The FAPRI global modeling system and outlook process

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THE FAPRI GLOBAL MODELING SYSTEM AND OUTLOOK PROCESS

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ABSTRACT

The history of market and policy analysis at the Food and Agricultural Policy Research Institute (FAPRI) is reviewed, and a general outline of the basic components of the FAPRI modeling system is provided. The FAPRI baseline modeling and outlook process is explained, including the design and scope of the models as well as the baseline and impact analysis process. Then the FAPRI 2009 baseline is summarized briefly. In addition the article provides the groundwork for remaining articles in this volume that use FAPRI prices projections or other elements of the FAPRI system for different country and regional models.

JEL classification: Q11, Q17, Q18.

Keywords: partial equilibrium model, agricultural policy, policy and price analysis, global market outlook, analytical process

Policymakers and a wide range of stakeholders in the food and agricultural sector need timely, reliable, and research-based analysis to support improved policy decision making. The approach taken by the Food and Agricultural Policy Research Institute (FAPRI) to modeling and delivery of timely and objective analytical results grew out of this information need. The approach has been with us a while, all of the time being improved and refined, In fact, 2009 marked the 25th anniversary of FAPRI's founding. The FAPRI approach to such analysis and dissemination of results has evolved in a number of ways during the last 25 years, including the application and further development of the analytic approach in a wide variety of countries and organizations and within FAPRI itself. The purpose of this collection is to

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describe the “FAPRI approach” and to highlight the application and development of the approach to outlook and policy analysis in terms of differing countries and differing analytical tools that have been added to extend the basic structure of models and analytical systems to specialize and add value to analytical results.

There are common elements in the analytical approach but also differences in application across countries. The common modeling elements are that all models are dynamic, partial equilibrium, multi-product, non-spatial, econometric-based modeling systems designed to generate basic supply and use tables as well as estimates of prices, and the corresponding farm income and taxpayer cost figures that policy makers and stakeholders want. Domestic and trade policies are modeled in explicit detail so that realistic policy impact analyses can be conducted using variables that represent actual policy instruments. Another common feature is that national prices of other country or regional models are linked to world prices generated in the annual FAPRI world market outlook analysis using the global FAPRI modeling system. Finally, common elements in the analytical process are that results undergo an interactive review process between modelers and industry/government practitioners that improves the usefulness of the analyses, and all major results are delivered in government briefings as well as public venues.

Differences among the modeling systems are in the scope of models in terms of commodity and country coverage, cross-country linkages, and whether the focus is on deterministic or stochastic analysis or both. By discussing examples of different applications of similar modeling approaches, we wish to foster an open discussion of this modeling and analytical process with a view to how this integration of research and outreach could be improved in countries where it is already applied and expanded to countries where it is not yet applied.

This first article in the collection will summarize the origins of the FAPRI approach, describe the scope and design of the FAPRI modeling system and the baseline analysis process, present the baseline results for 2009, and highlight examples of policy analyses conducted off of this or other recent baselines.

ORIGINS OF THE FAPRI APPROACH

What is being referred to as the “FAPRI approach” includes the design and structure of the models and databases, the processes involved in conducting the baseline and policy impact assessments, and the means by which results are disseminated. Each of these elements is briefly discussed as an introduction to what follows.

It is no accident that the models are designed to incorporate market information from the latest USDA World Agricultural Supply and Demand Estimates (WASDE) report and generate outputs that include detailed supply, use and price projections for all major crop, livestock and dairy products. This reflects the origins of the FAPRI approach in the USDA outlook process and specifically in the Forecast Support Group of Economic Research Service (ERS), where much of the domestic modeling evolved in the 1970s. It also reflects the goal of FAPRI to address the key variables that are of greatest interest to decision makers and stakeholders. The deeper antecedents, of course, were the early works of Ezekiel, Foote, Fox, Nerlove, Waugh and others (Judge 1977), which were also part of or closely linked to

ERS and the earlier Bureau of Agricultural Economics (BAE) of USDA. During the 1970s, in particular, model development at ERS benefited from strong modeling collaborations with Jim Houck and others at the University of Minnesota (for example, Houck, Ryan and Subotnik 1972) and a consortium of econometric modeling scholars led by Stan Johnson and Gordon Rausser (Rausser 1982).

One of the most critical aspects of FAPRI models is that policies are modeled in explicit detail so that actual policy instruments can be manipulated to approximate as closely as possible to real world conditions. For example, crop net returns in acreage equations include the key policy instruments that influence the farmer's crop planting decisions. Then, if changes are made in the level of one or more policy instruments, the effects can be traced through to cropping decisions directly.

The baseline and policy analysis process also reflects to some extent the interactive nature of the USDA outlook process, but the FAPRI process is far more capital-intensive. Lacking the large numbers of analysts available in the USDA, FAPRI chose to rely more heavily on the modeling systems. Still the individual analyst/modelers are critical to the process, and the quality of the analysis depends significantly on the skill and experience of these analysts and how well they interface with each other and with the modeling systems.

The dissemination process for the annual baseline has evolved over the years but has always begun with the principal clients, which are the U.S. Senate Committee on Agriculture, Nutrition and Forestry, and the U.S. House Committee on Agriculture. USDA, other government agencies, commodity and farm organizations and the press are briefed immediately thereafter. Policy analysis results are generally disseminated in the same way, except when they are more specialized results for a specific agency or Congressional committee. Reports on major policy issues are promptly made available to the general public.

ORIGINS AND EVOLUTION OF FAPRI

In November 1983, a formal proposal was launched by the University of Missouri and Iowa State University to establish the Food and Agricultural Policy Research Institute (FAPRI). After funding was appropriated by the U.S. Congress in December 1983, this joint institute was formally established in July 1984 between the Center for National Food and Agricultural Policy (CNFAP) within the Department of Agricultural Economics at the University of Missouri, and the Center for Trade and Agricultural Policy (CTAP) within the Department of Economics at Iowa State University [1].

By the time FAPRI was established, researchers at University of Missouri and Iowa State University had developed and conducted analysis with an international agricultural commodity modeling system that derived, as mentioned above, from earlier modeling work in ERS. This was supported by funding from the Iowa Corn Growers as well as from Experiment Station and Regional Research projects. At that time, international system was comprised of detailed U.S. models for a few key crop commodities and country-specific crop models for major countries and regions in the world to replace the U.S. single-equation export models used in earlier analytical systems. Over the last 25 years, the FAPRI system has expanded greatly to include many more commodities and countries. Most of the model

[1] More detailed summaries of this history are presented by Balm and Pim (1999) and Wilcox (2009).

components and enhancements were developed by graduate students at University of Missouri and Iowa State University, and this also provided valuable training and experience for those who stayed with FAPRI, as well as those who applied these skills elsewhere.

Over the years, the FAPRI consortium has expanded to include the University of Arkansas, which is responsible for world rice analysis; Texas Tech University, which shares responsibility for world cotton; and Texas AandM University, which is responsible for representative farm analyses. Collaboration on U.S. dairy modeling and analysis is with the University of Wisconsin. The University of Nevada-Reno recently joined the consortium to focus on range cattle and sheep modeling and analysis; and until recently, an Arizona State University affiliated analytical group worked on fruits and vegetables.

The continuity of FAPRI funding by the U.S. Congress has been critical to maintaining the scope, quality and timeliness of the FAPRI analysis. The Congressional support not only keeps the analytical process highly interactive with the policy process, but it provides essential core financing for the core staff, analytical tools and activities. Normally, about half of FAPRI funding comes from the Universities and other grant and contract projects with domestic and international agencies. Grants and contracts generally support the application of the model to particular problems or the development of new model components. The core capacity to maintain existing models and develop annual baseline projections depends critically on the Congressional appropriation.

The expansion of the FAPRI modeling system was driven by a growing demand for an increasing scope of coverage and complexity of models for analyses of the 1985 Farm Bill alternatives, numerous scenarios during the Uruguay Round GATT negotiations from 1989 to 1994, EU farm policy reforms, continuing policy changes in the United States, WTO alternatives for the Doha Round, and most recently the fast growing biofuel industry and increased interdependence of energy and agriculture markets.

Analysts serving on the agricultural committees of Congress and in other government agencies also needed more than the deterministic model results that project a specific path of prices, trade and government costs driven, for example, by smooth yield and export projections. So, beginning with analysis of the 2002 farm bill, FAPRI added a stochastic model and stochastic projections that are more realistic in increasingly volatile market situations. The stochastic model will be presented in a separate article, but this article summarizes the deterministic domestic and international FAPRI models as of 2009[2].

U.S. CROSS-COMMODITY MODELS CIRCA 2009

The scope of FAPRI models has expanded over time. In the early years, the U.S. model focused on just a few crop commodities, and supply and demand relationships were represented in a simplified manner. New market and policy issues created a demand for models with broader commodity coverage and more sophisticated representations of key behavioral relationships. The expanded deterministic model is used to generate FAPRI baseline projections for U.S. and world commodity markets and investigate questions that require detailed estimates of international market outcomes. A stochastic model of U.S. markets facilitates analysis of a wide range of possible market outcomes under alternative

[2] For comparison, a documentation of the 1990 FAPRI system is presented in Devadoss et al. (1993)

assumptions about the weather, energy prices and other supply and demand factors that contribute to inherent market volatility.

In 2009, the FAPRI deterministic model for the United States covered 16 crops, 20 crop products, 5 types of livestock and poultry, and 12 animal-based products (table 1). Modeled commodities accounted for approximately two-thirds of U.S. crop receipts in 2008 and 96 percent of livestock and poultry sector receipts [3]. Commodity coverage has been driven in part by the demands of policy analysis. Almost all of the crops covered by traditional farm programs are included in the model, while many other important crops are not modeled individually. Fruits, nuts, vegetables, and greenhouse and nursery products are not modeled separately, but aggregate sales receipts from these products are estimated for deriving farm income estimates.

The level of model detail varies greatly across commodities. For almost all commodities, the model estimates production, consumption and prices. For an important commodity like corn, the model includes far more detailed representations of supply and demand than for less important commodities. Corn planted area, harvested area, and yields per acre are estimated on a regional basis. Domestic corn consumption is divided into feed and residual, ethanol, high-fructose corn syrup, seed, and other food and industrial uses. Corn stocks held under government loan programs are estimated separately from other commercial stocks. The model estimates corn prices by the equilibrium condition that total supply (production plus imports and beginning stocks) must equal total demand (domestic consumption plus exports and ending stocks). U.S. exports must be consistent with net trade by all the other countries in the world model. When the stochastic system is used to generate a baseline projection or scenario analysis, a reduced-form equation is used to represent the world corn market response to changes in U.S. prices. This modeling process is discussed in more detail in another article by Meyer, Binfield and Westhoff in this volume.

Model parameters are derived from a combination of econometric estimation from time series data and prior information based on economic theory, technical relationships, the literature, and analyst judgment. For example, corn feed and residual use is a function of feed and livestock prices, an index of grain-consuming animals, and the quantities of competing feeds consumed. The equation is constructed to ensure that corn feed and residual use changes proportionally with livestock and poultry production, all else equal, and to ensure that changes in the use of competing feeds have appropriate effects on corn feed use. Given this assumed structure and parameters, econometric estimation is used to estimate the responsiveness of corn feed use with respect to corn and soybean meal prices and a weighted index of livestock prices.

The mix of approaches used to derive model parameters varies greatly. Where the structure of supply and demand is judged to be relatively stable across time, model parameters are generally obtained from econometric estimation based on time series data. However, there are other cases where econometric estimation is impractical or inappropriate. For example, the biofuel sector has grown and evolved rapidly in recent years. In many cases, available time series data only cover the last few years or do not exist at all. The structure of biofuel supply and demand has been changing so rapidly that one would be suspicious of any

[3] Author calculations based on farm sector cash receipt data reported by USDA's Economic Research Service, http://www.ers.usda.gov/data/FarmIncome/finfidmu.htm. The modeled crop commodities accounted for $121 billion of the $183 billion of crop receipts in 2008, and $135 billion of the $141 billion in livestock and poultry receipts.

econometric estimates based on time series data. To generate estimates of biofuel production and use, FAPRI analysts have constructed a series of equations that reflect their understanding of the major factors that determine biofuel supply and demand, including investment behavior, the various ways in which biofuels are utilized, and key aspects of federal biofuel policies.

