Are U.S. Agricultural Subsidies Amber or Green?*

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Abstract

Agricultural subsidies levied by industrial countries have been a source of contentious debate in multilateral trade negotiations. Developing countries argue that subsidies result in an overproduction of crops which depress prices on the world market. The 1996 and 2002 U.S. Farm Bills decoupled agricultural subsidies from current production, so the subsidies should be minimally trade distorting, but a provision in the 2002 Farm Bill that allowed farmers to update their subsidy base potentially broke this decoupling mechanism. The results suggest that farmers did anticipate a base update, which technically violates the classification of decoupled subsidies in the WTO's Green Box, but the magnitude of the distortion was small. However, under the assumption that farmers forecast a base update with certainty, which may be a more accurate reflection of the current policy environment, the acreage distortions are larger, and this questions the future ability of the U.S. to classify decoupled subsidies in the Green Box. So while decoupled subsidies appear to have been minimally trade distorting, future base updates may play a role in depressing international prices.

Keywords: Decoupled Subsidies, Agricultural Trade, International Crop Prices, Base Updating

JEL Codes: F13, O19, Q12, Q17

1 Introduction

Agricultural subsidies have been a major obstacle in GATT/WTO multilateral trade negotiations. The collapse of the current Doha Round talks at Cancun in September 2003 has been blamed on the refusal of developed countries to dramatically reform their agricultural domestic support policies.[1]

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[1] See "The WTO under fire - The Doha round", *The Economist*, September 20, 2003 (U.S. Edition).

For the first time, developing countries organized to form a powerful coalition that was able to resist mediocre reform proposals put forth by the U.S. and European Union (E.U.). Cotton subsidies, in particular, became a focal point of talks as the Communaute Financiere Africaine (C.F.A.) countries, who together are the third largest cotton exporters, claimed that U.S. agricultural support causes an oversupply of U.S. cotton, which severely depresses cotton prices and consequently their export earnings. Goruex (2003) has argued C.F.A. countries lose more than $130 million dollars each year due to U.S. cotton support. On the other hand, Panagariya (2005) argues that since the poorest countries in the world are net agricultural importers, higher import prices caused by the removal of subsidies would actually lower these countries' welfare and Ashraf et al. (2005) provide some evidence for this hypothesis. To add further complexity, these arguments are conditional on cointegration between producer and international prices, which may be weak, particularly in Africa. Fafchamps et al. (2003) have highlighted the lack of perfect price transmission between international coffee prices and farmer prices in Uganda. So, the issue of the welfare effects of agricultural subsidies on the poor remains controversial in both the policy and academic arenas.

The WTO *Agreement on Agriculture* classifies agricultural support programs into three boxes: Amber, Blue and Green. Amber Box subsidies are programs that directly influence production and consequently distort agricultural trade. The U.S. marketing loan program, which provides a floor on crop prices, is an example of an Amber subsidy. Amber subsidies contribute to the total Aggregate Measures of Support (AMS) and are subject to reduction commitments agreed upon by WTO member countries. The Blue Box subsidies are also trade distorting subsidies but contain provisions to transition into the Green Box. The U.S. did not report any Blue Box subsidies between 1996-01 but the E.U. classified approximately 22% of its total support into this category. *Decoupled subsidies*, which are lump-sum transfers based on a defined planting history, qualify as Green Box subsidies since they are designed to be minimally trade distorting. According to the WTO *Agreement on Agriculture*, these payments must be based on production levels in a fixed reference period and not related to production or prices after the reference period. Furthermore, having established a base, no production in subsequent years is required to receive payments. The U.S. agricultural policy is explained in more detail in Section 2.

Since decoupled subsidies in theory do not distort current production, they (along with the temporary Blue Box support) are exempt in the calculation of a country's AMS. As a result, decoupled subsidies are becoming an increasingly popular avenue of domestic support; in addition to the U.S., the E.U., Mexico, and Turkey currently use decoupled subsidies to support their farmers. Therefore, in order to assess the impact of agricultural support on developing countries, it is important to understand how these direct payments work and to what extent they are decoupled from production and are not trade distorting.

U.S. agricultural policy is formulated in sequences of five to seven year bills, known as Farm

Bills. The 1996 Farm Bill was a radical change from existing U.S. farm policy since it decoupled subsidy payments from current production and prices. Subsidy payments continued to be the product of a base (or contract) acreage, program yield, and the crop subsidy rate, but the legislation changed the calculation of each component. Whereas previous subsidy rates were inversely related to price, the rates for the 1996 Farm Bill (1996-02) became essentially fixed. Under the previous bill, a farmer's crop base (program yield) was a rolling average of planted acres (realized yield). The 1996 Bill fixed the base acreage and program yields at 1991-95 averages. So, for seven years, farmers received lump-sum payments for each crop based on their 1991-95 planting history. The 2002 Farm Bill (2002-07) continued to decouple payments, but it made two important changes. First, the government partly re-introduced price-dependent subsidy rates to counter a series of low crop prices. More importantly, farmers were allowed a one-time option to change their base to reflect their 1998-01 planting average. The impact of allowing farmers to update their base in 2002 is the focus of this paper.

Economists have challenged the assumption that decoupled subsidies do not affect production.[2] Sumner (2003) argues that anticipation of the base update provision in the 2002 Farm Bill caused acreage distortions in the prior years. He uses a rough back-of-the-envelope calculation to argue that the potential to update base could translate to subsidies being 27 percent as linked to current production as coupled payments (such as marketing loans).[3] Sumner incorporated this assumption into his economic report for Brazil's formal complaint in the WTO against U.S. cotton subsidies. The WTO ruled broadly in favor for Brazil in April 2004. Brazil also challenged the update provision in the 2002 Farm Bill, but in response, the WTO Appellate Body wrote:[4]

> "The Appellate Body ... *declines to rule* on Brazil's conditional request that the Appellate Body find that the updating of base acres for direct payments under the FSRI Act of 2002 (the 2002 Farm Bill) means that direct payments are not Green Box measures that fully conform to paragraph 6(a) of Annex 2 of the *Agreement on Agriculture* ...." [italics mine]

So while some, including Baffes and Gorter (2003), have argued that the base update violates the WTO definition of decoupled subsidies, and should therefore be classified within the Amber Box, the WTO itself remains unclear on the implications of base updating. But while most

[2]See Tielu and Roberts (1998), Roberts and Jotzo (2001), Vercammen (2004), Hennessy (1998) and Sumner (2003). These papers argue that lump-sum transfers create a wealth effect, which makes farmers both less risk averse and less credit constrained and this leads to increased crop production. While there have been Computable General Equilibrium (CGE) models that have addressed the effects of the 1996 Farm Bill on acreage (for example, see Lin et al. (2000)), Goodwin and Mishra (2002) and Key et al. (2004) are the only studies to my knowledge that provide an econometric analysis of U.S. acreage response to decoupled subsidies. Goodwin and Mishra (2002) find that the subsidies had a small impact on acreage but Key et al. (2004) find that crop acreage among farmers who participated in government programs increased relative to those who did not receive payments between 1992 and 1997.

[3]This assumes that farmers expected an update within five years with probability 0.6.

[4]see WTO document WT/DS267/AB/R, page 289.

authors acknowledge that decoupled subsidies may be linked with current production through base updating, there have been no empirical tests of this hypothesis.[5] This paper uses a pseudo-panel, constructed from the USDA's Agricultural Resource Management Survey (ARMS), to test the extent that farmers' expectations of a future policy change affected their current production. Specifically, I investigate if crop acreage prior to the policy change was influenced by expected future subsidy payments. If so, this casts doubt on the classification of these subsidies in the WTO Green Box.

The results suggest that farmers anticipated the base update and the evidence is particularly strong in 2001, one year prior to the actual occurrence. I also find that relative cotton plantings were influenced by future subsidies, which may imply that farmers were building their cotton base at the expense of low-valued bases. Using a structural model, I estimate the probability of expecting a base update in 2001 at 42%, which coincides with the official estimate that 40% of farmers updated their base (see Young et al., 2004). However, the structural model reveals that anticipation lead to only small distortions. The total cotton and rice acreage distortions are estimated at only between 1.4-2.3%. So while both the reduced form regressions and the structural model suggest that farmers expected a base update prior to the 2002 Farm Bill, the acreage response was modest, especially in comparison to the acreage response caused by Amber Box subsidies (the marketing loans). I conclude that the base update had a statistically significant, but an economically insignificant impact on acreage and that U.S. decoupled subsidies are minimally trade distorting. However, anticipating a base update with certainty, which may be a closer reflection of reality now that the government has already allowed this, would have resulted in cotton and rice distortions between 3.5-5.8%. These potential distortions are not insignificant, given that these payments should be entirely decoupled from current and future plantings. So if farmers believe with certainty that another base update will occur at the end of the current farm bill (in 2007), economists and policy makers should be concerned about the implications on international prices for the exported commodities.

The remaining paper is organized as follows. Section 2 briefly summarizes the recent changes in U.S. agricultural policy. Section 3 proposes a theoretical framework that shows the potential effects of subsidies on acreage choices. Section 4 discusses the data and provides summary statistics. Section 5 uses a reduced form strategy to test if farmers anticipated the base update. Section 6 estimates a structural model and quantifies the distortion caused by subsidies, and Section 7 concludes.

2 U.S. Agricultural Policy

For the last three farm bills, subsidies have remained the product of a base acreage, program yield and subsidy rate. What has changed in each bill is the way each component is calculated. Subsidy

[5] Goodwin and Mishra (2002) provide anecdotal evidence that farmers were producing certain crops with an expectation that future policy changes would allow them to alter their base.

rates were price dependent during the 1991 Farm Bill (1991-95). Farmers received a payoff, known as a *deficiency payment*, if the commodity price fell below a pre-specified target price. A crop's base acreage in a given year was calculated as the rolling previous five year average of acres planted.[6] So, subsidies during this period were not decoupled since a farmer could constantly alter his base each year. The price dependent subsidies, in addition to the marketing loans (discussed below) that provided a floor on the crop price, provided a safety net in times of low prices. In order to receive payments, farmers were required to follow land idling requirements, which restricted farmers from planting beyond an announced percentage of area to certain crops.

The surprise Republican victory in November 1994 election gave the Republicans control of both Houses in Congress for the first time in forty years. In June 1995, the Republican party, traditionally the party that supported a more market oriented approach to agricultural policy, drafted an "unexpected" proposal that outlined the path towards decoupled subsidies which "attracted immediate interest when it was circulated, despite its radical break with past farm support policies" (Orden et al., 1999, p. 135). The proposal sought to fully decouple major crop subsidies from production by fixing farmers' base acreage and yields, which became known as *production flexibility contracts* (PFC). Along with the lifting of the idling requirements under the previous bill, the PFC payments were meant to allow farmers to follow a market oriented approach in determining their crop choice. Farmers could receive payments even if they did not actually plant the crops; they simply needed to have established a crop base to receive the PFC payments. The payments were a function of the crop base, which became frozen at the 1991-95 average planted acres, and the yields, which were fixed at 1995 levels.[7] The subsidy rates were decoupled from prices and were essentially fixed in legislation.[8] So for the next seven years, farmers received lump-sum payments on an historic base and yield and these payments were independent of current prices.

Budgetary reasons and the desire to revoke the mandatory idling requirements were major factors in introducing PFC payments. And given that the decoupling scheme was first proposed in June 1995, this would have been at the end, or close to the end, of most crops' planting season. Therefore, it is generally believed that farmers did not anticipate the base freezing, and even if they had, the implication would have been small because the planting season was essentially over. The proposal allowed the government to reduce the uncertainty of budget flows that resulted from price dependent subsidies. Moreover, farmers were eager to accept the bill because it removed idling requirements and at that time, they were enjoying extremely high commodity prices. With subsidies

[6]Program yields were computed as the previous five year Olympic average, which excludes the maximum and minimum values in the period, of realized yields.

[7]The 1996 Bill actually did allow farmers to alter their base adding or subtracting land from Conservation Reserve Program (CRP).

[8]The subsidy rates were determined by the total base acreage each year, and since the base acreage was not permanently fixed, the rates were not *exactly* known. However, the rates were known with a fair amount of certainty and so I treat the base acreage as fixed and the payment rates as known in the models below.

inversely related to prices, they would have received no payments if prices remained high. Under the new bill, they were assured payments irrespective of current prices. Furthermore, commodity prices were projected to remain high, so the new policy garnered political support and was signed into law in April 1996.

Another major form of support is the marketing loan program, which has been a cornerstone of agricultural policy since the 1930's. The loan program works as follows. At the beginning of the crop season, the government announces a national loan rate and farmers receive a loan by pledging their crop as collateral.[9] Loans are repaid based on a repayment rate, which is based on local prices for some crops, or world prices for others (cotton and rice). If the repayment rate is above the loan rate, the farmer repays the loan with interest. If the repayment rate falls below the original loan rate, the farmer can forfeit the collateral to the government. Therefore, the original loan rate acts as a price floor for the crop. The 1996 Farm Bill introduced *loan deficiency payments* (LDP), which is essentially the same scheme, but instead of the government receiving the crop if prices fall, the farmer receives the LDP, equal to the difference between the loan rate and repayment rate, and sells the crop through the normal marketing channels. These loan programs are classified as Amber Box support in the WTO because they are clearly trade distorting. The magnitude of acreage distortion caused by the loan scheme is discussed in Section 6.

Farmers enjoyed high commodity prices during the first two years of the 1996 Farm Bill. However, between 1998-02, commodity prices crashed. Lacking the safety net that price dependent subsidies provided, the government passed disaster relief support in 1998-01, known as *market loss assistance* (MLA). The MLA payments were also based on base acreage, and therefore, decoupled from current production but not, of course, from prices. According to Sumner (2003), the MLA payments were one and a half times the decoupled payment rates in 1998 and double the payment rates in 1999-2001. These MLA payments clearly contradicted the decoupling of subsidies from prices and were therefore classified in the Amber Box. Figure 1 graphs the total U.S. domestic support from 1996-00. The Amber Box subsidies are low in 1996 and 1997, when prices were low, but then rose dramatically because of the loan payments and MLA payments. In 1996, the Amber subsidies filled approximately 26% of the AMS ceiling, but this increased to 88% by 2000.

To circumvent a similar situation from re-occurring, the 2002 Farm Bill re-introduced a farmer safety net by making the subsidy rate partly fixed (now called *direct payments* instead of PFC payments) and partly price dependent (called *counter-cyclical payments*). The 2002 Farm Bill can be thought of as a compromise between the two previous bills; subsidies remained decoupled

[9] Loan rates for corn and wheat were based on the previous 5-year Olympic price average. Rice rates were fixed in legislation and cotton loan rates were a function of the 5-year Olympic spot market prices. Sorghum, barley and oat loan rates were "set at a level considered fair and equitable relative to the feed value of corn." (see `http://www.ers.usda.gov/Features/farmbill/titles/titleIcommodities.htm` for details). Loan rates are adjusted to the county level.

but are partly tied to prices.[10] The payments continued to be a function of base acreage and yields, which again remained fixed throughout the Bill from 2002-07. However, farmers were given a one time option to update their crop bases to reflect their 1998-01 planting history, and were allowed to establish oilseed base for the first time.[11]

The idling requirements prior to the 1996 Farm Bill prevented farmers from choosing their optimal crop portfolio. So when the bases were frozen unexpectedly in 1996, farmers were likely to have received payments based on sub-optimal base acreage allocations. The base update provided farmers the opportunity to trade away low valued bases in favor for higher valued bases. One concern is that if farmers anticipated the update, farmers "stuck" with a suboptimal base allocation because of the land idling requirements would alter their crop choice to secure a more profitable future base allocation. A second concern is that even farmers who held an optimal base allocation could have ensured larger future subsidy payments by switching from growing low-valued crops to producing high-valued crops in order to establish a more profitable base allocation for the future farm bill. This is a particularly relevant issue for cotton-exporting nations since the overproduction of U.S. cotton would have depressed world prices. Furthermore, this concern is not just historical since farmers may be expecting another update in 2007.

Table 1 shows that rice and cotton bases are considerably more valuable than wheat, sorghum, barley and oats.[12] The ranking of the subsidy rates closely reflects the rankings of revenue per acre (see Table 2), so while farmers may not know the exact subsidy rates in the future, they could predict the relative value of the crop subsidies with certainty. Since cotton is a valuable crop base, anticipation may have lead to an overproduction in cotton. Young et al. (2004) find evidence that farmers substituted low-valued bases, such as barley and oats, for valuable bases like cotton and rice. The important question from a trade perspective, though, is not how the farmers re-allocated their land, but if this base update was anticipated prior to the 2002 update provision. If so, farmers may have built valuable crop base at the expense of lower valued crops. The model developed in the next section formalizes this argument.

3 Model

This section incorporates the subsidy provisions to develop a general framework for analyzing a farmer's response to decoupled subsidies. The model is used to motivate reduced form regressions

[10]Most observers believe that had the government not reinstated the price dependent subsidies in 2002, the MLA payments would have continued since prices were still low.

[11]Those who updated their base were also given the option update their program yields as well. The rules were somewhat complicated. For an excellent summary, see Young et al. (2004).

[12]The per acre payments in the table are calculated assuming the national average program yields for each crop, so it is possible that farmers who are extremely efficient at producing, for example wheat, could receive a higher per acre wheat subsidy than corn.

that test the potential for building crop base acreage and is then directly estimated by imposing structure on the model.

