon_t,$$

where ε_t is *i.i.d.* with mean 0 and variance σ_ε^2 given $\{\Delta Y_t^d, z_t\}$, and where z_t is a vector of other variables that may explain the price deviation. We expect that $d\Delta P_t / d\Delta Y_t^d < 0$, i.e., the greater the realization of national average yield over the expected level, the more likely harvest time price will be lower than expected price.

Generating the Empirical Distribution of Payments—Overview

To generalize our empirical distribution of payments, we use a bootstrap method that allows for flexible right-hand-side regression modeling and for modeling interactions between variables. In particular, we use a paired bootstrap approach in a resampling methodology that involves drawing *i.i.d.* observations with replacement from the original data set (Efron 1979, Yatchew 1998), maintaining the pair-wise relationship in each observation between the variables, e.g., variable values y_i and x_i are always kept together as a row. The bootstrap data-generating mechanism is to treat the existing data set of size T as a population from which G samples of size T are drawn. Equation (3) is re-estimated for each of these bootstrapped data sets. Variation in estimates results from the fact that upon selection, each data point is replaced within the population. We can use this standard bootstrap to generate a distribution of ΔP given ΔY^d.

However, while we can directly estimate $\Delta\hat{P}_{gt}$, $g = 1,\ldots,G$, by substituting the G sets of bootstrapped coefficients and the $(T \times 1)$ vector ΔY_t^d into equation (3), to compensate for the limited sample size we can increase the smoothness of the bootstrapped distribution of ΔP by substituting ΔY_t^d with yield deviations—denoted as ΔY^{d*}—that are generated from a random sample drawn from an estimated yield distribution using a kernel approach described in the next section. Doing so will allow us to estimate a set of price shocks associated with an arbitrarily large set of yield shocks, albeit defined by the actual data. While smoothing the distribution of yield will of course reduce the coefficient of variation of yield, we minimize this reduction by sticking to a nonparametric approach.[4]

Smoothing the Distribution of Yield

Like Deng, Barnett, and Vedenov (2007) and Goodwin and Ker (1998), we utilize the nonparametric kernel-based probability density function (Härdle 1990, Silverman 1986) for generating a smoother yield density than that which would be supplied by the bootstrap of equation (3). This function, as applied to our notation, is

$$(4)\quad \hat{f}(y_j^d) = \frac{1}{Th}\sum_{t=1}^{T} K\left(\frac{y_j^d - Y_t^d}{h}\right), j = 1,\ldots,J.$$

This function allows us to generate values of ΔY^d from a distribution that approaches a continuous function as J approaches infinity. This function gives support to generating yield values over the observed range of detrended yields, i.e., the $(J \times 1)$ vector y^d is drawn over the range $\{\min(Y_t^d)\ldots \max(Y_t^d)\}$, $t = 1\ldots T$, where y_i^d are the yield points for which the density function is estimated. The function $K(.)$ is a Gaussian kernel (*ibid.*).[5] The optimal bandwidth h for smoothing the density is calculated according to equation 3.31 in Silverman (1986), which is a common choice for single mode densities such as those being evaluated here. We simulate the yield distribution by taking N draws of yield values, denoted as Y_n^{d*}, from the estimated kernel density, with the yield draws denoted as ΔY_n^{d*}. Given the expected (trend) yield for a reference year, the yield deviate ΔY_n^{d*} is calculated for each Y_n^{d*}.

Imposing Estimated Yield Correlations on Simulated Yield Data

Prices are decided based on national-level yield shocks. ACR payments are a function of state-level yield shocks. In this case, the representative farmer's distribution of revenue is estimated at the county level. Hence, in addition to simulating national yield ΔY^{d*}, we simulate state and county yields using the same kernel approach as above. Of course, as drawn, these simulated national, state, and county yields, being *i.i.d.*, do not have the same Pearson correlation matrix as the original actual yield data, even if they have the correct mean and variances.

To maintain correct spatial relationships between the yield measures, the observed correlations between the national-, state-, and county-level yields need to be imposed on the simulated yields, but without changing the mean and vari-

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[4] As a supplement to the modeling results based on the kernel density for yield, the appendix presents alternative results for two of the key output tables based on generating the yield densities without any smoothing. In particular, the block bootstrap (Lahiri 1999) approach is used to randomly resample with replacement the national, state, and county yields from the actual yield dataset. Year-wise relationships among the yield values are maintained when resampling, thereby ensuring that the simulated dataset has the same correlation between the national, state, and county yields as the original data.

[5] We found the estimated density of program payments for corn to be insensitive to the choice between Gaussian and biweight kernels.

ance of each yield vector. This is done by applying nonparametric Monte Carlo techniques to the three simulated yield vectors in order to induce them to have the same correlations as the actual yield data. Specifically, heuristic combinatorial optimization (Charmpis and Panteli 2004) was used to rearrange the generated univariate *i.i.d.* yield samples, in order to obtain the desired Pearson's correlation between them while leaving the yield values unchanged.