Another example is the set of equations that determine U.S. crop supplies. The 2009 deterministic version of the U.S. model generates estimates of crop acreage and yields for each of nine regions. For each model crop, acreage is a function of expected supply-inducing net returns for the crop in question and competing crops. Supply-inducing net returns depend on expected market prices, production expenses, and expected farm program benefits, weighted to reflect the degree to which various policies are judged to be coupled to acreage choices. The model imposes symmetry on crop area choices, so the effect of changes in corn returns on soybean acreage is consistent with the effect of soybean returns on corn acreage. Most parameters are assumed rather than estimated, but a number of steps are taken to calibrate the parameters to observed data. For example, the responsiveness of the total area planted to all major field crops as a group with respect to their weighted average net returns was estimated econometrically, and the constructed area equations for particular crops are consistent with these estimates of total area response.

The model also offers flexibility in the determination of expected market prices, where the analyst can put different weights on adjusted prices from the previous year or the model-generated prices for the year in question. In other words, the model can use fairly naïve expectations, quasi-rational expectations, or something in between. The deterministic model used to generate FAPRI's 2009 baseline projections placed equal weights on adjusted lagged prices and model-generated prices to determine crop area.

Crop yields per acre are a function of output and input prices, crop area planted, and a trend. Elasticities of crop yields with respect to output and input prices are very small in the short run, but larger in the long run when investments in new technology have time to bear fruit. The price and area elasticities are based on the literature and analyst judgment, but the trend rate of growth in technology is estimated from a restricted equation based on time series data. As with other model parameters, there is always room to modify these econometrically estimated parameters as needed to reflect new information. For example, if it is judged that the release of new seed varieties is likely to increase the rate of crop yield growth for the next several years, it is easy to override the econometrically estimated rate of trend yield growth.

These equations are constantly reviewed and revised as new information becomes available. Sometimes the new information only requires a change in one or more model parameters; in other cases, it requires more fundamental changes in model structure. Some portions of the model are more stable across time than others. For example, biofuel model equations are updated every time a new baseline is prepared, with frequent changes in model structure to reflect new policies, new technologies, reviewer comments, and other new information. Likewise, crop supply equations are constantly revised to reflect new government farm programs. A more fundamental overhaul of the crop supply equations is underway that is intended to result in state-level estimates for key producing states and that will incorporate a broader set of policies, such as effects of crop insurance on crop supplies. In contrast, equations that determine the domestic use of minor crops may be updated far less frequently.

The level of detail in the U.S. models is far greater than in the commodity models for other countries, because the main source of support and main client for analytical results is the U.S. Congress. Detail is greater not only in the supply and demand components of the models but also in the derived results that are of particular interest not only to policy makers but to all stakeholders. These include national and regional net returns for crops, livestock and dairy products, net farm income, government farm program outlays, and food CPI estimates that are all derived from the model outputs.

INTERNATIONAL COMMODITY MODELS CIRCA 2009

The whole FAPRI model is a set of dynamic, multi-market (multi-commodity and multi-country), econometric, non-spatial, partial-equilibrium models. The international model covers most of the commodities listed in table 1 but not all commodities are covered in all countries [4]. A total of 61 countries and regional aggregates are covered in the model (table 2). Over time the commodity, country, and variable coverage have been expanded to richly capture market dynamics. For example, the FAPRI livestock sector covered only 12 countries and/or regional aggregates in 1995. This number has increased to more than double at the present coverage of 26 countries. More importantly, whereas many of the countries simply had net trade specifications, now most countries have complete coverage of live animal as well as meat supply and utilization variables.

Table 1. Commodity Coverage in FAPRI's Deterministic Model of U.S. Markets, 2009

Crops	Crop-based products	Livestock and poultry	Animal-based products
Corn	Ethanol	Beef cattle	Beef
Wheat	Biodiesel	Dairy cattle	Pork
Soybeans	Sugar	Hogs	Chicken
Upland cotton	High-fructose corn syrup	Chickens	Turkey
Long-grain rice	Distillers grains	Turkeys	Fluid milk
Short/medium grain rice	Corn gluten feed		American cheese
Sorghum	Corn gluten meal		Other cheese
Barley	Corn oil		Nonfat dry milk
Oats	Corn stover		Butter
Sunflowerseed	Soybean meal and oil		Evaporated milk
Peanuts	Sunflower meal and oil		Ice cream
Canola	Canola meal and oil		Eggs
Hay	Peanut meal and oil		
Sugar beets	Cottonseed		
Sugarcane	Cottonseed meal and oil		
Switchgrass			

[4] The following commodities are not covered in the international models: hay, switchgrass, corn co-products, turkey, evaporated milk, ice cream, and eggs.

Table 2. Country Coverage in FAPRI's Model of International Markets

Algeria	Indonesia	Philippines	Africa, Other
Argentina	Iran	Russia	Asia, Other
Australia	Iraq	Saudi Arabia	Commonwealth of Independent States
Bangladesh	Israel	Senegal	Europe, Other
Brazil	Ivory Coast	Sierra Leone	Latin America, Other
Cambodia	Japan	South Africa	Middle East, Other
Cameroon	Kazakhstan	South Korea	Rest of World
Canada	Kenya	Taiwan	
China	Malaysia	Tanzania	
Colombia	Mali	Thailand	
Cuba	Mexico	Tunisia	
Egypt	Morocco	Turkey	
EU	Mozambique	Ukraine	
Ghana	Myanmar (Burma)	United States	
Guatemala	Nigeria	Uruguay	
Guinea	Pakistan	Uzbekistan	
Hong Kong	Paraguay	Venezuela	
India	Peru	Vietnam	

The modeling system captures the biological, technical, and economic relations among key variables within a particular commodity and across commodities. The model is based on historical data analysis, current academic research, and a reliance on accepted economic, agronomic, and biological relationships in agricultural production and markets. Specifically, the model attempts to explicitly capture the extensive linkages that exist in agricultural markets such as the derived demand for feed in livestock and dairy sectors, competition for land in production, and consumer substitution possibilities for sets of close substitutes.

For each commodity sector, the economic relationship that supply equals demand is maintained by determining a market-clearing price for the commodity. For several major grains and livestock products U.S.-specific prices are considered as reference world price, while specific prices in other countries serve as the reference world price of the other commodities such as rice (Thailand), barley (Canada), cotton (Northern Europe), sugar (Caribbean), ethanol (Brazil), biodiesel (Central Europe), and dairy (Northern Europe). In general, for countries where domestic prices are not solved endogenously, their domestic prices are modeled as a function of the world price using a price transmission equation. Since the sub-model for each sector/commodity is linked to the other sub-models, changes in one commodity sector impacts other sectors. Figure 1 provides a diagram of the overall modeling system.

Crops supply comes from land harvested multiplied by yields. Planted area responds to relative agricultural returns reflecting the competition for land among crops within defined geographical areas. More specifically, acreage functions in the international crops model are expressed as a function of own and competing crop returns and lagged acreage. In 2009, the international model yield equations were re-specified to introduce price-cost sensitivity, as well as to capture the effect of extensification.

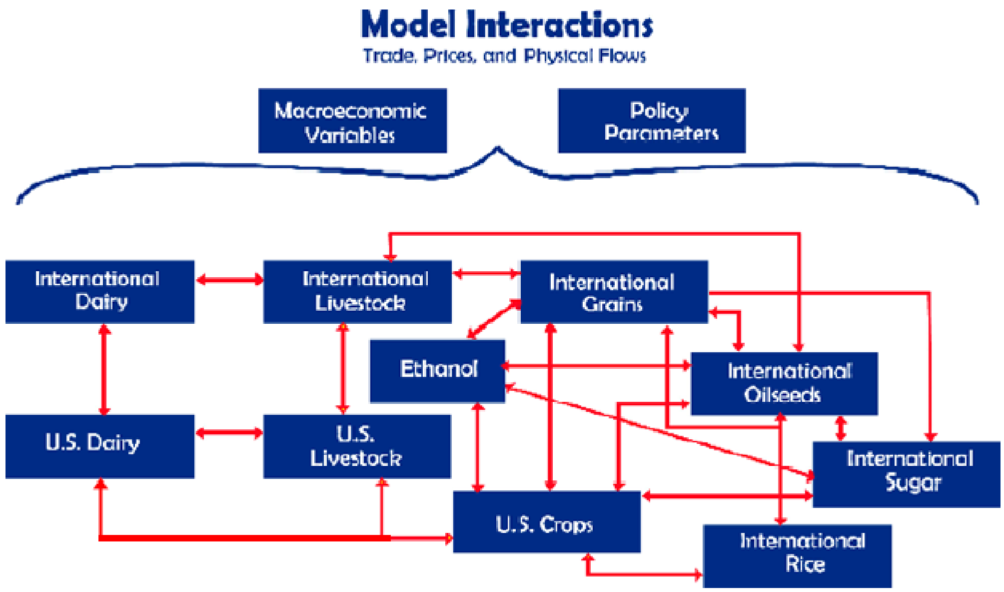

Figure 1. Model interactions in the FAPRI system.

With its strong policy orientation, FAPRI includes extensive policy variable coverage in its models. In particular, agricultural and trade policies for each commodity in a country are included in the sub-models to the extent that they affect the supply and demand decisions of the economic agents. These include taxes on exports and imports, tariffs, tariff rate quotas, export subsidies, intervention prices, other domestic support instruments, and set-aside rates. For the baseline analysis, existing agricultural and trade policy variables are extended at current levels through the outlook period.

Data for commodity supply and utilization are obtained from the Production, Supply and Distribution (PSD) online database of the U.S. Department of Agriculture (USDA), the F.O. Lichts online database, the Food and Agriculture Organization (FAO) of the United Nations (FAOSTAT Online), the European Commission Directorate General for Energy and Transport, and Brazilian Sugarcane Industry Association (UNICA), among others. Macroeconomic data such as gross domestic product (GDP), GDP deflator, population, and exchange rate are exogenous variables that drive the projections of the model. They are from the International Monetary Fund and IHS Global Insight.

BASELINE AND POLICY ANALYSIS PROCESS THE "FAPRI WAY"

Every year for 25 years,[5] FAPRI has conducted a 10-year market outlook analysis for major crop and livestock products. FAPRI has always interpreted this analysis as a baseline projection, not a forecast. The baseline may be a useful indicator of emerging issues or market directions, but its greatest value is as a point of comparison for impact analyses that estimate changes in supply, use, prices and other key variables that would result from changes in policy or other exogenous factors. Baseline policy assumptions always assume the

[5] As well as for a couple years prior to the formal establishment of FAPRI.

continuation of current policy, because this makes it possible to analyze the impacts of policy changes. Likewise, the deterministic baseline assumes normal weather, trend rates of technology growth and the most recent macroeconomic projections; and stochastic analysis provides possible ranges around the deterministic paths. As already noted above, the size and complexity of the FAPRI analytical system, including the stochastic component, has greatly increased over the years in response to client needs, and this was facilitated by rapidly increasing computing technology.

The principles of the baseline process have not changed, but the procedures have evolved and improved over time to a series of steps that have become routine. There are five main steps:

1. Updating models, data, and assumptions, including the November WASDE and latest macroeconomic projections so that starting conditions for the analysis are as current as possible;
2. Late November "meltdown" at ISU, when analysts spend a week together to produce the preliminary baseline;
3. Early December peer review of this preliminary baseline in Washington, D.C., where other analysts from government and international agencies, agribusiness, and other universities provide feedback and critique of the analysis;
4. Mid-January "meltdown" at MU, when analysts spend a week to update the analysis and address comments from the review, as well as newly updated figures from WASDE and macroeconomic projections;
5. Late February or early March completion of the baseline, briefing of U.S. Congress, USDA, and release to the media and public.

