Abstract
Several 2007 farm bill proposals focused on reforming commodity programs to reduce revenue variability. The bills that emerged from both the House and Senate authorizing committees contained revenue-triggered payment programs. Since revenue variability incorporates not only price variability but also yield variability and the interactions between crop yields and prices, revenue-triggered payment programs would likely change the expected payment received by a producer as well as the probability distribution of payments for any given year.

Limits on annual levels of support are a critical measure of compliance with the World Trade Organization (WTO) Agreement on Agriculture and have been a key point in the on-going Doha Development Round trade negotiations. The proposed revenue-triggered payment programs would likely be reported as amber box payments to the WTO - the same as the programs they would replace. However, a shift to revenue-triggered payment programs could affect the probability distribution of aggregate payments and thus the ability of the U.S. to stay within the Aggregate Measure of Support (AMS) levels allowed under the WTO agreement.

Four field crops account for about 82 percent of current U.S. crop program payments: corn, soybeans, wheat and cotton. We analyze payments under current and proposed commodity programs for these four crops. The analysis focuses on both expected annual payments and the likelihood of exceeding AMS limits.

Simulations are constructed using 1975-2005 NASS county, state and national yield data, as well as, historical price data for cotton, wheat, corn, and soybeans. A representative farm is specified for each county with an expected yield equal to the expected county yield and yield variability consistent with the average crop insurance rates for the county.

Results indicate that the revenue-triggered farm bill proposal adopted by the House of Representatives Committee on Agriculture generally results in increased payments relative to current programs. The proposal adopted by the Senate Committee on Agriculture, Nutrition and Forestry provides farmers with the option of a revised price-triggered payment program or a revenue-triggered program. Those that opt for the revenue-triggered program would also give up the direct payments that exist under current law. The revised price-triggered program generally increases soybean and wheat payments relative to current programs while cotton and corn payments are largely unchanged. For wheat producers, the Senate revenue-triggered program pays more than the Senate price-triggered program but, on average, the revenue-triggered program pays less for the other three crops. This is particularly true for cotton producers who would give up a significant amount in direct payments.

Estimates of the aggregate payments suggest that the House revenue-triggered program is most likely to generate high aggregate payments. However there is not a dramatic change in the distribution of Federal outlays between price-triggered and revenue-triggered programs.
Introduction

Several 2007 farm bill proposals focused on reforming commodity programs to reduce revenue variability. The proposals would alter or replace current price-triggered programs with programs that make payments when revenue, that is, price multiplied by yield, falls short of expected or target levels. For example, proposals have been suggested that trigger payments due to shortfalls in county (National Corn Growers), state (Senate Committee on Agriculture, Nutrition and Forestry and American Farm Bureau) and national (USDA, House Committee on Agriculture, and American Farmland Trust) revenue. Since revenue variability incorporates not only price variability but also yield variability and the interactions between crop yields and prices, revenue-triggered payment programs would likely change the expected payment received by a producer as well as the probability distribution of payments for any given year.

Limits on annual levels of support are a critical measure of compliance with the World Trade Organization (WTO) Agreement on Agriculture and have been a key point in the on-going Doha Development Round trade negotiations. It is possible for revenue-triggered programs to not count against a country’s Aggregate Measure of Support limits (Coble and Miller), but it would likely require that the trigger be based on whole-farm revenue and have at least a 30 percent deductible (i.e. a guarantee of no more than 70 percent of expected revenue). The proposals currently under consideration in the U.S. do not meet those requirements so they

1 Professor and Associate Professor in the Department of Agricultural Economics, Mississippi State University.
2 We thank participants at the Domestic and Trade Impacts of U.S. Farm Policy: Future Directions and Challenges Conference for helpful comments. We also express appreciation for the earlier work done by Sarah Thomas, former graduate student at Mississippi State University.
would likely be reported as AMS payments. However, a shift to revenue-triggered payment programs could affect the probability distribution of aggregate payments and thus the ability of the U.S. to stay within the AMS levels allowed under the WTO agreement.

