WHY STOCHASTICS MATTER: ANALYZING FARM AND BIOFUEL POLICIES

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Paper prepared for presentation at the 107th EAAE Seminar *"Modeling of Agricultural and Rural Development Policies"*. Sevilla, Spain, January 29th -February 1st, 2008

Abstract

Standard deterministic analysis of agricultural and biofuel policies can yield incomplete or misleading results. Stochastic analysis is especially important when policies have asymmetric effects and when there is intrinsic interest in uncommon events or the distribution of possible outcomes.

The paper examines four recent cases where a stochastic approach was critical to a complete and balanced examination of important US policy issues. In each case, a stochastic model of the US agricultural and biofuel sectors was used to estimate 500 sets of possible market outcomes for the 2007-2016 period.

Changes in support levels, a proposed revenue-based program, possible World Trade Organization limits on internal support measures, and biofuel use mandates are all found to have potential impacts that could have been missed by traditional deterministic analysis. A stochastic approach could also be valuable in looking at EU policy questions such as possible reductions in intervention prices and export subsidies.

Key words:

Agricultural policy, biofuels, stochastic analysis, structural model

1. Introduction

What difference does it make if policy x is adopted?

A high proportion of work at the Food and Agricultural Policy Research Institute (FAPRI) has focused on answering such "what-if" questions. For many years, FAPRI's main tool was a deterministic model of the world agricultural sector that produced point estimates for each of the next ten years of prices, production, consumption, stocks, trade, government expenditures, farm income, and other indicators of interest. FAPRI still uses such a model to develop its annual baseline projections for world agricultural markets, and to examine a variety of policy questions (FAPRI 2005, FAPRI 2007a).

For many issues related to US agricultural and biofuel policy, FAPRI has found that deterministic point estimates only tell part of the story. In many cases, deterministic estimates are incomplete at best and wholly misleading at worst. Consider the following cases based on actual policy analysis requests received by FAPRI in 2007:

- In the US farm bill debate, both the House and the Senate have proposed increases in selected loan rates and target prices. Higher loan rates and target prices can trigger an increase in government payments to producers, but only if market prices are sufficiently low. The grain and oilseed prices in FAPRI's 2007 deterministic baseline are consistently above the levels that would trigger payments. Does that mean that the increase in support prices would have no impact?

- The US Senate and House farm bills create new programs that would make payments to producers when per-acre revenues (price times yield) fall below specified triggers. The per-acre revenues for grains and oilseeds in FAPRI's 2007 deterministic base are above the levels that would trigger payments under the proposals. Does that mean these new programs would have no effect?

- US proposals in the World Trade Organization (WTO) negotiations would limit the US Aggregate Measure of Support (AMS) to $7.6 billion per year. At the prices and quantities in FAPRI's 2007 deterministic baseline, the US AMS is slightly below the proposed limit. Does that mean the US proposal would have no effect on US farm programs?

- Newly enacted US energy legislation effectively requires a certain level of maize-based ethanol production. FAPRI analysis indicates that at the petroleum prices prevailing in world markets in early January 2008, maize-based ethanol production would exceed the levels required by the new law. Does that mean the mandate does not matter?

In each of these cases, deterministic analysis tells only part of the story. Actual market outcomes are certain to differ from the FAPRI deterministic baseline. Prices and yields, for example, will sometimes be lower than projected in the deterministic baseline, with important implications for all four questions.

Because of the limitations of deterministic analysis, FAPRI has adopted a stochastic approach to analysis of US farm and biofuel policies. The approach allows FAPRI to evaluate how policy proposals perform over a wide range of possible market outcomes. In some cases this primarily provides a broader perspective on policy questions, but in many cases the average values from the stochastic analysis are qualitatively different than the results from deterministic analysis.

The remainder of this paper will examine the four cases in more detail, briefly describe FAPRI's stochastic modelling approach, and discuss implications for analysis of European policy issues.

2. Examples from US policy analysis

In 2007, debate over the US farm bill, WTO negotiations, and biofuel policies led to a heavy demand for FAPRI analysis by members of the US Congress and other policy makers. The four cases discussed here demonstrate the limitations of deterministic analysis and the value that was added by a stochastic approach.

2.1. Increases in crop support prices

In early stages of the farm bill debate, many commodity groups sought increases in loan rates and target prices for their commodities (FAPRI 2007c). Loan rates determine benefits under the marketing loan program. For grains and oilseeds, marketing loan benefits are available when an indicator of county market prices is below the county loan rate. Producers can receive marketing loan benefits on all of their production, and generally can only receive the benefit if they produce the crop in question.[1] The program is therefore directly coupled to production decisions, as producers can use the loan program to place an effective floor beneath their per-unit returns. National average loan rates are set by law; county loan rates for grains and oilseeds are set by USDA to reflect typical regional basis patterns.

Target prices are part of formulas used to determine benefits under the countercyclical payment (CCP) program established by the 2002 farm bill. CCP's are available when the US season-average farm price for a commodity is less than the target price minus the direct payment rate.[2] CCP's are paid on a fixed base determined by historical plantings and yields.[3] As such, CCP's are less tied to current production choices than are marketing loan benefits.

The current national average loan rate for wheat is $2.75 per bushel ($101 per tonne). The wheat target price is $3.92 per bushel ($144 per tonne), and the wheat direct payment rate is $0.52 per bushel ($19 per tonne), so CCP's occur when the US season average price falls below ($3.92 - $0.52) or $3.40 per bushel ($125 per tonne). Both the House and the Senate bill would increase both the loan rate and the target price for wheat. For example, the Senate bill raises the wheat loan rate to $2.94 per bushel ($108 per tonne) and the target price to $4.20 per bushel ($154 per tonne). The target price increase would raise the trigger price for CCP's to ($4.20 - $0.52) or $3.68 per bushel ($135 per tonne).[4]

In the FAPRI (2007a) deterministic baseline, the projected US farm price for wheat is consistently above current and proposed loan rates and CCP trigger prices (figure 1).[5] Ignoring the importance of uncertainty, a naïve deterministic analysis might therefore conclude that the proposed increases in support prices would have no market impacts. Payments under both the marketing loan and CCP programs are zero in the baseline, and would be zero even if the increase in support prices were implemented, the deterministic price projections suggest.

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[1] As with many aspects of US policy, there are some minor exceptions to this general rule.
[2] Direct payment rates are also set by law. Direct payments are not tied to prices and do not require production.
[3] The 2002 farm bill gave producers an opportunity to update their base acreage to reflect 1998-2001 planted acreage and their CCP payment yields to reflect a portion of 1998-2001 actual yields. No such updating of program bases is included in the new farm bills passed by the US Senate and US House of Representatives.
[4] See FAPRI 2007b for provisions of the bill for other commodities.
[5] Based on market developments since the 2007 baseline was prepared, it is clear that at least 2007/08 wheat prices will be much higher than projected in early 2007.