As models expanded and complexities increased, some things changed and others remained the same. For example, in the early years, data blocks were passed from one modeling component to another by writing them on a blackboard, but this later gave way to passing blocks of data electronically over a local area network. The first method had the advantage that everyone saw what was passed in real time, but of course the current method reduces time and potential error in the data exchange. The current process still preserves the important human intervention that is deemed necessary to see not only what has changed from one iteration to another but also why it changed. In principle, the electronic data exchange could be done easily enough without sitting in the "meltdown" room together, [6] [6] but there is no substitute for having the analysts in the same room for this important process that requires significant personal interaction and discussion.

Another valuable annual interaction is with other members of an informal partial equilibrium (PE) modeling network called the World Outlook Consultation. FAPRI and other modelers specializing in agricultural commodity and policy analysis around the world meet in May of every year (since 1992) to discuss emerging modeling and policy issues and better understand differences in outlook assessments each group has conducted. This network includes USDA, OECD, FAO, European Commission, Agriculture and Agri-Food Canada, and others. It is another type of review process that is important in providing checks and balances in the FAPRI analytical process.

[6] In fact, this is done before and after baseline meetings and sometimes for policy impact analysis activities.

BASELINE RESULTS FOR 2009

The 2009 outlook results are presented because this is the basis for the analyses of other models reported in this volume. The *FAPRI 2009 U.S. and World Agricultural Outlook* (FAPRI 2009) presents projections of world agricultural production, consumption, and trade under average weather patterns, existing farm policy, and policy commitments under current trade agreements and customs unions. This outlook analysis uses the macroeconomic forecast developed by IHS Global Insight in January 2009. These macroeconomic assumptions condition the projections and include GDP growth rates, inflation rates, exchange rates, energy and input prices and population growth rates. Market turbulence originating in the advanced economies spreads and slows down world economic expansion in 2009, but a significant recovery is projected for the following year, with a long-term real GDP growth rate of 3.5% reached by 2011 (figure 2). After recovery, the emerging markets of China and India post solid growth, averaging 8.6% and 7.5% per year, respectively. After significant but temporary gains in 2009, the U.S. dollar resumes its real depreciation over the rest of the decade. The petroleum price (West Texas Intermediate) also recovers after the drop in 2009 and reaches a peak of $86 per barrel in 2013.

Although commodity prices decline from their highs in 2009/10, these macroeconomic developments combined with biofuel policies support a growing demand for dairy products, meat, vegetable oil and grains, which sustains most of these prices well above the levels existing before the price surge. This article provides brief examples of the price projection paths (figures 3 and 4) and more detailed commodity price results (annex 1) because these are the most common outputs from FAPRI and are used as world reference prices in modeling and analysis of other countries or regions.

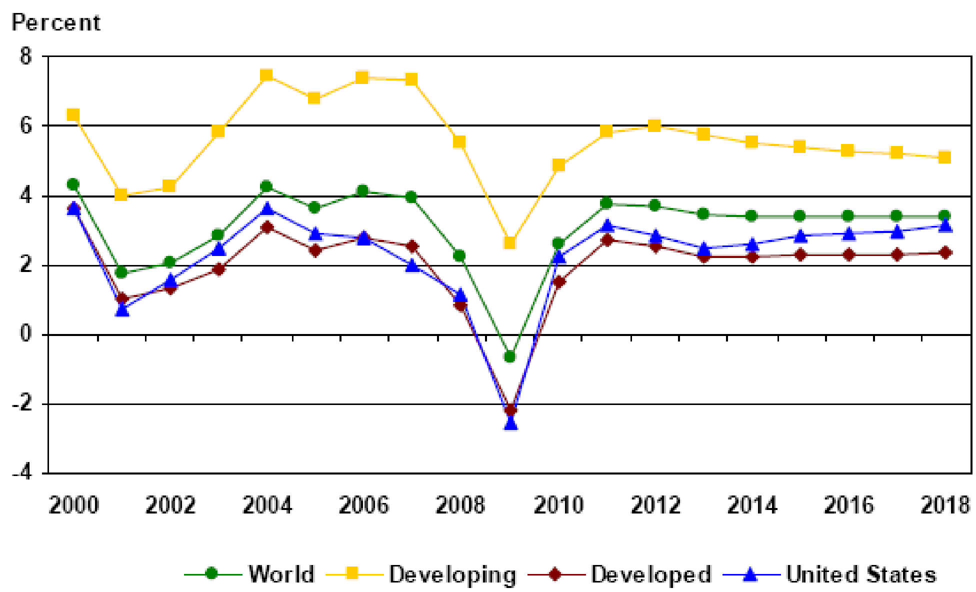

Figure 2. Real GDP growth rates, historical and January 2009 projections.

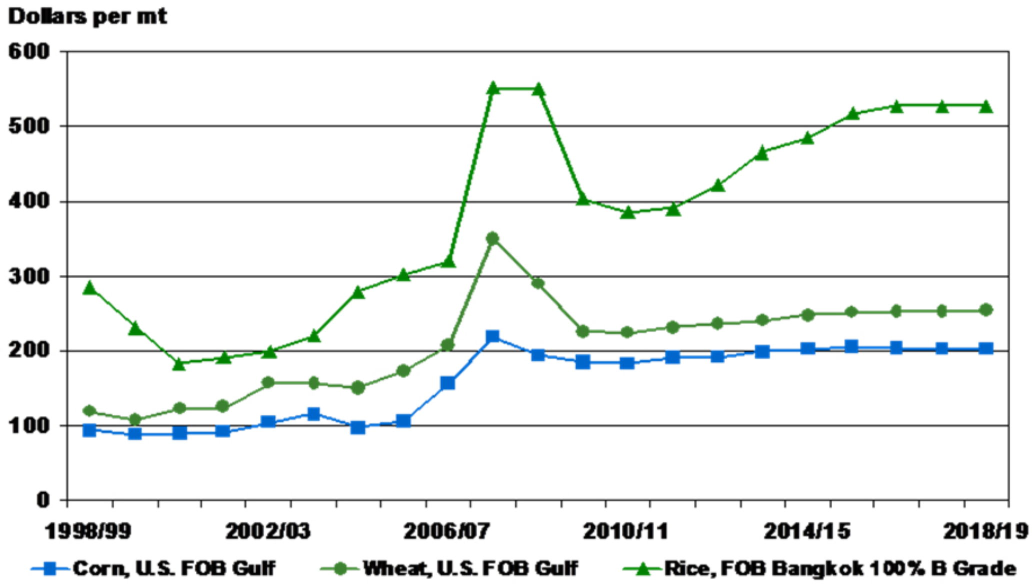

Figure 3. Nominal grain prices, historical and 2009 FAPRI projections.

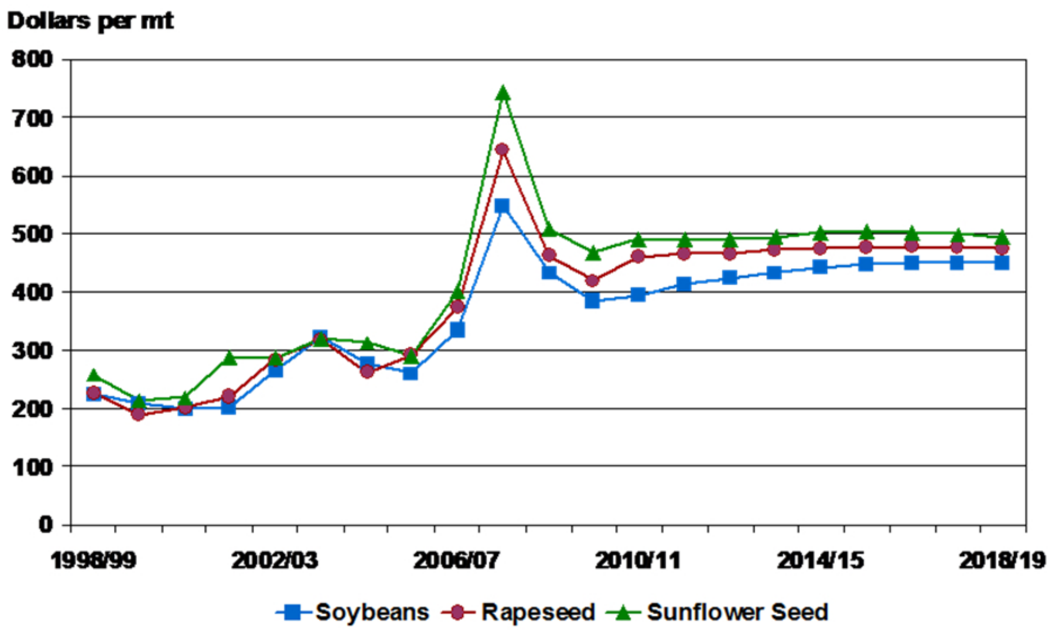

Figure 4. Nominal oilseed prices, historical and 2009 FAPRI projections.

The outlook reflects a transition from the decades-long period of falling real prices of grains and food more generally to a new market environment in which commodity and food prices are higher, more volatile and more tightly linked to petroleum prices. Much of the market behavior seen during the past few years is linked to the growing interdependence of energy and agricultural markets. This market behavior and the conditions surrounding it are likely to continue, and the prospects of returning to the low and declining real price patterns of the previous decades are less likely.

ANALYTICAL RESPONSE TO EMERGING ISSUES: DOMESTIC MODEL

The model is constantly revised in response to emerging issues in agricultural markets and policies. Rapid growth of the biofuel sector made it essential to find better ways to represent biofuel production, consumption, trade, and prices in the model. A wide range of biofuel policy questions posed by members of Congress and federal agencies required a detailed representation of tax credits, tariffs, and biofuel use mandates. The expanded and enhanced model was used to respond to policy analysis requests, leading to a variety of FAPRI reports and published papers, such as Westhoff (2007), Westhoff, Thompson and Meyer (2008), and Meyer and Thompson (2009).

The incorporation of a detailed biofuels model in the FAPRI agricultural sector model made it possible to look at questions that cannot be properly examined with other approaches. Analyses that are based on models with a narrower scope miss important cross-commodity effects that can qualitatively change results. For example, a model looking only at the ethanol and corn sectors will overlook the consequences for the soybean market of shifting land from soybean to corn production in response to the increase in corn demand and prices that result when corn ethanol production expands. The likely resulting change in soybean prices raises questions about analysis that effectively holds soybean prices constant.

General equilibrium models have numerous advantages in examining policies that have effects across a range of markets. Such models generally sacrifice some dynamic and other detail in representing particular markets and policies in order to retain their overall scope. Thus, it is often necessary to examine policy changes in a stylized way that may miss important nuances. The FAPRI approach tries to reflect the most important policy provisions in an explicit manner, thus facilitating analysis that directly addresses the questions posed by policy makers. Neither a general equilibrium approach nor a FAPRI-style approach is uniformly superior, and there are many questions where both approaches can yield important insights.

New and proposed farm legislation always yields new modeling challenges. The 2008 farm bill, for example, created the Average Crop Revenue Election (ACRE) program. Because the program makes payments based on state-level revenues per acre for particular crops, a model that only generates national or regional estimates of prices and yields will not be sufficient to estimate program impacts. During the farm bill debate, FAPRI supplemented its basic model with a satellite model that estimated state-level ACRE benefits in a manner consistent with national prices and yields generated by FAPRI's stochastic model of U.S. agricultural markets. Results from the state-level model were then used to calibrate the national and regional models in an iterative fashion. The ACRE program is one motivation for current FAPRI-MU efforts to develop a state-level crop supply model for key producing states.

Proposed climate legislation has led to a broader set of challenges. The FAPRI system is well suited to estimate impacts of changes in input costs and energy prices that might result from climate change legislation. The system can trace effects on production of various commodities, resulting impacts on prices, consumption, and trade, as well as the implications for farm income, consumer food costs and other sectoral indicators. However, some of the most important effects of climate change legislation on the farm sector may not result from supply and demand changes in response to higher energy costs, but from incentives such legislation would provide to sequester carbon by planting trees or produce energy from crops such as switchgrass or other perennials. The 2009 version of the FAPRI U.S. model does not include a forestry sector and its representation of potential energy crops is simple. Building a detailed forestry component to the model would be a major undertaking that would require time and resources that may not be available. In the short run, one practical alternative is to simply do sensitivity analysis showing how the farm sector responds to different assumed shifts of acreage out of production of traditional crops and pasture uses.

