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Abstract

In the context of U.S. farm policy, this paper analyzes the effect that expectations about base acreage and yield updating in future policies have on a farmer's production decisions in the presence of price, yield and policy uncertainty. We consider a risk averse farmer producing a single crop whose income consists of market revenue and government payments. We consider two policy regimes. Decisions on acreage and fertilizer use made in the current policy regime are linked to government payments in the future policy regime through the possibility of a base acreage and yield update in the future regime. There is policy uncertainty about the possibility of the updates being allowed in the future. We combine stochastic dynamic programming with present value calculations to link current acreage and input use decisions to future program payments. The average optimal planted acreage and fertilizer use are increasing in the subjective probability of the future update. The estimated maximum percentage increase in the average optimal planted acreage is 6.25%. The estimated maximum percentage increase in the average yield, resulting from optimal fertilizer use is much smaller at 0.134%.

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Abstract

In the context of U.S. farm policy, this paper analyzes the effect that expectations about base acreage and yield updating in future policies have on a farmer's production decisions in the presence of price, yield and policy uncertainty. We consider a risk averse farmer producing a single crop whose income consists of market revenue and government payments. We consider two policy regimes. Decisions on acreage and fertilizer use made in the current policy regime are linked to government payments in the future policy regime through the possibility of a base acreage and yield update in the future regime. There is policy uncertainty about the possibility of the updates being allowed in the future. We combine stochastic dynamic programming with present value calculations to link current acreage and input use decisions to future program payments. The average optimal planted acreage and fertilizer use are increasing in the subjective probability of the future update. The estimated maximum percentage increase in the average optimal planted acreage is 6.25%. The estimated maximum percentage increase in the average yield, resulting from optimal fertilizer use is much smaller at 0.134%.

The 2002 U.S. Farm Security and Rural Investment (FSRI) Act maintained the decoupled payments, the so-called direct payments (DPs), that were first introduced in the the 1996 Federal Agriculture Improvement and Reform (FAIR) Act as the Production Flexibility Contract (PFC) payments. The 2002 FSRI Act also introduced the counter-cyclical payments (CCPs), which were also paid on farmers' historical base acreage and were triggered by prices that fell below a pre-established level. Farmers were also allowed to update their base acreage for DPs and CCPs and program yield for CCPs. This possibility could create incentives for farmers to increase current plantings and yields to increase future decoupled payments. Thus expectations about future policies is a potential mechanism linking farmers' current production decisions and the decoupled payments.

The following "coupling" mechanisms of decoupled payments have also been identified in the literature on decoupled payments: (i) in the presence of uncertainty and decreasing absolute risk aversion (DARA), decoupled payments reduce the coefficient of risk aversion (wealth effect) and income variability (insurance effect) (Hennessy 1998; and Sckokai and Moro 2006); (ii) in the presence of imperfect credit markets, decoupled payments can ease the credit constraints faced by farmers (Roe, Somwaru, and Diao 2003; and Goodwin and Mishra 2006); (iii) decoupled payments can influence the labor supply decisions of farmers, by affecting the choice between leisure and total labor supply or between on- and off-farm labor supply (El-Osta, Mishra, and Ahearn 2004; and Ahearn, El-Osta, and Dewbre 2006); (iv) decoupled payments provide incentives to keep land in agricultural use (including keeping land idle) by increasing land values and rents (Goodwin, Mishra, and

Ortalo-Magné 2003a; Goodwin, Mishra, and Ortalo-Magné 2003b; and Roberts, Kirwan, and Hopkins 2003); and (v) expectations about future decoupled payments can influence farmers' current production decisions (Sumner 2003; McIntosh, Shogren, and Dohlman 2007; and Coble, Miller, and Hudson 2008). See Abler and Blandford (2005); and Bhaskar and Beghin (2007) for a review of the literature on decoupled payments.

In 2005, the World Trade Organization's (WTO) Appellate Body ruled against the validity of U.S. cotton direct payments (WTO 2004; and WTO 2005) as a green-box payment. The ruling was on the basis of planting restrictions, that disqualified farmers from receiving these payments if they planted certain fruits and vegetables on base acreage. The Appellate Body did not rule against these payments on the basis of the base acreage update that was allowed in the 2002 FSRI Act, as the Body was unable to ascertain the effect such an update would have on farmers' plantings. Our paper provides a measure of the supply effect of expected future base acreage and yield updates, both in terms of acreage and yield via fertilizer use. Farmers may expand acreage and intensify yield by using more fertilizer.