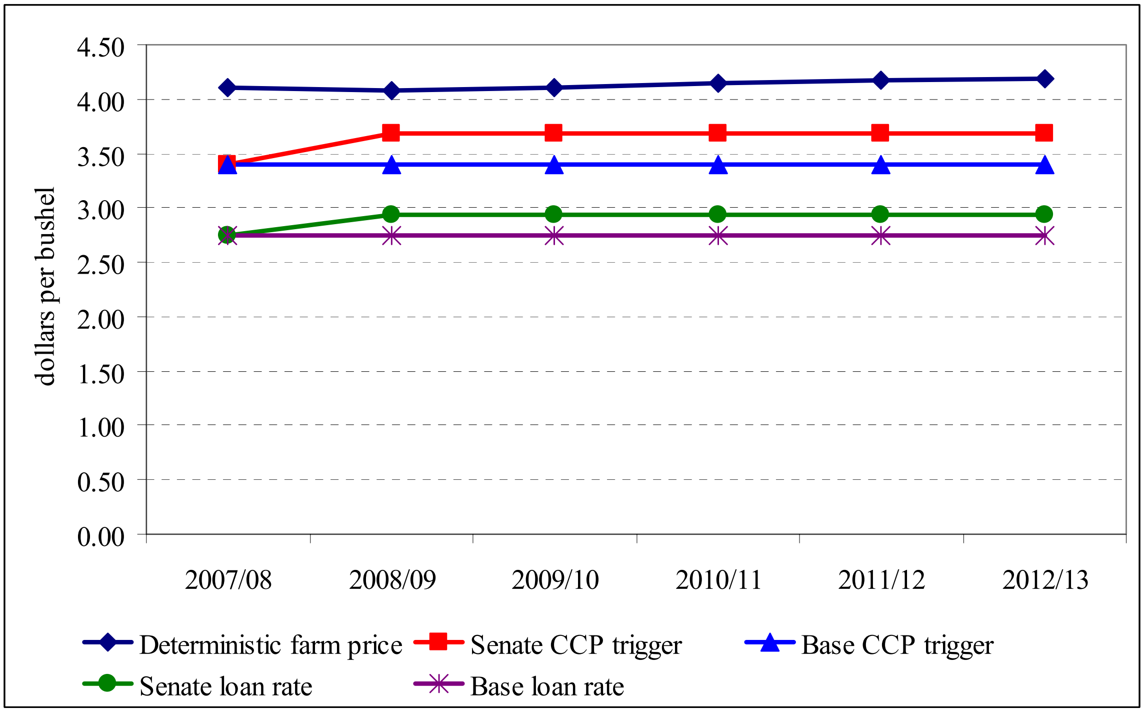

Figure 1. US wheat policy prices under current policies and Senate farm bill proposals, compared to the FAPRI 2007 deterministic projection of wheat farm prices

To conclude that the proposed increase in support prices is innocuous is to ignore the role of uncertainty. Actual market price outcomes are of course uncertain. Even if the FAPRI model were a perfect forecasting tool given a particular set of assumptions, actual market outcomes will deviate from the deterministic baseline values because many of the underlying assumptions will not hold true in practice. To take the most obvious example, the baseline assumes average weather conditions and steady rates of technological change, so crop yields generally grow in line with long-term trends with no weather-induced annual variation. Just introducing random weather conditions would result in crop production and prices that could deviate significantly from the deterministic baseline values. A wide range of other random factors will also help make actual market outcomes far different from the deterministic baseline projections.

The FAPRI stochastic model incorporates a number of important sources of variability in agricultural and biofuel markets, as described later in the paper. The model generates 500 sets of market outcomes, where each outcome is based on a particular set of assumptions about selected exogenous variables that drive model results. These different assumptions result in a range of market outcomes for production, prices, trade, government budgetary costs, farm income, consumer food prices, and other variables of interest (Westhoff, Brown and Hart 2006).

Consider the 2007 stochastic baseline projections for U.S. wheat prices relative to the proposed Senate trigger price for CCP's (figure 2). The mean price from the stochastic analysis is almost identical to the deterministic price projection shown in figure 1. However, the stochastic model generates a range of wheat price outcomes, and more than 10 percent of the outcomes are lower than the Senate-proposed CCP trigger price. Thus, even though the deterministic baseline suggested no CCP's or marketing loan benefits would result even with the Senate-proposed increases in target prices, the stochastic analysis suggests there is at least some chance there would be CCP's at the higher target prices.

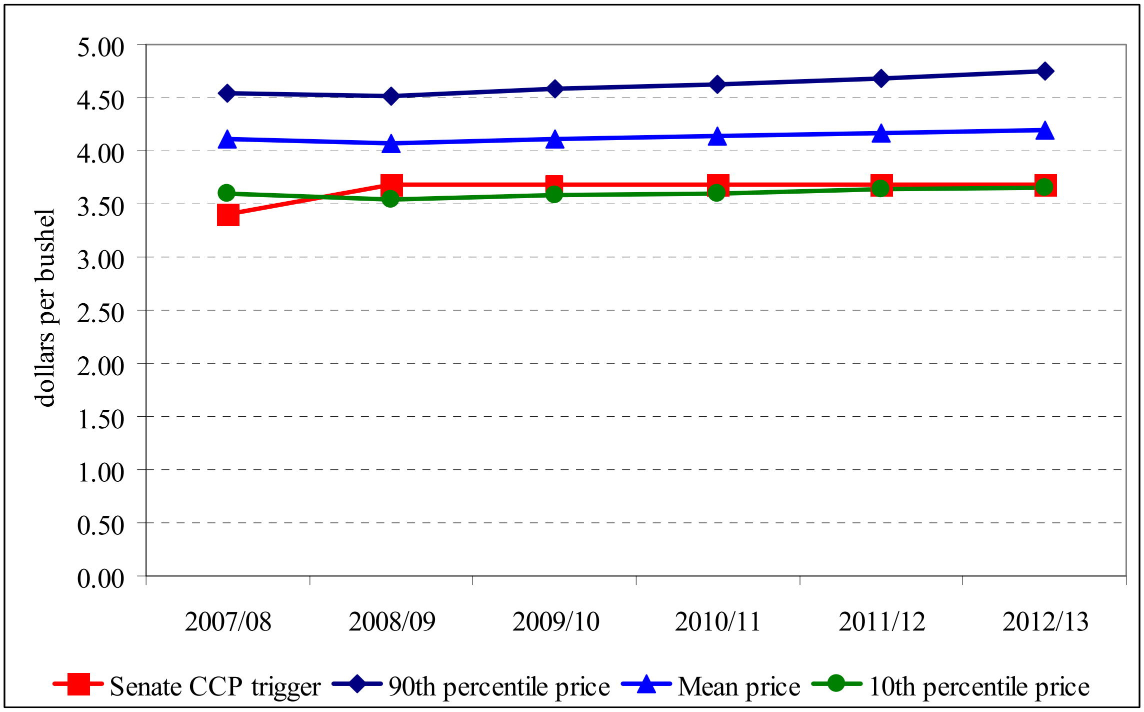

Figure 2. The trigger for CCP payments under the Senate farm bill and the mean, 10th percentile, and 90th percentile estimates for US wheat prices in the FAPRI 2007 stochastic baseline