Generating the Empirical Distribution of Payments Given the Estimated Yield Distribution

The estimated price shocks given ΔY^{d*} and the coefficient estimates from the bootstraps of equation (3) are calculated as

$$\Delta\tilde{P}^{*} = \tilde{\beta}_0 + \tilde{\beta}_1 \Delta Y^{d*}, \tag{5}$$

where ΔY^{d*} is the $N \times 1$ vector of yield shocks derived from the kernel yield distribution, $\tilde{\beta}_1$ is the $(1 \times G)$ vector of draws of the coefficient on the yield deviate from the regression bootstraps, and $\tilde{\beta}_0$ is the product of the bootstrap draws of the other bootstrapped coefficients times the assigned values of the explanatory variables in $\mathbf{z}$, i.e., given K–1 explanatory variables in $\mathbf{z}$ (including the constant), the values in $\tilde{\beta}_0$ are

$$\tilde{\beta}_{0g} = \sum_{k=2}^{K} \tilde{\beta}_{kg} * \bar{z}_k ,$$

for $g = 1, \ldots, G$. The resulting $\Delta\tilde{P}^{*}$ is an $(N \times G)$ matrix, i.e., every yield shock ΔY_n^{d*} is associated with a $(1 \times G)$ distribution of price shocks. For our simulation, $N = G = 1000$.

To calculate the program payments, $\Delta\tilde{P}^{*}$ must be transformed to back the price per bushel, $\tilde{P}^{*}$. For a reference year, say 2006, the simulated price per bushel is $\tilde{P}_{gn}^{*2006} = E(P_{2006}) \cdot (\Delta\tilde{P}_{gn}^{*2006} + 1)$, $g = 1, \ldots, G$, $n = 1, \ldots, N$. Finally, by substituting the vectors $\Delta\tilde{P}^{2006*}$ and ΔY^{2006d*} into equations (1a) through (1c), we generate the probability density functions for the 2006 payment distributions as seen from the beginning of the 2006 crop year.

Parameters used in the CCP calculations are the H.R. 2419 corn loan rate of \$1.95 per bushel (used in the LDP calculation as well), direct payment rate of \$0.28 per bushel, target price of \$2.63 per bushel, and program yield of 114.4 per bushel per acre.

Data

Data on planted yields and acres for corn are supplied by the National Agricultural Statistics Service (NASS) of the U.S. Department of Agriculture. As support payments can be collected for corn for silage as well as corn for grain, and because silage can be a significant portion of corn production in some regions outside the heartland, we merge together data on corn for grain and corn for silage. We convert tons of silage to bushels using a conversion rate of 7.94 bushels per ton, as per the Farm Services Agency (2006a).

Realized prices P_t are the harvest-time price of the December Chicago Board of Trade (CBOT) futures contract for corn, $t = 1975, \ldots, 2005$.[6] For the expected value of price P_t, or $E(P_t)$, we utilize a non-naive expectation, namely the average of the daily February prices of the same CBOT contract. While we have prices back to 1969, the data before the mid-1970s does not reflect China and Russia as regular participants in global grain markets, and is unlikely to be representative of contemporary global markets.

In addition to the yield shock, we include several other explanatory variables in our regression of equation (3). The dummy variable *FarmAct* takes the value of "1" for years 1996 and above (and 0 otherwise), reflecting the federal government being out of the commodity storage business under recent Farm Acts.[7] As commodity storage may be expected to have a stabilizing influence on futures prices (Tomek and Gray 1970), we include the corn stocks to use ratio, as measured at the beginning of the crop year, in order to maintain equation (3) in reduced form. As the inflation rate may impact price variability (e.g., Lapp and Smith 1992), we include the inflation rate (CPI-U) over the quarter immediately prior to planting, the idea being that a lag may exist in the impact of near-term inflation on the commodity price, with a higher rate increasing the price shock.

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[6] For certain federal crop insurance products, USDA's Risk Management Agency uses a smoothed November price of the December contract as the harvest time price for corn.

[7] This variable might be interpreted as the change in the weather premium after the 1996 Farm Act.

To model international linkages in a reduced form, we include deviation of actual yield from expected yield of corn in time *t* in the rest of the world, as calculated from FAOSTAT data. To account for the difference in the timing of seasons north and south of the equator, this variable is disaggregated into northern and southern hemispheres. The expectation is that a negative yield shock in the rest of the world will increase the U.S. corn harvest time price relative to the expected price. Finally, as exchange rate changes can be expected to have an impact on corn exports (Babula, Rupple, and Bessler 1995), we include the percentage change in the nominal exchange rate between planting time and harvest, where the expectation is that an increase in this value lowers the export demand for U.S. corn, and therefore its price.