Other papers that have analyzed the effect of expectations about future base acreage update are Sumner (2003); McIntosh, Shogren, and Dohlman (2007); and Coble, Miller, and Hudson (2008). Coble, Miller, and Hudson (2008) also analyze the effect of expectations of a future yield update on farmers' input use. These three papers indicate that positive expectations about a future base acreage update affects farmers' planting decisions. Coble, Miller, and Hudson (2008) especially provide strong evidence from a survey of Iowa and Mississippi farmers, that farmers attach a positive probability to an expected base acreage and program yield update.[1]

Our approach formalizes and quantifies the influence of expected payments under future policy which might allow a base acreage or program yield update on acreage and fertilizer use decisions under current policy. Farmers can increase yields by increasing fertilizer use. The fertilizer that we consider is anhydrous ammonia. We analyze the impact of updating expectations on a risk averse farmer's acreage and fertilizer use decision in the presence of price, yield and policy uncertainty. The farmer makes acreage planting and fertilizer use decisions in the current policy regime, (2002-2006), not knowing the policies that will be in place in the future policy regime (the duration of the 2007 Farm Bill).[2]

If base acreage updating is allowed in the future regime, then the new base acreage for DPs is considered to be the average of the acreage in the last four years of the current regime. The 2002 Farm Bill allowed for other base acreage updating options; however, for the purpose of this analysis we only consider two of the options, new base acreage as the average of four years of the current regime and no base acreage update. For details on other base acreage update options see Young et al. (2005). If program yields are allowed to be updated, then the new program yield is considered to be 93.5% of the average of the last four years of the current regime.[3]

The subjective beliefs of the farmer formed under the current Farm Bill, regarding a future base acreage and program yield update occurring is discretized into five values, between 0 and 1 to capture the varying degrees of policy uncertainty that the farmer faces about future updates. The farmer's problem is to maximize the present value of expected utility by choosing acreage and fertilizer use during 2002-2006 while taking into account the possibility of a "future" base acreage and program yield update in 2007-2011. Thus, the farmer cares not only about her current utility but also about her future utility. The paper is organized as follows. The model is discussed in the next section. Section 3 describes the numerical analysis. Section 4 presents the results and Section 5 concludes.

Model

We follow Duffy and Taylor (1994) in formulating the acreage and nitrogen use optimization problem for a risk averse farmer. The farmer produces a single crop, corn,[4] and faces price and yield uncertainty, with price and yield being negatively correlated. She earns income from the sale of her crop and government payments. Three government payments are considered: DPs, CCPs and loan deficiency payments (LDP). DPs and CCPs are paid on fixed base acres and program yield, though CCPs are triggered by low prices.[5] LDPs are also triggered by low prices, though these payments are paid on current production. Thus, updating base acreage and program yields would affect DPs and CCPs. The per-period profit of the farmer is written as:

(1) $$\pi_t = \tilde{P}_t\tilde{Y}(N_t,t)A_t + max(LR - (\tilde{P}_t - \eta), 0)\tilde{Y}(N_t,t)A_t + 0.85D * BA * Y_d$$

$$+0.85 * max(CR, 0) * BA * Y_c - TC(A_t, N),$$

where $\tilde{P}_t$ is the stochastic price, A_t is the current acreage, LR is the loan rate, $\tilde{P}_t - \eta$

represents the posted county price. The LDP rate is the amount by which LR exceeds the posted county price. To maintain tractability of the model, we abstract from using the posted county price to compute the LDP rate, as this would have added another stochastic variable to the model. Instead we use η to link $\tilde{P}$ and the posted county price, where η is the average gap between season average price and the posted county price.[6] We follow Babcock and Hart (2005) to compute η. D is the DP rate, CR is the CCP rate which equals $TP - D - max(\tilde{P}_t, LR)$, where TP is the target price. Variable $\tilde{Y}_t(N, t)$ is the stochastic yield, which depends on nitrogen application, N and time, t. The deterministic part of yield, is specified as a function of the mean of the distribution of yield, EY_t, and the stochastic part of yield is a function of the standard deviation of the distribution of yield, σ_Y. TC is the total cost of production, which is a function of current acreage and nitrogen application. BA is the base acreage for the duration of the 2002 FSRI Act, and Y_d and Y_c are program yields for DPs and CCPs respectively. Thus, profit π_t, is a function of $\tilde{P}_t$, N_t and A_t.

The farmer faces policy uncertainty, in that she doesn't know the policies that will be in place for 2007-2011, deemed the future Farm Bill period. Specifically, we consider the policy uncertainty about a future opportunity to update base acreage and program yields. The farmer's expectations about possible future base acreage and program yield updates are captured by subjective probability, δ, with $\delta \in [0, 1]$. Five values of δ are considered to capture the varying degrees of conviction that the farmer has regarding the future base update. $\delta = 0$ implies that the farmer is certain that updating will not be allowed in the future Farm Bill. On the other hand, $\delta = 1$ implies that the farmer is certain that updating will be allowed in the future Farm Bill. The farmer takes into account the possibility of future acreage and yield updates, while maximizing the present value of expected utility from profits.