Model results confirm this conclusion. In the scenario that incorporates the proposed changes in target prices and loan rates included in the Senate farm bill, CCP's for wheat occur in 84 (17 percent) of the 500 stochastic outcomes for 2008/09, and the mean value of wheat CCP's in 2008/09 across all 500 outcomes is approximately $81 million. In comparison, with 2002 farm bill target prices in place, CCP's occur in only 24 (5 percent) of the 500 baseline stochastic outcomes for 2008/09, and the mean value of wheat CCP's is just $12 million. Thus, the stochastic analysis suggests that the proposed change in policies increases average budgetary outlays on the CCP program for wheat by approximately $69 million in 2008/09.

These results demonstrate the strength of the stochastic analysis. By recognizing that future market prices cannot be known with certainty, the stochastic analysis finds that a support price increase that would appear to have no impact when examined using a naïve deterministic approach could actually have an impact on market outcomes, budgetary expenditures, and other variables of interest.

At the same time, figure 2 reminds encourages a note of humility. In retrospect, the projected wheat price distributions in the 2007 stochastic baseline now appear laughably narrow. Actual US wheat market prices in 2007/08 will not only exceed the 90th percentile price shown in figure 2, but actually will exceed all 500 stochastic outcomes. While this has been an exceptional year, it does not seem reasonable to assume that this year's wheat market is really a once-in-500-year phenomenon. The experience is a reminder that the partial stochastic approach utilized captures only a few possible sources of uncertainty. Selected exogenous variables are allowed to vary, but other exogenous variables are held fixed and the model structure and parameters are treated as if they were known with certainty. A series of model adjustments will be made prior to the development of the 2008 FAPRI stochastic baseline to ensure that the resulting distribution of wheat market prices appears more reasonable in light of recent experience.

2.2. Average crop revenue program

Both the House and Senate farm bills include programs that would make payments to producers when per-acre crop revenues fall short of trigger levels. The House bill provides a national revenue-based option that is patterned on a proposal by the Bush Administration. The "average crop revenue" (ACR) program in the Senate bill is based on outcomes at the state level.

If the Senate ACR program becomes law, producers will have to make a one-time choice whether to participate in current commodity programs or the ACR program before the latter begins operation in 2010. Those who choose the ACR would forego direct payments, countercyclical payments and marketing loan benefits in favour of a program that would make a fixed payment of $15 per base acre ($37 per hectare) and additional payments when state-level revenues fall short of a trigger level.

For a given commodity and state, the revenue level that triggers revenue-based ACR payments is equal to 90 percent of a state level trend yield[6] multiplied by a three-year average of prices.[7] Payments occur when this trigger is greater than the product of actual state yields and a national harvest-time price.[8] Payments are made on base acreage, which has been fixed since 2002, rather than on actual planted or harvested acreage. The revenue-based part of the ACR program, therefore, has a number of features in common with the current CCP program, in that payments are based on market conditions but not on individual production decisions. The fixed payment portion of the ACR program, in contrast, is essentially the same as the current direct payment program, in that payments are tied neither to market conditions nor current production decisions.[9]

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[6] Based on a linear trend fit over 1980-2006 yields per planted acre for each state and commodity.
[7] The prices used are pre-planting prices in the crop insurance program. In the case of maize, for example, the pre-planting price is the February average of December futures on the Chicago Board of Trade.
[8] The actual yield is a yield per planted acre and the price is the harvest-time price under the crop insurance program. In the case of maize, the harvest price is based on the November average of December futures prices.
[9] An important qualification is that payments under both the CCP and direct payment programs are not available to producers who plant fruits and vegetables on base acreage, with some exceptions. The United States has notified the WTO that it considers direct payments to be green box subsidies. Other countries have argued that the fruit and vegetable planting restriction means that the payments are not truly decoupled from production decisions and should not qualify for green box treatment.

The program poses a number of analytical challenges. For example, how would the payments affect production decisions? FAPRI assumed that fixed ACR payments would have only small production effects, similar to direct payments, given the degree to which the payments are decoupled from both production and prices. The revenue-based ACR payments were assumed to have slightly larger production effects, similar to those of the CCP program. Besides these more theoretical issues, there were also major practical concerns, such as how to proxy price triggers based on futures prices when the model solves for actual and expected market prices.[10]

Most relevant to this discussion is the calculation of projected payments under the revenue-based part of the ACR program. Consider the case of maize. Given the FAPRI 2007 deterministic baseline and some simplifying assumptions, it would appear the program would never result in revenue-based ACR payments to maize producers. Over the 2010/11-2014/15 period, the national average revenue per acre is consistently above the level that would trigger revenue-based payments under the program (figure 3).