U.S. agricultural policy is reassessed every five to seven years. Consider the simplified version where the current decoupled subsidy policy lasts for T years (which is known to farmers). At time T, the policy is reassessed; the government either continues the policy forever with no change *or* allows farmers the one-time option to update their base acreage. If they update, this new base becomes fixed from time T to infinity. The decision is *a priori* unknown and farmers place a probability, ρ_t, that the government will allow base updating. The probability parameter is time dependent to allow farmers to update their beliefs as news dissipates closer to time T, but the mechanism by which farmers update their beliefs is not explicitly modeled.

I assume risk-neutral farmers maximize the present value of discounted future profits, which is assumed to be additively crop and time separable, from time zero to infinity. The farmer is assumed to maximize profits over the set of all possible crops, denoted J. Therefore, a farmer in, say, Montana, is allowed to grow cotton, but would probably choose zero cotton acreage because weather and soil conditions are not conducive for growing cotton. The farmer's maximization problem is

$$\max_{\left\{a,x\right\}_{j,t=0}^{J,\infty}} E_0 \sum_{t=0}^{T-1} \beta^t \sum_{j=1}^{J} \Big[\pi_{jt}(a_{jt}, x_{jt}, p_{jt}; \theta_j) + \xi_{jt}\bar{\eta}_j\bar{a}_j\Big] + (1-\rho_t) \sum_{t=T}^{\infty} \beta^t \sum_{j=1}^{J} \Big[\pi_{jt}(\cdot) + \xi_{jt}\bar{\eta}_j\bar{a}_j\Big]$$
$$+ \rho_t \max\left\{ \sum_{t=T}^{\infty} \beta^t \sum_{j=1}^{J} \pi_{jt}(\cdot) + \xi_{jt}\bar{\eta}_j\bar{a}_j, \sum_{t=T}^{\infty} \beta^t \sum_{j=1}^{J} \pi_{jt}(\cdot) + \xi_{jt}\bar{\eta}_j \sum_{l=1}^{4} \frac{a_{j,T-l}}{4} \right\} \quad (1)$$

subject to a land constraint, $\sum_{j=1}^{J} a_{jt} \leq A_t$. The first term of (1) is the farmer's discounted profits in the first regime, from time zero to $T-1$. His before-subsidy profits for crop j at time t, $\pi_{jt}(a_{jt}, x_{jt}, p_{jt}; \theta_j)$, are assumed to be a function of acreage denoted by a_{jt}, a vector of inputs denoted by x_{jt}, price denoted by p_{jt}, and crop-specific parameters, θ_j. During this period, the farmer receives decoupled PFC payments which are the product of the subsidy rate, ξ_{jt}, and his fixed base acreage and yield (which is assumed exogenous at the beginning of time), denoted $\bar{a}_j$ and $\bar{\eta}_j$, respectively.[13] The farmer discounts future profits by the factor β. The farmer places a probability, ρ_t, that the government will allow a base update. If this situation does not occur, the farmer continues to receive payments based on the fixed acreage and yield. If the government allows an update, the farmer is given the option to update his base.[14] If he chooses not to update, his base remains the same as the previous $T-1$ years. If he chooses to update, his new base becomes the average of the previous four years' plantings. Note that if the farmer chooses to update, he must update all his crop bases, as was required by the 2002 Farm Bill. Although in reality the marketing

[13]The PFC payments are actually equal to 85% of the product of the subsidy rate, base and yield, but this detail is ignored for now.

[14]Farmers were allowed to update their yields under a complicated set of rules, but this detail is ignored here and throughout the analysis. The main predictions of the model do not change by assuming fixed yields.

loan program plays a significant role in the farmer's optimization problem, it is not modeled here for simplicity. The structural model in Section 6 deals with the loan issue.

To analyze the model, first suppose $\rho_t = 0, \forall t < T$, so the farmer believes with probability one that his current base and yield designation will remain unchanged after the policy assessment. Under this scenario, the subsidies are theoretically decoupled since they do not distort the first order condition (FOCs) with respect to acreage choice.

Now suppose $\rho_t > 1$. This introduces acreage distortions. To solve the problem, the farmer computes his optimal control sequence conditional on updating and not updating and then chooses the sequence that provides him the maximal value. Conditional on updating, the acreage FOCs are

$$0 = \begin{cases} \frac{\partial \pi_{jt}(\cdot)}{\partial a_{jt}} - \lambda_t, & \forall j,\ t \notin \text{[T-4,T-1]} \\ \frac{\partial \pi_{jt}(\cdot)}{\partial a_{jt}} + \frac{\rho_t \bar{\eta}_j}{4} \sum_{l=0}^{\infty} \beta^{T-t+l} \xi_{j,T+l} - \lambda_t, & \forall j,\ t \in \text{[T-4,T-1]} \end{cases} \tag{2}$$

The farmer chooses the path that gives him the maximal value. The second term in (2) represents crop j's acreage distortion caused by base updating. Note that the degree of the distortion rests on 1) the magnitude and distribution of the probability parameter ρ_t across time and individuals and 2) the magnitude of the future subsidy value. *Ceteris paribus*, the distortion should be greater for cotton and rice because the subsidy rates, ξ_{jt}, are higher than for wheat and barley. Also note that the distortion only occurs in the four years prior to the base update. The model predicts no distortions for the beginning years of the policy or in the years after the base update decision. Once the decision is made, crop bases remain fixed forever and the subsidies revert to lump-sum transfers. The model can be used to test the hypothesis that farmers anticipated the base update. If ρ_t is close to zero, this suggests that the update provision was not anticipated and that payments are decoupled. If ρ_t is significantly different from zero, this is evidence that the decoupled mechanism was flawed. The data used to analyze the model are discussed in the next section.

4 Data

Farm-level panel data would be ideal to test the model developed above but such data do not exist for U.S. farmers. I therefore use the ARMS data, which is a nationally representative, repeated cross-sectional survey of U.S. farms from 1996-2003. The ARMS data sampling procedure is such that working at the county level is too small a unit, thereby necessitating district level aggregation to create the pseudo-panel.[15] In the data, there are only about 6-9 farms per county, while there are between 45-50 farms per district. Since working at the county unit results in far fewer farms, aggregating to the district level represents a good compromise between obtaining precise estimates

[15]The USDA has defined districts, called crop reporting districts, that aggregate several counties within a state by agricultural similarities. See `http://www.ers.usda.gov/Emphases/Harmony/MoreFeatures.htm` for a map of the districts.

and spatial variation. Unfortunately, since the ARMS sampling procedure only provides state-level weights, I aggregate the farms using simple averages. Only the 2002 and 2003 ARMS surveys report crop base acreage and yields under the two farm bills. But since the 1996 Farm Bill precluded base altering, except under certain circumstances, I pooled and aggregated the program participation data to obtain district-level base and yield values under both farm bills, and then matched these district values to the previous years data. I also obtained state and national price levels and county-specific loan rates from USDA publications.[16]

Table 2 reports summary statistics for each crop. The table shows that the district average revenue per acre for each crop closely mirrors the order of the subsidy per acre payments in Table 1. The median base acres for 1996 and 2002, reported in columns 3 and 4, appear low and the reason for this is mostly likely non-response. It appears that the sensitivity of agricultural subsidies led some large farms not to report their base acreage.

As the table indicates, the percentage increase between 1996 and 2002 cotton and rice base acres was larger than wheat and oats, suggesting that farmers traded away less valued bases in favor of more valuable bases. Analyzing the individual-level data in the 2002 and 2003 ARMS surveys sheds more light into this phenomenon. Column 1 of Table 3 shows that just about half of the farmers surveyed in 2002 and 2003 updated their base acreage for each crop, which is slightly higher than the 40% number reported in Young et al. (2004). Of those who updated, however, columns 2 and 3 show that most farmers increased high valued bases like cotton and rice, but a much smaller fraction increased low valued bases like barley and oats. This fact is further highlighted in Table 4, which reports average cotton base share under the 1996 and 2002 Farm Bills for farms above and below the other median crop base shares. For example, farms above the median wheat share in 1996, on average, increased their cotton base share from 23% to 41%. Those below the median wheat share only increase their cotton base share from 55% to 59%. The same is true for sorghum; those above the median sorghum share in 1996 increased their cotton base from 34% to 44%, while those below the median only increased from 52% to 57%. Corn and barley display the the same pattern. Rice, a high valued base, has the opposite trend; farms with a relative large rice base decreased their cotton share, while those with a small share increased cotton base. This is consistent with farmers maximizing their subsidy payments by trading off low valued bases for high valued bases.

5 Reduced Form Model

The model developed in Section 3 predicts that if farmers anticipated a base update, future subsidies will distort current production. If the update was unanticipated, then the subsidies were truly

[16] I thank Tom Fink for providing the county-level loan rates. County-level rice loan rates were not available and are therefore not included in the analysis. If county-level loan rates were missing, I used state or national rates depending on availability.

decoupled from production. This section tests this hypothesis using a reduced form approach. Recall that the model gives the following acreage FOCs for each farmer

$$0 = \begin{cases} \frac{\partial \pi_{jt}(\cdot)}{\partial a_{jt}} - \lambda_t, & \forall j,\ t \notin \text{[T-4,T-1]} \\ \frac{\partial \pi_{jt}(\cdot)}{\partial a_{jt}} + \frac{\rho_t \bar{\eta}_j}{4} \sum_{l=0}^{\infty} \beta^{T-t+l} \xi_{j,T+l} - \lambda_t, & \forall j,\ t \in \text{[T-4,T-1]} \end{cases} \tag{3}$$

where T is the date of the policy reassessment. These equations implicitly define each farmer's optimal acreage choice for crop j at time t. I assume farmers choose amongst a fixed set of J crops, and as a result, there are many corner solutions in the data where farmers choose acreage of crop j equal to zero.[17] I therefore estimate (3) using Tobit regression methods. Specifically, I run the following regression for each crop separately[18]

$$a_{it}^* = \beta_0 + \beta_s s_i + \sum_{l=1}^{T+1} (\zeta_l * s_i)\, \gamma_l + \beta_d d_{it} + \beta_{\bar{a}} \bar{a}_i + z_i' \beta_z + \sum_{l=1}^{T+1} \zeta_l + \nu_i + \epsilon_{it}, \tag{4}$$

$$a_{it} = \max(0, a_{it}^*) \tag{5}$$

where a_{it} is the acreage choice of crop j by district i at time t, $\bar{a}_i$ is 1996 base acreage, d_{it} are the decoupled subsidies (included MLAs) measured in total dollars from 1996-01[19], z_i is a vector of soil characteristics, ζ_l is a year dummy ($= 1$ if $l = t$) and ν_i is a district random effect. The error disturbance is denoted ϵ_{it}. The future subsidy term, s_i, is the empirical analog to the right term in (3) and is computed

$$s_i = \bar{\eta}_i \left(\xi_{T+1} + \xi_{T+2}\right), \forall j \tag{6}$$

where ξ_{T+l} denotes the crop subsidy rate at time $T + l$ and $\bar{\eta}_i$ denotes the district's fixed yield.[20,21] Note that since the subsidy rate is constant across districts, this variable is essentially a rescaling of the district's fixed program yield.

The expected subsidy (s_i) and subsidy-time interaction ($\zeta_l * s_i$) coefficients are the main interest. The interpretation of the subsidy coefficient is that holding other factors fixed, a dollar increase in the expected subsidy increases current acreage by β_s. The interaction coefficients, γ_l, are interpreted as the additional impact of future subsidies in a given year. If the regressions find $\beta_s \neq 0$, however, this does not necessarily imply that subsidies are not decoupled. Districts

[17] The set of crops include barley, corn, cotton, oats, rice, sorghum, soybeans and wheat.

[18] I run the model from 1996-2003, where $T = 2002$ (hence the summation to time $T + 1$).

[19] So d_{it} is the product of the subsidy rate at time t and the 1996 base acreage and program yield. For 2002-03, I set this variable equal to zero.

[20] As in the theoretical model, I assume that farmers could only update their base acreage. Allowing yield altering makes the future subsidy term, s_{ij}, endogenous and therefore complicates the analysis without providing any additional insights.

[21] Since subsidy rates in the 2002 Farm Bill were partly price dependent (the CCPs), I assume that farmers had "perfect foresight" with respect to future prices and the CCP payments. This assumption is maintained throughout the analysis. Note that since the subsidy rates are common to all agents, I do not actually need to multiply the yields with the rates. I do so to be consistent with the model above. The analysis would not change if I define $s_i = \bar{\eta}_i$.

with higher historic yields, captured by s_i according to equation (6), for a given crop should be associated with larger acreage for that crop. However, there is no reason to believe that historic yields should have *differential* impacts across years, especially when controlling for year effects and the base acreage, which captures the district's planting history. So the γ_l coefficients are of primary importance and non-zero estimates are evidence that the subsidies are not truly decoupled. Since the subsidy terms are interacted with time, the γ_l terms also serve to proxy the role of the probability term in (3). The model indicates that even if the base update was anticipated with perfect foresight, subsidies should not distort acreage choice for $t \notin$[T-4,T-1] (1996-97 and 2002-03). Between $t \in$[T-4,T-1] (1998-01), if the expectation of a future update increased as time progressed, these coefficients should be increasing over time. Therefore, if the base update was anticipated, I expect an inverted-U type curve of the γ_l coefficients; the coefficients from 1998-01 should be increasing and significant, while the coefficients outside this time frame should be insignificantly different from zero.

The specification allows for a district random effect, denoted ν_i. While the assumption that ν_i is uncorrelated with the covariates may be strong, it is required in this case. The reason is that s_i is time invariant. Estimation using district fixed effects would wash away this term and leave the γ_l terms difficult to interpret since these terms capture the effect of *all* time-invariant unobservables on acreage over time, instead of just the impact of the future subsidies. As a result, I specify a random effects Tobit model and try to control for unobservables that would be correlated with s_i. I use detailed soil characteristics as one set of controls.[22] The soil vector includes average PH, calcium carbonate, clay content, gypsum, organic matter, soil permeability rate, cation exchange capacity, bulk density, liquid limit, plasticity index, salinity and the Sodium Absorbtion Ratio. Also included are measures of rock fragments (percentage weight of rock fragments in the soil between three and ten inches and greater than ten inches) and the fraction of soil that can pass through a number 4, 40, and 200 sieve, respectively. The second control is the 1996 reported crop base, $\bar{a}_i$, which proxies the district's capability of growing the crop. Note that since this variable is determined prior to 1996, it is also exogenous in the regression.

The marginal effects of the Tobit regressions are reported in Table 5 and for ease of exposition, the γ_l coefficients for each crops are graphed in Figures 2-9. An inverted-U curve appears for the barley, corn, cotton, rice and soybean regressions. For these crops, the marginal effect of future subsidies is largest in 2001 and highly significant. The wheat, sorghum and oats graphs do not display a strong pattern. The soybean graph shows there is a sharp increase in 2001 coefficient (see Figure 8). Prior to the 2002 Farm Bill, soybeans were not a program crop and therefore not eligible for PFC payments. The 2002 Farm Bill allowed farmers to use their recent historic planting averages to establish soybean base, which is fairly valuable. The graph shows a sharp increase in soybean acreage in response to future subsidies in 2001, suggesting that farmers may have planted

[22]The soil data come from the USDA Natural Resources Conservation Service (1995) database.

soybeans in anticipation of future subsidies, which at the time they did not receive.[23] The table shows that the marginal impact of the s_i variables are large for the lower valued crops and for soybeans. This result is expected. A subsidy rate increase of one dollar on lower valued crops is a larger percentage increase for these crops and so the marginal increase on acreage should be higher for these crops. And since soybeans were not eligible for PFC payments between 1996-2001, it is not surprising that the marginal impact of future subsidies is large conditional on farmers anticipating a base update. The marginal response for cotton, however, is only three acres in 2001. For rice, it is even small at less than one acre. This implies that while farmers anticipated a base update–the future subsidy variable is highly significant and the measured impact is greatest in 2001 for most crops–the magnitude of the effect, at least for cotton, is small. I return to the magnitude of the distortion in Section 6.

Turning to the other coefficients, the base acreage coefficient is positive and highly significant for all crops. This variable captures the district's planting history and therefore should be highly correlated with acreage. The coefficient on current subsidies, reported in the first row of Table 5, is negative and significant for some crops, but the magnitude is very small, which suggests that this coefficient is a precisely estimated zero. Goodwin and Mishra (2002) find evidence that decoupled subsidies are positive and significantly associated with current acreage, but the effect is small. Although it is difficult to compare their results to mine since their measure of decoupled payments is at the farm level, not at the crop-level, my findings of a negligible impact are consistent with their results.

The Tobit regressions in (4) are, of course, sparse and contain omitted variables. Crop acreage choice, derived in (3), is a function of the current environment, including the relative factor prices, loan rates, as well as competing crop prices. I omit these variables since they are likely to be endogenous. As a robustness check, however, I re-run the regressions including the crop price and loan rate as additional covariates.[24] The marginal effects, reported in Table 6, do not dramatically change the future subsidy coefficients. The price coefficients, which are negative and significant for most crops, are difficult to interpret since they are endogenous. The loan variable is only statistically significant for cotton (negative) and soybean (positive). Falling prices between 1998-02 caused the USDA to set loans rates to their maximum value during these years. Since there is very little variation both across time and districts, it is not surprising that the loan coefficients are not precisely estimated for most crops. The important point, however, is that the γ_l coefficients do not change from the prior specification.

[23]Since soybeans were not eligible for decoupled payments under the 1996 Farm Bill, I use the district's 2002 Farm Bill yield to compute s_i, so endogeneity is a concern for this crop regression.

[24]For districts that did not grow a particular crop, I assumed that if they had, they would have received either the average state or national price, depending on availability. County-level rice loan rates were unavailable, so the year dummies include the loan effects for these regressions.