In this paper, we estimate revenue variability—deviations from expected revenue—for the field crops that account for most U.S. crop production: corn, soybeans, wheat and cotton. We compare the performance of current programs with possible revenue-triggered payment programs at various levels of aggregation. Maps are reported that show the regional distribution of payments for the four crops. Finally, expected aggregate payments and the probability distribution of aggregate payments are compared for both current programs and proposed revenue-triggered programs.

**Data and Model Structure**

Revenue is a random variable that is the product of two other random variables – yield and price. Yield and price may also be correlated. The nature of the randomness observed in agricultural crop prices and yields is quite distinct. Because of potential arbitrage, agricultural crop prices are highly spatially correlated (Dismukes and Coble). As a result, price variability for a particular commodity is similar across most regions of the U.S. Interestingly, relative price variability is also quite similar across most major program crops. Conversely, yield variability is driven by factors such as rainfall, temperature, disease, and insect infestation, which may be widespread or quite localized. The implication of this is that crop revenue risk can be quite different than price risk.

Our analysis is based on county, state, and national yield data and national crop price data from USDA’s National Agricultural Statistics Service (NASS). We also utilize NASS county level yields and Risk Management Agency (RMA) crop insurance data to model county-specific representative farm yields.
To measure variability of yields at the county, state and national levels, we estimated a linear time trend for each data series using 1975-2004 data and calculated variability from the residuals relative to the predicted yield for 2007. Given detrended national, state, and county yield series, we next compute farm yield variability for a representative farm in each county. These crop-specific representative farms are assumed to have a mean yield equal to the expected county yield and yield variability consistent with the average riskiness of farms insured by RMA’s crop insurance yield insurance (Coble, Heifner, and Zuniga). Following Miranda, farm yield is modeled as:

\[ f y \sim \mu + \beta (c y - \mu_c) + e_f \quad \forall f \in c \]

where \( f y \) is the realization of the random yield on farm \( f \) in year \( t \), \( c y \) is the realization of the random yield in county \( c \) in year \( t \), \( \mu_f \) is the expected farm yield, and \( \mu_c \) is the expected county yield. The coefficient, \( \beta \) measures the responsiveness of farm yield to deviations from expected county yield. Finally, \( e_f \) represents idiosyncratic effects on farm yield deviations from the expected value that are orthogonal to county yield deviations. In our analysis we assume \( e \sim N(0,k) \) where \( k \) represents the standard deviation of the idiosyncratic farm yield risk.

For representative farms, it is assumed that \( \beta = 1 \). Miranda shows that if the county yield were truly an aggregation of all farms in the county, then our assumed \( \beta = 1 \) would be the acreage weighted average of all \( \beta \)'s in the county. A grid search for \( k \) is conducted by inserting equation (1) into equation (2) which simulates crop insurance premium rates.

\[ \text{Min} |PR_{65} - ELC_k| \text{ where } ELC_k = E \left[ \frac{P_k(C \mu_f - \bar{y}_f)}{P_k C \mu_f} \right] \]
$PR_{65}$ is the weighted average premium rate for 65 percent coverage paid by crop yield insurance purchasers in each county for each crop, while $ELC_k$ is the expected loss cost given a standard deviation of $k$. The expected loss cost is conditioned on the program parameters price guarantee, $P_g$, and coverage level, $C$. Given $C$ set to 0.65, we search for the value of $k$ that minimizes equation (2) using a grid search from 10.0 to 60.0 by intervals of 2. Once the standard deviation of idiosyncratic farm yield is obtained, farm yields can be simulated. Finally, the matrix $[Y]$ is created, which has national, state, and county yield deviations for each of the four crops. Thus the matrix has $T$ rows representing historical yields.

Price variability is estimated from NASS data. National annual marketing-year average (MYA) prices for 1974 through 2005 are used. These data are used to estimate a percentage price change from the previous year’s price level. State basis adjustments from the national price are also derived from the historical data so that state harvest time prices are the sum of the MYA price and the basis. These data for the four crops are maintained in the matrix $[P]$ which also has $T$ rows for historical years.