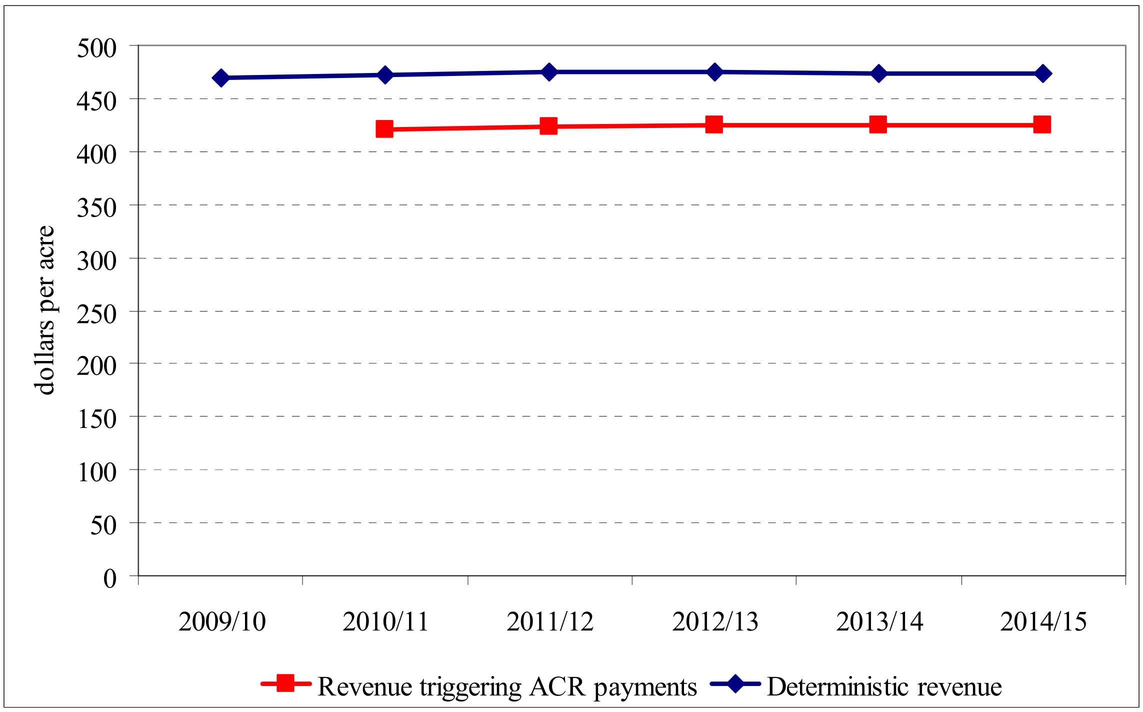

Figure 3. Maize revenue per acre that would trigger payments under the ACR program and 2007 FAPRI deterministic baseline estimates of maize revenue per acre.

Clearly, a deterministic approach to the question is inadequate. Prices, yields and revenues are uncertain, as is the level of guaranteed revenue, since it is based on a moving average of market prices. Actual revenues are likely to decline enough to trigger variable ACR payments, at least occasionally. Furthermore, it is not enough to look at the question using the distribution of national level prices, yields

[10] Assuming a fairly constant basis between futures prices and season-average market prices, the model utilized season-average market prices as a proxy for the harvest price. For the pre-planting price, the model used the expected prices generated by the model, which are lagged prices adjusted for deviations from trend yields.

and per-acre revenues, because the program is based on state-level revenue calculations. Finally, the program is optional, so some assessment must be made of how many producers will choose to participate in the program. All of these concerns add layers of complication to the analysis.

FAPRI's stochastic analysis of the ACR proposal (FAPRI 2007 b) used a three-step approach to the problem. The first step treated the program as if it were mandatory and based on national-level revenue triggers. In this most direct application of the model, the national average revenue per acre for each crop was compared to an estimated revenue guarantee based national trend yields and a three-year moving average of expected prices in the model.

The distribution of revenues per acre depends not just on the distributions of prices and yields, but also on the (negative) covariance between the two. This provides a prime example of why the way in which the model is made stochastic matters a great deal. Suppose, for example, that the model were made stochastic simply by introducing random weather shocks that made yields deviate from their deterministic values. Also suppose for the sake of argument that the elasticity of total demand is approximately negative one. With such an approach, drawing a yield that increases supply of a given commodity by, say, 10 percent would result in an offsetting 10 percent reduction in prices, leaving revenues unchanged. If a revenue-based program did not result in any payments when examined deterministically, it would also result in no payments when examined stochastically using such a simplistic approach.

FAPRI's stochastic model uses correlated draws of a variety of exogenous supply-side *and* demand-side variables to generate the assumption sets for each of the 500 stochastic outcomes. Because both supply- and demand-side shocks are considered, revenues will be variable even if demand elasticities were near negative one (actual demand elasticities vary across crops and across time).

Under the counterfactual assumption of an ACR program based on national yield triggers and mandatory participation, mean revenue-based program expenditures for maize rise from $123 million in 2010/11 to $263 million in 2014/15 (figure 4). These estimates represent the mean of 500 outcomes where payments are zero in most outcomes. For example, in 2010/11, ACR revenue-based payments for maize occur in only 50 (10 percent) of the 500 stochastic outcomes, but in 27 (five percent) of the outcomes, the payments exceed $1 billion.

The second step of the analysis recognizes that the program is based on state revenues instead of national revenues. Even when national revenues per acre are above the implied national trigger, producers in states suffering local yield shortfalls might qualify for payments. To evaluate a state-level program with a national-level model requires some way to proxy the relationship between state and national yields and revenues. This was done by using observed data for state-level yields and revenues for the last 27 years to calculate what payments would have been had the program been in place over that period with state-level triggers, as compared to payments over the same period if national-level triggers had been in place. From this, equations were created that reproduce the historical payments with state-based triggers in place.

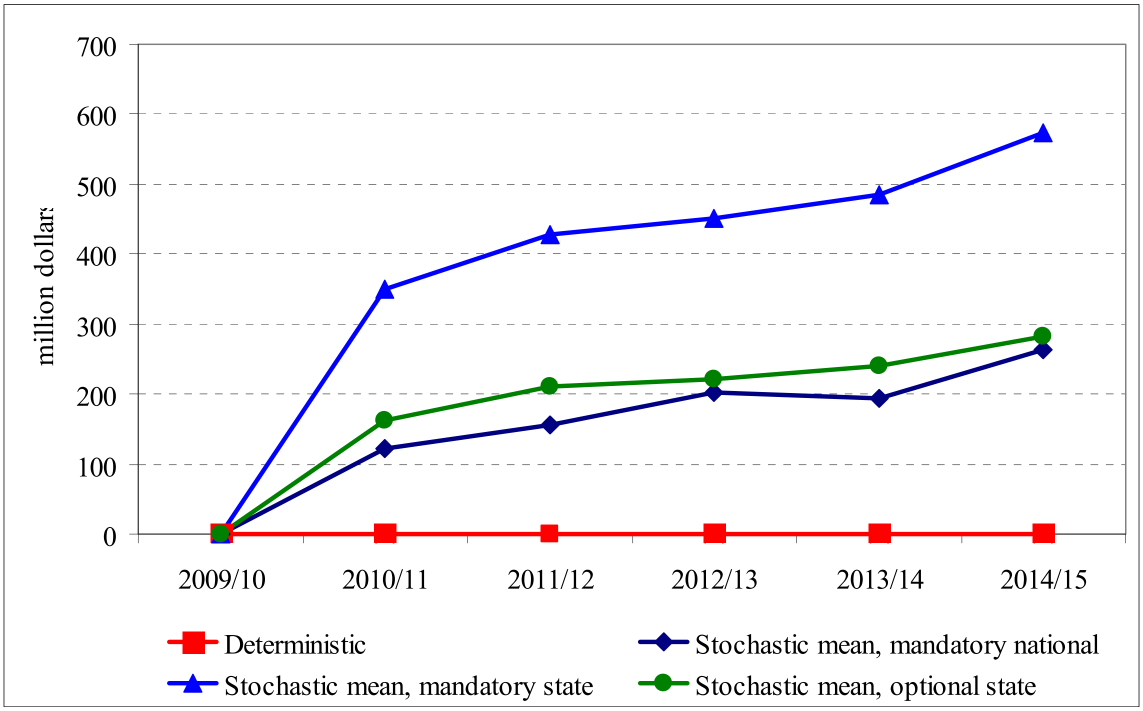

Figure 4. Revenue-based ACR expenditures on maize using alternative approaches.