As a third specification check, I re-run (4) assuming fixed effects instead of random effects. As mentioned above, the interpretation of the γ_l coefficients under this specification is difficult, but the results can be used as a check against the baseline random effects specification. In particular, the γ_l coefficients should display the same pattern as the random effects case. The results, reported in Table 7, are computed using Honoré (1992) fixed effect Tobit estimator.[25] The spike in the 2001 γ_l coefficients is consistent under the fixed specification, re-affirming that future subsidies explain the movement in 2001 acreage. For every crop, with the exception of rice, the 2001 future subsidy-time interaction term is larger than the previous years, contradicting the hypothesis of no base update anticipation. I also add prices and loans to the fixed effect specification but do not report the results since they do not change.

The dependent variables in the regressions are either exogenous (soil characteristics) or determined prior to 1996 (the base acreage and yields), so they are uncorrelated with potential omitted variables. Therefore, standard bias concerns regarding the estimation of these coefficients are mitigated because of the unique institutional features of U.S. agricultural policy. The Tobit results suggest that the future subsidies were strongly associated with higher acreage. Furthermore, as time moved closer to the base update year, the impact of future subsidies on acreage became stronger. This appears to reject the notion that U.S. subsidies are truly decoupled.

5.1 Base Builders?

The second estimating strategy is to look in particular at the behavior of cotton farmers. Since cotton base is extremely valuable, if cotton farmers anticipated a base change, I would expect them to "over-plant" cotton relative to other crops in an attempt to build a larger future cotton base at the expense of other crops. I restrict attention to cotton farmers and investigate cotton acreage decisions relative to corn, wheat, sorghum and soybeans, which are the major cotton substitutes. I also include rice since rice base is more valuable than cotton. The degree of substitutability between crops depends on the cross-price elasticities. Lin et al. (2000) have estimated the cotton own acreage price elasticity at .466 and wheat, corn, sorghum and soybean cross-price elasticities at -.058, -.072, -.103 and -.081, respectively. These numbers are not extremely high, but larger than their reported wheat cross-price elasticities with respect to substitute crops. Nearly seventy percent of the cotton districts in my sample report nonzero acreage in three or four crops. So crop substitution among cotton farmers is possible.

I start by eliminating the Lagrange multiplier in (3) by combining acreage FOCs to obtain

$$0 = \begin{cases} \frac{\partial \pi_{st}(\cdot)}{\partial a_{st}} - \frac{\partial \pi_{jt}(\cdot)}{\partial a_{jt}}, & \forall j \neq s,\ t \notin \text{[T-4,T-1]} \\ \frac{\partial \pi_{st}(\cdot)}{\partial a_{st}} - \frac{\partial \pi_{jt}(\cdot)}{\partial a_{jt}} + \frac{\rho_t}{4} \sum_{l=0}^{\infty} \beta^{T-t+l} \left(\xi_{s,T+l} \bar{\eta}_s - \xi_{j,T+l} \bar{\eta}_j \right), & \forall j \neq s,\ t \in \text{[T-4,T-1]} \end{cases} \quad (7)$$

[25] I thank Bo Honoré for making his code available.

These equations implicitly define the optimal acreage choice between crop j and s. The empirical analog of (7), with cotton as the reference crop, becomes

$$\left(a_{it}^{cot} - a_{it}\right) = \alpha_0 + \alpha_s(s_i^{cot} - s_i) + \sum_{l=1}^{T+1} \zeta_l * (s_i^{cot} - s_i)\delta_l + \alpha_{\bar{a}}(\bar{a}_i^{cot} - \bar{a}_i) + \alpha_d(d_{it}^{cot} - d_{it}) + z_i'\alpha_z + \sum_{l=1}^{T+1} \zeta_l + \nu_i + \epsilon_{it}, \tag{8}$$

where the notation is consistent with the previous regressions. I restrict the sample to districts who report non-zero cotton acreage and run the regressions for each crop separately using standard random effect panel methods, since the dependent variable is no longer a censored variable. I run the regressions for corn, wheat, sorghum, soybeans and rice.

The model predicts that a positive expected subsidy differential between cotton and the alternative crop will lead to a distortion towards cotton acreage in a scenario where base updating is anticipated. Positive and significant α_s and δ_l coefficients imply that the expected cotton subsidy differential is positively associated with increased relative cotton acreage. As before, α_s could simply be capturing the fact that districts with higher cotton yield differentials plant more cotton. But again, there is no reason to expect these differentials to vary across time, especially when controlling for year effects and relative base acreage. As with the Tobit regressions, non-zero α_s and δ_l imply that subsidies are not decoupled and these coefficients also provide evidence of base building.

The results of the regression are reported in Table 8. The current subsidies differential term, $(d_{it}^{cot} - d_{it})$, no longer matters for any crop. This is further evidence that the PFC and MLA payments did not distort acreage choice between crops. The future subsidy coefficients broadly conform to the hypothesis that farmers anticipated a base update. The δ_l coefficients, which are graphed in Figures 10-14, show a pronounced (and statistically significant) spike in the 2001 interaction coefficient for all crops except rice. Rice is the only crop for which the differential term is statistically insignificant in 2001, which makes sense since rice is more valuable than cotton. The regressions suggest that relative cotton plantings were positively associated with expected future subsidies implying that farmers were building valuable cotton base and the expense of others. This occurred even though cotton prices during this period were at historic lows. It appears that in 2001 farmers were willing to trade off current profits for larger future subsidy payments, and the results provide an explanation for the pattern found in Table 4 which shows that farmers with a large fraction of low-valued crop bases traded for more valuable cotton base.

As with the Tobit model, the regression in (8) contains omitted variables, as relative crop acreage choice is a function of many other variables. But again, the subsidy payment differentials are uncorrelated with omitted variables so the δ_l coefficients are unbiased. As a sensitivity check, I include price and loan differences as conditioning variables in the random effects regressions, but the results are not reported since the δ_l coefficients do not change. Running fixed effects regressions on (8) with and without price and loan controls do not change the results either.

As an additional robustness check of the hypothesis that farmers anticipated the base update and built more valuable crop base, I specify a similar regression to equation (8), but now use wheat, a low valued base, as the reference crop. These regressions consider the movement of crop acreage relative to wheat for the same set of cotton growing districts from the previous regressions. I estimate the following equation

$$\left(a_{it}^{wht} - a_{it}\right) = \alpha_0 + \alpha_s(s_i^{wht} - s_i) + \sum_{l=1}^{T+1} \zeta_l * (s_i^{wht} - s_i)\delta_l + \alpha_{\bar{a}}(\bar{a}_i^{wht} - \bar{a}_i) + \alpha_d(d_{it}^{wht} - d_{it}) + z_i'\alpha_z + \sum_{l=1}^{T+1} \zeta_l + \nu_i + \epsilon_{it} \quad (9)$$

The results of these regressions are reported in Table 9. The 2001 time interaction with the wheat differential is negative for corn, sorghum and soybeans and statistically insignificant for all crops. This suggests that among cotton farmers, relative wheat plantings are negatively (and statistically insignificant) associated with the expected subsidy differential, as expected. There is no evidence that cotton farmers tried to build wheat base, despite the historically low cotton prices and the rebound in wheat prices. Farmers increased their relative cotton plantings, and the regressions in this section imply that the increase was positively associated with future subsidies.

I interpret these results as evidence that the U.S. subsidy program is not decoupled due to the anticipation of a base update. I find empirical support of the anecdotal evidence, reported by Goodwin and Mishra (2002), that farmers were concerned with a future base update and planted in a way to capture potential gains. The results reject a perfect foresight model in which agents anticipate a base update well before 2002. Instead, it appears that only one year prior to the update provision, acreage plantings were positively associated with future subsidy revenue, and this result is robust across alternate specifications. Furthermore, the second set of results suggest that farmers built cotton base at the expense of lower valued bases. In the next section I use a structural model to quantify the distortion magnitude caused by the decoupled subsidies.

6 Structural Model

Figure 15 graphs annual U.S. cotton production and exports against annual U.S. and international cotton prices. The graph highlights several important features. U.S. cotton production peaks in 2001 and U.S. exports closely track production until 2001 but then continue to increase even though production falls. This is due to the gradual decline in U.S. mill consumption. U.S. and international cotton prices fall dramatically until 2001 and then rebound. The regression results in the previous section have suggested that the decoupled subsidies contributed to the peak in cotton exports and trough in international prices in 2001, which makes concerns about base updating appear warranted. However, the structural model below shows that the distortion caused by the base update is actually quite small. This implies that the increase in exports after 2000 was mostly due to the drop in domestic mill consumption.

The advantage in quantifying the distortion using a structural model comes, of course, at the cost of additional assumptions. I therefore seek to specify the model by imposing as few assumptions as possible. Risk-neutral farmers are assumed to maximize the present value of discounted future profits, which are assumed to be additively crop and time separable, from 1996 to 2003. Profits are a function of a vector of controls, including acreage, fertilizer/chemicals, labor and capital. Profits also depend on subsidies and the marketing loan provisions. Since the ARMS survey does not report data on marketing loans, I assume that farmers place all of their output under loan. Given that the marketing loans provide a floor on the crop price, it is difficult to imagine a scenario in which a farmer would never place all of his crop under the loan program.

Crop production functions, which are a function of the input controls, are assumed to have constant returns to scale (CRTS) in acreage. The justification of this assumption is that since the ARMS data only provides input expenditure at the farm-level, estimating crop-specific production functions that allow for decreasing returns to scale in acreage is not feasible without making strong assumptions. One method is to utilize USDA publications which provide regional input costs per acre by crop to impute crop-level expenditures from total expenditures. However, this produces a noisy and unconvincing measure of inputs (for instance, it is not clear how to obtain crop-specific capital given total farm capital). Consequently, measurement error precludes obtaining precise estimates in a regression of output on acreage and the imputed crop expenditures.[26] Specifically, I assume the following production function

$$q_{ijt} = a_{ijt} F(x_{ijt}; \phi_j), \tag{10}$$

where q_{ijt} is the district i's production of crop j at time t, a_{ijt} is the acreage choice, x_{ijt} is a vector of inputs, possibly crop-specific, and ϕ_j is a vector of parameters. I allow $F(\cdot)$ to be a completely general function that maps inputs into yield. For example, $F(\cdot)$ could be the standard Cobb-Douglas function.

Building on the model outlined in Section 3, and adding the loan provisions, the representative farmer in district i solves the following program

$$\begin{aligned} \max_{\{a,X\}_{i,j,t=0}^{I,J,T+1}} & E_0 \sum_{t=0}^{T-1} \beta^t \sum_{j=1}^{J} \Big[\big(L_{ijt} + p_{ijt}\big) q_{ijt} + .85 \left(\xi_{jt} \bar{a}_{ij} \overline{\eta}_{ij}\right) \Big] \\ & + (1 - \rho_{it}) \sum_{t=T}^{T+1} \beta^t \sum_{j=1}^{J} \big(L_{ijt} + p_{ijt}\big) q_{ijt} + .85 \left(\xi_{jt} \bar{a}_{ij} \overline{\eta}_{ij}\right) \Big] \\ & + \rho_{it} \sum_{t=T}^{T+1} \beta^t \sum_{j=1}^{J} \big(L_{ijt} + p_{ijt}\big) q_{ijt} + .85 \left(\xi_{jt} \overline{\eta}_{ij} \sum_{l=1}^{4} \frac{a_{ij,T-l}}{4} \right). \end{aligned}$$

[26] Nevertheless, I ran regressions of crop output on acreage and the imputed crop-level expenditures using standard fixed effects and the technique proposed by Olley and Pakes (1995) and Levinsohn and Petrin (2003). The expenditure coefficients are noisy, but the acreage coefficients are very close to one and highly significant, which provides empirical support for my assumption of CRTS in acreage.

s.t. $\sum_{j=1}^{J} a_{ijt} \leq A_{it}$. The first term is the farmer's discounted profits from time 0, the beginning of the farm bill, to time $T-1$. The second term represents the farmers profits if base updating is not allowed–the farmers base remains unchanged. With probability ρ_{it} the farmer expects a base update, which enables him to alter his base to equal his previous four year planting average for that crop. This base then remains fixed through the final period. The farmer receives the decoupled subsidies during this time, which are 85% of the product of the subsidy rate[27], ξ_{jt}, the fixed base acreage, $\bar{a}_{ij}$, and the fixed program yield, $\bar{\eta}_{ij}$. The marketing loans, L_{ijt}, provide a floor on the price received and calculated

$$L_{ijt} = \{l_{ijt} - p_{ijt}\}_{l_{ijt} > p_{ijt}} \tag{11}$$

where l_{ijt} is the loan rate and $\{Q\}_{a>b}$ is an indicator function that takes the value Q if $a > b$ and zero otherwise.

I am interested in estimating the probability parameter, ρ_t. To identify the evolution of the "anticipation" over time, I parameterize the probability term as follows:

$$\rho_{it} = \begin{cases} 0, & t = 0, t > T, \\ t^{\tau}, & 0 < \frac{t}{T} < T, \tau \geq 0 \\ 1, & t = T \end{cases} \tag{12}$$

where ρ_{it} is independent of district i and takes on values starting from $\rho_{it} = 0$ at $t = 0$ and increasing to $\rho_{it} = 1$ in at year T, the year of the update provision. The function form captures the plausible assumption that the probability that farmers learn of updating increases over time, but it is flexible enough to allow for fast learning ($\tau < 1$), constant learning ($\tau = 1$), or slow learning ($\tau > 1$). For subsidies to be truly decoupled, the estimation must yield large values of τ, which implies that base updating provision was not anticipated.

Solving (11) for the acreage choices yields the following FOCs

$$0 = \begin{cases} E_t \left(L_{ijt} + p_{ijt}\right) F(x_{ijt}) - \lambda_{jt}, & \forall j,\ t \notin \text{[T-4,T-1]} \\ E_t \left(L_{ijt} + p_{ijt}\right) F(x_{ijt}) + t^{\tau} \bar{\eta}_{ij} \sum_{l=0}^{1} \beta^{T-t+l} \xi_{ij,T+l} - \lambda_{jt}, & \forall j, t \in \text{[T-4,T-1]} \end{cases} \tag{13}$$

I do not observe crop-specific inputs so, following Keane (2003), I transform the FOCs to contain observable data

$$0 = \begin{cases} E_t a_{ijt}^{-1} \left(L_{ijt} + p_{ijt}\right) q_{ijt} - \lambda_{jt}, & \forall j,\ t \notin \text{[T-4,T-1]} \\ E_t a_{ijt}^{-1} \left(L_{ijt} + p_{ijt}\right) q_{ijt} + t^{\tau} \bar{\eta}_{ij} \sum_{l=0}^{1} \beta^{T-t+l} \xi_{ij,T+l} - \lambda_{jt}, & \forall j, t \in \text{[T-4,T-1]} \end{cases} \tag{14}$$

Given the the data $W_{ijt} = \left(p_{ijt}, q_{ijt}, L_{ijt}, \eta_{ij}, \xi_{ijt}\right)'$ and the parameters $\theta = \left(\lambda_{it}, \tau\right)'$, I can solve for

[27] The law stipulates subsidy payments to be 85% of the product of the subsidy rate, base acreage and program yield.

the optimal acreage choice

$$a(W_{ijt};\theta) = \begin{cases} E_t\lambda_{it}^{-1}\left(L_{ijt}+p_{ijt}\right)q_{ijt}, & \forall\ j,\ t \notin \text{[T-4,T-1]} \\ E_t\left(\lambda_{it} - t^{\tau}\sum_{s=0}^{1}\beta^{T-t+s}\xi_{ij,T+s}\bar{\eta}_{ij}\right)^{-1}\left(L_{ijt}+p_{ijt}\right)q_{ijt}, & \forall\ j,t \in \text{[T-4,T-1]} \end{cases} \tag{15}$$

I use nonlinear least squares to estimate the parameters θ in (15) by pooling the 267 districts over eight crops (cotton, corn, wheat, sorghum, soybeans, oats, barley and rice) and across eight years (1996-2003). I minimize the criterion function

$$\min_{\theta\in\Theta} Q(\theta) = \frac{1}{T}\frac{1}{J}\frac{1}{N}\sum_{t=1}^{T}\sum_{j=1}^{J}\sum_{n=1}^{N}\left(a_{ijt}^{0} - a(W_{ijt};\theta)\right)^2, \tag{16}$$

where Θ represents the parameter space and a_{ijt}^{0} is the observed acreage choice by district i for crop j at time t.

Because there are so many districts over the eight years, it is not feasible to estimate a district-year specific rental rate. To reduce the dimensionality, I assume that all districts within the same state have identical shadow prices, and that these shadow prices are constant over time. This reduces the dimensionality to $\theta \in \Re^{38}$ (37 states plus the probability parameter). I do not consider this an unreasonable assumption; the shadow price is the rental rate of land and it is reasonable to assume that the rental rate is equivalent within states. Holding the shadow price fixed over time is a stronger, but necessary, assumption required to reduce the dimensionality of the problem.

The U.S. average farm real estate value in 1996 was \$844 and increased to \$1,270 by 2003 (USDA, 2003). The farm real estate values include land and buildings in agricultural use, so these numbers are an overestimate of the value of agricultural land. The results of the estimating (16) are reported in Table 10. The shadow prices are precisely estimated and range from \$102 per acre (Ohio) to around \$725 per acre (California). The average rental rate across all states is \$283. Although these numbers are lower than the reported real estate values, they are on the same order of magnitude as the actual reported land values. Furthermore, Kirwan (2004) reports that more than 45% of farmland is leased by farmers at an average cash rental value around \$70 per acre. Taking this into account, the estimates appear reasonable.