Both the discipline of producing an annual set of projections for the agricultural sector and the demands of policy makers to examine current issues mean that the FAPRI model is constantly being modified. The annual baseline development process always points out places where the model has failed to anticipate market developments, and reviewer comments force analysts to reexamine model structure and parameters. Sometimes policy makers ask questions that the model was deliberately built to answer, which makes it possible to respond to analysis requests in a matter of days or even hours. More often, however, the most important questions are regarding novel policies that were not anticipated when the model was built.

ANALYTICAL RESPONSE TO EMERGING ISSUES: INTERNATIONAL MODEL

In anticipation of the emerging policy issues related to biofuels, a parallel effort was made to develop a world ethanol and biodiesel model. This was deemed of significant importance for a number of reasons. First, since the biofuel market in the U.S. is largely operating in isolation due to the set of policies that protect the U.S. market, it was necessary to select and solve for a world reference price outside of the U.S., which in this case is Brazil for ethanol, and Central Europe for biodiesel. Second, a growing number of countries have joined the bandwagon of countries who jumpstarted the development of their biofuel sector with their own targets and sets of incentives impacting their respective commodity markets as well as the world market, especially when they are major world players like Argentina and Brazil.

With the U.S. and international biofuel model, FAPRI has the capability to richly capture the impact of different Renewal Fuel Standard (RFS) alternatives, such as different combinations of U.S. corn-based ethanol and imports of sugarcane-based ethanol from Brazil. This gave FAPRI a unique capability to examine worldwide land use impacts directly resulting from biofuel scenarios. For example, Fabiosa, et al (Forthcoming) used the FAPRI model to examine the land use impacts of an exogenous expansion of ethanol demand, first in the United States, then in Brazil, China, the European Union-25, and India, quantifying new lands coming into production and land reallocation away from major crops and pasture competing for resources with ethanol feedstock crops.

With the recent growing concern and interest on greenhouse gas emissions, work was started, as a complement to the FAPRI model, to develop a capability to quantify emissions from agricultural activity on a global scale. This has resulted in the development of the Greenhouse Gases from Agriculture Simulation Model (GreenAgSiM). Where the FAPRI model excelled in quantifying world market impacts of alternative policy regime, GreenAgSiM now allows FAPRI to add value to its standard results by adding a capability to evaluate the impact of changes in agricultural policy on greenhouse gas emissions. A recent work by Dumortier, et al (2009) displayed the enhanced capability of the FAPRI-ISU model working the GreenAgSim model in analyzing the sensitivity of greenhouse gas emissions from land-use change to modifications in assumptions concerning crop area, yield, and deforestation.

CAVEATS AND SUMMARY

The FAPRI modeling system and subcomponents of the system have been extensively used in commodity market and policy analysis with results widely disseminated in the U.S. and around the world and published in numerous refereed academic journals, our FAPRI web sites at University of Missouri and Iowa State University and many other publication outlets. The wide dissemination of results in different public and professional meetings and publications is itself a continuous crosscheck on the validity and reliability of the system and the process. The FAPRI system and the models that comprise the system are under constant scrutiny and revision by FAPRI analysts to meet new analytical needs and correct flaws revealed by past results that missed the mark. In many ways the models that comprise the system are like living organisms, where “survival of the fittest” rules the day. For the same reason, any documentation of this system is always incomplete and out of date. Likewise, the baseline presented here will be replaced with a new one to be completed early in 2010.

When a lot of effort has gone into developing a model, it is often tempting to find a way to “trick” the model into examining novel questions. When time and resources are limited, that is sometimes the only practical alternative. However, it is important not to succumb to the temptation to think everything looks like a nail just because one has a good hammer. Quite often it is necessary to make major model expansions and enhancements to address policy questions. While this usually results in a better model suited to answer a broader set of questions, there is a countervailing concern that needs to be weighed. In a world with limited analytical resources, making a model bigger and more complex comes at a very real cost—the bigger the model, the less attention any one part of the model is likely to receive. Bigger is not always better, and it is important to remember both the benefits and the costs of model expansion.

The challenge that always faces FAPRI is finding the appropriate balance between increasingly complex and comprehensive questions and the desire not to “stretch” the modeling system to address questions it was not designed to analyze. Here again is where the analyst is critically important. In many ways, the modeling system is only as good as the analysts that operate it. The judgment and skill of the analyst must be combined with the computational efficiency that models provide. The models are not “black boxes,” because the analyst has to know how the result was derived and the factors that influenced the outcomes. This is the essence of structural models, which these models certainly are.

The most recent challenges relate to the increasing interdependence of agricultural and energy markets and the interface of agricultural and environmental concerns. In the first case, the issue has led to research on the effects of agricultural based renewable fuels on energy markets and the two-way linkages between these markets. In the second case, climate change policy issues have increased the importance of longer term assessments and possible inclusion of land use for forestry. Whether FAPRI systems can be modified to include these substantial extensions or if it is more efficacious to interface with other modeling systems remains to be determined.

The other articles in this volume show different kinds of extensions of the FAPRI approach that operate independently but link to FAPRI results. The second article explains how the FAPRI global system was simplified by using calibrated reduced-form equations for U.S. exports so that the stochastic analysis can be conducted. The third article presents the Korean model that is far more detailed than even the U.S. FAPRI model in commodity coverage and links to FAPRI world price projections. The fourth article combines stochastic analysis with business strategy methods to analyze South African policy choices. The fifth article applies the FAPRI approach to the European Union, where countries operate under a common policy but have implementation mechanisms that can be quite different from country to country. The sixth article takes the same principle down to the regional level within the United Kingdom to assess differing impacts of differentiated implementation of the Common Agricultural Policy in different regions. The seventh article links a simplified global model to the FAPRI U.S. model to explore global food security and land-use impacts of U.S. policy.

ACKNOWLEDGMENT

The authors would like to thank Stanley R. Johnson for very helpful and constructive comments. The authors are responsible for all errors that remain.

ANNEX TABLE

Commodity Price Projections

	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19
Wheat					(U.S. Dollars per Metric Ton)						
U.S. FOB Gulf	289	225	224	231	235	241	247	251	252	253	253
Canadian Wheat Board	306	240	244	253	258	263	266	268	269	270	271
AWB Limited Export Quote	255	199	197	203	206	212	217	220	221	221	222
European Union Market	285	207	210	212	209	212	211	211	209	207	205
Rice											
FOB U.S. Houston	638	479	468	495	524	557	568	589	594	595	596
FOB Bangkok 5% Broken	521	383	366	371	402	448	467	498	509	508	507
FOB Bangkok 100% B Grade	550	403	385	390	422	465	485	516	528	527	526
Corn											
FOB U.S. Gulf	194	185	184	191	192	199	202	204	203	203	202
CIF Rotterdam	235	222	219	226	229	236	240	243	242	241	240
Barley											
Canada Feed	179	162	164	170	175	179	184	186	188	189	191
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018

Sorghum											
FOB U.S. Gulf	182	179	179	186	189	196	199	202	203	205	206
Soybeans											
Illinois Processor	368	346	348	358	366	375	383	389	391	392	394
CIF Rotterdam	434	385	394	413	424	435	444	448	449	450	451
Soybean Meal											
FOB Decatur 48%	328	294	282	278	280	285	290	293	292	291	290
CIF Rotterdam	387	348	334	329	331	337	343	347	346	344	344
Soybean Oil											
FOB Decatur	778	801	873	946	978	1,009	1,030	1,052	1,076	1,097	1,118
FOB Rotterdam	856	881	959	1,038	1,072	1,105	1,128	1,151	1,177	1,200	1,222
Rapeseed											
CIF Hamburg	463	420	460	466	466	473	475	477	479	476	475
Cash Vancouver	406	369	403	408	408	415	416	418	420	417	416
Rapeseed Meal											
FOB Hamburg	211	199	193	187	188	191	195	197	198	198	197
Rapeseed Oil											
FOB Hamburg	927	975	1,101	1,155	1,184	1,218	1,237	1,256	1,282	1,295	1,311
Sunflower											
CIF Lower Rhine	509	469	491	490	492	496	502	503	502	500	497
Sunflower Meal											
CIF Rotterdam	210	204	198	191	189	189	191	190	186	181	177
Sunflower Oil											
FOB NW Europe	999	1,029	1,097	1,140	1,172	1,205	1,236	1,263	1,292	1,316	1,340
Palm Oil											
CIF Rotterdam	639	659	706	743	772	800	826	852	879	905	931
Palm Kernel Meal											
CIF Rotterdam	165	153	151	148	148	149	149	148	145	141	137
Palm Kernel Oil											
CIF Rotterdam	706	707	748	792	834	872	913	952	993	1,029	1,067
Peanut, U.S. Runners 40/50					(U.S. Dollars per Metric Ton)						
CIF Rotterdam	1,377	1,238	1,250	1,283	1,299	1,315	1,332	1,343	1,351	1,355	1,358
Peanut Meal											
48/50%, Southeast Mills FOB	152	141	135	132	131	133	135	136	135	133	132
Peanut Oil											
CIF Rotterdam	1,349	1,429	1,510	1,596	1,642	1,675	1,703	1,726	1,750	1,767	1,786
Sugar											
FOB Caribbean (raw)	287	287	279	287	292	298	305	310	315	323	329
New York Spot (raw)	469	466	500	483	480	484	488	492	491	487	485
Cotton											
Cotlook A Index	1,345	1,441	1,537	1,551	1,569	1,601	1,630	1,650	1,673	1,694	1,712
U.S. Farm	1,083	1,141	1,231	1,259	1,277	1,303	1,326	1,338	1,353	1,365	1,377
Ethanol					(U.S. Dollars per Gallon)						
Anhydrous Ethanol Price, Brazil **	1.76	1.48	1.36	1.29	1.34	1.37	1.45	1.51	1.53	1.62	1.69
Ethanol, FOB Omaha	2.47	1.68	1.75	1.81	1.91	1.99	2.10	2.19	2.17	2.06	2.00
Biodiesel											
Central Europe FOB Price **	5.25	3.74	4.08	4.47	4.73	4.86	5.02	5.14	5.28	5.43	5.56
Biodiesel Plant	4.64	3.45	3.53	3.84	4.12	4.24	4.33	4.41	4.49	4.59	4.69
Beef					(U.S. Dollars per Metric Ton)						
Nebraska Direct Fed-Steer	2,034	1,976	2,094	2,171	2,222	2,243	2,258	2,257	2,262	2,263	2,267
U.S. Retail	9,534	9,343	9,833	10,440	10,920	11,256	11,419	11,424	11,437	11,454	11,467
Steer Price, Alberta	1,952	1,820	1,923	1,989	2,036	2,056	2,076	2,080	2,086	2,084	2,088
Australian Export (CIF U.S.)	2,510	2,537	2,584	2,596	2,610	2,618	2,625	2,625	2,627	2,628	2,630
Japanese Farm											
Dairy beef	8,071	9,469	9,474	10,067	10,374	10,606	10,840	11,024	11,163	11,277	11,396
Wagyu beef	18,851	17,444	16,708	17,117	17,124	17,071	17,148	17,229	17,299	17,368	17,458