The results suggest payments are much higher with state-based revenue triggers than with national level triggers. Program expenditures on maize are more than double the level implied by a national set of triggers (figure 4).

The final step is to recognize that the proposed program is optional. Each producer must make a one-time choice whether to participate in the ACR program or stay with traditional programs, and the choice applies to all commodities for which the producer has base acreage. Thus, it is not sufficient to observe that estimated mean ACR payments on maize base acreage are slightly less than payments under traditional programs[11] and therefore conclude that maize producers will choose not to participate. Instead, it is necessary to consider typical mixes of base acreage on farms and other region and farm-specific issues. Because mean ACR payments per soybean base acre exceed those under traditional programs and most maize producers have both maize and soybean base, the participation choice is less obvious. With limited time to conduct the analysis, FAPRI assumed that 50 percent of maize base acreage would participate in the ACR program.[12]

[11] Mean revenue-based ACR payments for maize are greater than the sum of marketing loan benefits and CCPs under traditional programs, but this effect is more than offset by the fact that the $15 per base acre fixed ACR payment is less than the average maize direct payment of $24 per base acre.
[12] Participation rates were assumed to be greater for wheat (70 percent) and soybeans (60 percent), but zero for upland cotton and rice. For cotton and rice, foregone direct payments are much larger than plausible ACR benefits.

Taking this assumed participation rate into account, the final estimates of mean ACR revenue-based payments on maize base acreage rise from $161 million in 2010/11 to $282 million in 2014/15. These estimates, of course are sensitive to all of the assumptions used in the analysis. Furthermore, while the stochastic approach provides richer results than a deterministic analysis, it does not avoid the issue of baseline dependence. If mean prices were rising over time or if mean yields were growing more rapidly than the 1980-2006 trend, program expenditures would decline over time.[13] If prices were falling or yields were declining relative to the historical trend, expenditures would rise. Estimates prepared using the 2008 stochastic baseline to be prepared in the weeks ahead will therefore differ from the 2007 model results simply because there will be changes in mean prices and yields.

2.3. US AMS estimates

As part of current WTO negotiations, the United States has offered to reduce its amber box commitment by 60 percent from the current bound level, to $7.6 billion per year. The AMS is a complex measure that is distinct from alternative measures of government support, such as budgetary expenditures or producer subsidy equivalents. In US notifications[14] the portion of the AMS that counts toward WTO commitments to limit the "total current AMS" is comprised primarily of two components:

- Actual budgetary expenditures under the marketing loan program. These expenditures can vary dramatically from year to year, and are expected to be near zero in 2008.

- The imputed value to producers of the dairy and sugar price support programs. In essence the calculation multiplies total US production by the difference between US support prices and a measure of international prices in the 1980s. Combined, these two components total slightly over $6 billion in 2008.

In FAPRI's 2007 deterministic baseline, marketing loan benefits were projected to be zero or very small for most commodities. Given the accounting approach used in US notifications, this would result in a total current AMS below the US-proposed limit in every year of the projection period (figure 5). Based on the FAPRI 2007 deterministic baseline, the imputed value of the dairy and sugar price support programs would account for almost the entire US total current AMS.

From the deterministic results, one might conclude that the US offer would not require any US policy changes. If market prices for major commodities remain high, it is true that current US policies would be consistent with the US proposal. Indeed, even the increases in target prices and loan rates included in the House and Senate versions of the farm bill would be consistent with the US proposal, as neither would

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[13] A more fully stochastic approach would recognize that yield trends themselves are uncertain and would allow them to vary. The current approach treats yield trends as fixed and merely estimates variation around those fixed trends.

[14] There is considerable controversy over the appropriateness of the US AMS notification. The accounting scheme used here reflects the practices of recent US notifications, without judging their appropriateness.

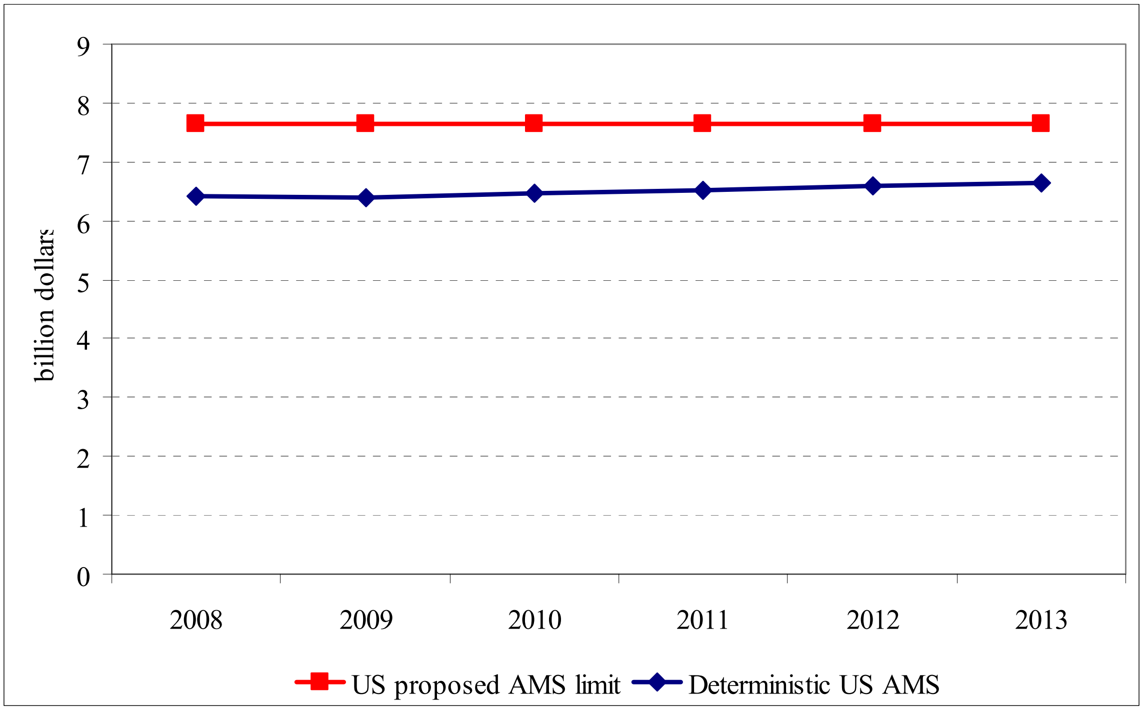

Figure 5. US total current AMS under the US WTO proposal and in FAPRI's 2007 deterministic baseline

increase support levels enough to significantly increase the AMS when the problem is looked at in a deterministic sense.