Econometric Results

Table 1 provides the econometric results for a linear specification of equation (3). The coefficient on ΔY is significant at the 1 percent level. Of the additional explanatory variables, *stocks/use*, π, and Δr are significant to at least the 10 percent level. A semi-nonparametric (SNP) specification of equation (3) was also examined, and the relationship $d\Delta P \,/\, d\Delta Y$ was found not to be statistically different than for the parametric specification in Table 1.[8]

Discussion of Payment Simulation Results

For the simulation, two regions are selected, one with a relatively low correlation (0.457) of state yield with national yield (North Dakota) and one with a relatively high correlation (0.906) with national yield (Illinois). The lowest level of aggregation used here is the county, where we assume a representative farmer whose yield distribution is the counties' (Barnes County in North Dakota and Logan County in Illinois) yield distribution. For both regions, the correlation of state yield with the yield of the chosen counties is similar, thereby simplifying the interpretation of the payment simulation results. Table 2 shows the similarity of the Pearson correlation coefficients for the actual yield data and the simulated data for the chosen regions.

For the two regions, two price scenarios are examined. One is a relatively low market price scenario in which the CCP and marketing loan benefits have significant probability of providing payments given current loan rates and target prices, and one a relatively high market price scenario that has insignificant probability of producing CCP payments and marketing loan benefits.

The lower price scenario uses an ACR revenue pre-planting price that would have been calculated for 2006, or \$2.58 per bushel, which is the average of the 2004 through 2006 February values of the December futures contract (\$2.83, \$2.32, and \$2.59, respectively). The cash price at pre-planting in 2006 was \$2.07 (February Central Illinois cash price for yellow No. 2).

The higher price scenario uses an ACR revenue pre-planting price that would have been calculated for 2009, or \$4.27 per bushel, which assumes that the February 2009 price of the December futures contract falls by 21 percent over that in February 2008.[9] Assuming a basis of -0.30 (the average of the last ten years), the associated February 2009 cash price is thus \$3.97. In this higher price scenario, the revenue pre-planting price is \$4.58, which is the average of \$4.27 and the \$4.06 and \$5.40 February prices for 2007 and 2008, respectively.

Table 3 presents summary statistics for the payment distributions under both price scenarios. In the low price scenario for Logan County, the mean ACR payment of \$5 per acre is notably lower than the mean LDP+CCP payment of \$53 per acre, where we denote all marketing loan benefits as LDPs for brevity. The reason is that the LDPs and CCPs do not automatically com-

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[8] To examine the potential for bias due to misspecification in estimating equation (3), in addition to a linear parametric estimate of the equation, we also estimated the equation using a semi-nonparametric (SNP) econometric approach based on the Fourier transformation (Fenton and Gallant 1996). The SNP regression is limited by degrees of freedom in the number of variables that can receive the SNP treatment, and as such, the SNP regression variables in our application are limited to ΔY and its first-order sine and cosine transformations. Using the regression results in a bootstrap-based test (Efron 1987), the hypotheses Ho: $d\Delta P^{para} \big/ d\Delta Y^{para} - d\Delta P_t^{snp} \big/ d\Delta Y_t^{snp} = 0$ cannot be rejected at the 90 percent level or better for all $j \neq k$. This result suggests that the parametric model is adequate to the task of modeling the interaction between price and yield, but with the additional benefit of allowing additional explanatory variables.

[9] The 21 percent represents one of the largest percentage price drops between successive Februaries witnessed between 1969 and 2008, and happened between 1981 and 1982.

Table 1. Regression Results and Sample Statistics for the Function Explaining ΔP_t

Variable	Coefficient	T-statistic	Variable Mean	Variable Std. Error
Constant	-0.247	(-4.035)	1	0
ΔY_t	-1.512	(-6.161)	-0.02836	0.08141
FarmAct	-0.014	(-0.321)	0.3226	0.4752
Stocks to use ratio	0.229	(1.743)	0.2307	0.1522
ΔY_t^{SH}	-0.193	(-0.398)	0.0002463	0.03756
ΔY_t^{NH}	-0.179	(-0.871)	0.002486	0.09894
π	10.205	(2.883)	0.009463	0.005721
Δr_t	-0.424	(-1.997)	0.005123	0.09043
Ln–L	33.599			
R^2	0.720			

Notes: ΔY_t is the percentage deviation in U.S. corn yields from the expected (trend) yield. *Stocks to use ratio* is the ratio of total U.S. corn stocks at the end of the previous crop year to total utilization of U.S. corn (Economic Research Service 2007). *FarmAct* equals 1 for 1996 to 2005 and 0 otherwise. ΔY_t^{NH} is the percentage deviation in northern hemisphere corn yield (less the United States) from the trend yield in that world region, and ΔY_t^{SH} is the percentage deviation in southern hemisphere corn yield (less the United States) from the trend yield in that world region (constructed using data from the FAOSTAT website). π is the inflation rate (CPI-U) over the quarter prior to planting. Δr_t is the percentage change in the nominal exchange rate (Euro/$) between planting and harvest time.