The representative farm yield, price and revenue simulation is based on 500 random draws of a five-year time path. For every location, a simultaneous random draw is made from yield matrix $[Y]$ and price matrix $[P]$ (i.e., all yield deviations from trend and price changes are drawn from the same historical year) to maintain the empirical correlations between prices and yields, between yields at different levels of aggregation, and between yields for different crops and regions. The idiosyncratic portion of farm yield is independently drawn for each representative farm. Starting prices for the simulations are determined from December 2007.

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3 Crop insurance is generally sold at the basic or optional unit level, which is typically more disaggregated than the farm. Thus, the effective premium rate data is largely a mix of basic and optional unit rates and captures some other risks that might not be considered yield risk (i.e. prevented planting or quality loss). Thus, the effective premium rates were adjusted downward by 15 percent to approximate farm-level yield variability.
futures market prices for 2008 delivery months. The MYA price is obtained by taking the relative price change associated with the randomly drawn yield shock and multiplying by the previous year’s MYA price. State prices are obtained by adjusting national price for a regional basis.

**Policy Alternatives Examined**

Farm program payments are calculated given the simulated prices and yields. Program parameters such as direct payment rates, loan rates, coverage percentages, and target prices are specified as described in the various programs. Planted acreage for each crop in each county was obtained from NASS for the 2005 crop year and was assumed constant throughout the simulation period. Base acreage for 2002 for each county is obtained from the Farm Service Agency. Base yields are derived by comparing the national average base yield to the expected yield. This ratio is applied to the 2007 expected yield for each county.

**Current Program**

The current farm programs included in our analysis are Direct Payments (DPs), Loan Deficiency Payments (LDPs), and Counter-Cyclical Payments (CCPs). LDPs are calculated as:

\[
LDP = \max(0, LR - MYA) \times PA \times y_f
\]

where \( LR \) is the loan rate and \( PA \) is planted acres.\(^4\) DPs are calculated as:

\[
DP = DP_R \times 85\% \times BA \times \bar{y}_f
\]

where \( \bar{y}_f \) is the program yield, \( DP_R \) is defined as the direct payment rate, and \( BA \) is the base acreage. For each crop, CCPs are calculated as:

\[
CCP = \left(\text{CPP}_{tp} - DP_R - \max(LR, MYA)\right) \times 85\% \times BA \times \bar{y}_f
\]

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\(^4\) We recognize that LDPs are paid based on posted county prices at the time the LDP is exercised. However, to simplify the modeling we use MYA instead of posted country prices. Assuming markets are efficient, this simplifying assumption should not greatly bias the results.
where $CCP_{TP}$ is the target price and all other variables are as defined previously.

National payment totals are derived by multiplying per acre payments by the planted acres in the county for the LDP and base county base acres in the case of direct payments and counter-cyclical payments. Payments are then summed to the national level. Given that only four of the program crops are modeled, total payments are scaled up by a factor of 1.2 to reflect the historical proportions of program payments received by these four crops.

**House of Representatives Modified Current Program Option**

The farm bill proposed by the House of Representative’s Committee on Agriculture would offer producers the option to choose between two alternative programs. We have modeled both programs. The first we will describe as the modified current program option, which maintains the current commodity title program structure, but modifies parameters in those programs. While this program would maintain the same structure as current programs it would lower the target price on cotton from 72.4 cents to 70.0 cents per pound, while increasing the target price on soybeans from $5.80 per bushel to $6.10 per bushel, and increasing the target price on wheat from $3.92 to $4.15. Direct payment rates would remain at current levels, while the wheat loan rate would increase from $2.75 to $2.94 per bushel.

**House of Representatives National Revenue-Triggered Option**

As an alternative to the modified current program, producers could choose a national-level, revenue-triggered counter-cyclical payment (RCCP). For each crop, the RCCP would be calculated as follows:

\[
RCCP = \text{Max}\left[0, \left(\frac{TR - NR}{\hat{y}_n}\right)\right] \times 85\% \times BA \times \tilde{y}_f
\]

where $TR$ is the U.S. target revenue per acre for the crop, $NR$ is the U.S. realized revenue per acre, and $\hat{y}_n$ is the national payment yield. $NR$ is calculated as the NASS final U.S. average.
yield for the crop times the higher of the U.S. marketing year average price or the loan rate. \( TR \) is legislatively-defined at $344.12 per acre for corn, $496.93 per acre for cotton, $231.87 per acre for soybeans, and $149.92 for wheat.