Once again, stochastic analysis suggests the full story is more complicated. In at least some of the stochastic outcomes under current US policies, commodity prices are low enough to generate significant expenditures under the marketing loan program. While the mean level of the total current AMS remains slightly below the US-proposed commitment level, there are a number of outcomes where the proposed AMS limit is exceeded (figure 6). In 2008, for example, the proposed limit is exceeded in about 25 percent of the stochastic outcomes. Over the period from 2008-2016, the proposed limit is exceeded at least once in 91 percent of the stochastic outcomes.

The stochastic analysis suggests that policy changes almost certainly would be required to conform to the US proposal. While it would be a mistake to read the stochastic results as true probabilities of various occurrences, given the design and limitations of the stochastic analysis, it is interesting to note that most of the stochastic results for any given year are below the proposed limit, but that the limit is almost always exceeded at least once over the nine-year period.

The stochastic results also have other implications for the WTO negotiations and the farm bill debate. The focus here has been on amber box support, but arguable proposals to limit "overall trade-distorting support" (OTDS) have received even more attention in the negotiations. FAPRI stochastic analysis suggests the OTDS limit would have to be set below \$14 billion before it would become as binding as the

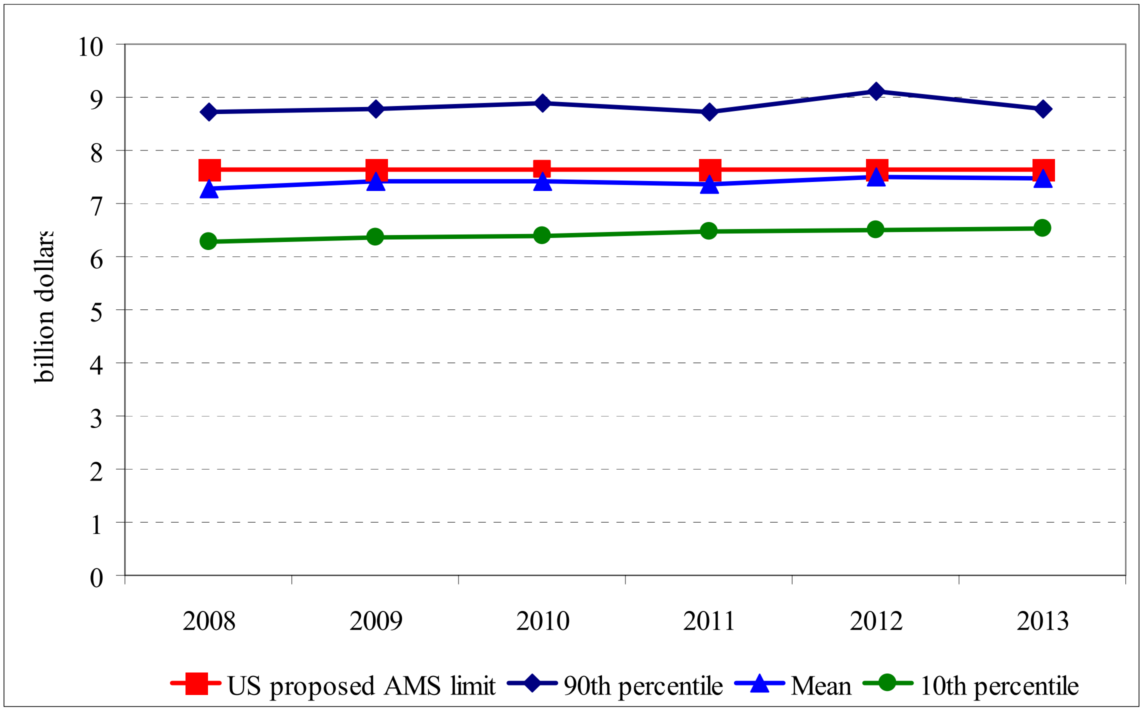

Figure 6. US total current AMS under the US WTO proposal and in FAPRI's 2007 stochastic baseline

proposed $7.6 billion AMS limit. If the OTDS limit is set at a higher level and current US policies remain in place, the US exceeds the proposed AMS limit more often than it exceeds the hypothetical OTDS limit in the 2007 stochastic analysis.

Concern has been expressed that the House and Senate farm bills would increase WTO support measures. Higher loan rates, for example, increase the stochastic mean value of the total current AMS. However, the increases in budgetary expenditures and AMS measures are relatively small, given high projected average grain and oilseed prices. Another component of the proposed farm bills may actually reduce the US AMS. The House and Senate dairy proposals would replace the current price support for milk with price supports for butter, nonfat dry milk and cheese. It is argued that removing the price support for fluid milk, *per se*, will reduce the calculated AMS for the dairy sector, even though the support levels for butter, cheese and nonfat dry milk will remain at current levels.

2.4. New energy legislation mandating biofuel use

The Energy Independence and Security Act (EISA), signed into law in December 2007, mandates the use of specified levels of biofuels in each year between 2008 and 2022. Specific mandates are established for total biofuel use, biodiesel, cellulosic ethanol, and "advanced biofuels."[15] To slightly oversimplify, the bill implicitly mandates the use of 15 billion gallons (57 billion litres) of maize starch-based ethanol by 2015.

[15] Advanced biofuels are defined it a way that explicitly excludes maize starch-based ethanol.

For comparison, actual 2007 US ethanol production was approximately 6.5 billion gallons (25 billion litres).

Large increases in biofuel production are certain to have major implications for commodity markets. A distinct question, however, is how much difference the new mandates will make. If production and use was already going to exceed the proposed mandates, their market impact may be minimal. Indeed, earlier biofuel use mandates established by a 2005 energy bill have been greatly exceeded, suggesting they may have had little marginal impact on the market.

FAPRI's model for US biofuel markets is based on the assumption that both producers and consumers of biofuels will react to market signals, as with any other commodity, except as constrained by policy. On the supply side, ethanol production capacity and capacity utilization rates are functions of industry profitability measures. Capacity expansion takes time and limits potential production in any given year. Capacity utilization rates are specified as logistic functions so that most capacity is utilized when net returns over operating costs are sufficiently positive, but operating rates drop rapidly when returns near zero or turn negative. Net return calculations consider the value of ethanol and coproduct feeds and the cost of maize, energy and other variable inputs.