Table 2. Descriptive Statistics for Actual and Simulated Corn Yield Per Acre (1975 to 2007) for Two Counties[a]

Statistic	Actual Data			Simulated Data[b]		
LOGAN COUNTY, IL						
Pearson's Correlation	National	Illinois	Logan County	National	Illinois	Logan County
National	1			1		
Illinois	0.891	1		0.882	1	
Logan County	0.701	0.867	1	0.701	0.859	1
Mean	147.4	155.7	171.9	143.0	153.0	170.88
Std. Dev.	13.7	21.8	27.4	10.7	19.2	24.5
BARNES COUNTY, ND						
Pearson's Correlation	National	North Dakota	Barnes Co.	National	North Dakota	Barnes Co.
National	1			1		
North Dakota	0.483	1		0.483	1	
Barnes County	0.373	0.882	1	0.373	0.882	1
Mean	147.4	97.18	115.2	143.0	96.7	114.1
Std. Dev.	13.8	25.4	35.2	10.7	24.3	31.4

[a] The statistics are for yields of corn for grain detrended to a 2006 basis. National and county yields are yields per harvested acre, and state yields are yields per planted acreage (as needed for ACR calculations).

[b] Simulated yields are generated from kernel density functions, and correlations between the simulated yields are imposed using heuristic combinatorial optimization techniques.

pensate for the "natural hedge," i.e., the inverse correlation, between price and yield, which is strong for the Illinois farmer but not the North Dakota farmer. Hence, while the mean ACR payment is lower than the LDP+CCP payment for the Barnes County farmer as well, at $15 versus $31, the difference is notably smaller.

Table 3. Summary Statistics for the Distribution of Commodity Payments for Corn for Two Price Scenarios

	Total payments per acre ($)						
Program	Mean	Median	Std. Error	Coefficient of Variation [a]	90% Confidence Interval (lower, upper)		Frequency of Payment (percent)
A1. BARNES COUNTY, NORTH DAKOTA (2006 CASH PRICE SCENARIO OF $2.07)							
LDP	11	3	15	1.377	0	41	55
CCP	20	26	9	0.437	0	26	91
LDP+CCP	31	29	20	0.662	0	67	91
ACR	15	0	25	1.705	0	71	40
B1. LOGAN COUNTY, ILLINOIS (2006 CASH PRICE SCENARIO OF $2.07)							
LDP	16	5	20	1.294	0	57	55
CCP	37	48	16	0.437	0	48	91
LDP+CCP	53	53	32	0.601	0	105	91
ACR	5	0	13	2.497	0	32	27
A2. BARNES COUNTY, NORTH DAKOTA (HIGHER CASH PRICE SCENARIO OF $3.97) *no LDP and CCP payments at this price level*							
ACR	40	15	52	1.293	0	149	58
B2. LOGAN COUNTY, ILLINOIS (HIGHER CASH PRICE SCENARIO OF $3.97) *no LDP and CCP payments at this price level*							
ACR	34	28	34	0.986	0	98.7	78

[a] The coefficient of variation measure is not denominated in dollars.

Notes: When the cash price at pre-planting in 2006 is $2.07/bu., the price scenario uses a revenue pre-planting price that would have been calculated for 2006, or $2.58/bu., which is the average of the 2004 through 2006 February values of the December futures contract ($2.83, $2.32, and $2.59, respectively).

When the cash price at pre-planting is $3.97, the February price of the December futures contract is assumed to be $4.27. In this higher price scenario, the revenue pre-planting price is $4.58, which is the average of the hypothetical $4.27 and the 2007 and 2008 February futures values ($4.06 and $5.40, respectively).

In the higher price scenario, no LDP+CCPs are made of course, but the ACR still provides revenue payments, as shown in Table 3. By that same token, the ACR can represent significant budgetary outlays for the government when prices are high.

In the lower price scenario, the 90 percent upper tail of payments for Logan County is significantly lower for the ACR than for LDP+CCP, at $32 per acre versus $105 per acre as shown in Table 3. For this same price scenario, the 90 percent upper tail of payments for Barnes County is approximately the same for the ACR and the LDP+CCP. Nonetheless, at the low price levels where a comparison can be made between ACR and LDP+CCP, the other heartland states should have payment results similar to Illinois. As these states account for the bulk of U.S. corn production, if the ACR program replaced the LDP+CCP as the sole source of variable program support under Title I, it would likely result in significantly lower probability of high budgetary outlays than the LDP+CCP when prices are relatively low.