The estimated probability parameter is $\tau = 4.76$ and highly significant. Figure 16 graphs the probability function over time. The graph clearly shows that the expectations did not grow at a constant rate over time. The graph suggests that in 2001, farmers expected an update with 15% probability in 2000 and rose to 42% by 2001. It is interesting to note that the estimated probability in 2001 roughly corresponds to the USDA estimate that 40% of the farmers *actually* updated their base in 2002 (see Young et al. (2004)). Note that at no point in the estimation do I impose the fraction of farmers who actually updated so the matching the anticipation probability with the actual percentage of farmers who updated is a check on the reliability of the structural model. Figures 17-24 graph the national total observed crop acres and the model predictions by crop. The model performs extremely well, particularly for barley, cotton, corn and rice. The predicted acres for these crops closely match the observed acreage and for the remaining crops, the general predicted trends also match the observed data. The graphs and the matching of the estimated anticipation probability with the actual fraction of farmers up updated are both indicators that this simple structural model fits the data extremely well.

6.1 Counterfactual Analysis

With the estimates in hand, I can now simulate farmer acreage choices in a world where there is no possibility for base updating. The counterfactual analysis compares the predict acreage choices with acreage choices without base updating. In other words, I compare the model's predict acreage choices with $\tau = 4.76$ to the predict acreage obtained with $\tau = -\infty$ (a zero probability of a base update, $\rho_{it} = 0, \forall i, t$).[28] Since the probabilities are so low up through 2000, there is virtually no distortion caused by the update in these years. With the probability increase to 42% in 2001, the first column of Table 11 shows that this amounts to an 1.4% increase in total cotton acreage and a 2.3% increase in total rice acreage in 2001 compared to the no-update predictions. So, while it appears the probability of an update was large, the overall production distortion was small.

Given that the government has allowed a base update, farmers may expect another update at the end of the current bill, which is set to expire in 2007. I therefore re-run the model assuming farmers had perfect foresight and forecasted the update with probability $\rho_{it} = 1, \forall i, t$. The second column of Table 11 reports that this scenario results in an increase in cotton acreage by 3.5% and rice acreage by 5.8% in 2001 vis-á-vis the model without updating. These counterfactual results are not insignificant given that decoupled subsidies should have a zero impact on acreage. Therefore, economists and policy makers should be concerned about future base updates on international prices. The current farm bill expires in 2007, and it will be interesting to see if current acreage movements are more closely tied to the potential future base update.

Although this paper has focused on decoupled subsidies, the estimated structural model allows me to analyze the impact of the loan marketing program on acreage. It is generally acknowledged that the marketing loan program causes dramatic production distortions, and consequently, the U.S. classifies the program in the Amber Box in the WTO. Using the estimated parameters, I can compute the model's acreage predictions in a world with no price floor. Given that prices began crashing in 1998-2001, the loans should have only affected production during this period. The results of the increase in acreage between 1998-2001 caused by the loans are reported in the third column of Table 11. The results are large; it is estimated that cotton acreage was 20% higher between 1999-2002 due to the price floor provided by the loans. Even though this analysis assumes that prices do not adjust, the estimated cotton distortion caused by the loans is almost identical to

[28] I do not attempt to model the demand for crops and so I assume that prices do not adjust.

Sumner's 18.4% estimate of the impact of cotton loans on acreage (in the same period) in his report to the WTO.[29] This is further evidence that this simple structural model accurately predicts crop acreage choices. The marketing loans clearly distort crop acreage by a much larger amount than the decoupled subsidies, so it is therefore important to keep these two features of U.S. farm policy distinct when discussing the impact of U.S. agricultural support on international prices.

7 Conclusion

I find evidence that U.S. subsidy payments are not truly decoupled. The failure of this mechanism is attributed to the base update provision in the 2002 Farm Bill and the evidence is supported by both reduced form regressions and by a structural model. But while this finding contradicts the WTO definition of a decoupled subsidy, the resulting acreage distortion was small and it appears that the subsidies are minimally trade distorting.

The reduced form results indicate that future subsidies were associated with current acreage choices, suggesting that farmers may have anticipated a base update prior to the occurrence. The results suggest that for higher valued crops, like cotton, corn and rice, the impact of anticipated subsidies in 2001 was significantly higher than previous years. For soybeans, the results are even more dramatic, which suggests farmers were anticipating the government would introduce decoupled subsidies for soybeans. I also find evidence that farmers were planting more valuable crops at the expense of lesser valued crops in an effort to build more valuable base.

The structural model is used to quantify this impact on acreage. The model predictions closely match the actual crop choices. The estimated update probability in 2001 at 42% is virtually identical to the official 40% of farmers who actually updated in 2002. But while the probability that farmers expected a base update is high, this apparently did not translate to dramatic acreage distortions. For cotton, the impact in 2001 is estimated at 1.4%. So while the subsidies are not decoupled from a statistical point of view, the economic magnitude of the distortion is small. However, since the government has allowed an update once, farmers may be expecting another update at the end of the current farm bill. Re-running the model allowing for prefect foresight implies a 3.5% increase in acreage for cotton. This is not an insignificant amount given that decoupled subsidies, by definition, should have zero impact on acreage. Future base updates are likely to cause greater distortions than the one study in this paper, so this is an issue that should concern policy makers.

[29] Sumner uses the FAPRI model to conduct his counterfactual analysis.

References

Ashraf, N., McMillan, M., Zwane, A., 2005. My policies or yours: Have OECD agricultural policies affected incomes in developing countries? NBER Working Paper 11289.

Baffes, J., Gorter, H. D., 2003. Decoupling support to agriculture: An economic analysis of recent experience. The World Bank, Mimeo.

Fafchamps, M., Hill, R., Kaudha, A., Nsibirwa, R., 2003. The transmission of international commodity prices to domestic producers. Oxford University, Mimeo.

Goodwin, B., Mishra, A., 2002. Are "decoupled" farm program payments really decoupled? an empirical evaluation. Ohio State University, Mimeo.

Goruex, L., 2003. Prejudice caused by industrialized countries subsidies to cotton sectors in Western and Central Africa. Background document to the submission made by Benin, Burkina Faso, Chad and Mali to the WTO (TN/AG/GEN/4) .

Hennessy, D., 1998. Production effects of agricultural income support policies under uncertainty. American Journal of Agricultural Economics 80, 46–57.

Honoré, B., 1992. Trimmed lad and least squares estimation of truncated and censored regression models with fixed effects. Econometrica 60, 533–65.

Keane, M., 2003. SML estimation based on first order conditions. Yale University, Mimeo.

Key, N., Lubowski, R., Roberts, M., 2004. The 1996 federal agriculture improvement and reform act: Correcting a distortion? USDA Economic Research Service, Mimeo.

Kirwan, B., 2004. The incidence of U.S. agricultural subsidies on farmland rental rates. Massachusetts Institute of Technology, Mimeo.

Levinsohn, J., Petrin, A., 2003. Estimating production functions using inputs to control for unobservables. Review of Economics Studies 70, 317–342.

Lin, W., Westcott, P., Skinner, R., Sanford, S., De La Torre Ugarte, D., 2000. Supply response under the 1996 farm act and implications for the U.S. field crops sector. Economic Research Service, USDA Technical Bulletin No. 1888.

Olley, S., Pakes, A., 1995. The dynamics of productivity in the telecommunications equipment industry. Econometrica 64, 1263–1298.

Orden, D., Paarlberg, R., Roe, T., 1999. Policy Reform in American Agriculture: Analysis and Prognosis. The University of Chicago Press, Chicago.

Panagariya, A., 2005. Agricultural liberalization and the developing countries: Debunking the fallacies. Columbia University, Mimeo.

Roberts, I., Jotzo, F., 2001. 2002 U.S. farm bill: Support and agricultural trade. ABARE Research Report 1.13.

Sumner, D., 2003. Implications of the U.S. farm bill of 2002 for agricultural trade and trade negotiations. Australian Journal of Agricultural Resource Economics 47, 99–122.

Tielu, A., Roberts, I., 1998. Farm income support. ABARE Current Issues 98.

USDA, 2003. Agricultural land values. National Agricultural Statistics Service.

USDA Natural Resources Conservation Service, 1995. State soil geographic database. Publication Number 1492.

Vercammen, J., 2004. A stochastic dynamic programming model of direct subsidy payments and agricultural investment. University of British Columbia, Mimeo.

Young, E., Skully, D., Westcott, P., Hoffman, L., 2004. The 2002 U.S. farm act implications of base updating. USDA Economic Research Service, Mimeo.

8 Tables

Subsidy Payments Per Acre

Crop	Subsidy/Acre
Rice	$147
Cotton	$47
Corn	$39
Sorghum	$25
Wheat	$20
Barley	$13
Oats	$1

Table 1: Payments based on the average subsidy rates and program yields from 1996-02. Soybeans were not eligible for payments during this period.

District Summary Statistics

Crop	Revenue/Acre	1996 Base	2002 Base	% Increase	N
Barley	122	1.93	2.04	5.7%	508
Corn	235	33.07	41.27	24.8%	1575
Cotton	379	37.20	58.85	58.2%	488
Oats	68	0.91	0.89	-2.7%	858
Rice	436	26.56	50.25	89.2%	131
Soybeans	189	-	35.02	-	1341
Sorghum	124	2.07	4.70	127.1%	536
Wheat	146	18.44	22.03	19.5%	1570

Table 2: Column 2 units are dollars per acre. Columns 3 and 4 reported median values.

Base Updating Statistics

Crop	Percent Updated	Percent Increased	Percent Decreased
Barley	49%	52%	48%
Corn	54%	76%	24%
Cotton	53%	84%	16%
Oats	57%	45%	55%
Rice	47%	84%	16%
Sorghum	52%	68%	32%
Wheat	51%	68%	32%

Table 3: This table reports percentages of farmers who update their crop base. The data are computed using individual farm surveys from the 2002 and 2003 ARMS survey.

Cotton Base Updating

Crop	1996 cotton base share		2002 cotton base share	
	>=p50	<p50	>=p50	<p50
Barley	8.4%	23.9%	59.5%	31.8%
	(4.8%)	(7.6%)	(12.4%)	(4.4%)
Corn	23.5%	53.8%	48.7%	54.8%
	(3.5%)	(4.6%)	(5.3%)	(5.9%)
Cotton	88.3%	30.4%	90.0%	41.6%
	(1.6%)	(2.4%)	(1.7%)	(3.8%)
Oats	22.4%	32.2%	36.8%	40.3%
	(6.4%)	(11.0%)	(8.0%)	(12.6%)
Rice	17.7%	34.6%	16.5%	43.0%
	(6.3%)	(8.5%)	(6.6%)	(7.0%)
Sorghum	33.7%	51.7%	44.4%	57.4%
	(6.1%)	(5.8%)	(6.7%)	(6.7%)
Wheat	22.9%	55.0%	40.5%	59.4%
	(3.4%)	(4.1%)	(4.7%)	(4.9%)

Table 4: This table reports farmer average cotton base shares for those above and below the median (column 1) crop base share. For instance, farmers reporting above the median barley base share under the 1996 Farm Bill had on average an 8.4% cotton base. Under the 2002 Farm Bill, farmers above the median barley base reported on average a 59.5% cotton base share. The data are computed using individual farm surveys from the 2002 and 2003 ARMS survey. Standard errors in parentheses.

Tobit Regressions

	Barley	Corn	Cotton	Oats	Rice	Sorghum	Soybeans	Wheat
Subsidy	-0.004	-0.002***	0	-0.03	-0.001***	-0.01***	-	-0.003**
	(0.004)	(0.001)	(0)	(0.029)	(0)	(0.003)	-	(0.001)
s_i	16.12***	2.754	1.375***	53.975***	-0.071	5.283**	12.78***	11.641***
	(2.859)	(1.704)	(0.276)	(8.597)	(0.089)	(2.426)	(1.155)	(4.26)
s_i*y97	0.756	3.708**	0.58***	-6.025	-0.005	-0.979	0.35	4.61
	(2.374)	(1.47)	(0.285)	(9.383)	(0.091)	(2.336)	(1.486)	(3.864)
s_i*y98	0.324	5.908***	-0.201	0.245	0.569***	-1.237	2.475*	1.756
	(2.386)	(1.538)	(0.291)	(9.46)	(0.157)	(2.389)	(1.488)	(3.831)
s_i*y99	-0.617	4.086**	0.414	-9.067	0.673***	3.056	2.301	8.644**
	(2.52)	(1.706)	(0.305)	(9.648)	(0.187)	(2.547)	(1.496)	(3.97)
s_i*y00	-3.597	7.403***	0.284	-10.79	0.656***	-1.495	4.22***	4.892
	(2.488)	(1.68)	(0.303)	(9.612)	(0.18)	(2.522)	(1.494)	(3.922)
s_i*y01	11.482***	9.977***	1.413***	-1.142	0.636***	2.553	9.656***	5.919
	(2.484)	(1.56)	(0.297)	(9.568)	(0.164)	(2.446)	(1.507)	(3.884)
s_i*y02	-3.716	4.822***	0.16	-23.605**	0.092	-3.336	5.61***	-0.238
	(2.709)	(1.488)	(0.317)	(9.716)	(0.089)	(2.42)	(1.492)	(4.169)
s_i*y03	15.145***	2.302	0.875***	9.051	-0.079	-4.844**	2.93**	0.892
	(2.728)	(1.485)	(0.32)	(9.71)	(0.09)	(2.436)	(1.495)	(4.192)
1996 Base	0.151***	0.492***	0.073***	0.041***	0.135***	0.493***	-	0.548***
	(0.033)	(0.054)	(0.013)	(0.012)	(0.016)	(0.046)	-	(0.048)
Year	x	x	x	x	x	x	x	x
Soil	x	x	x	x	x	x	x	x
chi2	154	291	395	236	80	312	2081	319
LL	-3959	-9860	-3215	-4354	-813	-3696	-8527	-10400
N	1966	1966	1966	1966	1966	1966	1966	1966

Table 5: This table reports the random effects Tobit regressions of equation (4) for each crop. Soybeans were not eligible for decoupled under the 1996 Farm Bill. Marginal subsidies effects reported. Significance levels : $*$:10% $**$:5% $***$:1%. Standard errors in parentheses.

Tobit Regressions with Price and Loan Controls

	Barley	Corn	Cotton	Oats	Rice	Sorghum	Soybeans	Wheat
Subsidy	-0.005*	-0.002***	-0.003***	-0.037	-0.001***	-0.009***	-	-0.003**
	(0.003)	(0.001)	(0)	(0.027)	(0)	(0.003)	-	(0.001)
s_i	14.565***	2.728	1.031***	38.433***	-0.042	10.749***	13.526***	11.627***
	(2.28)	(1.721)	(0.39)	(7.878)	(0.095)	(2.533)	(1.314)	(4.254)
s_i*y97	0.043	3.742**	0.589	1.995	-0.002	-1.711	-0.217	4.376
	(2.645)	(1.472)	(0.42)	(9.104)	(0.098)	(2.32)	(1.563)	(3.857)
s_i*y98	0.822	5.937***	0.172	1.554	0.585***	-1.376	2.29	1.948
	(2.669)	(1.54)	(0.428)	(9.234)	(0.171)	(2.376)	(1.565)	(3.824)
s_i*y99	-0.524	4.108**	1.388***	-6.027	0.677***	2.218	1.892	8.641**
	(2.769)	(1.708)	(0.457)	(9.408)	(0.205)	(2.512)	(1.577)	(3.962)
s_i*y00	-2.691	7.455***	1.12**	-9.15	0.676***	-2.776	4.104***	4.902
	(2.739)	(1.685)	(0.448)	(9.357)	(0.196)	(2.513)	(1.572)	(3.915)
s_i*y01	11.09***	10.008***	1.96***	1.816	0.651***	1.211	10.142***	5.823
	(2.755)	(1.565)	(0.44)	(9.39)	(0.179)	(2.43)	(1.59)	(3.877)
s_i*y02	-3.481	4.902***	-0.697	-16.038*	0.105	-3.975*	5.207***	0.059
	(2.905)	(1.489)	(0.464)	(9.537)	(0.096)	(2.402)	(1.575)	(4.188)
s_i*y03	14.888***	2.342	0.186	12.986	-0.07	-5.729**	2.621*	1.133
	(2.902)	(1.549)	(0.463)	(9.551)	(0.097)	(2.417)	(1.582)	(4.21)
1996 Base	0.148***	0.492***	0.181***	0.037***	0.126***	0.425***	-	0.55***
	(0.02)	(0.053)	(0.019)	(0.009)	(0.017)	(0.039)	-	(0.047)
Price	-5.107***	0.955	-9.024	-2.015***	0.529	-5.407***	-8.47***	-5.54*
	(0.478)	(0.91)	(12.603)	(0.139)	(0.549)	(0.769)	(1.341)	(3.152)
Loan	138.6	-10.8	-1751***	-74.112	-	322.96	3673***	-91.17
	(136.93)	(926.83)	(183.25)	(46.961)	-	(287.13)	(624.44)	(1472.6)
Year	x	x	x	x	x	x	x	x
Soil	x	x	x	x	x	x	x	x
chi2	.	318.045	.	166.804	90.542	168.86	1370.353	327.492
LL	-3997.118	-9858.945	-3340.119	-4236.021	-814.789	-3669.88	-8482.391	-10400
N	1966	1966	1966	1966	1966	1966	1966	1966

Table 6: This table reports the random effects Tobit regressions of equation (4) for each crop with loan and price controls. Soybeans were not eligible for decoupled subsidies under the 1996 Farm Bill. District rice loan rates were unavailable. Marginal effects reported. Significance levels : $*$:10% $**$:5% $***$:1%. Standard errors in parentheses.