The farmer maximizes the present value of expected utility from profits with respect to acreage and nitrogen application, over the period 2002-2011. The farmer's problem is expressed as:

$$\max_{A_t, N_t} E\left[\sum_{t=0}^{4} \beta^t U(\pi_t(A_t, \tilde{P}_t, \tilde{Y}(N_t, t))) + \beta^5(\delta VB + (1-\delta)VNB)\right], \tag{2}$$

where U represents the utility function exhibiting decreasing absolute risk aversion preferences. U is a constant relative risk aversion utility function with $U(\pi) = \frac{\pi^{1-\phi}}{1-\phi}$ for $\phi > 0$ and $\phi \neq 1$, where ϕ is the coefficient of relative risk aversion. β is the discount factor and E is the expectations operator over price and yield. The first term of (2) represents the maximization problem under the current regime (2002-2006). The terminal value for this problem is specified by the expected utility from the possible future income stream in the future regime (2007-2011). There are two possible income streams in the future regime; one associated with updating, VB, and the second, associated with no updating, VNB.

VB is the value function for the stochastic dynamic programming (SDP) problem associated with updating (SDP_{VB}) and VNB is the value function for the SDP problem associated with no updating (SDP_{VNB}). The farmer weighs future expected utility with δ. As the farmer's beliefs about the expected base acreage and yield update changes, land allocation and nitrogen use decisions in 2003-2006 are affected, as decisions in these years could influence future farm payments. The new base acreage and program yield are assumed to be the average of the acreage planted and 93.5% of the reported yields in 2003-2006, (the last four years of the current Farm Bill), respectively. Thus, equation (2) provides the link between acreage and nitrogen use decisions in 2003-2006 with future farm payments. Under updating, there are two avenues for the farmer to increase future direct payments; first, through the new base acreage and second, through the updated program yield. Thus, the farmer's current actions affect VB. Hence, the higher is the value of δ, the stronger is the link between current acreage and nitrogen use decisions in 2003-2006 and future farm payments.

The two SDP problems are solved for a five-year time horizon, representing the years 2007-2011, for a discrete state and control space.[7] The decision variables are the current acreage, A_t, and current nitrogen application (in lbs /acre), N_t, which are discretized into r values each. The stochastic state variables are price, $\tilde{P}$ and shocks to yield, $\tilde{\xi}$. Both the variables are discretized into t and s number of states respectively. Additionally, for SDP_{VB} the state space includes all the possible values for the new base acreage and program yields. Since price and yield shocks are stochastic, there is a probability associated with the realization of each of the possible t price and s yield shock states. The probability transition matrix, M, is a $(t*s) \times (t*s)$ matrix containing these probabilities. An element $p^{i,j,k,l}$ of the probability transition matrix represents the probability of moving from a current price of i and yield shock of j to a price of k and yield shock of l in the next period. We rewrite (2) as:

(3)

$$\max_{A_t,N_t} \sum_{t=0}^{4} \sum_{k=1}^{t} \sum_{l=1}^{s} \beta^t M^{i,j,k,l} U(\pi_t(A_t, N_t, \tilde{P}_t, \tilde{\xi}_t)) + \beta^5 \sum_{k=1}^{t} \sum_{l=1}^{s} M^{i,j,k,l} (\delta * VB + (1-\delta) * VNB).$$

The two SDP problems for 2007-2011 are:

(4)

$$VB_t(\tilde{P}_t, \tilde{\xi}_t, BA', Y_d') = \max_{A_t,N_t} \sum_{k=1}^{t} \sum_{l=1}^{s} M^{i,j,k,l} U(\pi_t(\tilde{P}_t, \tilde{\xi}_t, A_t, N_t, BA', Y_d')) + \beta \sum_{k=1}^{t} \sum_{l=1}^{s} M^{i,j,k,l} VB_{t+1}(\tilde{P}_{t+1}, \tilde{\xi}_{t+1}, BA', Y_d'), \quad t = 1, 2, ...5 \quad \text{and,}$$

(5)

$$VNB_t(\tilde{P}_t, \tilde{\xi}_t) = \max_{A_t,N_t} \sum_{k=1}^{t} \sum_{l=1}^{s} M^{i,j,k,l} U(\pi_t(\tilde{P}_t, \tilde{\xi}_t, A_t, N_t)) + \beta \sum_{k=1}^{t} \sum_{l=1}^{s} M^{i,j,k,l} VNB_{t+1}(\tilde{P}_{t+1}, \tilde{\xi}_{t+1}), \quad t = 1, 2, ...5$$

where BA' is the new base acreage for DPs and CCPs for 2007-2011, and Y_d' is the new program yield for the two programs. Variables BA' and Y_d' are treated as endogenous state variables. The option of not updating is also included amongst all the possible base states considered.