Annex Table (Continued)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Pork											
Barrows and Gilts National Base											
51-52% Lean Equivalent	1,055	1,078	1,169	1,213	1,240	1,208	1,190	1,183	1,176	1,204	1,238
U.S. Retail	6,474	6,528	6,876	7,311	7,589	7,552	7,507	7,452	7,425	7,569	7,828
Ontario Hogs Index	1,220	1,228	1,330	1,371	1,402	1,357	1,340	1,339	1,331	1,364	1,410
Japanese Wholesale	5,020	5,242	5,452	5,685	5,775	5,725	5,716	5,736	5,748	5,833	5,928
Chicken											
U.S. 12-City Wholesale	1,756	1,783	1,791	1,821	1,846	1,874	1,908	1,938	1,963	1,981	1,998
U.S. Retail	3,850	3,893	3,994	4,121	4,200	4,265	4,318	4,362	4,423	4,476	4,520
EU Producer	2,233	1,849	1,794	1,842	1,838	1,878	1,926	1,974	2,019	2,058	2,097
Japanese Wholesale	3,212	3,205	3,218	3,332	3,419	3,501	3,600	3,685	3,758	3,815	3,873
Turkey											
U.S. Wholesale	1,930	1,909	1,919	1,944	1,957	1,978	2,015	2,053	2,084	2,104	2,123
U.S. Retail	2,759	2,722	2,756	2,831	2,880	2,927	2,969	3,010	3,072	3,135	3,195

** Represents world price.

					(U.S. Dollars per Metric Ton)						
Milk											
U.S. All Milk	404	286	314	353	364	368	372	378	385	391	398
Canadian Fluid Milk	789	630	700	763	793	811	805	799	809	840	859
Australian Average Milk	432	249	240	261	272	276	282	289	294	298	301
Cheese											
FOB Northern Europe	4,963	2,480	2,356	2,619	2,748	2,802	2,879	2,969	3,027	3,078	3,121
U.S. Wholesale	4,091	3,021	3,325	3,679	3,763	3,765	3,791	3,841	3,896	3,949	4,002
Canadian Wholesale	9,877	8,537	8,142	9,048	9,494	9,682	9,947	10,259	10,460	10,635	10,784
Australian Export	4,681	2,402	2,289	2,529	2,648	2,698	2,768	2,851	2,905	2,951	2,991
Butter											
FOB Northern Europe	3,895	2,141	1,863	1,861	1,891	1,952	2,029	2,079	2,161	2,221	2,292
U.S. Wholesale	3,226	2,729	3,009	3,318	3,377	3,415	3,418	3,505	3,602	3,709	3,818
Australian Export	3,649	1,942	1,780	1,807	1,854	1,890	1,935	2,010	2,058	2,093	2,135
Nonfat Dry Milk											
FOB Northern Europe	3,246	2,103	1,975	2,110	2,254	2,280	2,328	2,402	2,467	2,526	2,572
U.S. Wholesale	2,865	1,868	1,876	2,145	2,258	2,310	2,389	2,438	2,485	2,531	2,577
Australian Export	3,330	1,967	1,814	1,975	2,147	2,178	2,235	2,324	2,401	2,472	2,526
Whole Milk Powder											
FOB Northern Europe	3,999	2,101	1,988	2,184	2,225	2,283	2,365	2,462	2,553	2,621	2,671
Australian Export	3,913	1,973	1,857	2,029	2,154	2,205	2,277	2,363	2,443	2,504	2,547

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INTERACTIONS BETWEEN ENERGY MARKETS AND AGRICULTURE IN THE U.S.: A STOCHASTIC APPROACH

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ABSTRACT

As part of the Baseline Outlook generating process, FAPRI at the University of Missouri (FAPRI-MU) uses a stochastic partial equilibrium model in addition to a deterministic model. The projections allow representation of some of the uncertainty inherent in commodity markets and the examination of separate contributions to price movements from sources such as yields, trade or energy prices. In this article, the stochastic methodology and its advantages are outlined. The connection between energy prices and the agricultural sector are investigated in order to show when and under what conditions movements in energy prices are transmitted to commodity prices.

JEL classification: Q11, Q13, Q18, Q42.

Keywords: aggregate supply and demand analysis, prices, agricultural markets and marketing, cooperatives, agribusiness, agricultural policy, food policy, alternative energy sources.

The dramatic price movements in agricultural commodity markets from 2007 to 2009 have increased the interest from policy makers in the implications of such volatility. The most recent U.S. agriculture and biofuel policies therefore require the use of analytical tools that acknowledge these uncertainties and that can address policies designed to minimize the impact of commodity market volatility on specific policy objectives. Traditional deterministic models have yields with smooth growth paths, foreign demand that is predictable and petroleum prices that exhibit none of the observed volatility. These deterministic policy models have been used extensively including the analysis of biofuel models (Hertel et al.,

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2008, OECD, 2008 Taheripour et al.,2008). However, these models can fail to adequately represent the policy effects under certain scenarios. In the presence of domestic loan programs or international support agreements, a deterministic analysis may result in a flawed assessment, which was a driving force in the extension of FAPRI's policy models to a stochastic framework (Binfield et al., 2002; Westhoff, Brown and Hart, 2006).

The rise of the biofuel sector has strengthened the role that energy markets play in agriculture and has potential effects on commodity price volatility, emphasizing the asymmetries in policy effects on those markets (Meyer and Thompson, 2009a). Early analysis of these linkages used simplified relationships between corn, ethanol and petroleum prices (Tyner and Taheripour, 2008). Others have examined biofuel markets stochastically, but in models which simplify policy and commodity coverage (McPhail 2008). The FAPRI stochastic model incorporates appropriate policy representation and the broad interactions in agricultural markets.

With the market-clearing quantities of ethanol well in excess of those outlined in the Energy Policy Act of 2005, the assumption at that time of a tight link from petroleum to corn seemed appropriate particularly in a deterministic analysis. With its much higher levels of mandated ethanol use, the Energy and Independence and Security Act of 2007 seems more likely to determine quantities consumed in the future than market forces, potentially breaking the link between corn and petroleum prices. The compliance mechanism for meeting the mandated quantities along with the extended time to build capacity mean market adjustments may carry significant lagged effects. The combination of agriculture and biofuel policies increases the importance of context, commodity price levels and volatility in determining the net effects of those policies (Meyer, Thompson and Westhoff, 2009b).

This article first discusses the need to use a stochastic model for the analysis of changes to renewable energy policy and lays out the selection process for the variables chosen for stochastic analysis and the creation of the stochastic draws used. The next topic is the framework of the stochastic model, with a particular emphasis on the biofuels market segment. In describing the model, the dynamics of supply through the long run formation of ethanol capacity and its short run utilization decisions are examined first. Using the model, this article highlights a policy analysis comparison that utilizes the given structure and provides evidence of the effects of context and need for distributional analysis of specific selected variables. The final topic is the potential the model has to create five hundred of the representative world prices, which are used as exogenous inputs for FAPRI's partner institutions.

THE BENEFITS OF STOCHASTIC ANALYSIS

While the FAPRI-MU model has thus far been referred to as a stochastic model for agricultural policy analysis, it is in truth both a partial equilibrium, as well as partial-stochastic model. It is a partial equilibrium model in that it covers agriculture and biofuel markets while taking macroeconomic and broader energy markets as given. It is a partial-stochastic model because it does not include all sources of uncertainty or the entire possible distributions of select variables but seeks to capture those more relevant to agriculture and biofuel markets and policies. As the models have grown, they have become increasingly less partial, expanding in scope beyond just agriculture markets to include biofuel markets and adding additional variables to the list of stochastic elements. The process continues at FAPRI-MU as the newest model additions include agriculture and bio-energy market feedbacks into broader energy markets.

One example of the advantages of stochastic modeling is in the estimation of the changes in expenditures when US loan rates are changed (see Westhoff (op cit) for a detailed discussion of this). Grain and soybean producers receive benefits from the marketing loan program when county prices fall below the government rate. Renegotiation of the Farm Bill always involves some proposals to change these rates and therefore requires analysis of the impact on government expenditure. The estimates are not just of interest to producer groups and policy makers attempting to keep the bill within the budgetary framework, but they also have implications for the ability of the U.S. to keep spending within the disciplines of the Uruguay Round Agreement on Agriculture (URAA).

In recent years, a theme of the FAPRI Global Outlook has been that demand for grain and oilseeds as feedstocks for biofuels has resulted in a baseline where grain and soybean prices have been higher than the loan rate trigger. Therefore, projected expenditures on these programs has been low. In reality, prices of grains and oilseeds are likely to fluctuate significantly over the projection period due to yields, energy prices or other factors, triggering expenditures on the program. When the stochastic process is used, some outcomes will inevitably trigger expenditures and results that a deterministic examination with trend yield growth would not show. The difference can be significant. A stochastic analysis of previous farm bills shows a difference in expenditures on government farm programs that is on average \$3 billion higher than that of the deterministic Baseline (FAPRI, 2005). Since loan payments are included in the Aggregate Measure of Support (AMS) under the URAA, a deterministic analysis will significantly underestimate the chances that the U.S. will exceed its limits under that agreement.

The historical entry point of energy prices into agriculture markets has been through effects on the cost of production and transportation of commodities to market. The evolution of biofuel production and the supportive policies have significantly changed the primary effect to one of a demand side pull for agricultural commodities to be used as feedstocks in biofuel production. The demand side pull is not as simple as establishing a rigid price relationship among petroleum, ethanol and corn and therefore a simple linkage to ethanol production. It appears obvious that additional linkages of agricultural markets to potentially volatile energy markets would increase the need for policy analysis to be constructed in a stochastic framework. Indeed, many attribute a significant proportion of recent market volatility in agricultural prices to the increase in demand for grain and oilseeds for the production of biofuels. But the advantage of the stochastic approach goes beyond capturing some aspects of this. The relationship between oil prices and agricultural commodity prices is complicated as a result of the fact that the biofuel sector is driven to a large extent by multiple government policies, the effect of each being highly dependent on market context.

There are three primary policies in the U.S. that influence liquid biofuels markets: an incentive to blend biofuels through a blenders credit, a tariff on imported biofuels, and use mandates for biofuels, all classified by the biofuel type or feedstock used in their production. In the U.S., the biofuels mandates were established as part of the Renewable Fuel Standard (RFS) of the Energy Policy Act of 2005 and were further expanded in the EISA. The blenders credits, when examined independently, help boost the wholesale price of ethanol, if not the quantities in all situations. The blender's credits are government payments and are transfers from taxpayers to motor fuel consumers. These credits are used to induce consumption, but this effect may be limited by the presence of the quantitative mandates. The mandates create a minimum demand and provide support to feedstock prices such as corn. When mandates are significantly binding and determine the blended quantities, i.e. when the market driven demand is significantly lower than the mandate, the blenders credit may increase the wholesale price paid to producers but may have no appreciable effect on the quantities blended. When oil prices fall, the mandates establish a floor demand for ethanol and biodiesel even when it would not normally be competitive. Corn's price response relative to a change in oil price is therefore different at different oil price levels, determined by whether or not the mandate is binding or not. It also makes clear that a simple rigid representation that links corn, ethanol and petroleum prices may be valid only over a selected range of petroleum prices and other factors. Evidence of this can be seen by looking at the relationship between corn prices and oil prices from mid-2007 to late 2009 (figure 1).

At higher oil prices, ethanol became competitive spurring demand for corn, and the prices of corn and petroleum moved together. In July of 2008, as oil prices began to fall, corn prices followed them down until October of 2008, when the market appeared to have reached the ethanol mandate demand floor. Petroleum prices continued to decline while ethanol and corn prices declines flattened. The mandate supported ethanol consumption and maintained corn prices in the range between $120 and $160 per metric ton. Also, if oil prices are low enough, the presence of the blenders credit has no effect on ethanol consumption or production because transacted quantities are being determined by mandate levels. In order to properly address issues such as these, a stochastic model is required.