On the demand side, the model considers three major uses of ethanol. Before EISA, mandatory additive uses of ethanol reflected ethanol's use as an oxygenate to meet clean air requirements and to satisfy other mandates. This use of ethanol is relatively inelastic and generally is essentially a fixed fraction of gasoline use.[16]

The second use of ethanol reflected in the model is in the voluntary E10 (a blend of 10 percent ethanol and 90 percent gasoline) blend market. In most of the country, there is no current requirement to use ethanol to meet regulatory requirements, so use of E10 is essentially voluntary. In the model, it is assumed that limited E10 use will occur even at ethanol prices greater than ethanol's energy value as a fuel, reflecting ethanol's value as an octane enhancer, state policies that favour E10, and other factors. E10 use becomes much more elastic when ethanol prices fall to levels more consistent with ethanol's energy value (roughly two-thirds that of gasoline on a volume basis).

Finally, the third use of ethanol in the model is E85 (a blend containing up to 85 percent ethanol). Current E85 use is modest, in part because of limited availability of vehicles equipped to run on the fuel and service stations dispensing it, but also because ethanol prices until recently were above ethanol's value as fuel based on its energy content. In the model, the size of the potential E85 market expands over time and responds to price incentives, and the portion of the potential market that is filled is a function of relative ethanol and gasoline prices. Kruse et al (2007) provide a more complete description of the model and discuss impacts of several potential pre-EISA scenarios.

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[16] Regulatory changes, including policy changes that led to the elimination of MTBE from the domestic fuel supply, accounted for much of the growth in ethanol use from 2005-2007.

Without EISA in place US ethanol prices are expected to be positively correlated with petroleum and gasoline prices and strongly affected by the availability and size of tax credits provided to those who blend ethanol with gasoline. All else equal, higher gasoline prices increase demand for ethanol, which results in higher ethanol prices for a given level of supply. Higher ethanol prices result in greater profits for ethanol producers, resulting in higher levels of capacity utilization and increased investment in new capacity.

As a result, ethanol production in 2016/17 in the 2007 FAPRI stochastic baseline is strongly correlated with petroleum prices (figure 7). The stochastic baseline utilizes a distribution of petroleum prices centered on forecasts prepared by Global Insight, Inc. In early 2007, their forecast called for a decline in the US refiner's acquisition price for petroleum from roughly $60 per barrel in 2006 to about $50 in 2016.[17] With current petroleum prices much higher, projections based on the early 2007 estimates may now appear out of date.

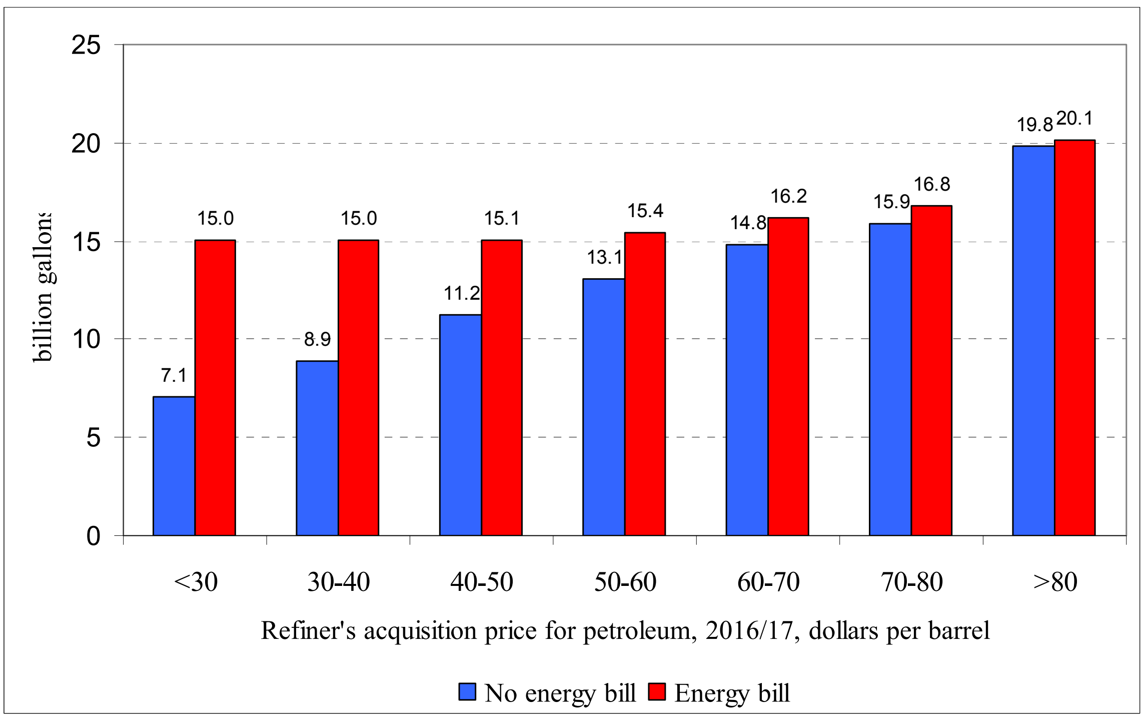

Figure 7. US production of maize starch-based ethanol in 2016/17, sorted by petroleum price outcomes, based on the 2007 FAPRI stochastic baseline and analysis of EISA

The mean projected level of 2016/17 maize-based ethanol production in the 2007 FAPRI stochastic baseline is significantly below the EISA mandated level, but that could be ascribed in part to the assumption that average petroleum prices would be much lower than prices observed in early 2008. Note

[17] The more commonly cited price for West Texas Intermediate petroleum, which corresponds closely to the contract for light sweet crude traded on the New York Mercantile Exchange, was forecast to decline from $66 per barrel in 2006 to $56 per barrel in 2016.

that at petroleum prices over $70 per barrel, projected maize-based ethanol production levels exceeded the levels required by EISA.

Results suggest that EISA could have little market impact at high petroleum prices but potentially large impacts at low petroleum prices. By requiring 15 billion gallons of maize-based ethanol use even when low petroleum prices would otherwise lead to low demand for ethanol, the bill effectively places a floor beneath one important component of demand for maize. This has broad implications for the agricultural sector as a whole, affecting not just the level but the variability of commodity prices. Average estimated impacts of EISA on commodity markets are far greater than those resulting from adoption of either the House or Senate farm bills.[18]

3. Implications for analysis of European agricultural markets and policies

In the examples that have been used for the US in the sections above, a primary motivation for stochastic analysis is to correctly reflect outcomes of different policies on actual government spending. The focus on the cost of policies reflects both the way that policies are operated in the US, with many payments still linked to market conditions, and the nature of the policy making process. In the US agricultural support expenditure is not generally limited by a budget, rather *projected* spending is limited at a level related to projected baseline spending, and thus medium term projections are central to the policy making process.