The solution to equation (3) provides the optimal acreage planted and nitrogen application rates in 2002-2006, which depend on δ. Thus, corresponding to each value of δ is an optimal acreage allocation and a nitrogen application rate. The optimal acreage and nitrogen application rate for $\delta = 0$ (certainty of no update), are determined by market conditions and the farm policies of the 2002 FSRI Act. It is the benchmark we use to compare the optimal acreage and nitrogen application rate for $\delta > 0$.

Numerical Solution

We use a discrete state, discrete action stochastic dynamic programming approach to solve the two SDP problems. The price state variable is discretized into eight state values. The following price states ($/bu) were chosen to represent the probable range of prices: 1.625, 1.875, 2.125, 2.375, 2.625, 2.875, 3.125 and 3.375. The yield shock state variable is discretized into two values, $-\sigma_Y$, a negative shock and σ_Y, a positive shock. Variable A_t is discretized into four values, starting at 750 acres with increments of 50 acres. Similarly, N is discretized into four values each, starting at 175 lbs/acre in increments of 5 lbs/acre. Since the farmer can choose any one of the four acreage choices in each of the four years, 2003-2006, and any four of the nitrogen application rates, the total combination of new base acreage and program yields is large (65,792).

The initial base acreage for DP and CCP is set as the mid-point of the range of the choice set of A_t. The initial program yield for DP and CCP is set at 93.5% of the average EY_t over 1998-2001, which is obtained from the optimization of expected utility over the period 1998-2001.[8] Table 2 provides information on other policy parameters. Risk parameter ϕ is set at 2 (Antón and Le Mouël 2004).

The functional form considered for the total cost, $TC(A_t, N)$, is $TC = FC + (b +$

$R + p_N N)A_t + cA_t^3$, where FC is the fixed cost, R is the rental rate of land, p_N is the price of N and b and c are constants. Given FC, R and p_N, we calibrate b and c using the profit maximization necessary condition and the acreage price elasticity.[9] We also account for the effect of the possible future update on rent as a large proportion of farmers are tenants. When we solve SDP_{VB}, the total cost includes an additional component that captures the increase in rent when the update results in an increase in direct payments, $\Gamma\left(\frac{0.85*D*BA'*Y_d'}{A_t} - \frac{0.85*D*BA*Y_d}{BA'}\right)$, where Γ is the incidence of a \$ increase in direct payments on rent (per acre). We set Γ at \$0.33, as estimated in Roberts, Kirwan, and Hopkins (2003).

The elements in the probability transition matrix are derived from the joint distribution of price and yield. We assume that price follows a log-normal distribution and yield follows a conditional beta distribution, with negative correlation between price and yield. The parameters, p and q, of the conditional beta distribution are specified as $p = p_0 + p_1 t + p_2 N + p_3 * N^2$ and $q = q_0 + q_1 t + q_2 N + q_3 * N^2$, where t is time and p_is and q_is are the parameters to be estimated. We assume that the yield distribution shifts over time. The parameters are estimated using data from an experimental farm in Iowa (Mallarino, Ortiz-Torres, and Pecinovsky 2005), using maximum likelihood procedures. The experimental farm has data on yields for 1979-2003, for four applications of N (0, 80, 160 and 240 lbs/acre), with three replications for each year.[10]

For estimation purposes, yields from the experimental farm are transformed as, $Y = \frac{Yield-mn}{mx-mn} \in [0,1]$. mn, is set at five bushels less than the minimum observed yield, mx

is set at ten bushels greater than the maximum observed yield, following Babcock and Hennessy (1996), and $Yield$ is the observed yield. Y is now distributed as a conditional beta distribution, with $0 < Y < 1$.