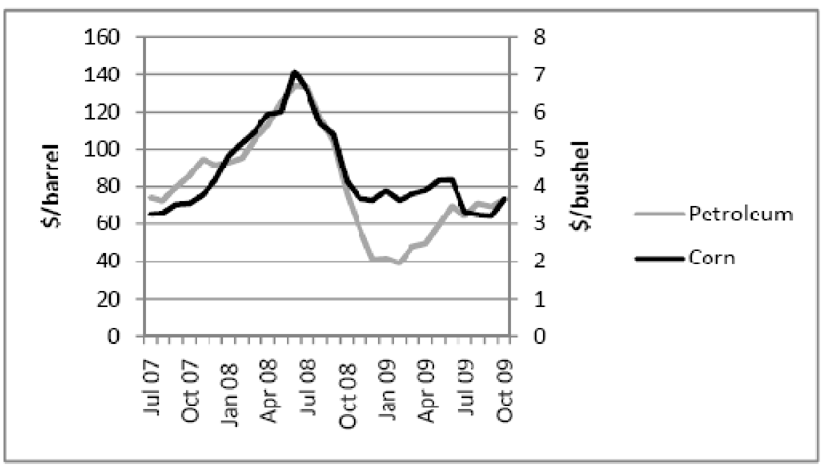

Figure 1. Monthly U.S. corn (nearby futures) price and West Texas Intermediate oil price.

GENERATING STOCHASTIC OUTCOMES

The model that is used to generate the stochastic projections that are referred to in this article is a simplified version of the U.S. deterministic model that FAPRI-MU uses as part of the Global Outlook process (Meyers *et al.*, 2010). The rest of the world model is represented by reduced form equations and some of the US regional coverage is aggregated. The model still covers all the major markets for grains (wheat, corn, barley, sorghum, oats and rice), oilseeds (soybeans, rapeseed, sunflower seed, peanuts and palm oil) cotton sugar, beef, pork, poultry and dairy products. The model is a dynamic partial equilibrium model similar to those used elsewhere in this journal edition. The only difference is that the model is simulated 500 times using 500 alternative values for each year for certain key variables and error terms.

Although the stochastic model differs from the deterministic model, it is set up so that it will produce the same projections as the deterministic model if the same set of exogenous variables is incorporated into each. However, the mean of all the stochastic simulations will result in different values due to non-linearities in the model and asymmetries in the manner in which the policies work.

There are a number of possible approaches to generating alternative random draws for the simulation of the stochastic model. Any number of equations or exogenous variables could be utilized. The technique employed involves a certain amount of analyst judgment, with the distinct objective of plausible distributions and knowing that not all uncertainty has been captured. The stochastic variables come from five basic areas; crop yields, exogenous energy and cost variables, domestic demand, domestic stockholding and reduced form equations for the rest of the world represented through trade equations. The segmentation into these groupings is largely a matter of practicality, where utilizing problematic spurious correlations may be worse than assuming no direct correlation of the error terms.

Absolute yield deviations are drawn from empirical distributions across all the crops covered in the model. These yield deviations are drawn based on historical joint distributions, maintaining the historical error correlations in the grouping. The empirical distributions are extended to allow for absolute yield deviations which are unobserved in history. As an example, the yields drawn on a joint distribution mean that an above average corn yield is likely to be accompanied by an above average soybean yield in the same year. Other crops, particularly those grown in geographically more distinct areas, may show less correlation than corn and soybeans.

Exogenous energy prices and costs of production, which often have significant energy components embedded in them, are also drawn as a set to maintain historical correlations. Petroleum, natural gas and the individual components, such as fuel costs, seed costs and labor costs are drawn together. The resulting cost indices are used to calculate each cost of production component, and the petroleum and natural gas prices feed directly into other areas of the model, including the biofuels model.

Errors on demand equations, the portion of demand that remains unexplained by prices and income, are drawn on in three separate groups. The errors on key elements of domestic demand are drawn as a joint empirical distribution, maintaining historic relationships unexplained by price and income movements. Stocks or carry-over quantities are drawn as separate group, again drawn from joint distribution to ensure historic relationships among crops. Foreign demand errors, which are in practice reduced-form trade equations, represent the third demand grouping. Foreign demand is separated from domestic demand because, as a result of being represented through a reduced form trade equation, the equation and its errors must incorporate all the unexplained variation from world area, yields, exchange rates, demand shocks and other factors that manifest in demand for U.S. trade. The draws are used to create 500 sets of 10-year correlated draws, which are then used to simulate the model.

In practice the generation of these stochastic draws is a combination of art and science. Consider the oil price shown in figure 2.

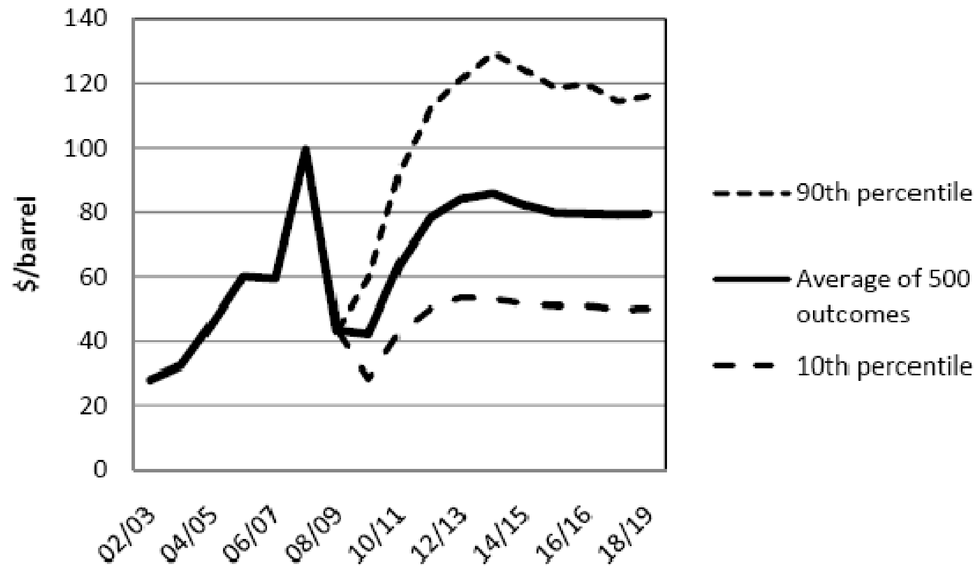

Figure 2. The oil price used in the stochastic model, the refiners acquisition price.

The deterministic baseline uses the forecast of oil price that comes from IHS Global Insight, which is therefore also imposed as the average of the stochastic draws. If a strict statistical approach based on history were to be applied, then the average would be lower. Using the forecast as the average of the stochastic runs reflects the widespread expectations from industry that oil prices are going to be higher than in the last decade. In order to generate the 500 draws, some persistence was imposed through a lagged dependant variable, with an empirical distribution applied to multiplicative adjustment terms. There is a restriction on how much oil prices can move within a particular year, but over time the oil price can climb to high (or fall to low) levels.

THE BIOFUEL SUB-MODEL

The expansion of the biofuels industry has required significant changes to the FAPRI-MU domestic model. The rapid growth of linkages between agriculture and energy required a representation of the biofuels industry to include demand for feedstock for fuels, and the supply of by-products from the industry that are fed to livestock or used in the production of electricity. Given the nature of energy policy, equations for fuel prices and transport energy had to be included. Energy policy is incredibly complex, comprising of tax breaks, technical restrictions, and mandates, all of which must be modeled in order to create a system that can properly represent the wide range of policy questions that have been asked. The end result was a model that has doubled in size and continues to expand as new feedstocks and energy interactions are added.

Production

In order to capture the dynamics of supplies in biofuels markets, the FAPRI model splits production into capacity and capacity utilization. This separates short and long run dynamics and as the industry expands, these dynamics play a role in biofuel prices and influence the impacts of policy changes. Capacity and capacity utilization are both a function of net returns. The net returns reflect an industry average, while capacity is the existing capacity of the industry as a whole. In the case of dry-mill ethanol operations, net returns accounts for corn and input costs as well as revenue from ethanol and distillers grains production, and are therefore net returns over variable costs. Capacity includes an additional cost which reflects the cost of capital.

Capacity utilization is exclusively a function of current period net returns. The equation is specified in logistic form, which gives it behavior representative of the average variable cost curve and also bounds capacity utilization between 0% and 100% (figure 3a). This also means that capacity utilization has a low cost utilization rate that the function will return to in the long run. For capacity, the elasticity with respect to current year net returns is very low because there is limited scope to decelerate or to accelerate the schedule for plant construction. In contrast, the elasticity with respect to one- and two-year lagged net returns is substantially higher in light of the average 18-month construction process. Longer lagged net return terms have declining effects. The lagged dependent variable reflects the fixity of a mill which, once built, represents a dedicated capital with no alternative use. Depreciation is represented by a negative coefficient associated with the ten-year lagged capacity term.

In the short run, adjustment to production comes primarily through changes in capacity utilization and, given the logistic function, additional capacity requires an increasingly large change in net returns (figure 3b). These large returns signal additional capacity which comes online in subsequent periods, pushing production out further and lowering industry utilization rates (figure 3c). During this period of adjustment, existing capacity may be a limiting factor in the production of additional ethanol. In a stochastic setting, capacity utilization is the primary biofuel production adjustment mechanism to deal with short run response to the stochastic draws on yields and energy prices.

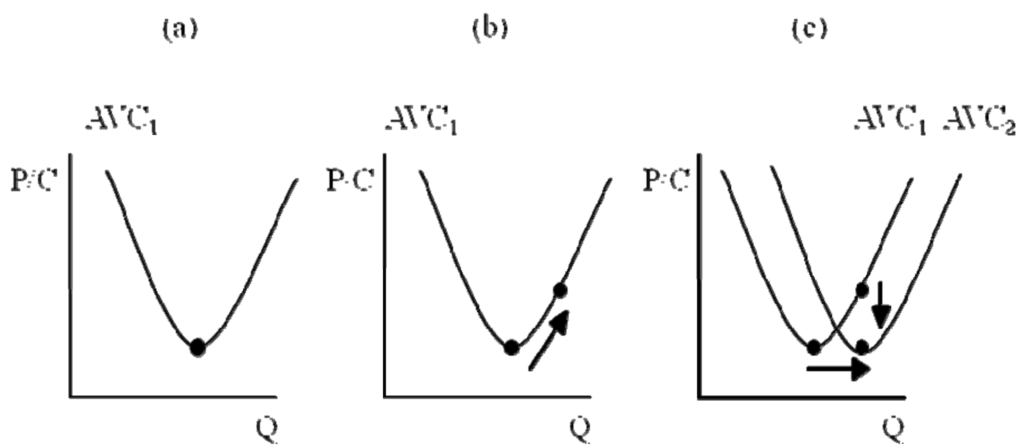

Figure 3. Representation of adjustment in capacity and capacity utilization.

In the ethanol market, response to a large crop or a sudden increase in ethanol demand may be limited by available capacity and thus the linkage between petroleum prices, ethanol prices and corn prices may be broken. It is still possible for a large corn crop to be met with low corn prices despite the assertion that petroleum and ethanol prices place a floor on feedstock prices. The limits of capacity further highlight the non-linear response that can be expected from the industry. Reflecting the structure of the U.S. industry, the model focuses on ethanol from corn from both wet and dry mills, and biodiesel from soybean oil. The specification for wet mill and biodiesel plant capacity, capacity utilization and production is analogous to the dry mill plant equations. However, the net returns reflect the co-products relevant to those economic decisions. Other sources of biofuels are included at lesser detail, including biodiesel from other oils and ethanol from cellulosic sources where the model includes corn stover, switchgrass and other feedstocks.

Demand

The supply specification outlined above is a simple set of equations, but they allow for complex dynamic effects of policy on biofuel and feedstock prices. The dynamics on the demand side are both more complex in their representation, as well as in their dynamic effects on biofuel and feedstock prices. The complexity is derived not based on market behavior alone but based on the complexity of the policies in place in the biofuels market. The interplay of producers, blenders and consumers is presented here in a simplified form, but the complexities of the demand portion of the model can be seen in greater detail in other FAPRI studies (Thompson, Meyer and Westhoff 2009). The demand for biodiesel and ethanol are treated separately. The demand for biodiesel is more straightforward given its low share of distillate markets, while the ethanol market needs to incorporate both legislative and technological constraints when examining demand.