**Senate Modified Current Program Option**

As in the House of Representatives, the farm bill adopted by the Senate Committee on Agriculture, Nutrition and Forestry provides two commodity program options for producers. However, under the Senate farm bill, producers would not be allowed to choose an option until the 2010 crop year. The Senate modified current program option simply changes parameters in the current program structure – much like the House modified current program option. The key changes that would occur in the Senate modified current program option is that upland cotton target prices would decline from 72.40 cents per pound to 72.25 cents per pound. For soybeans, the target price would be increased from $5.80 per bushel to $6.00. For wheat, the target price would be increased from $3.92 to $4.20 and the loan rate would be increased from $2.75 to $2.94. Direct payment rates would be unchanged from the current levels.

**Senate Average Crop Revenue Option**

The Senate average crop revenue (ACR) option would give producers a state-level revenue-triggered payment program. In addition producers would receive direct payments equal to $15 per acre times 85 percent of the farmer’s current base acres and a recourse (rather than a non-recourse) loan. The ACR payment would be calculated as:

\[
ACR = 0.85 \times BA \times \bar{y} \times \frac{\max \left\{ 0.9 \times \hat{y}_s \times Price - SR \right\}}{\hat{y}_s}
\]

where \( SR \) is the state realized revenue, \( \hat{y}_s \) is a trend-adjusted state-level expected yield per planted acre, and \( Price \) is the Federal Crop Insurance revenue insurance pre-planting price averaged over the current and the previous two years. The change in \( Price \) from year to year
would be capped at 15 percent. The state realized revenue would be the product of the realized state yield per planted acre and the harvest price used to settle Federal Crop Insurance revenue insurance policies.

**Insurance Wrapping**

The original Senate committee language, as proposed in the Chairman’s mark, would have integrated farm-level revenue insurance with the ACR program by “wrapping” revenue insurance around the ACR. This implies that ACR program payments would be deducted from any revenue insurance indemnity payments. The ACR program would cover systemic losses and the farm-level revenue insurance product would cover any residual idiosyncratic losses. We model this wrapped insurance proposal assuming a farm-level revenue insurance product with 65 percent coverage and upside price protection

\[
\text{Wrapped Indemnity} = \max[0, (65\% \times APH_f \times \max(EP, HP)) - y_f HP - ACR]
\]

where \(APH_f\) is the farm’s crop insurance actual production history (APH) yield, \(EP\) is the crop insurance pre-planting expected price, and \(HP\) is the crop insurance harvest price. The ‘wrapping’ of insurance around the ACR program is achieved by adding any ACR payments to revenue before calculating the crop insurance indemnity. For some scenarios, we also model an unwrapped revenue insurance product. For these scenarios, ACR is omitted from the indemnity equation. The revenue insurance products are assumed to be actuarially-fair so the federal transfer associated with the insurance products is simply the premium subsidy, which is currently 59 percent for 65 percent coverage.

**Results**

Table 1 shows the average annual per acre payments received for each of the four crops. We report results for five policy scenarios: the current program, the House modified price-triggered program, the House revenue-triggered program (RCCP), the Senate modified price-
triggered program and the Senate proposed revenue-triggered program (ACR). The scenarios are composed of the following program combinations:

- **Current Policy**: LDP, DP, CCP, and 65% coverage crop revenue insurance with upside price protection
- **House modified current program**: Modified LDP, DP, modified CCP, and 65% coverage crop revenue insurance with upside price protection
- **House revenue-triggered program**: Modified LDP, DP, RCCP, and 65% coverage crop revenue insurance with upside price protection
- **Senate modified current program**: Modified LDP, DP, modified CCP, and 65% coverage crop revenue insurance with upside price protection
- **Senate ACR program**: Modified DP, ACR, and 65% coverage crop revenue insurance with upside price protection.