Tobit Fixed Regressions

Variable	Barley	Corn	Cotton	Oats	Sorghum	Soybeans	Rice
Subsidy	0.04	0.00	0.00	-0.06	-0.03	-	-0.01***
	(0.06)	(0.00)	(0.00)	(0.22)	(0.05)	-	(0.00)
s_i*y97	8.64	3.27	4.22***	-10.62	-18.04	-1.25	0.27
	(18.84)	(2.22)	(1.66)	(62.21)	(19.37)	(2.56)	(1.38)
s_i*y98	-7.56	7.16***	-0.31	23.45	2.15	4.39*	9.93***
	(14.52)	(2.28)	(1.34)	(53.38)	(27.25)	(2.53)	(1.86)
s_i*y99	-25.63	3.87	3.32	-20.57	10.86	2.14	11.24***
	(27.00)	(2.41)	(2.86)	(58.70)	(40.77)	(3.13)	(3.05)
s_i*y00	-40.90	8.78***	1.72	-18.31	-17.33	8.13**	13.38***
	(29.86)	(2.54)	(1.62)	(75.60)	(18.85)	(3.51)	(3.17)
s_i*y01	69.23	11.32***	11.74**	7.66	-0.36	18.21***	10.69***
	(108.60)	(3.49)	(5.57)	(65.40)	(25.46)	(4.98)	(2.27)
s_i*y02	4.76	6.67**	2.51	-56.63	-13.48	7.9**	3.19***
	(34.20)	(2.69)	(3.50)	(67.33)	(25.02)	(3.72)	(1.21)
s_i*y03	78.27	4.31**	5.93	58.64	-31.63	4.78	-0.37
	(50.50)	(1.98)	(5.91)	(71.51)	(22.08)	(2.93)	(1.46)
Fixed effects	x	x	x	x	x	x	x
Year effects	x	x	x	x	x	x	x
N	1966	1966	1966	1966	1966	1966	1966
Loss Function	1106374	7432693	5105740	56706.99	3457501	8698583	445649
Chi2	216.1	80.2	1304.6	31.6	64.8	115.3	8949.3

Table 7: This table reports the fixed effects Tobit regressions for each crop. The equations were estimated following Honoré (1992). Soybeans were not eligible for decoupled subsidies under the 1996 Farm Bill. The wheat regression did not converge so it is not reported. Significance levels : $*$:10% $**$:5% $***$:1%. Standard errors in parentheses.

Cotton Acreage Difference Regressions

	Corn	Sorghum	Soybeans	Wheat	Rice
Subsidies	-0.004	0.006	-	-0.001	-0.004
	(0.003)	(0.004)	-	(0.005)	(0.003)
$(s_i^{cot} - s_i)$	-0.59	-6.261	-0.502	5.698	-3.006
	(3.379)	(3.976)	(3.566)	(4.701)	(2.475)
$(s_i^{cot} - s_i)$*yr97	3.891	6.460**	4.515	5.535	7.124***
	(2.715)	(3.087)	(2.977)	(4.036)	(2.579)
$(s_i^{cot} - s_i)$*yr98	-2.254	-2.91	-2.978	-2.856	3.508
	(2.786)	(3.166)	(2.986)	(4.137)	(2.763)
$(s_i^{cot} - s_i)$*yr99	6.006**	-2.821	6.467**	4.336	4.993*
	(3.018)	(3.424)	(2.994)	(4.452)	(2.976)
$(s_i^{cot} - s_i)$*yr00	2.716	-2.307	-0.177	0.404	6.527**
	(3.01)	(3.417)	(3.032)	(4.453)	(2.962)
$(s_i^{cot} - s_i)$*yr01	13.186***	10.879***	11.601***	11.740***	3.398
	(2.785)	(3.175)	(3.025)	(4.189)	(2.803)
$(s_i^{cot} - s_i)$*yr02	-0.981	6.244*	5.087*	1.403	3.999
	(3.208)	(3.646)	(2.999)	(4.695)	(2.64)
$(s_i^{cot} - s_i)$*yr03	4.177	10.068***	12.050***	8.423*	4.523*
	(3.195)	(3.625)	(2.99)	(4.668)	(2.612)
Base Diff	0.933***	1.113***	-	0.722***	1.102***
	(0.167)	(0.201)	-	(0.161)	(0.143)
Year	x	x	x	x	x
Soil	x	x	x	x	x
R^2	0.562	0.599	0.442	0.537	0.525
χ^2	321	324	183	217	271
N	488	488	488	488	488

Table 8: This table reports the random effects acreage difference regressions of (8) for each crop (cotton is the reference crop). Soybeans were not eligible for decoupled subsidies under the 1996 Farm Bill. Significance levels : $*$:10% $**$:5% $***$:1%. Standard errors in $***$:1%. Standard errors in parentheses.

Wheat Acreage Difference Regressions

	Corn	Sorghum	Soybeans	Rice
Subsidies	-0.008	-0.009	-	0.002
	(0.008)	(0.008)	-	(0.006)
sub	110.907***	92.062***	162.607***	2.379
	(25.787)	(28.87)	(30.289)	(2.976)
$\left(s_i^{wht} - s_i\right)$*yr97	-11.613	66.474**	10.192	3.854
	(27.094)	(30.873)	(27.671)	(3.212)
$\left(s_i^{wht} - s_i\right)$*yr98	-17.147	-14.818	-28.711	0.229
	(27.439)	(31.172)	(27.747)	(4.453)
$\left(s_i^{wht} - s_i\right)$*yr99	-8.022	51.961*	-15.827	0.825
	(28.092)	(31.355)	(27.649)	(5.177)
$\left(s_i^{wht} - s_i\right)$*yr00	-4.833	19.733	-19.164	2.323
	(28.125)	(31.964)	(27.822)	(5.059)
$\left(s_i^{wht} - s_i\right)$*yr01	-24.425	-4.478	-17.126	0.734
	(29.683)	(33.638)	(29.202)	(4.589)
$\left(s_i^{wht} - s_i\right)$*yr02	-51.651*	-36.818	-27.236	1.485
	(29.129)	(32.971)	(28.43)	(3.22)
$\left(s_i^{wht} - s_i\right)$*yr03	-23.792	-16.315	-1.367	1.932
	(29.146)	(33.05)	(28.367)	(3.215)
Base Diff	0.24	0.231	-	0.584***
	(0.179)	(0.186)	-	(0.145)
Year	x	x	x	x
Soil	x	x	x	x
χ^2	167.395	192.669	172.256	168.096
R^2	0.406	0.456	0.582	0.416
N	488	488	488	488

Table 9: This table reports the random effects acreage difference regressions of (8) for each crop (cotton is the reference crop). Soybeans were not eligible for decoupled subsidies under the 1996 Farm Bill. Significance levels : $*$:10% $**$:5% $***$:1%. Standard errors in $***$:1%. Standard errors in parentheses.

Structural Model Parameters

State	λ	SE	State	λ	SE
Alabama	196.4***	(5.3)	Nevada	376.4***	(6.9)
Arizona	425.4***	(14.9)	New Mexico	214.3***	(13.0)
Arkansas	679.5***	(93.4)	New York	283.5***	(10.2)
California	725.8***	(26.0)	North Carolina	217.3***	(7.7)
Colorado	177.9***	(2.4)	North Dakota	225.4***	(3.6)
Florida	431.0***	(9.1)	Ohio	102.9***	(1.3)
Georgia	284.2***	(4.5)	Oklahoma	243.6***	(9.1)
Idaho	258.2***	(27.2)	Oregon	120.0***	(17.2)
Illinois	187.5***	(2.7)	Pennsylvania	295.2***	(6.8)
Indiana	376.9***	(6.8)	South Carolina	231.4***	(8.3)
Iowa	239.8***	(8.3)	South Dakota	287.7***	(5.5)
Kansas	314.6***	(5.3)	Tennessee	292.0***	(4.8)
Kentucky	271.6	(314.7)	Texas	256.2***	(6.6)
Louisiana	438.4***	(148.7)	Utah	223.6	(166.9)
Maryland	269.4***	(6.8)	Washington	113.9***	(1.9)
Michigan	131.7***	(1.5)	West Virginia	159.9***	(3.5)
Mississippi	298.0***	(5.9)	Wisconsin	323.9***	(11.6)
Montana	253.4***	(23.8)	Wyoming	245.9***	(45.1)
Nebraska	280.3***	(6.5)	Probability (τ)	4.755***	(0.7)

Table 10: Nonlinear least squares estimates obtain by minimizing criterion function in (16). Each state has its own Lagrange multiplier. The average λ=282.5. The probability parameter τ is estimated at 4.76. Significance levels : $*$:10% $**$:5% $***$:1%. Standard errors in parentheses.

Counterfactual Analysis

Crop	Counterfactual 1	Perfect Foresight	No Loans (1999-2002)
Corn	0.9%	2.1%	22.5%
Cotton	1.4%	3.5%	20.0%
Sorghum	0.3%	0.7%	9.8%
Soybean	-	-	14.6%
Wheat	0.9%	2.1%	3.7%
Barley	0.3%	0.7%	4.8%
Rice	2.3%	5.8%	-
Oats	0.0%	0.0%	83.4%

Table 11: The second column reports the increase 2001 predicted acreage vis-á-vis a model with no updating. The third column reports the increase 2001 acreage assuming perfect foresight vis-á-vis a model with no updating. The last column reports the increase in 1999-02 total crop acreage vis-á-vis a world with no marketing loans.