Table 4 shows the impact of the payments on total revenue per acre (gross revenue plus the payment) of the farm for both the low and high price scenarios, assuming that the producer is in fact farming the base acre. In analyzing the simulation output, row-wise correspondence is maintained between the payments and gross revenue calculations in order to correctly characterize the density of total revenue, i.e., variance (total revenue) = var (payment + gross revenue), not var (payment) + var (gross revenue).

As the third to last column of Table 4 shows for either price scenario, the ACR program re-

Table 4. Impacts of Commodity Payments on Revenue per Acre under the Two Price Scenarios

		Total Revenue per Acre						
					Coefficient of Variation			
Scenario	Pre-Planting Price (cash $/bu)	Mean	Median	Std. Error	Value	Percent Reduction	90% Confidence Interval (lower, upper)	
A. BARNES COUNTY, NORTH DAKOTA								
Gross revenue	2.07	222	218	60	0.270	--	126	332
CCP+LDP + GRev	2.07	253	250	64	0.252	7	145	366
ACR + GRev	2.07	237	226	48	0.203	25	178	332
Gross revenue	3.97	427	418	115	0.270	--	241	637
CCP+LDP + GRev	3.97	*no impact*						
ACR + GRev	3.97	467	444	86	0.185	31	364	639
B. LOGAN COUNTY, ILLINOIS								
Gross revenue	2.07	333	334	43	0.128	--	259	401
CCP+LDP + GRev	2.07	386	393	47	0.122	5	293	447
ACR + GRev	2.07	338	335	37	0.110	14	292	403
Gross revenue	3.97	639	640	82	0.128	--	496	769
CCP+LDP + GRev	3.97	*no impact*						
ACR + GRev	3.97	673	668	62	0.093	28	589	779

Notes: “GRev” is gross revenue per acre.

When the cash price at pre-planting in 2006 is $2.07/bu., the price scenario uses a revenue pre-planting price that would have been calculated for 2006, or $2.58/bu., which is the average of the 2004 through 2006 February values of the December futures contract ($2.83, $2.32, and $2.59, respectively).

When the cash price at pre-planting is $3.97, the February price of the December futures contract is assumed to be $4.27. In this higher price scenario, the revenue pre-planting price is $4.58, which is the average of the hypothetical $4.27 and the 2007 and 2008 February futures values ($4.06 and $5.40, respectively).

duces the coefficient of variation of revenue for the Barnes County farmer more than it does for the Logan County farmer, but the difference is most notable in the low price scenario. In addition, the decrease in the coefficient of variation with the ACR relative to that with the CCP+LDP is greater for Barnes County than for Logan County. For the $2.07 price scenario for Barnes County, adding the CCP+LDP payments to gross revenue decreases the coefficient of variation of revenue by 7 percent, but adding the ACR payment instead reduces the coefficient of variation by 25 percent. For the $2.07 price scenario for Logan County, adding the CCP+LDP payments to gross revenue decreases the coefficient of variation of revenue by 5 percent, but adding the ACR payment instead reduces the coefficient of variation by 14 percent. Barnes County, with its low correlation of state yield with national yield, receives substantial risk-reduction benefits from a payment that explicitly addresses state yield.[10]

Figure 1 graphs the density functions of the same simulated data from Table 4 for the low price scenario. In the figure, the ACR density function demonstrates that it compensates for most of the downside revenue loss events (as it does in the high price scenario as well, but which is not shown for the sake of brevity). Not all the downside revenue losses can be captured given