An element of the transition matrix, $p^{i,j,k,l}$, is derived as the joint probability of price state k lying in the interval $(\underline{k}, \bar{k})$ and the yield shock state l lying in the interval $(\underline{l}, \bar{l})$. Thus, the price states have been constructed as mid-points of intervals. The first price interval starts at \$ 1.5/bu and goes upto a maximum of \$ 3.5/bu in increments of 25 cents. Similarly, the negative yield shock state, $-\sigma_Y$, is considered to lie in the interval, $(0, \mu_Y)$ and the positive yield shock, σ_Y, is considered to lie in the interval, $(\mu_Y, 1)$, where μ_Y is the mean of the conditional beta distribution with $t = 2002$. Once we obtain the parameters of the conditional beta distribution of Y, we obtain EY_t using mn and mx in the profit function, as $EY_t = \mu_Y(N, t) * (mx - mn) + mn$. The same transformation is made to construct the possible new program yields and the yield shock state values. The yield shock states are approximately equal to ± 30 bu/acre deviations around the EY_t.

The expected price is estimated using the deflated average weighted price[11] for the years 1985-2007. The following equation was estimated for expected price:[12]

$$log(P_t) = 0.38 + 0.58 * log(P_{t-1}) + 0.40D_p \quad (6)$$

where D_p is a dummy variable which is equal to 1 for 1995 and 0 otherwise.[13]

Once we obtain the parameters of the marginal distributions of price and yield, we use a copula approach (Cherubini, Luciano, and Vecchiato 2004) to compute the joint probability distribution of price and yield. Sklar's theorem states that if $F(V, Z)$ is a joint distribution function with margins $F_1(V), F_2(Z)$, there exists a unique copula C, with domain $Ran\ F1 \times Ran\ F2$, such that $F(V, Z) = C(F_1(V), F_2(Z))$. Thus, it is possible to derive the joint probability distribution of any two random variables with any marginal distributions, using a copula. We use a bivariate Gaussian copula to derive the joint probability distribution of price and yield. The bivariate Gaussian copula is specified as:

$$C^{Ga}(v, z) = \frac{1}{\sqrt{1-\rho^2}} \int_0^v \int_0^z \exp\left(\frac{2\rho xy - x^2 - y^2}{2(1-\rho^2)} + \frac{x^2 + y^2}{2}\right) dsdt$$

where $v = F_V(V < v_1)$, $z = F_Z(Z < z_1)$, $x = \Phi^{-1}(s)$ and $y = \Phi^{-1}(t)$. Parameter ρ is the correlation coefficient between price and yield.

SDP_{VNB} is solved for 16 states (8 price states $\times$ 2 yield shock states), while SDP_{VB} is solved for 1052672 states (8 price states $\times$ 2 yield shock states $\times$ 256 base acreage states $\times$ 257 program yield states). While constructing the new program yields, we need to account for the possibility of the negative or positive yield shock occurring in each of the years 2003-2006. There are five unique possibilities with the yield shocks; negative shock in all the four years, positive shock in all the four years, negative shock in two years and positive shock in two years, negative shock in three years and positive shock in three years. We solve SDP_{VB} for each of these five cases and compute the expected VB which enters (3).[14]

SDP_{VB} and SDP_{VNB} are solved using backward recursion. The terminal value functions, VB_6 and VNB_6 are initially assumed to be the utility from profits that are close to zero.[15] We then solve for VB_1 and VNB_1 and substitute these back as VB_6 and VNB_6 to get an estimate of expected utility from future income. We then solve again for VB_1 and VNB_1. These are the values that enter in (3). Finally we calculate the present value of expected utility as defined in (3) for each base acreage state $\in BA'$ and program yield state $\in Y'_d$. The farmer maximizes the present value of expected utility over all base acreage, program yield, price and yield shock states.

Results

The solution to the optimization problem is the optimal planted acreage and nitrogen use in each of the years 2002-2006, conditional on the price state in the year 2001 and the farmer's subjective probability about the expected base acreage and program yield update. For ease of exposition, we present the results in terms of the average optimal planted acreage, $\bar{A}$, and the average yield determined by nitrogen use, $\bar{Y}$, over the years 2003-2006, which are determined by the price states. This is because the expected price states depend on the lagged price states (equation 6). This does not mean that yield shock states have no impact on the optimal acreage; they affect the acreage and nitrogen application rate in each year, though this effect is equal across all price states. Hence, we present the results for the eight price states. Note, that the optimal acreage and nitrogen application rate for 2002 are not affected by the possible future update, as they do not count towards updated base acreage or program yield.

$\bar{A}$ and $\bar{Y}$ for each of the price states and all values of δ are presented in table 3. With a few exceptions, $\bar{A}$ and $\bar{Y}$ strictly increase as δ increases. When $\delta = 0$, $\bar{A}$ and $\bar{Y}$ are determined by market conditions and farm programs in place in 2002-2006. Thus, $\bar{A}$ and $\bar{Y}$ at $\delta = 0$ are the benchmark to which we compare $\bar{A}$ and $\bar{Y}$ for $\delta > 0$. $\bar{A}_{|\delta>0} - \bar{A}_{|\delta=0}$ measures the supply effect of the expected base acreage update. Similarly, $\bar{Y}_{|\delta>0} - \bar{Y}_{|\delta=0}$ measures the effect of an expected program yield update on nitrogen application rates, which influence yields.