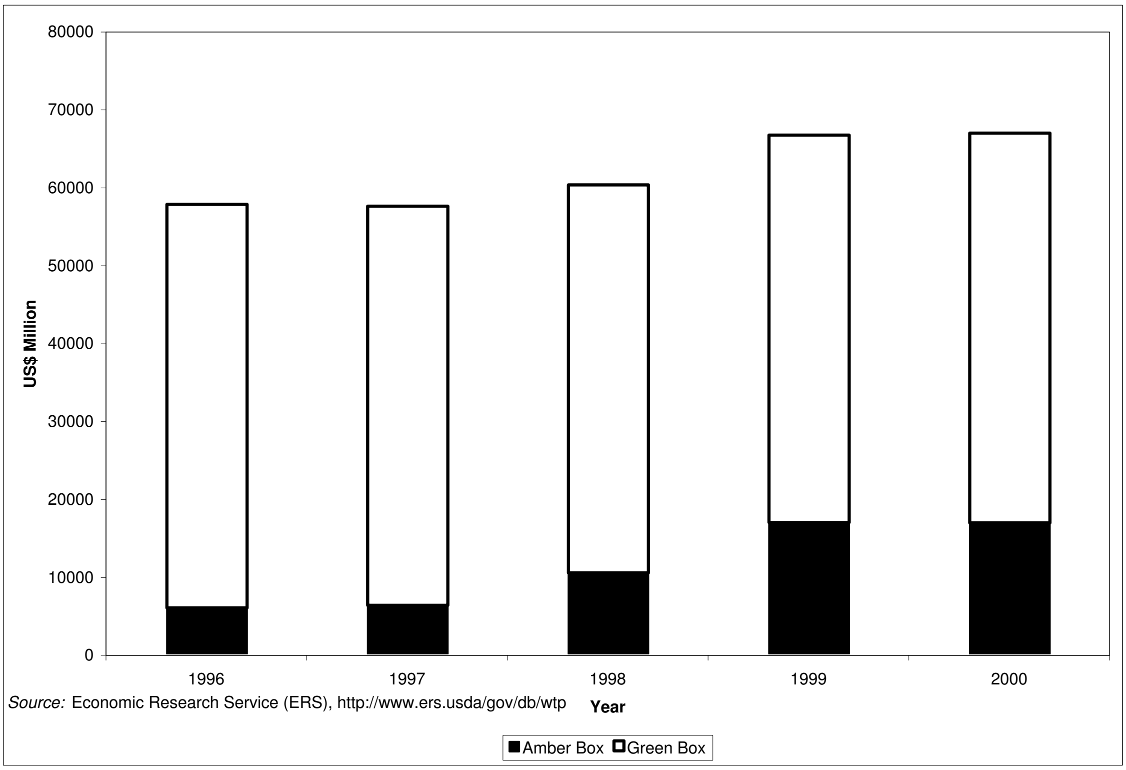


Figure 1: United States Total Domestic Agricultural Support

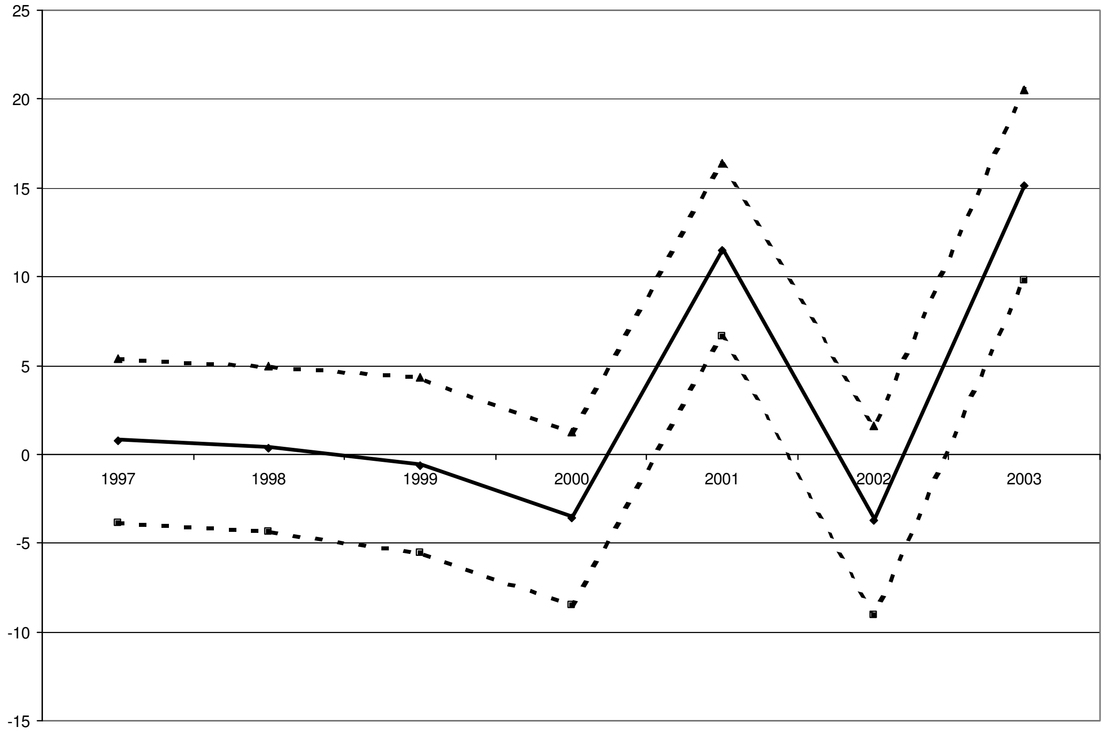


Figure 2: Barley Coefficients from Tobit Regression

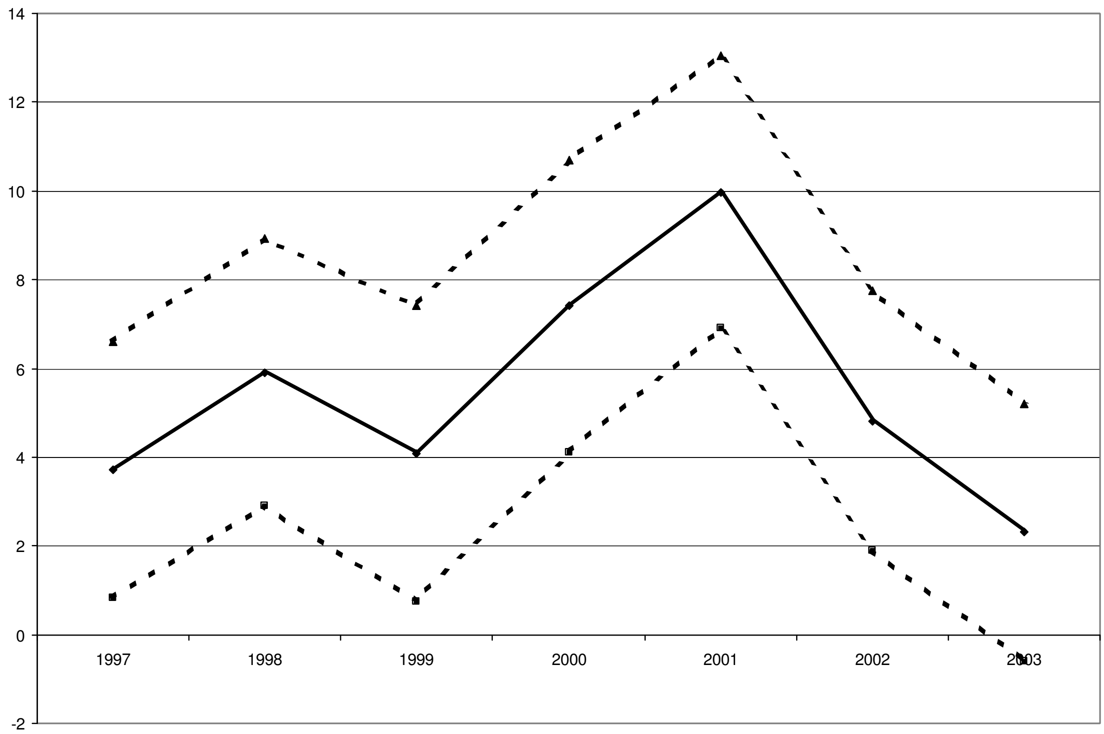


Figure 3: Corn Coefficients from Tobit Regression

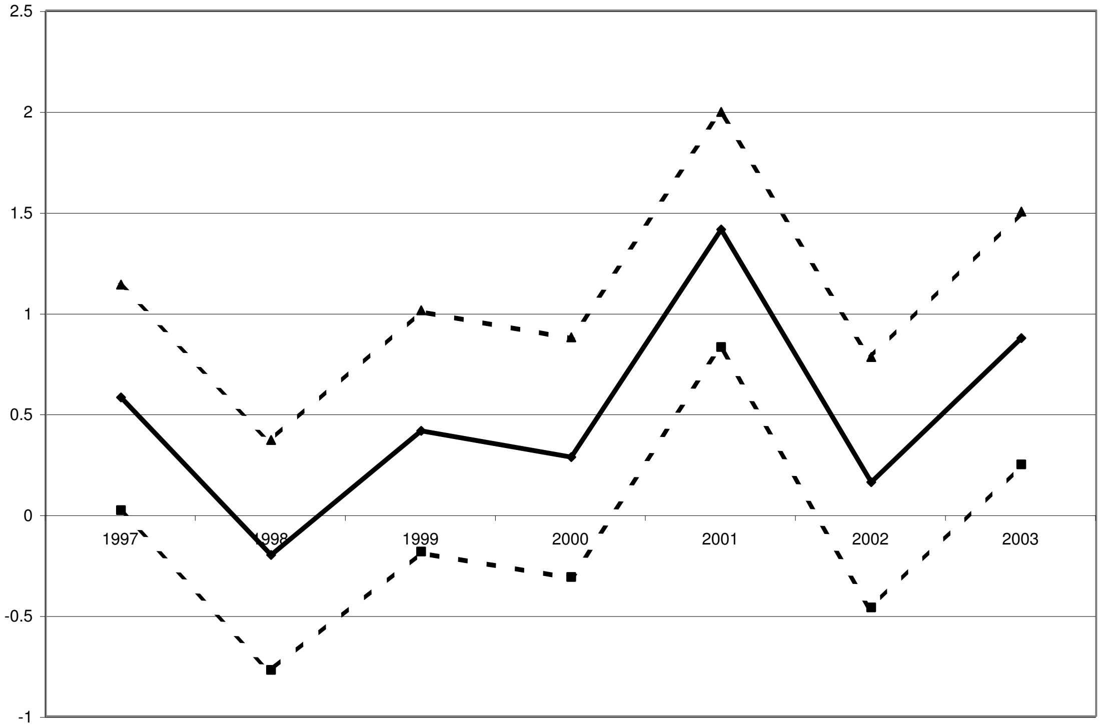


Figure 4: Cotton Coefficients from Tobit Regression

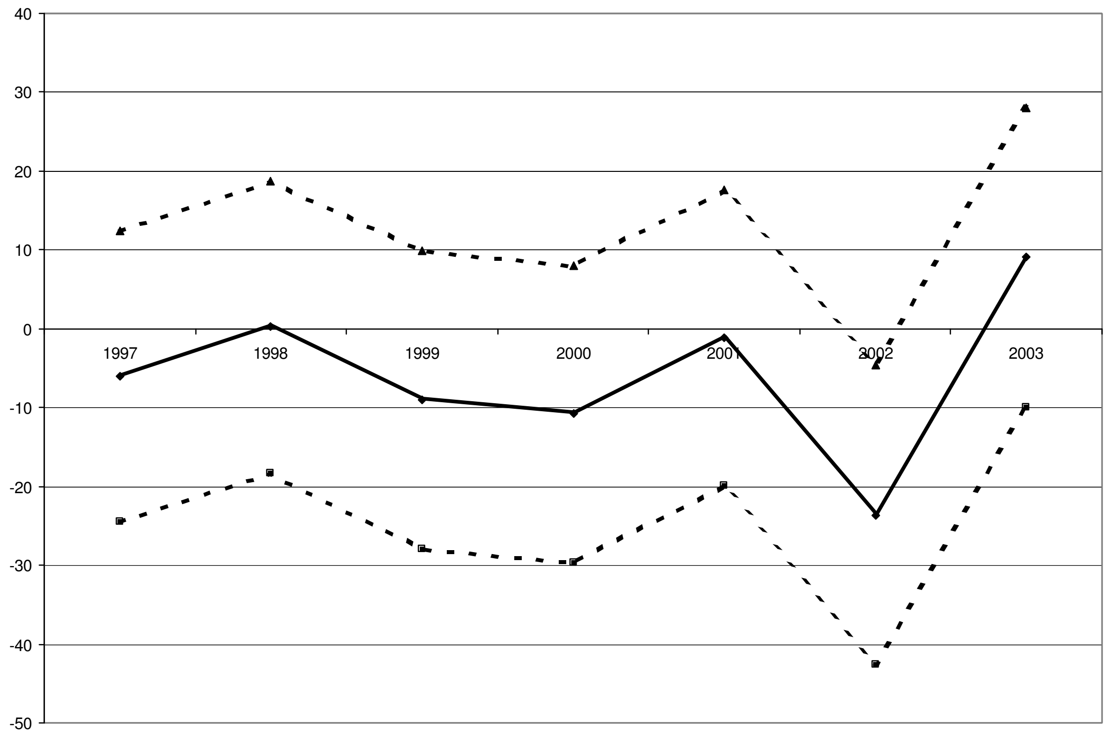


Figure 5: Oats Coefficients from Tobit Regression

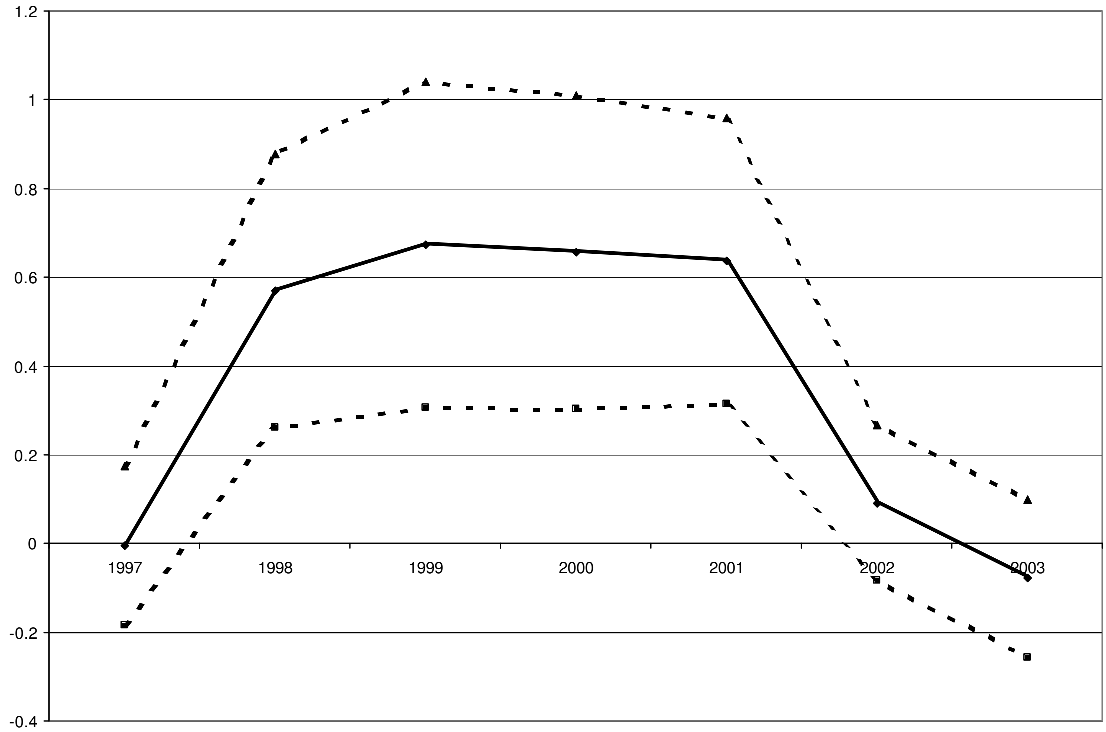


Figure 6: Rice Coefficients from Tobit Regression

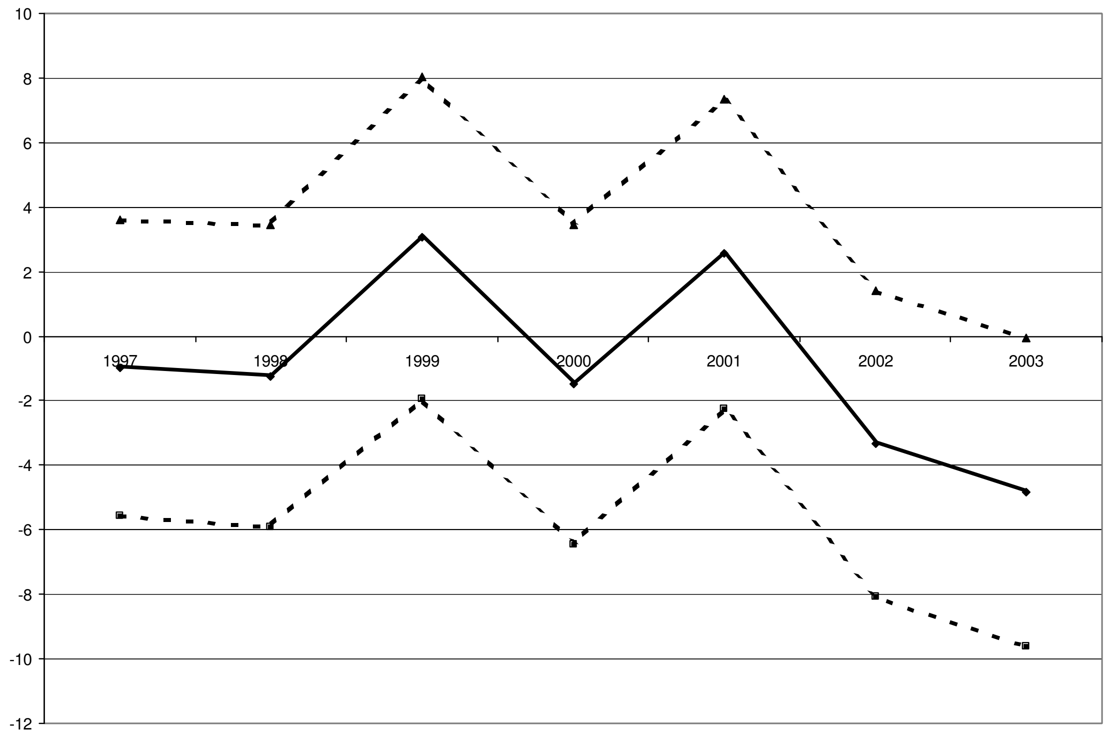


Figure 7: Sorghum Coefficients from Tobit Regression

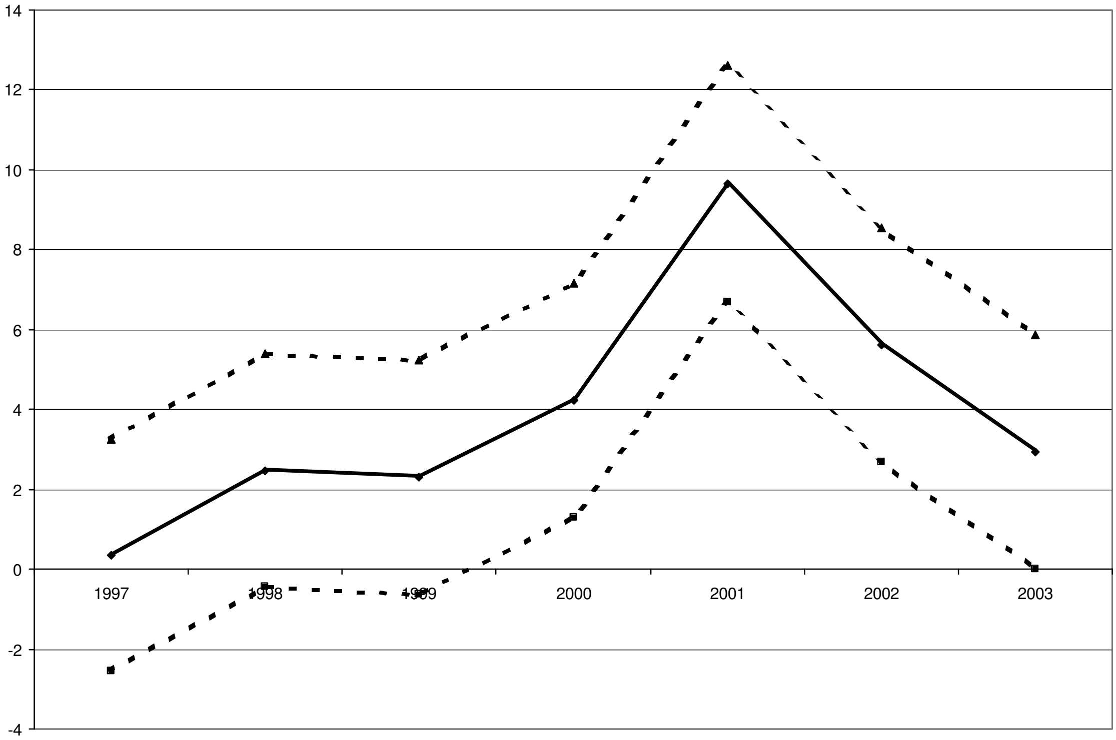


Figure 8: Soybean Coefficients from Tobit Regression