The results are averaged over 500 iterations and over the simulated five-year period (2008-2012). Note, that for purposes of comparison the Senate revenue-triggered program is simulated over the five-year period, though in fact producers would not be allowed to opt into the ACR program until 2010.

The current programs provide the largest degree of per acre revenue to cotton at $111 per acre whereas corn receives the second highest at $44 an acre and soybeans and wheat both receive similar levels of current program payments at slightly over $26 per acre. Comparing the House modified price-triggered program to current programs, we observe slight increases for soybeans and wheat, identical results for corn, and approximately a $6 decline in per acre payments for cotton due primarily to the reduction in the cotton target price. Comparing the House national revenue-triggered program to the current programs, payments for soybeans
increase from approximately $26 per acre to $29 per acre. Corn payments increase on average by slightly more than $1 per acre. Cotton payments under the House revenue-triggered program would increase by about $6 per acre, while wheat payments increase by about $1 per acre. Thus, the House national revenue-triggered program would increase payments on a per acre basis for all four commodities examined relative to the current program.

Turning next to the Senate programs, the Senate modified price-triggered program results in higher payments per acre on soybeans and wheat, while holding corn and cotton payments at their current levels. The Senate revenue-triggered program results in higher payments for soybeans than current programs by about $6 per acre. It decreases corn payments by about $5 per acre and increases the payments on wheat by a little more than $10 per acre. The most dramatic change is for cotton, where the total expected payment would decrease from $111 per acre under current programs to $48 per acre under the Senate revenue-triggered program. This is largely due to the significant decrease in direct payments since the $15 per acre direct payment under the Senate revenue-triggered program is much lower than the direct payments currently received by cotton producers.

Table 2 reports an analysis of how wrapping revenue insurance around the House or Senate revenue triggered plans would affect revenue insurance premium rates. We assume that the producer purchases a 65 percent coverage farm-level revenue insurance policy with upside price protection. The table shows the actuarially-fair wrapped premium rates as a percentage of the actuarially-fair unwrapped premium rates. For the House national revenue-triggered program, the average wrapped premium rates are between 92 and 93 percent of the unwrapped premium rates for corn, cotton, and wheat and 86 percent for soybeans.5

5 The recourse loan component of the ACR program is not included in the analysis.
6 The Farm Bill adopted by the House of Representatives does not include a crop insurance wrap-around provision. This option is presented here only for comparison purposes. Because the revenue triggered programs are tied to
When one examines the Senate state-level, revenue-triggered program, the reduction in crop insurance premium rates is largest for wheat with wrapped rates averaging 78 percent of the unwrapped rates. The smallest reduction occurs for cotton where wrapped crop insurance premium rates are about 89 percent of unwrapped rates. The (negative) correlation between payments and realized farm-level revenue is higher under the Senate revenue-triggered program than under the House revenue-triggered program. This is because the Senate program triggers payments based on state-level realized revenue while the House program triggers payments based on national realized revenue.

**Geographical Distribution of Results**

Figures 1 through 16 contain maps showing the average annual per acre government payments for the various policy options. Results are reported by crop and program option: a) current programs, b) House modified current programs, c) House national-level, revenue-triggered program, and d) Senate state-level, revenue-triggered program.

In general, the maps show that regional differences in per acre program payments are driven by the yield potential for that region (i.e. a higher program yield translates into greater program payments). This is particularly true for direct payments, price triggered payments, and the House national revenue-triggered program (RCCP). However, payments also depend on yield risk exposure – particularly for the state-level, revenue-triggered program (ACR) and for crop insurance.

**Distribution of Aggregate Farm Program Payments Under Alternative Scenarios**

In Figure 17 we report the cumulative distribution function of aggregate payments for the 2010 crop year and for six alternative commodity program specifications. Again, we have base acres rather than planted acres, there is an additional reduction in the correlation between these programs and what producers actually receive as compared to proposals such as those from the NCGA which would use planted acre revenue.
modeled only the four largest program crops. Historically these four crops represent about 83 percent of total crop payments and the totals in this figure are scaled up to reflect that percentage. It is important to note that we do not include the dairy and sugar support programs which are a non-trivial portion of the U.S. AMS.