We also compute the percentage increase in $\bar{A}$ and $\bar{Y}$ for $\delta > 0$ relative to $\delta = 0$. These are presented in tables 4 and 5. For price states, \$1.625, \$1.875, and \$2.125, farmers receive both DPs and CCPs. There is therefore a stronger link between an expected update and future DPs and CCPs.[16] For the higher price states of \$2.375, \$2.625, \$2.875, \$3.125 and \$3.375, only DPs are made to farmers and therefore the results for these price states captures the supply effect of the expected base update for the "decoupled" DPs.[17]

The maximum percentage increase in $\bar{A}$ is 6.25% for \$1.625 and \$1.875 and $\delta = 1$ and for \$1.875 and $\delta = 0.75$. When we average over all price states, the percentage increase in $\bar{A}$ is 4.74% for $\delta = 1$. This falls to 3.04% for $\delta = 0.5$. When we average over the price states for which only DPs are received, the percentage increase in $\bar{A}$ is 3.84% for $\delta = 1$, which decreases to 2.4% for $\delta = 0.5$.

The percentage increase in $\bar{Y}$ is much smaller. When averaged over all the price states, the maximum percentage increase in $\bar{Y}$ is 0.055% for $\delta = 1$. The reason behind this result is that increasing nitrogen use has decreasing returns and increasing yields is costly. We also compute the percentage change in average output ($\bar{A} * \bar{Y}$), for $\delta > 0$ relative to $\delta = 0$.

The results are presented in table 6. The percentage change in average output is driven by the percentage change in $\bar{A}$. Averaged over all the price states, the maximum percentage increase in average output is 4.8% for $\delta = 1$.

To ensure that we do not constrain results with bounds of discretization, we also solve (3) for an extended range of acreage and nitrogen application rates, keeping the number of choices fixed. The new range for acreage starts at 800 acres, increasing in increments of 50 acres. The new range for nitrogen application rates starts at 180 lbs/acre increasing in increments of 5 lbs/acre. The results are robust to the new range and show that all solutions are truly interior ones.

We also solve (3) with $\Gamma = 0$, i.e, when there is no feedback from increased direct payments on the rental rate of land. The maximum percentage increase in $\bar{A}$ and average output is about 9%. The percentage increase in $\bar{Y}$ remains small. The 6-9% range in increase in acreage that we find represents an upper bound on the acreage supply response to an expected base acreage update. These results would be consistent with viewing our model as a stylized representation of aggregate agricultural supply.

Conclusion

There is a large literature analyzing the effects of decoupled payments in the United States (the PFC payments in the 1996 FAIR Act and the DPs in the 2002 FSRI Act) on farmer decisions. Results from the literature on decoupling as well as from our paper indicate that decoupled payments do have some coupling effects.

Our paper adds to the current literature, by formally examining and quantifying the role of base acreage and program yield updating in a farmer's decision making process on current acreage and fertilizer use decisions. The latter has been conjectured but not formalized in previous analyses. We analyze the effect of expected base acreage and program yield updates in the future (2007) Farm Bill on a farmer's acreage decision in 2003-2006, in the presence of price and yield uncertainty. The average optimal planted acreage under the current policy (2003-2006) is increasing in the subjective beliefs of the farmer about a future opportunity to update base acreage and/or program yield. We find that the maximum percentage increase in the average optimal planted acreage over 2003-2006 is 6.25%, and the maximum percentage increase in average yield from optimal nitrogen use over 2003-2006 is 0.134%. The maximum percentage in average output (the product of acreage and yield) over 2003-2006 is 6.39%. The results are conditional on price and certainty of an update being allowed.

Our results clearly indicate that expectations about future policies influence producer decisions. These results have important policy implications for the WTO negotiations in the Doha round. At present, the proposals of the U.S. and EU, or even the Harbinson proposal for the Doha round do not contain any changes to the green-box payments. Furthermore, the WTO ruling against the cotton DPs in the United States, was on the basis of the planting restrictions. The WTO Appellate Body did not rule against the base updating allowed for DPs because it was agnostic on its effects. Our results provide a measure of the effect of base acreage and program yield updating, which could help in future disputes on the legality of decoupled payments. Even though the magnitude of the effect is moderate, base acreage and program yield updating shouldn't be allowed for decoupled payments. Hence, the green-box criteria for decoupled payments must be made clear, with no room for ambiguities.