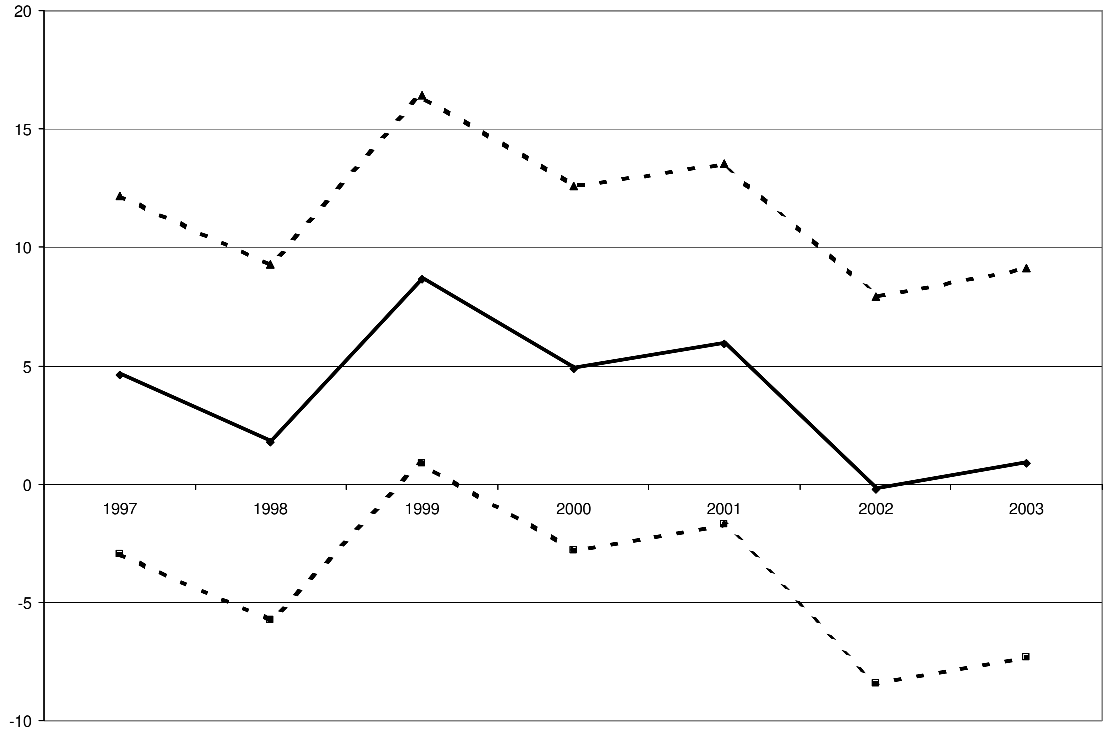


Figure 9: Wheat Coefficients from Tobit Regression

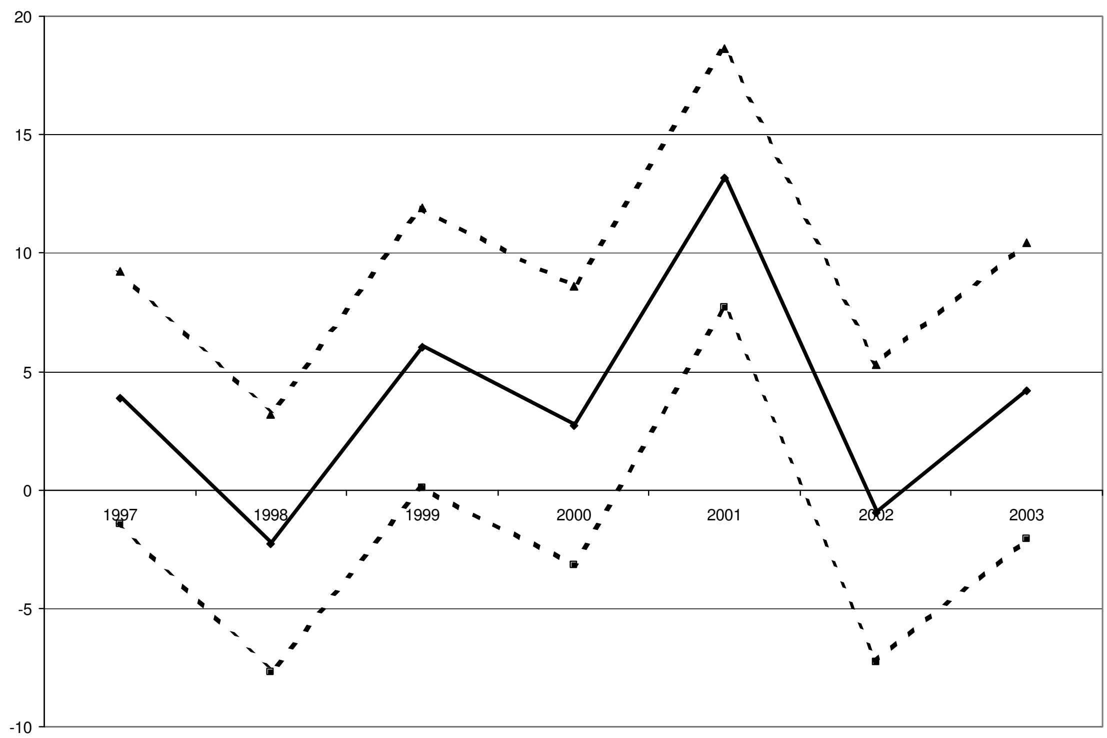


Figure 10: Corn Coefficients from Acreage Difference Regression

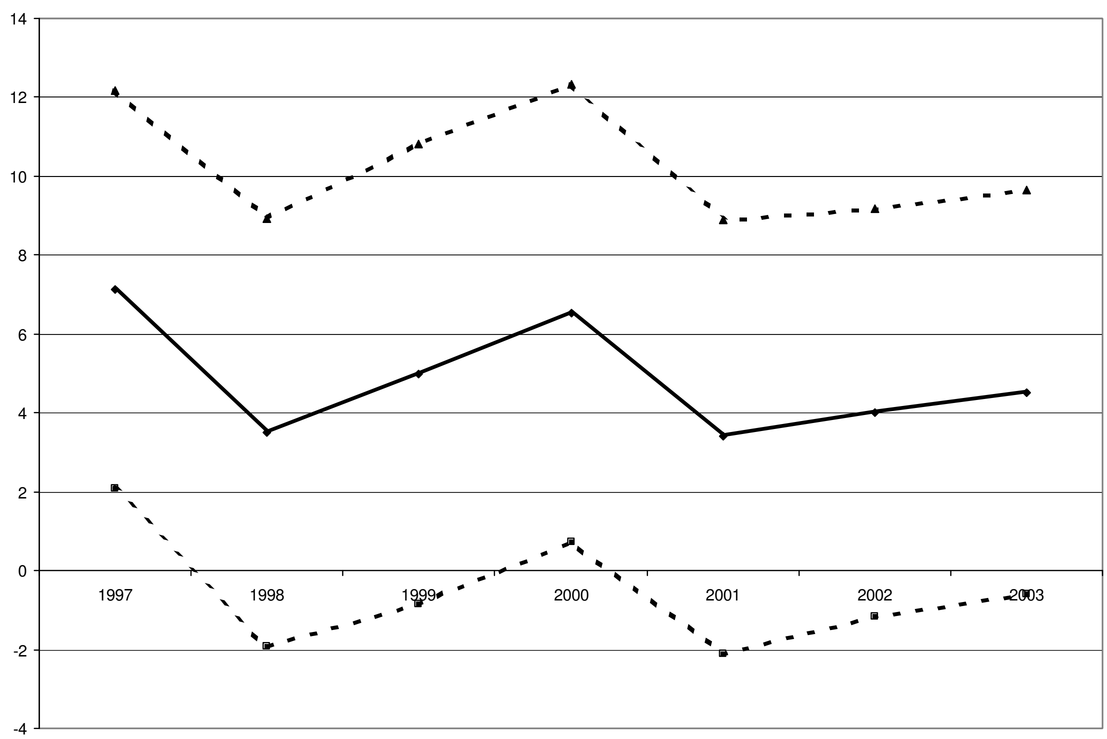


Figure 11: Rice Coefficients from Tobit Regression

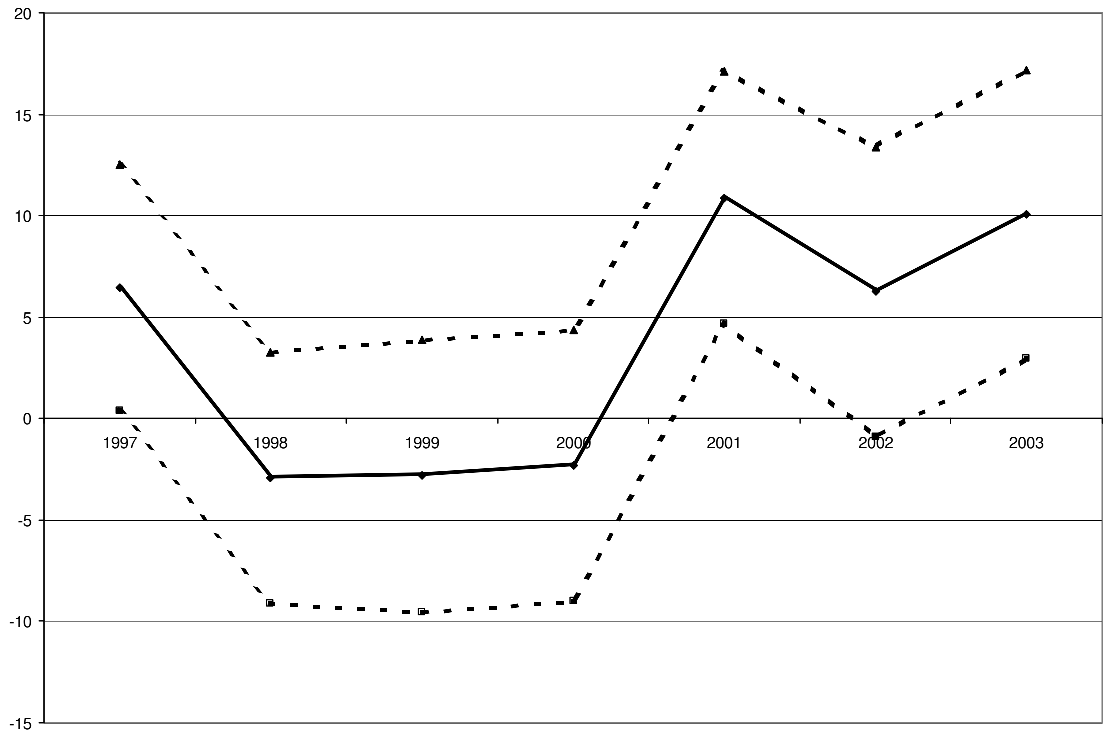


Figure 12: Sorghum Coefficients from Acreage Difference Regression

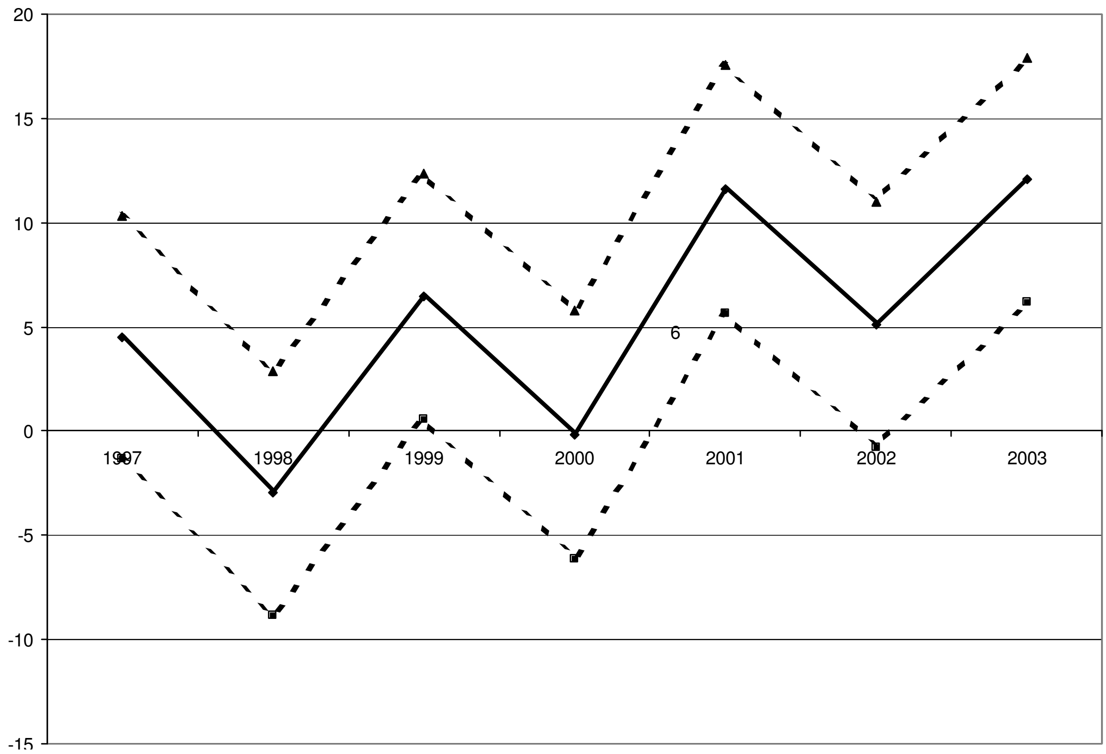


Figure 13: Soybean Coefficients from Acreage Difference Regression

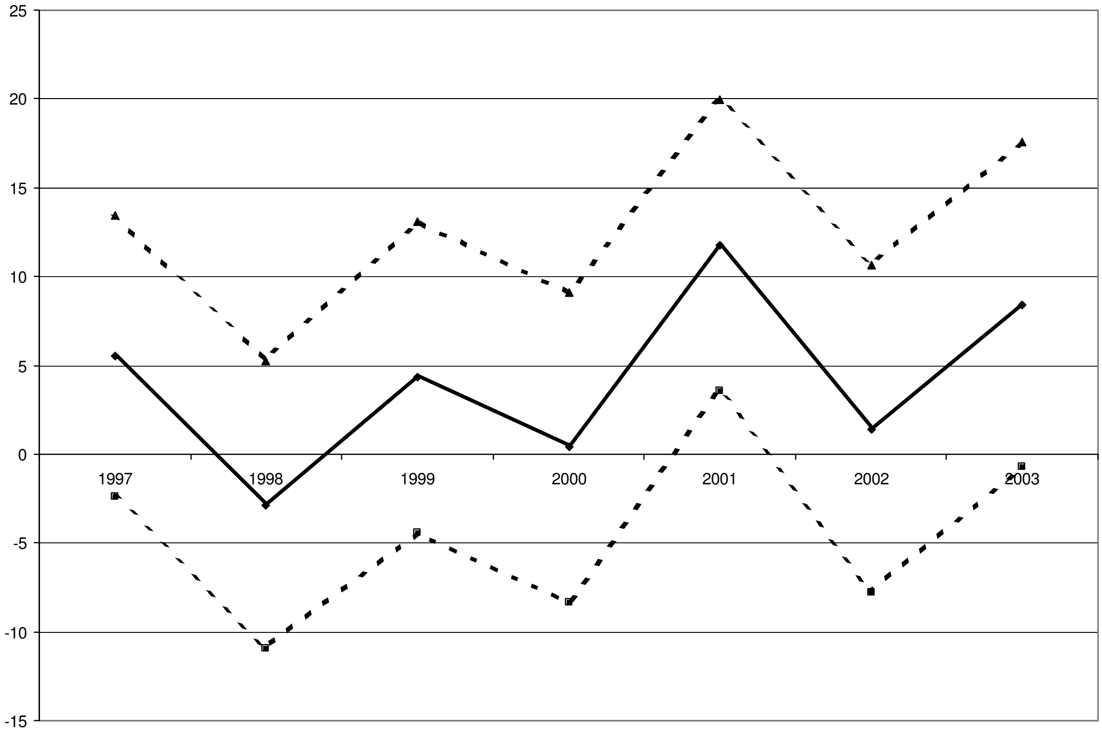
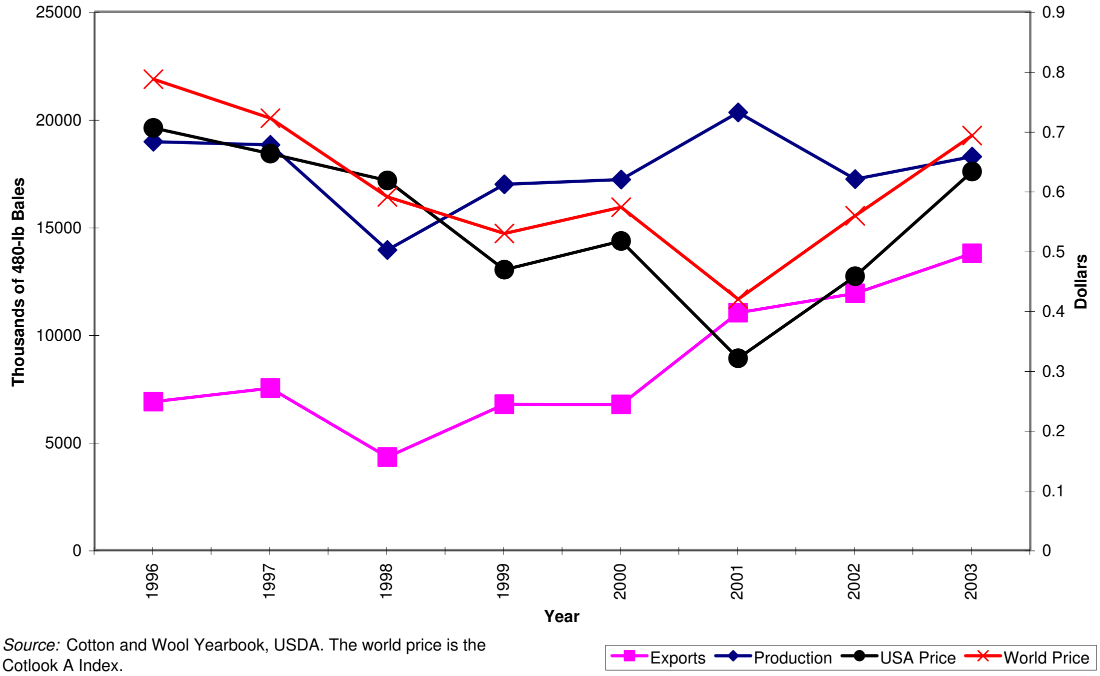


Figure 14: Wheat Coefficients from Acreage Difference Regression



Source: Cotton and Wool Yearbook, USDA. The world price is the Cotlook A Index.