To model the producer’s choice of payment program under the Senate farm bill proposal, we assume that producers will choose the price-triggered program when pre-planting futures market prices ($EP$) suggest that there will be a price-triggered countercyclical payment in the upcoming crop year.

The program that is most likely to result in high aggregate payments is the House national-level, revenue-triggered program, which clearly is to the right of all the other distributions. Some of the proposed Senate programs generate lower payment levels than current programs. Interestingly, when producers are given the program option in the Senate farm bill proposal, there is a wider variance of aggregate payouts than in most of the other designs. Ultimately, given the current high prices, there is a fairly low probability that any of the proposed program designs would generate payments in excess of $12 billion in 2010. For example the Senate ACR proposal has a 90th percentile of approximately $7.5 billion per year. The 90th percentile for the House RCCP alternative (the most likely to generate high annual payments of the alternatives examined) is about $3.0 billion per year higher. Note that these payments omit two major components of U.S. AMS – sugar and dairy supports. Josling et al. report that these payments have averaged $5.5 billion per year from 2002 through 2006. If these payments remain near that level, the House RCCP proposal would still have a 90th percentile of about $16 billion – well below current limits. This suggests that one of the reasons that lawmakers have not seemed particularly concerned about U.S. AMS limits under WTO is that there is not a high probability that the U.S. will exceed the current limit of $19.1 billion.
However, if a reduction in AMS limits is achieved in the WTO negotiations, then there would be a higher likelihood that the U.S. would exceed its limit under any of the proposals considered here. Press reports suggest that in WTO negotiations the U.S. has offered proposals that would lower U.S. AMS limits to between $13.0 and $16.5 billion per year. If such limits were adopted, then there would be a higher likelihood that the proposals considered here would exceed the U.S. AMS limit – even with the current high prices for several major crops. For example, if dairy and sugar support remains near $5.5 billion per year then there would be approximately a 40 percent chance of exceeding a $13 billion AMS limit under the House RCCP proposal in any given year. The other alternatives considered here would have somewhere between a 20 percent and 35 percent chance of exceeding the limit.
References


Table 1. Estimated Average Annual Producer Payments per Acre for Proposed Government Programs

<table>
<thead>
<tr>
<th>Proposed Program</th>
<th>Soybeans</th>
<th>Corn</th>
<th>Cotton</th>
<th>Wheat</th>
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</thead>
<tbody>
<tr>
<td>Current Program</td>
<td>$26.47</td>
<td>$44.04</td>
<td>$111.53</td>
<td>$26.70</td>
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<tr>
<td>House Modified Price CCP</td>
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<td>House RCCP</td>
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<td>Senate Modified Price CCP</td>
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<td>$36.27</td>
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<tr>
<td>Senate ACR</td>
<td>$32.27</td>
<td>$39.33</td>
<td>$48.40</td>
<td>$37.24</td>
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</table>
Table 2. Rate Reduction from Wrapping Individual-Coverage Revenue Insurance around Proposed Revenue-Triggered Government Programs

<table>
<thead>
<tr>
<th>Proposed Program</th>
<th>Soybeans</th>
<th>Corn</th>
<th>Cotton</th>
<th>Wheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>House RCCP</td>
<td>86.38%</td>
<td>93.58%</td>
<td>93.22%</td>
<td>92.05%</td>
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<tr>
<td>Senate ACR</td>
<td>80.91%</td>
<td>82.14%</td>
<td>89.47%</td>
<td>77.84%</td>
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</tbody>
</table>
Figure 3

Figure 4
Figure 9

Soybean Total Government Payments with Current Programs

Figure 10

Soybean Total Government Payments with House Updated Counter—Cylical Payments
Figure 11

Figure 12
Figure 13

Wheat Total Government Payments with Current Programs

Figure 14

Wheat Total Government Payments with House Updated Counter-Cyclical Payments
Figure 15

Wheat Total Government Payments with House National Revenue Counter—Cylical

Figure 16

Wheat Total Government Payments with Senate State Revenue Counter—Cylical
Figure 17. 2010 Distribution of Aggregate Program Crop Payments