Lastly, our model assumes a single crop for tractability. In a more realistic scenario, farmers would plant more crops and DPs would affect the allocation of land between these crops drawing land away from non program crops in addition to drawing from idled land. We mimic this situation with a higher acreage supply response but without any ability to say what would happen to all individual crops. Rationalizing our model as a stylized aggregate agricultural model, our results provide an upper bound on the aggregate supply response to an expected base update. Last and somewhat offsetting, our analysis is conducted in the short run. In the long run, costs curves are flatter and one would expect the acreage response to be higher than in the short run, even in aggregate. In the long run, acreage expansion resulting from expected future base update would also increase.

Notes

[1]They find that on average farmers believe that there is a 40% chance of a future base acreage or program yield update being allowed.

[2]We realize that updates have not been allowed in new Farm Bill, however, the question we are analyzing is not specific to the current Farm Bill, but is relevant to any future Farm Bill. Furthermore, we are analyzing the role of expectations in influencing farmers' current decisions in the context of decoupled payments, a relevant question for all countries engaging in decoupled payments based on historical land and/or yield patterns.

[3]The 2002 Farm Bill also allowed the farmers to update program yields, as the sum of the program yield for direct payments and 70% of the difference between the average yields for 1998-2001 and the program yield for direct payments. We abstract from the latter possibility.

[4]This simplifying assumption is made to reduce the dimensionality of computations and can be rationalized as representing a stylized aggregate agricultural crop supply, especially for low values of acreage responses to price. As explained later, our cost of production specification indicates the ability to bring land into production but does not stipulate where the new land comes from (competing crops or idled land). We also abstract from rotational considerations.

[5] Payments similar in nature to CCPs were made during 1998-2001 on an ad hoc basis due to low prices. These payments were termed the Market Loss Assistance (MLA) payments, and were then essentially institutionalized as CCPs in the 2002 Farm Act.

[6]We compute η for Floyd county in Iowa, as we use yield data from an experimental farm, located in Floyd county. We discuss this in more detail in the numerical analysis section.

[7]We truncate all future Farm Bills to a single future Farm Bill. An extension of our model could solve for an infinite horizon to include future Farm Bills.

[8]We assume that the program yields for DP and CCP are the same.

[9]We use an estimate of acreage price elasticity equal to 0.412. This estimate has been taken from Lin

et al. 2000. Data for FC and R has been taken from ERS data on production costs for corn for the heartland region. The average for the years 2002-2006 have been used. Data for p_N has been taken from ERS data on U.S. fertilizer prices. The price of anhydrous ammonia has been used. See Appendix A1 for details on total cost calibration.

[10]We delete observations for years in which outliers were identified. Observations for years 1982, 1986, 1988, 1990, 1993 and 1999 were deleted.

[11]Weights were based on production of corn in each state for the heartland region. Prices were deflated using the GDP price deflator.

[12]All coefficients are statistically significant at the 5% level of significance.

[13]The observation for 1995 was identified as an outlier.

[14]There is a probability associated with each of these five cases, derived from the conditional beta distribution.

[15]We assume that profits are 0.01, as the utility function is not defined for zero profits.

[16]There is a positive probability associated with moving to higher price states from these lower price states, however the probability is small.

[17]There is a positive probability associated with moving to a lower price state from these price states, however the probability is small.

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Table 1. Model Parameters

Discount factor	β	0.95
Coefficient of relative risk aversion	ϕ	2
Fixed cost	FC	$ 81444
Rental rate	R	$ 102.14/acre
Fertilizer price	p_N	$0.19/lb
Cost Coefficient	b	-217.91
Cost Coefficient	c	0.0002
Correlation coefficient between price and yield	ρ	-0.34
Rent increase parameter	Γ	$0.33
LDP price gap	η	$0.36
5 bu less than observed minimum yield	mn	5.71 bu/acre
10 bu more than the observed maximum yield	mx	199.86 bu/acre

Table 2. Policy Parameters

Loan Rate (2002-03)	1.98
Loan Rate (2004-11)	1.95
Target Price (2002-03)	2.60
Target Price (2004-11)	2.63
Direct payment rate	0.28
Base acreage under current policy regime	825 acres
Program yield under current policy regime	134.97 bu/acre

Table 3. Optimal Choices over 2003-2006

Optimal Acreage (acres)					
Probability of update: δ	0	0.25	0.5	0.75	1
Initial Price State in 2001					
1.625	800	800	825	837.5	850
1.875	800	800	825	850	850
2.125	800	825	850	850	850
2.375	825	850	850	850	850
2.625	850	850	850	850	862.5
2.875	850	850	850	862.5	875
3.125	850	850	875	887.5	900
3.375	850	887.5	900	900	900