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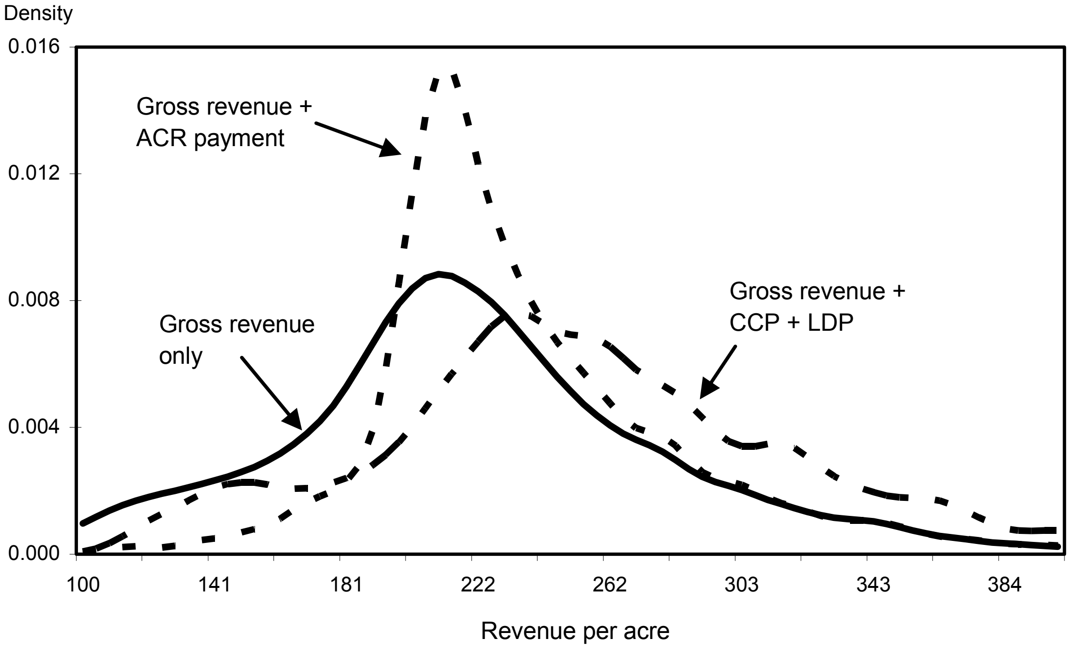
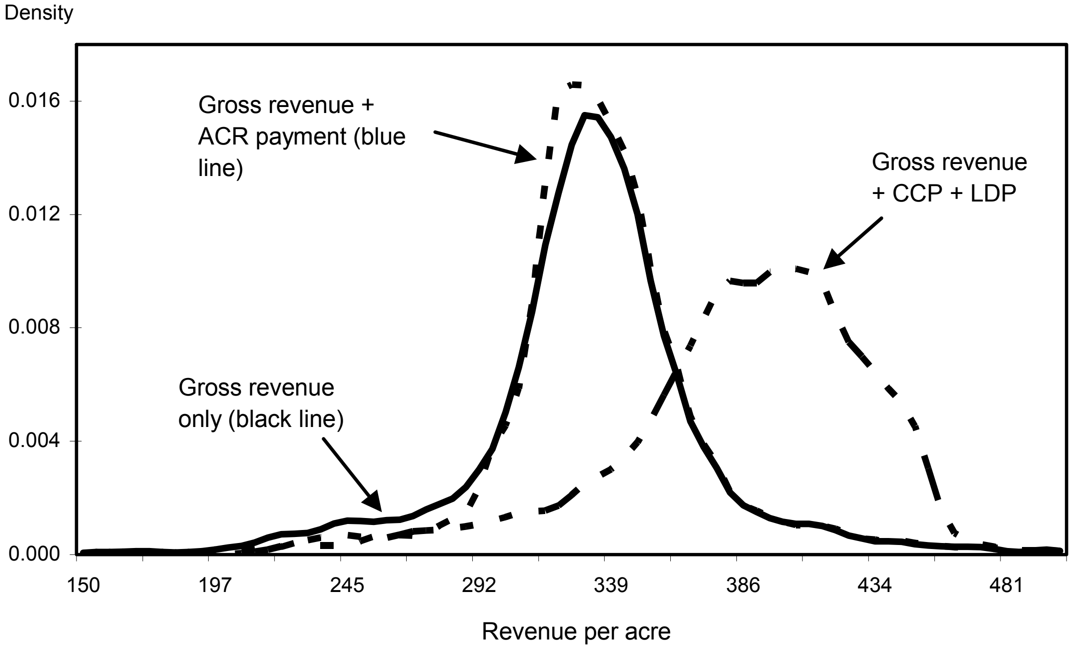
[10] The conclusions in the main text generally apply to the results in Table A1 in the appendix that use the alternative block bootstrap approach for generating the yield density. One difference is that in Table A1, for Logan County in the low price scenario, the difference between the two programs in the coefficient of variation of revenue, at 9 versus 10 percent, is smaller than in Table 4. Plus, median revenue for Logan County with ACR is significantly lower than with CCP+LDP. These results amplify the conclusion in the main text, which is that for Logan County in the low price scenario, the CCP+LDP program may be more desirable to the producer than ACR.



Corn producer with the Barnes County, North Dakota, average yield density



Corn producer with the Logan County, Illinois, average yield density

Figure 1. Probability Density of Revenue per Acre (pre-planting price for 2006)

Note: The cash price at pre-planting in 2006 is $2.07/bu.; the price scenario uses a revenue pre-planting price that would have been calculated for 2006, or $2.58/bu., which is the average of the 2004 through 2006 February values of the December futures contract ($2.83, $2.32, and $2.59, respectively).

that payments are made based on state and not local yields. For the low price scenario in Logan County (the second graph in Figure 1), the shift to the right in mean revenue given CCP+LDP payments is high enough, and the related reduction in downside risk is low enough, that the Logan producer would appear to be unlikely to prefer ACR over CCP+LDP in this case. For the Barnes County farmer, the income-augmenting effect of the CCP+LDP is small relative to its effect in reducing downside risk. Without knowing the farmer's expected utility function, it is hard to predict which program the farmer would prefer. Of course, at high prices (Table 4), there is no choice between the price-based programs and ACR revenue payment. The choice between programs would simply be based on the farmer's price expectations and differences in fixed payments under ACR and under the traditional program option.