Figure 15: US Cotton Production & Exports vs. US & International Cotton Price

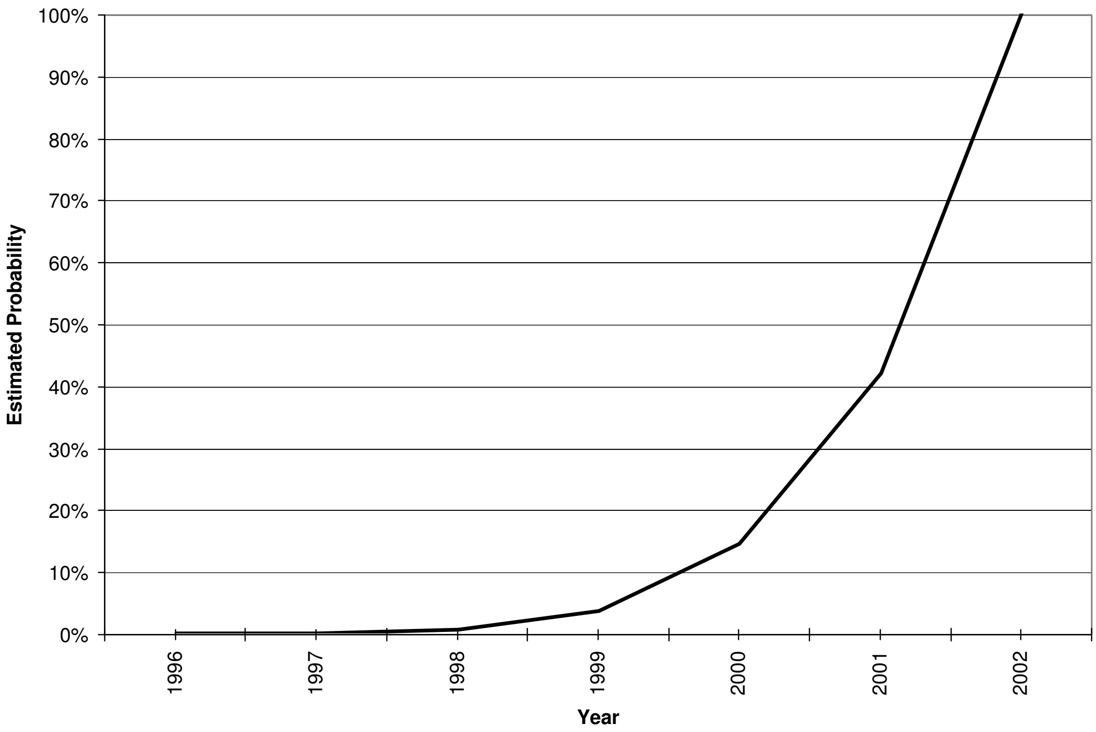


Figure 16: Estimated Probability Evolution

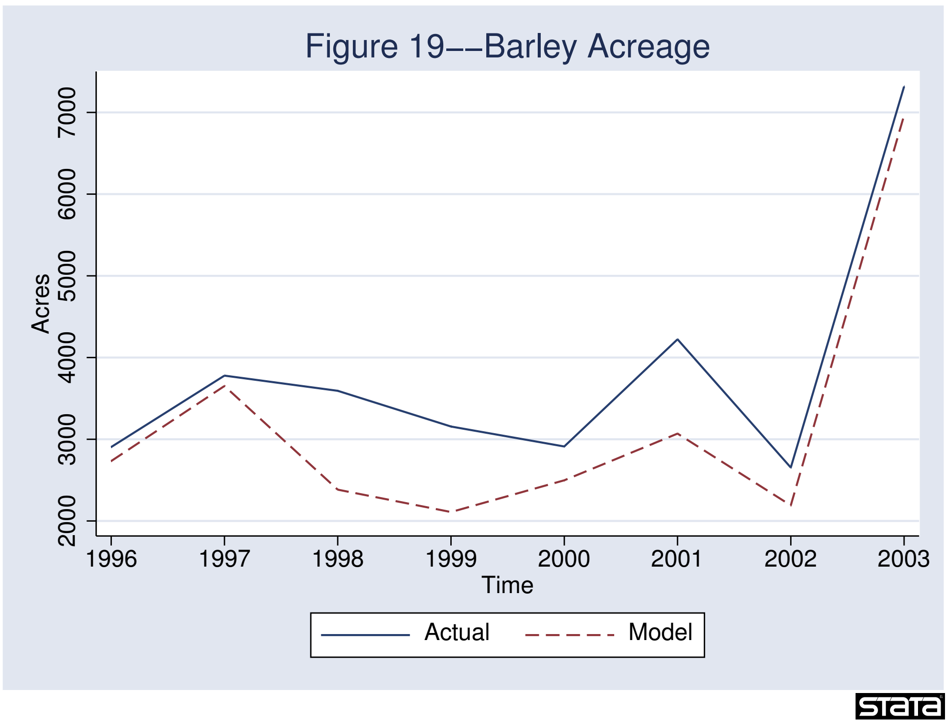


Figure 17: Barley Acreage Predictions from Structural Model

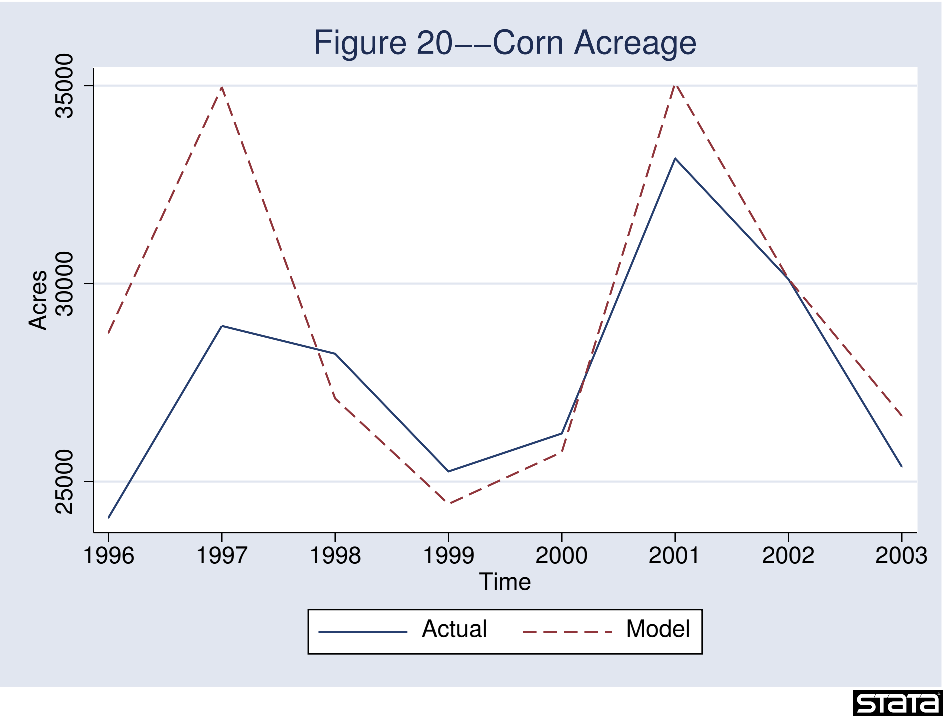


Figure 18: Corn Acreage Predictions from Structural Model

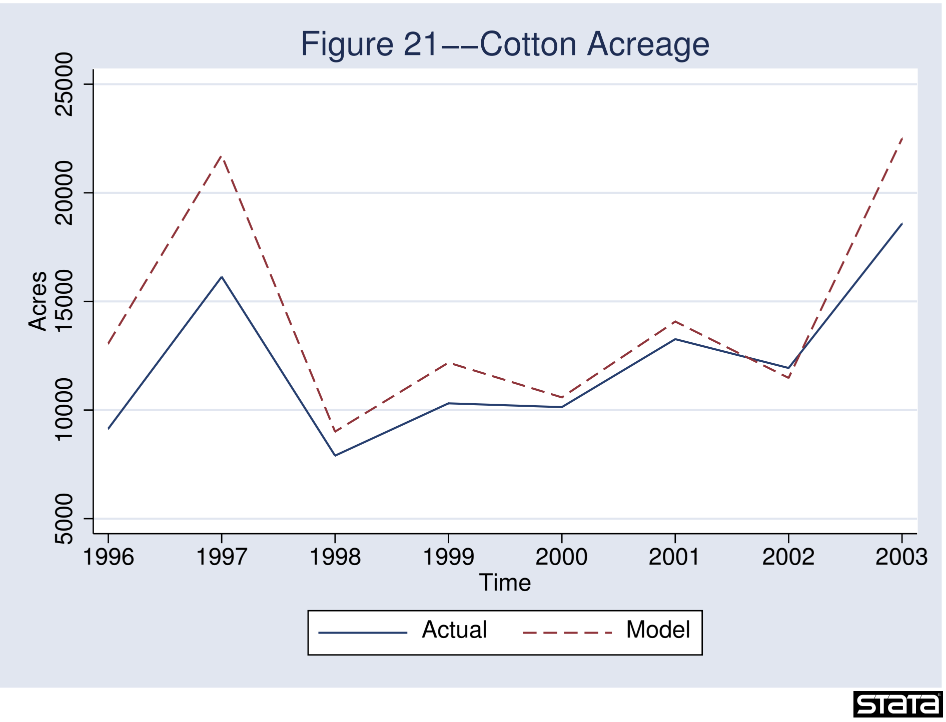


Figure 19: Cotton Acreage Predictions from Structural Model

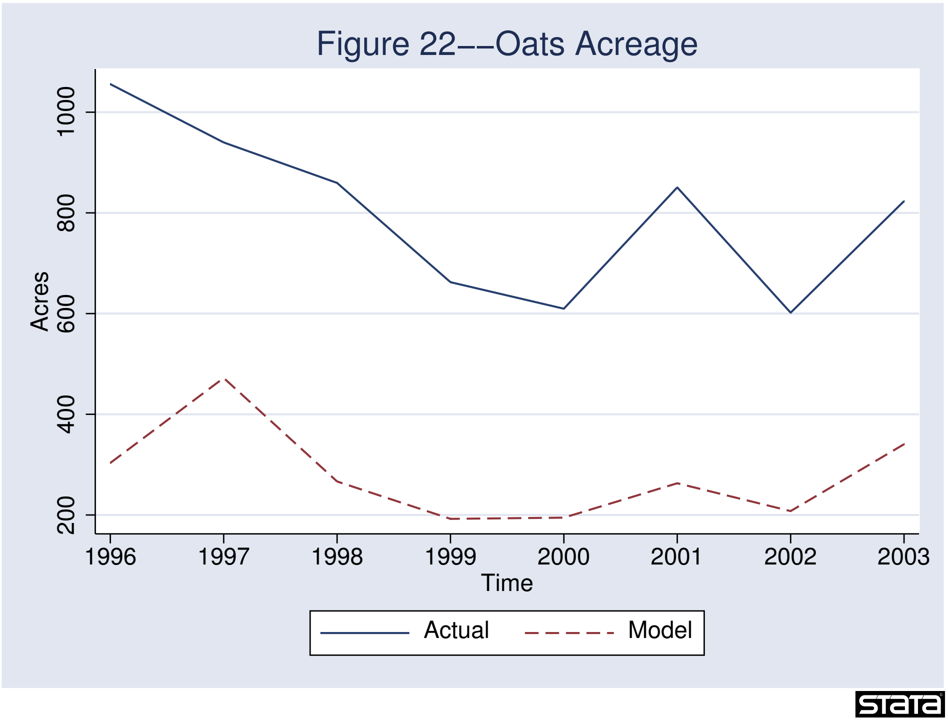


Figure 20: Oats Acreage Predictions from Structural Model

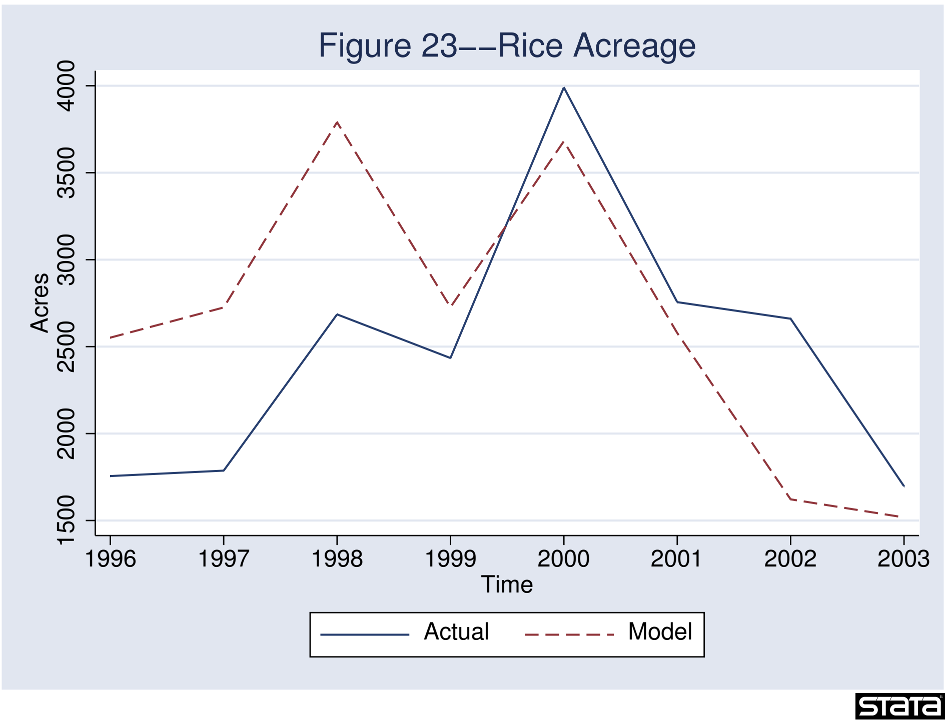


Figure 21: Rice Acreage Predictions from Structural Model

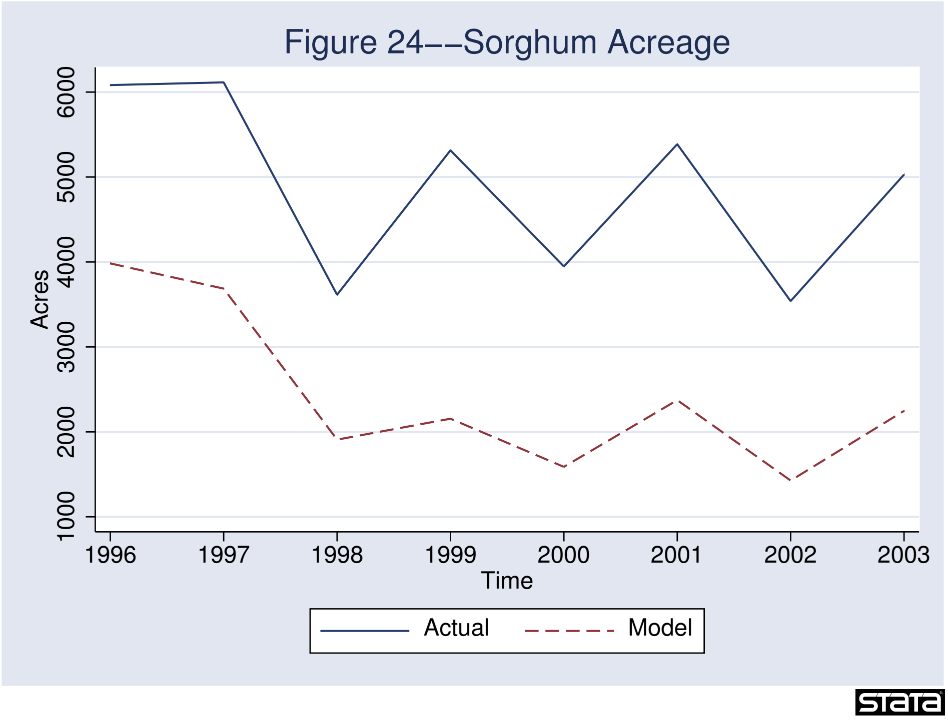


Figure 22: Sorghum Acreage Predictions from Structural Model

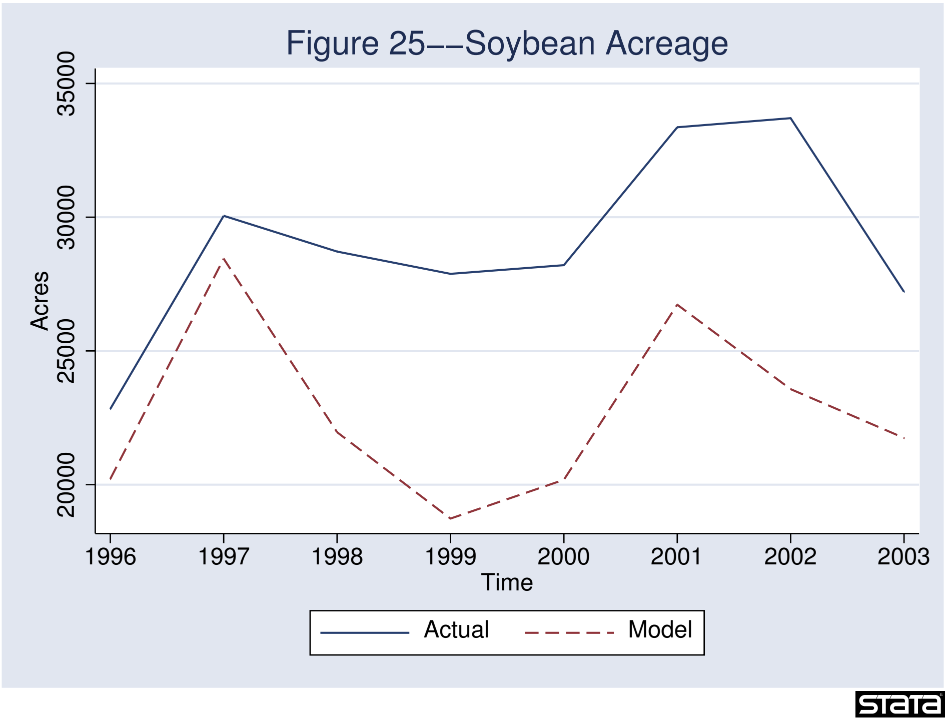


Figure 23: Soybean Acreage Predictions from Structural Model

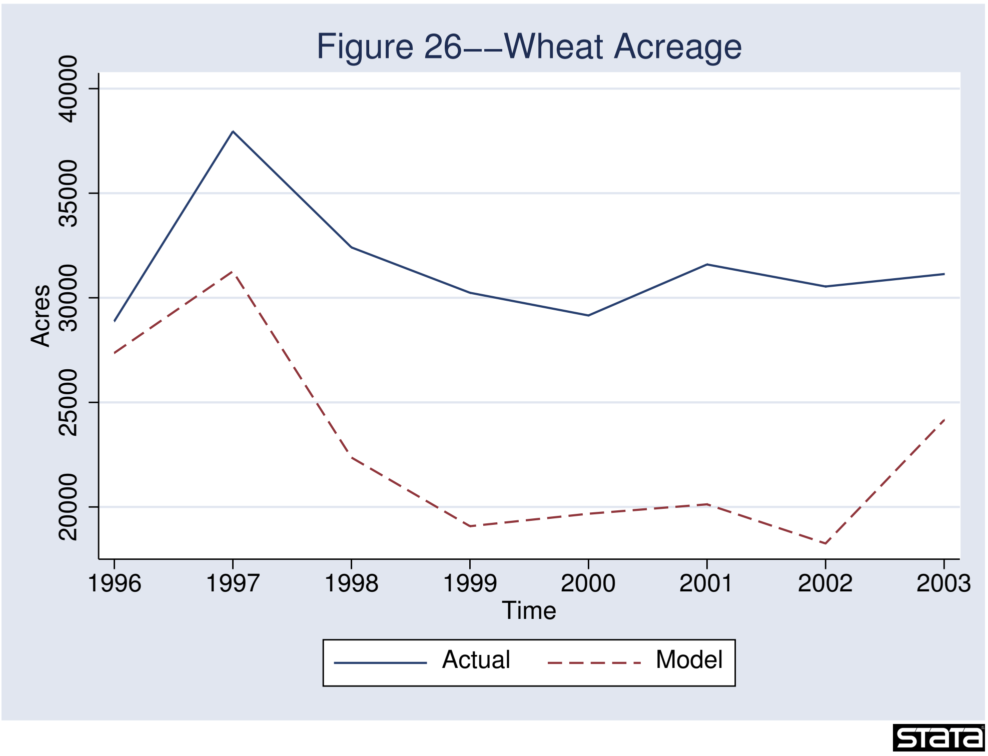


Figure 24: Wheat Acreage Predictions from Structural Model