Yield from optimal N use (bu/acre)					
Probability of update: δ	0	0.25	0.5	0.75	1
Initial Price State in 2001					
1.625	145.43	145.53	145.63	145.63	145.63
1.875	145.43	145.53	145.63	145.63	145.63
2.125	145.53	145.63	145.63	145.63	145.63
2.375	145.63	145.63	145.63	145.63	145.63
2.625	145.63	145.63	145.63	145.63	145.63
2.875	145.63	145.63	145.63	145.63	145.63
3.125	145.63	145.63	145.63	145.63	145.70
3.375	145.63	145.63	145.63	145.70	145.70

Table 4. Percentage Change in $\bar{A}$ for $\delta > 0$ Relative to $\delta = 0$[1]

Probability of update: δ	0.25	0.5	0.75	1
Initial Price State in 2001				
1.625	0.00	3.12	4.68	6.25
1.875	0.00	3.12	6.25	6.25
2.125	3.12	6.25	6.25	6.25
2.375	3.03	3.03	3.03	3.03
2.625	0.00	0.00	0.00	1.47
2.875	0.00	0.00	1.47	2.94
3.125	0.00	2.94	4.41	5.88
3.375	4.41	5.88	5.88	5.88

Table 5. Percentage Change in $\bar{Y}$ for $\delta > 0$ Relative to $\delta = 0$[2]

Probability of update: δ	0.25	0.5	0.75	1
Initial Price State in 2001				
1.625	0.068	0.134	0.134	0.134
1.875	0.068	0.134	0.134	0.134
2.125	0.066	0.066	0.066	0.066
2.375	0.00	0.00	2.91	0.00
2.625	0.00	0.00	3.81	0.00
2.875	0.00	0.00	2.8	0.00
3.125	0.00	0.00	2.73	0.054
3.375	0.00	0.00	0.054	0.054

[1] $\bar{A}$ is the average of the optimal acreage planted over 2003-06.

[2] $\bar{Y}$ is the average yield over 2003-06 resulting from the optimal nitrogen application rate in each of those years.

Table 6. Percentage Change in Average Output for $\delta > 0$ Relative to $\delta = 0$[3]

Probability of update: δ	0.25	0.5	0.75	1
Initial Price State in 2001				
1.625	0.068	3.26	4.82	6.39
1.875	0.068	3.26	6.39	6.39
2.125	3.193	6.32	6.32	6.32
2.375	3.03	3.03	3.03	3.03
2.625	0.00	0.00	0.00	1.47
2.875	0.00	0.00	1.47	2.94
3.125	0.00	2.94	4.41	5.94
3.375	4.41	5.88	5.93	5.94

[3] Average output is computed as $\bar{A} * \bar{Y}$.

Appendix

Not intended for Publication

A1. Total cost calibration

Data for the fixed cost, FC, has been taken from Economic Research Service (ERS) data on production costs for corn. FC has been defined as the total allocated overhead per acre and includes the following: (i) hired labor, (ii) opportunity cost of unpaid labor, (iii) capital recovery of machinery and equipment, (iv) taxes and insurance and, (v) general farm overhead. Given FC, R and p_N, we solve for the coefficients, b and c, using the profit maximization condition and the acreage price elasticity. We calibrate total cost to the average of 2002-06 data. The corn price and yield, equal \$2.39/bu and 157 bu/acre respectively. For a 825 acre farm, $FC = \$81,444$.

(1)

$$\pi_t = \bar{P}_t \bar{Y}_t A_t + max(LR - (\bar{P}_t - \eta), 0)\bar{Y}_t A_t + DP + CCP - (FC + (b + R + p_N N)A + cA^3).$$

DPs and CCPs do not enter into the profit maximization condition. The average LR over 2002-06 was \$1.96/bu, which results in a LDP payment rate of 0. The profit maximization condition is:

(2) $$\frac{\partial \pi}{\partial A} = \bar{P}\bar{Y} - b - R - p_N N - 3cA^2 = 0.$$

Acreage price elasticity implies:

(3) $$\frac{\partial A}{\partial \bar{P}}\frac{\bar{P}}{A} = \left(\frac{\bar{P} * \bar{Y} - b - R - p_N N}{3c}\right)^{-1/2} \frac{\bar{P} * \bar{Y}}{6cA}.$$

We solve for b and c for $A = 825$ acres and $N = 182.5$ lbs/acre[1]. The acreage price elasticity is equal to 0.412. We get $b = -217.91$ and $c = 0.0002$.

[1]These are the mid-points of the range of choices for A_t and N_t.