Retail ethanol demand is disaggregated into three types based on current policy and consumption patterns: 1. Consumers use ethanol in mandatory uses, as when it serves as a fuel additive or to meet state mandates, 2. voluntary low level blends, primarily 10 percent ethanol blends (E10) and 3. flex-fuel blends of up to 85 percent ethanol (E85). Each demand segment has a specific price response, all of which can be significantly influenced by the overall renewable fuel standard requiring quantitative blending minimums.

In its role as a fuel additive, ethanol is a complement to regular unleaded gasoline or may be a mandated use. State level mandates or the replacement of MTBE nationally are prime examples of a mandated use, and is highly unresponsive to changes in price (figure 4a). As prices continue to fall, demand in this category may actually begin to decline at some point as consumers opt for higher blending rates in voluntary blends.

In contrast to the additive market, ethanol is a substitute for regular unleaded gasoline when used in voluntary E10 and E85 blends, so increasing regular unleaded gasoline prices will tend to increase these ethanol uses. These voluntary demands are modeled in a two-step approach that identifies market potential and penetration separately. Market potential identifies the size of the market in the current period. In the case of voluntary E10 blends it is based on total motor fuel use, existing additive market use, and the maximum blend rate available in these low level blends. Currently this is held at 10% blends by law, but alternative policies allowing for higher level blends of 12% or 15% could be quickly implemented by simply changing the rate and thus the size of this market segment.

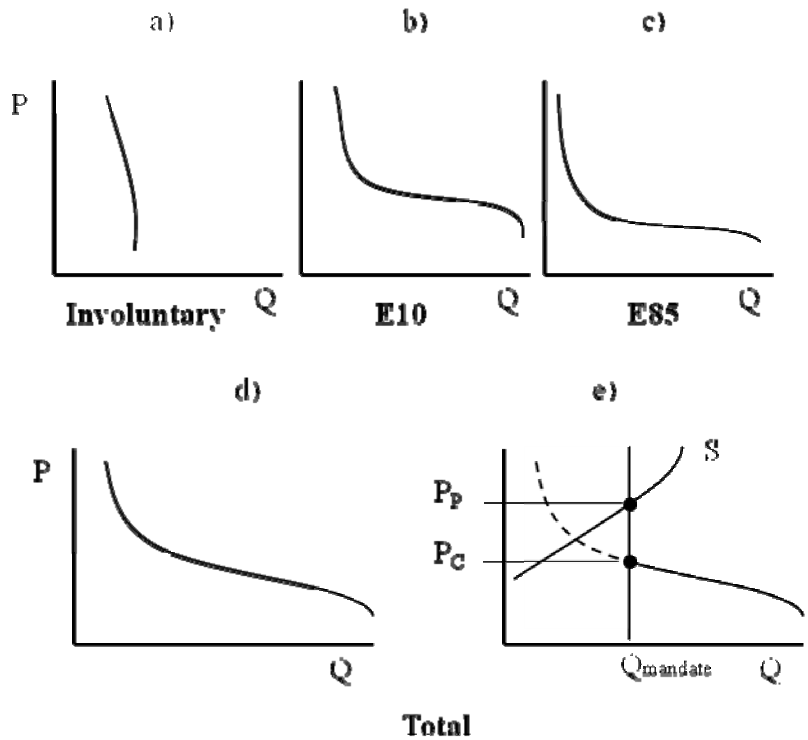

Figure 4. Representation of the different demands for ethanol for transport.

A logistic function governs the penetration of the E10 market based on the ratio of ethanol to regular unleaded prices. The demand equation has a distinct bend in its representation where, as prices fall, demand goes from being very inelastic to highly elastic (figure 4b). The kink point is at a ratio higher than ethanol's energy equivalence value so that it incorporates some of ethanol's additional value in low level blends. Above the bend, demand is unresponsive to price, as consumers may be purchasing ethanol for reasons beyond use as a fuel such as environmental concerns, a desire for energy independence or support for commodity producers. When the price ratio falls to the relative value purely as a fuel, demand becomes highly elastic. As demand approaches full market penetration, demand becomes very inelastic again.

While the basic structure is the same in high blend level markets, denoted E85, the parameterization is notably different. High blend levels require specialized capital in both distribution and consumption. Consumers must own a flex-fuel vehicle in order to use E85 and fuel suppliers must have pumps and distribution systems to dispense the blends. As a consequence, the equation for this potential market is restricted based on assumptions regarding the evolution of the flex-fuel vehicle fleet. Again, demand is highly inelastic at higher relative ethanol prices (figure 4c). The kink point where demand becomes very elastic is lower than in E10 markets. At high level blends the ethanol is simply a fuel replacer and is then valued at its energy equivalence.

The model assumes a rather easy transition to E85 consumption, minimizing the impact of the impending ‘blend wall’ where low-level blend markets, constrained to 10% maximum ethanol blends, are saturated. However, in reality this transition may prove problematic, and adjustment in the E85 market potential may respond over several periods. With binding mandates, prices may actually have to fall below energy equivalence to induce investment in dispensing and consumer purchase of flex fuel vehicles. This would result in longer lag effects in the size of E85 market and a lower kink point in demand than energy equivalence in the market penetration equation. Those changes would also produce lower ethanol prices relative to gasoline, so as to induce E85 demand, which may take several periods to completely adjust. The summation of the three consumer demand categories then generates total consumer demand response (figure 4d). With this consumer representation in the model, policy mandates can now be introduced. To appropriately model mandates, it is important to correctly represent the legislative feature that consumers are not the obligated parties under the mandates and they must be induced by the obligated blenders to use the quantities required.

Ethanol Blenders Demands

Fuel blenders operate between the ethanol supply and demand points and are the party on which falls the obligation to comply with mandates under the EISA of 2007. The equations that represent blender behavior are therefore derived demands. The mandates represent four quantitative requirements based on fuel type and greenhouse gas profiles determined by the EPA rule making process (EPA 2009). The mandates are not independent of each other but in fact build on each other in a nested framework. At the base of the framework are the bio-based diesel and the cellulosic or agricultural waste based biofuels which are restricted by both greenhouse gas profiles as well as feedstocks limitations. These two minimums are nested in a larger advanced biofuel mandate.

The advanced biofuel mandate includes fuels which qualify under bio-based diesel as well as cellulosic ethanol and other fuels which meet specific greenhouse gas profiles, including sugarcane ethanol. The gap between the advanced ethanol mandate and the mandates for bio-based diesel and cellulosic ethanol can be met by these other qualifying “advanced biofuels”. Thus, this category can be better termed “other advanced,” but there is no mandate for this quantity, which is actually the remainder of the advanced biofuel mandate after taking account of sub-mandates. The total mandate works in a similar fashion. It allows for the use of “conventional” cornstarch-based ethanol or other non-advanced ethanol to fill the gap between the blending of advanced biofuels and the total mandate. To be explicit, there is no mandate for conventional ethanol and certainly no corn ethanol mandate. It is possible that sugarcane based ethanol imports could exceed that amount required to fill the “other advanced” requirement and go towards filling the overall mandate. Such complexities are often ignored when discussing compliance with policy and where the mandates are treated inappropriately as strictly compartmentalized.

Within the FAPRI-MU domestic model, blenders will choose the cheapest fuels available while maintaining compliance with the individual mandates. Not all mandates need be binding at any given time, or none may be. Blender use depends on the ethanol retail price, the blenders tax credit, and the relevant wholesale price for the given fuel. When the market would demand quantities below the mandate, is the mandate then becomes the binding determinant of demand; and the blenders will bid up the price of the biofuel to obtain from producers the quantities needed to meet the requirement of that class of biofuel ($Q_{mandate}$) as seen in figure 4e. If the advanced mandate is binding, and other biofuels are not, the price of all biofuels capable of meeting that requirement - advanced biofuels, cellulosic biofuels and bio-based diesel - will be bid up until blenders are able to obtain the required quantities. Because consumers are not obligated to comply, the additional cost of purchasing the ethanol cannot be passed on to consumers on the ethanol portion of the blend or consumers would simply choose to purchase the lowest content blends they could, exacerbating the compliance hurdle for blenders. They are forced to buy the ethanol at a higher price (P_P) and sell it at a lower price (P_C) into the retail market where consumers will purchase that quantity, pushing the cost on to the gasoline content in the fuel[1] (figure 4e). Within the model, the cost of compliance is added to the weighted share of the gasoline price. The difference between the blenders purchase price, and the effective price at which they can sell the ethanol is the core cost of compliance.

In 2007 the EISA increased the overall mandate for biofuel use and continued the use of renewable identification numbers (RINs), to show compliance by blenders. Blenders will have to show enough RINs, each representing one gallon of biofuel use, to prove they meet their share of the national mandate. The buying and selling of RINs is permitted to meet the mandates, and a limited quantity is allowed to be carried into the following year to meet that year's obligation. If blenders in one region use more ethanol than required, then they can sell their extra RINs to other blenders. The mandate obligation may or may not be binding on a national basis. If it is binding at the national level, there would be implications for commodity markets, but if it is only locally binding, then there would be no market consequences. As a consequence, each mandate is considered separately on the basis of national supply of biofuel qualified to fill that mandate and demand for biofuels.

Blenders will balance the cost of meeting compliance through the blending of fuels with the purchase of RINs, making RIN pricing a direct calculation of the cost of compliance. Within the model, the blender demand for a specific class of biofuels is the greater of the economic equation described above or the applicable mandate volume. When the mandate is binding, the blenders demand will not fall as wholesale prices rise until the mandate is met. The FAPRI modeling system includes a necessary representation of these RIN markets including tracking compliance and RIN pricing by mandate type (Thompson, 2009).

YIELD EFFECTS VS. ENERGY EFFECTS IN THE CONTEXT OF BIOFUEL POLICY

To quantify the effects and show the contextual importance of the primary biofuels policies of blenders credits, tariffs and the updated renewable fuel standard in the EISA of 2007, a comparison is made between the 2009 FAPRI stochastic baseline (FAPRI 2009), where all policies are extended and the mandates in place for both ethanol and biodiesel, and

[1] This means the cost of the mandate compliance is borne by motorfuel consumers rather than taxpayers.

a stochastic scenario where these policies are eliminated. The baseline maintains these mandates, tariffs and credits:

- Biofuel use mandates established as part of the Renewable Fuel Standard (RFS) defined by the EISA of 2007 are enforced with the caveat that the cellulosic ethanol mandate is assumed to be waived and set to a lower quantity than the legislative allowances offered.
- Tax credits provided to biofuel blenders (or producers in the case of cellulosic ethanol) are held at the current $0.12 per liter (specifically $0.45 per gallon) for ethanol and $0.26 per liter ($1.00 per gallon) for biodiesel and $0.27 per liter (specifically $1.01 per gallon) for cellulosic ethanol.
- Tariffs on ethanol imports of $0.14 per liter (specifically $0.54 per gallon) are maintained as well as the ad-valorem tariff of 2.5% applied on all imports. A portion of ethanol tariffs of Caribbean origin only pay the ad-valorem tariff.

The exogenous macroeconomic forecast from IHS Global Insight anticipated an eventual recovery with robust growth and energy prices, at least in nominal terms, higher than the previous decade. The combination of high petroleum prices and multi-layered biofuel polices extended over the baseline, commodity prices that average above those of the previous decade with an average $160 per metric ton corn farm price, a $358 per metric ton soybean price, a refiners acquisition oil price of $81.10 a barrel and the biofuel policies led to ethanol production of more than 58.2 billion liters. The baseline period annual averages from 2011-2018 across the stochastic simulations are presented in Table 1, along with the results of a no-biofuel support scenario. For the scenario, these core policies are eliminated or allowed to expire as specified in current legislation:

- Biofuel use mandates established as part of the RFS defined by the EISA are eliminated starting January 1, 2010, for all biofuel classes: bio-based diesel, cellulosic ethanol, advanced ethanol and the overall total mandate.
- Tax credits provided to biofuel blenders or producers expire as legislated on January 1, 2011, for ethanol and January 1, 2010, for biodiesel and are assumed to be eliminated for cellulosic ethanol on January 1, 2010.
- Tariffs on ethanol imports are eliminated on January 1, 2011, with the ad-valorem tariff of 2.5% applied on all imports remaining in place.