In the EU, expenditure on the Common Agricultural Policy (CAP) is much less volatile than its counterpart in the US. Successive reforms have replaced price support with direct payments that are largely fixed in nominal euro terms.[19] In addition to this, reductions in the levels of the remaining price support measures have meant that public stock holding activities and export subsidization have fallen and disappeared in many cases. The 2003 Mid-Term Review (MTR), as well as strong commodity markets, have contributed to this. Does this mean that there is no role for stochastic analysis in the analysis of EU policy?

For an example of where a stochastic analysis would yield improved analysis of policy consequences we can take the example of the upcoming Health Check reform of the CAP (European Commission, 2007a). As in the first US example, a change in EU price support is suggested, although the EU is proposing reducing support prices rather than increasing them. It is proposed that following a virtual removal of support for maize that this is extended to other products while maintaining support only for breadmaking wheat. What impact is that likely to have?

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[18] FAPRI 2008 provides more in-depth discussion of the implications of EISA for commodity markets and farm income.
[19] For countries such as the UK that are not in the euro zone these payments can fluctuate significantly in national currency terms.

Most models of the EU agricultural sector (including those maintained by FAPRI currently) are likely to suggest that reducing support for the cereals sector is likely to have little effect on the market. Given strong global cereals markets due to increasing incomes and additional demand for biofuels, it is likely that for most of the countries of the European Union, projected cereals prices will be above intervention. The models will therefore not include any intervention purchases of grain and therefore there would be no implications in terms of lower prices or reduced intervention stocks from this part of the reform. That may indeed be the most likely outcome because intervention stocks are close to zero now and all indications are that prices will remain high.

Even with the new biofuel policies in place, prices could fall dramatically. Several years of "average" weather would see stocks replenished and prices fall, and under those circumstances a good year such as that experienced in 2004 could again lead to intervention stock build up and prices below 100 euro/tonne. Stochastic analysis can give us information as to how likely that eventuality might be. In addition, one of the major determinants of the path of the cereals sector in the EU is likely to be the evolution of yields in Romania post accession. Analysis of this type is a challenge for stochastic modelling, as past experience of yields in Romania may not be an indication of the future, and any re-specification of yield distribution on the basis of past accessions would be difficult, but nonetheless could yield important results for the EU.

The fact that US notifications of the AMS vary with market conditions means that stochastic analysis has a role to play in determining the implications of any WTO deal. For the European Union, the amount notified for the AMS is fixed. Unlike the US, however, the issue of export subsidies is more important. The EU has virtually committed itself to eliminating export subsidies as part of the Doha negotiations. At present, the level of export subsidies is low, and zero for most cereals and dairy products. Again, in an environment of high global commodity prices, models are likely to show export subsidy expenditure remaining low for their medium term projections.

The high dairy prices in 2007 and early 2008 have quelled some of the fears of the dairy sector as to the impact of the complete removal of export subsidies, which had been a source of concern given the very high proportion of dairy exports that required subsidies until very recently. As with the cereals example, a recovery in the weather in key producing regions, plus an expansion in production in the EU as is very likely, could push prices back down towards historical levels. It appears that the "thinness" of trade on the world market means that world prices can be very volatile. Will the prices of butter and SMP remain above their support levels in the absence of export subsidies? The answer is likely to be different under a stochastic analysis.

The two examples above also suggest a further role for stochastic analysis. In the past, the projection of prices for most of the major commodities in the EU has been a straightforward task. Given the high prices guaranteed under the CAP pre-MacSharry then it was reasonable to assume that EU prices would be close to this level. As price support levels were reduced, market prices began to sometimes float above their support level. Even in the case of dairy, whose prices have on the whole followed the support price, prices had begun to deviate even before the 2007 explosion in world prices. European producers therefore face a future in which prices are increasingly more volatile.

Under these circumstances the role of agricultural policy is likely to change. Producers are likely to be more interested in risk management tools (European Commission, 2006), such as making more use of futures markets or crop insurance. Stochastic analysis can yield important information as to the distribution of future prices, outputs or incomes that go beyond that available from standard models of the agricultural sector. Policy will still play an important role in the determination of this risks, with agricultural policy being joined (and perhaps even surpassed) by energy policy as determinants of market volatility.

Why, then, are the FAPRI models of the EU not stochastic? Running the models in this way is a complex undertaking. At present the US stochastic models is simulated in SAS whereas the EU models are solely in spreadsheet form at the moment. The EU model used for the FAPRI-Ireland and FAPRI-UK project use models that are built, maintained, and simulated in different countries. In this case it is time that is the restricting factor.

Producing stochastic projections faces other challenges in the case of the EU. The CAP has undergone significant reforms in the last 20 years. Even the policy tools that have persisted through that time may have been operated in different ways, such as export subsidies that are perhaps managed more aggressively than in the past. The EU model is an annual model and that raises the question of how to generate the necessary distributions. In the US case it is usual to generate the distributions from the errors in the equations, but it is questionable what relevance the errors from say, 1988, are in the current EU market environment.[20] For the New Member States these problems are compounded – data sets going back further than the most recent years may not be available at all.

The example of the biofuels sector is illustrative here. The 2007 Renewable Energy Sources Directive proposal (European Commission, 2007b) outlines aggressive new targets for the use of renewable fuels for transport. The subsequent demand for ethanol and biodiesel are likely to be major drivers of demand in the EU. But widespread production and consumption of these products are relatively new phenomena, and datasets are therefore maybe only one or two annual observations. As mandated incorporation rates drive the consumption side, the modelling issues may ease for consumption, but for production and trade there is precious little information to operationalize a model. This is not to say that the stochastic modelling of the EU cannot be done, just that it requires much time and intellectual effort.

[20] The EU GOLD model is not estimated, but rather calibrated on recent years' data in part as a result of these types of concerns.

4. Concluding remarks

For many market and policy questions, standard deterministic approaches to analysis are inadequate. The paper presents four recent examples from FAPRI analysis of US policy issues where standard approaches would yield results that would be incomplete at best and misleading at worst. In all four cases, policy changes that would appear to be innocuous when evaluated against a deterministic baseline are found to entail significant potential costs and/or benefits when considered stochastically.

Extending a stochastic approach to analysis of European markets and policies would be both valuable and challenging. The European situation is distinct, both in terms of the policy environment and in terms of the information available to apply a stochastic modelling approach. However, there are cases where approaches that explicitly recognize uncertainty in agricultural markets would produce more satisfactory results than traditional deterministic approaches.

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