This analysis over-estimates the risk reduction benefits of both LDP+CCP and ACR to the extent it is reasonable to assume a representative county farmer. A farm-level dataset of Illinois farmers covering 1996 through 2005 shows the correlation of farm-level yield in Logan County with county-level yield to be relatively high at 0.73.

The ACR uses state-level yields to calculate payments. However, administrative costs could be reduced by calculating payments at the national level. Alternatively, payments could be more closely tailored to farm revenue by making them use county yields, but at a high administrative cost for the government. Table 5 shows the impacts on revenue per acre of making ACR payments based on national or county yield measures. The change in coefficient of variation in moving from a national yield-based payment to the state-level payment is greater for Barnes County, where the decrease in coefficient of variation with the national payment is 7 percent but is 31 percent with the state payment, while for Logan County the values are 15 and 28, respectively. Moving to a county yield based ACR payment provides a substantial additional decrease in the coefficient of variation of revenue. This impact is similar for both counties given that their correlation of county yield with state yield is similar.[11]

Notwithstanding the reduction in coefficient of variation of revenue that the county-yield version of the ACR brings to the Logan County producer, if that producer had the choice, he might prefer an ACR payment based on the national-level yield aggregation. In this case, the lower level of precision in targeting yield appears to produce significantly higher mean revenue, albeit with increased risk of lower payment events, as suggested by the lower bound of the 90 percent confidence interval in Table 5.

In summary, among the key points of this section are (i) when prices are low relative to loan rates and target prices, ACR will likely result in significantly lower probability of high budgetary outlays than the LDP+CCP combination, but (ii) even when prices are relatively low, farmers in states with low correlation of yield with national average yield may prefer ACR payments to LPD+CCP in terms of the trade-off between mean and variance of revenue.

Concluding Remarks

The ACR revenue payments reduced the coefficient of variation of revenue for our representative farmers in North Dakota and Illinois more than did the existing support programs. However, the ACR provided a greater benefit in terms of reducing the coefficient of variation of revenue to the North Dakota farmer. This difference in impacts on the coefficient of variation confirms the intuition that price-based support does a better job of addressing yield variability for farms whose yields are highly (and positively) correlated with the national average, as would be the case for the representative Illinois farmer, than it would for the representative farmer whose yield is not highly correlated with national average yield. Farmers outside the production regions that drive the national average (the heartland in the case of corn) are less likely to be able to benefit from the "natural hedge" between price and yield. As the ACR directly targets state yield, it provides farmers in peripheral production regions better protection against revenue variability than does price-based support.

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[11] The conclusions regarding Table 5 also apply to Table A2 in the appendix, which uses the alternative block bootstrap result for generating the yield density. The decreases in coefficient of variation in the last column of Table A2 are similar to those in Table 5.

Table 5. Impacts of the ACR Payments on Total Revenue per Acre of Using Different Yield Aggregations in the Payment Rate Calculation (higher price scenario)

	Total Revenue per Acre						
Scenario	Mean	Median	Std. Error	Coefficient of Variation	90% Confidence Interval (lower, upper)		Decrease in Coefficient of Variation (percent)
BARNES COUNTY, NORTH DAKOTA							
Gross revenue	427	418	115	0.270	241	637	
National ACR + GRev	451	443	113	0.251	267	657	7
State ACR + GRev	467	444	86	0.185	364	639	31
County ACR + GR	478	453	72	0.150	414	637	44
LOGAN COUNTY, ILLINOIS							
Gross revenue	639	640	82	0.128	496	769	
National ACR + GRev	675	680	74	0.109	530	785	15
State ACR + GRev	673	668	62	0.093	589	779	28
County ACR + GRev	675	663	48	0.072	633	769	44

Note: The cash price at pre-planting is $3.97; the February price of the December futures contract is assumed to be $4.27. In this higher price scenario, the revenue pre-planting price is $4.58, which is the average of the hypothetical $4.27 and the 2007 and 2008 February futures values ($4.06 and $5.40, respectively).

However, the explicit consideration of yield in the ACR payment has a flip side for those farmers in the heartland. As the ACR payment rate automatically compensates for the inverse correlation between price and yield, it does not provide the systematic over-compensation for a price decrease or systematic under-compensation for a price increase that farmers in the core production regions face with the price-based programs. For our low price scenario for the Illinois farmer, the over-compensation effect appears to dominate the under-compensation effect to the extent that the Illinois farmer would likely prefer the price-based support over the ACR at low prices in spite of its better risk-reduction effects. For the North Dakota farmer, however, even for the low expected price scenario, the higher mean revenue under traditional program payments may not be sufficient to compensate for the higher variance of revenue associated with these payments.

At prices high enough that price-based programs provide little prospect of a payment, the ability to receive the ACR revenue payment would naturally be preferred to receiving CCPs and the marketing loan benefits. If the farmer believes that the high price scenario will last till the end of the current Farm Act cycle, then the CCPs and the marketing loan programs become largely irrelevant to the farmer decision to elect ACR. In such a case, the farmer will simply have to weigh the likely loss in direct payment in return for the ACR fixed $15 per acre payment plus the ACR revenue payment.

Market-based revenue payments such as the ACR can raise fears of the prospect of high budgetary outlays if crop prices were to fall from their previous high levels, but stay at levels still too high to produce CCP and marketing loan benefits. In February 2008, corn was high enough to preclude any significant probability of CCP payments or marketing loan benefits for 2009, at current loan rates and target prices. In the short run, ACR could have the potential for greater budgetary outlays than the price-based programs. However, as farming is a competitive industry, even if the current price regime continues well into the future, then costs will increase sufficiently to bring average economic profits back to zero. If so, the government could be under considerable pressure to raise loan rates and target prices, and if it did, the magnitude of differences between outlays under the programs could be reduced.

In a related note, simply allowing the producer a choice between ACR and the traditional suite of payment programs is itself not without additional potential budgetary costs to the government. In particular, if there turns out to be a substantial difference between payments under the two approaches in a crop year, it could be possible that producers who choose the option with the lower payment may lobby the government for a rule change to permit them to switch back to the other option for that year. If such lobbying were successful, the result would be higher budgetary expenditures than if an optional program were not available. Notwithstanding these issues, a benefit of the ACR or other similar revenue-based payment programs is that they may help direct future Title I support in directions that are more consistent with economic principles embodied in making revenue the basis for payments.

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Appendix

Table A1. Impacts of Commodity Payments on Revenue per Acre under the Two Price Scenarios—Block Bootstrap Used to Generate Yield Densities

		Total Revenue per Acre						
					Coefficient of Variation			
Scenario	Pre-Planting Price (cash $/bu)	Mean	Median	Std. Error	Value	Percent Reduction	90% Confidence Interval (lower, upper)	
A. BARNES COUNTY, NORTH DAKOTA								
Gross revenue	2.07	227	232	69	0.305	--	114	349
CCP+LDP + GRev	2.07	259	255	72	0.278	9	144	402
ACR + GRev	2.07	243	237	53	0.220	28	169	349
Gross revenue	3.97	435	444	132	0.305	--	219	669
CCP+LDP + GRev	3.97	*No impact*						
ACR + GRev	3.97	476	465	96	0.202	34	324	669
B. LOGAN COUNTY, ILLINOIS								
Gross revenue	2.07	332	329	49	0.146	--	246	417
CCP+LDP + GRev	2.07	388	405	52	0.133	9	250	388
ACR + GRev	2.07	336	331	44	0.132	10	280	417
Gross revenue	3.97	637	631	93	0.147	--	472	800
CCP+LDP + GRev	3.97	*No impact*						
ACR + GRev	3.97	669	666	75	0.111	23	585	808

Notes: “GRev” is gross revenue per acre.

When the cash price at pre-planting in 2006 is $2.07/bu., the price scenario uses a revenue pre-planting price that would have been calculated for 2006, or $2.58/bu., which is the average of the 2004 through 2006 February values of the December futures contract ($2.83, $2.32, and $2.59, respectively).

When the cash price at pre-planting is $3.97, the February price of the December futures contract is assumed to be $4.27. In this higher price scenario, the revenue pre-planting price is $4.58, which is the average of the hypothetical $4.27 and the 2007 and 2008 February futures values ($4.06 and $5.40, respectively).

Table A2. Impacts of the ACR Payments on Total Revenue per Acre of Using Different Yield Aggregations in the Payment Rate Calculation (higher price scenario)—Block Bootstrap Used to Generate Yield Densities

	Total Revenue per Acre						
Scenario	Mean	Median	Std. Error	Coefficient of Variation	90% Confidence Interval (lower, upper)		Decrease in Coefficient of Variation (percent)
BARNES COUNTY, NORTH DAKOTA							
Gross revenue	435	444	132	0.305	219	669	
National ACR + GRev	452	462	129	0.286	230	681	6
State ACR + GRev	476	465	96	0.202	324	669	28
County ACR + GR	487	460	82	0.169	411	669	45
LOGAN COUNTY, ILLINOIS							
Gross revenue	637	631	93	0.147	472	800	
National ACR + GRev	663	659	85	0.129	476	810	12
State ACR + GRev	669	666	75	0.111	585	808	24
County ACR + GRev	680	661	54	0.081	629	800	45

Note: The cash price at pre-planting is $3.97; the February price of the December futures contract is assumed to be $4.27. In this higher price scenario, the revenue pre-planting price is $4.58, which is the average of the hypothetical $4.27 and the 2007 and 2008 February futures values ($4.06 and $5.40, respectively).