The averages during the 2011 to 2018 time period across all 500 stochastic solutions comparing current policy to policy elimination provide a starting point for a discussion of the effects of biofuel support (table 1). The direct effect of continuing biofuel policies is to support domestic consumption of biofuels, both foreign and domestically produced. Removal of the biofuel polices would result in ethanol consumption falling by 22.77 billion liters. Much of this decline in consumption would be lost from domestic production, which would fall by an average of 21.86 billion liters a year.

Removing biofuel policies and the resulting decreased ethanol consumption, perhaps counter intuitively, drive up retail ethanol prices by $0.06 per liter while driving down wholesale ethanol prices by $0.12 per liter. Wholesale ethanol prices are driven down because blenders lose the tax credit for blending, which had allowed them to bid up prices paid to producers, passing a portion of the credit back to producers.

Table 1. The Impact of the Elimination of Selected Biofuels Policies on the Biofuels and Crop Markets, Stochastic Average 2011-2018

	Baseline	No total RFS, no tax credits no tariffs	Absolute difference	Percentage difference
Tax and tariff provisions		(Dollars per litre)		
Ethanol tax credit	0.12	0.00	-0.12	-100.0%
Biodiesel tax credit	0.26	0.00	-0.26	-100.0%
Ethanol specific tariff	0.14	0.00	-0.14	-100.0%
		(Billion litres)		
Renewable Fuel Standard	74.10	0.00	-74.10	-100.0%
Biofuel sector results		(Billion litres)		
Ethanol production	58.21	36.35	-21.86	-37.6%
Ethanol imports	5.24	4.42	-0.82	-15.6%
Ethanol domestic disappearance	62.68	39.91	-22.77	-36.3%
Biodiesel production	4.46	2.65	-1.80	-40.5%
		(Dollars per litre)		
Ethanol price, conventional rack, Omaha	0.55	0.43	-0.12	-21.2%
Ethanol effective retail price	0.54	0.60	0.06	11.4%
Dry mill returns over operating costs	0.10	0.03	-0.07	-69.0%
Biodiesel rack price	1.17	0.76	-0.42	-35.7%
Corn sector supply and use		(Million metric tons)		
Corn production	350.98	328.36	-22.62	-6.4%
Corn ethanol use	129.30	82.25	-47.05	-36.4%
Corn feed use	134.02	146.46	12.44	9.3%
Corn exports	52.96	64.66	11.70	22.1%
Soybean sector supply and use		(Million metric tons)		
Soybean production	90.41	90.99	0.58	0.6%
Soybean crush	53.83	53.45	-0.37	-0.7%
Soybean exports	31.88	32.60	0.71	2.2%
Crop planted acreage		(Million hectares)		
Corn	36.38	34.15	-2.23	-6.1%
Soybeans	31.05	31.36	0.31	1.0%
Wheat	23.80	23.99	0.19	0.8%
9 other crops plus hay	38.07	38.17	0.09	0.2%
Conservation reserve area	11.97	12.45	0.48	4.0%
12 crops + hay + CRP	141.27	140.12	-1.15	-0.8%
Crop sector prices		(Dollars per metric tons)		
Corn farm price	158.98	139.14	-19.83	-12.5%
Soybean farm price	357.52	324.21	-33.31	-9.3%
Wheat farm price	210.95	195.17	-15.78	-7.5%
		(Dollars per metric tons)		
Upland cotton farm price	1,298.55	1,283.72	-14.82	-1.1%
Soybean oil market price, Decatur	1,043.65	727.05	-316.60	-30.3%
		(Dollars per metric tons)		
Soymeal price, 48% protein	286.19	313.78	27.59	9.6%
Distillers grain price, Indiana	147.49	146.83	-0.65	-0.4%

This effect is present regardless of the effect of the RFS mandates. When the biofuel mandates are removed, the floor blending requirement is removed and ethanol blending is dictated by market forces, this serves to further drive down ethanol rack prices as producers no longer have to seek additional ethanol quantities to meet their obligated quantities. At the same time, the blenders no longer need to hold down retail price of ethanol relative to gasoline to sell the required blended volume. Without the mandate, incentives to breach the blend wall are reduced, resulting in less use and infrastructure investment in high level blends. As the low level blends reach saturation, or a blend wall, the ethanol must increasingly find a home in high level blends where the ethanol acts as a fuel replacer and is therefore valued at its lower energy equivalent.

Ethanol imports, primarily sugarcane ethanol from Brazil, decline by 0.82 billion liters even with the elimination of the import tariff of $0.14 per liter, as the ethanol was being imported to fulfill a portion of the advanced biofuel mandate, with the elimination of that mandate, ethanol imports must then compete with domestic supplies based purely on wholesale rack prices. The reduced demand for ethanol pushes down corn ethanol use by one third or 47.05 million metric tons and pushing down corn farm prices by $19.83 per metric ton. The lower corn price makes corn net returns less competitive, driving down corn area by 2.23 million hectares and increasing the area of other crops, but by less than the decline in corn area. Overall area of the crops tracked falls by 2.84 million acres as net-returns.

The elimination does push up soybean area a modest 0.31 million hectares on average over the period, as the elimination of bio-based diesel policies weighs heavily on the vegetable oil and animal fats markets. Biodiesel production falls by more than 40% as the biodiesel blenders credit and supporting bio-based diesel mandate are eliminated. Soybean oil prices fall by more than 30%, crush soybean crush falls but only modestly as soybean oil price declines are offset by soybean meal prices, which rise by more than $25 a metric ton. As lower supplies and reduced competition from distillers grains from dry mill ethanol production hold steady, overall soybean price declines to $33.31 per metric ton or about 9%. Overall feed prices decline, primarily through grain price declines, leading to an increase in meat and milk production and adecline in prices. The result is a decline in both livestock and crop receipts. Overall farm income falls by more than 6%, and consumer food expenditures fall by 0.3%, which is a small percent change but represents an average decline in food expenditures of more than $4 billion annually.

These period averages over all 500 solutions give an indication of the supportive effect on biofuel consumption, commodity prices and farm income of domestic biofuel policies but only allude to the importance of stochastic analysis. Removal of biofuel policy does not in all instances drop the corn price by $19.83 a metric ton or the ethanol price by $0.12 per liter for the period from 2011 to 2018. Context remains important. If a single year is examined - crop year 2015/16 – with the results segmented across exogenous petroleum price draws, the non-linear effects of policy become apparent. Figure 5 shows the petroleum price on the x-axis and the corresponding corn farm price on the primary y-axis, both with and without policies extended. The secondary y-axis is a calculation of the difference between the base and scenario, or the price effect of the policy at different petroleum prices. Policy effects are shown to decline as petroleum prices rise. In most instances when petroleum is more than $110, the market place wants to blend a quantity of biofuels in excess of the mandates. The mandates are having little effect, and thus when policies are eliminated, it is primarily the elimination of the blender's credit and import tariff that pushes ethanol demand lower.

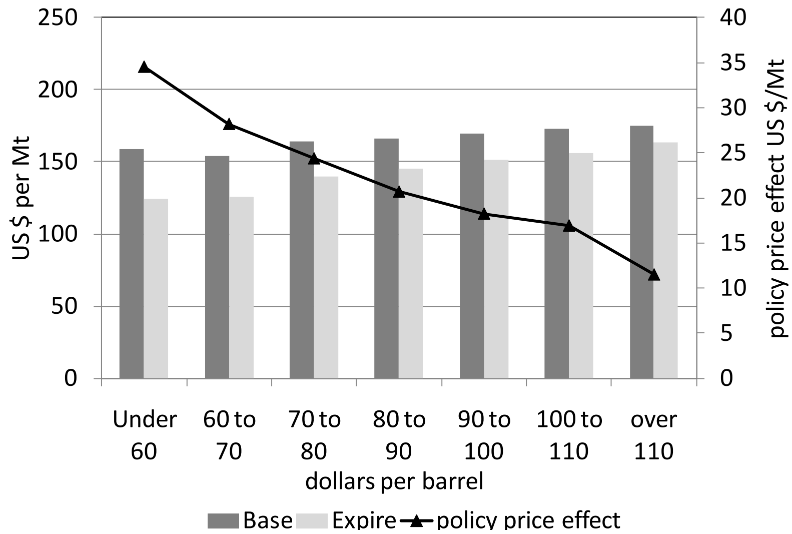

Figure 5. Policy effects on the relationship between petroleum prices and corn prices, 2015/16 crop year.

The blenders credit supports corn prices at all petroleum prices because it is a simple fixed per gallon payment to the blenders of biofuels, a portion of which gets passed back to biofuel producers. With no policies in place, as petroleum prices fall, corn prices fall in unison. With policies in place, corn prices are everywhere higher due to the blenders credits, but as petroleum prices decline, the mandates become increasingly more binding, reducing the elasticity of demand for ethanol, supporting ethanol prices and along with it, the prices of the primary feedstock corn. Clearly the use of a simple linkage between petroleum prices, ethanol prices and corn prices under current biofuel policies would be insufficient and misleading over significant range of petroleum prices.

The policies' effects are also dependent on crop yields. Again, blenders credits support overall corn demand but do not change the underlying demand elasticity. When yields in a given year falter in the absence of biofuel policies, prices rise, and the consumers of corn ration their demand. Livestock feeders cut back corn in the ration, foreign demand falls, and stock holding is reduced. With mandates in place, and binding, the blenders of biofuels cannot cut back on their demand. Even in the event that it makes aggregate motor fuel more expensive, the mandates are quantitative in nature and are not determined by a share of motor fuel. This results in a significant portion of corn demand being highly elastic.

The ability to carry stocks of RINs helps ease this pressure somewhat but is limited by available RIN stocks and a legislative maximum on the share of current blending obligations that can be met by prior excess blending.[2] With policy in place, as yields decline, the mandates are more likely to become binding and to up corn prices at an increasing rate (figure 6). Path dependency in the system may also play a role in prices as yields increase. Ethanol production capacity is primarily a function of returns in previous years. In the short run, capacity may be a limiting factor in processing ethanol. A large crop could still result in low corn prices as utilization of existing capacity is maximized, and this segment of corn demand again becomes inelastic, allowing the fall in corn prices to accelerate.

[2] EISA 2007 regulations limit 'rolled over' RINs for compliance quantities to 20% of current obligation.

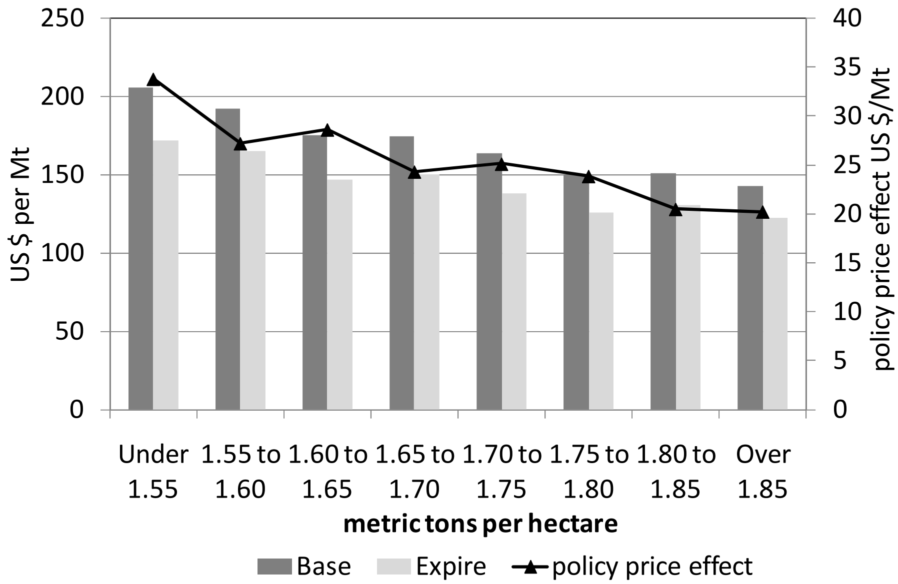

Figure 6. Policy effects on the relationship between corn yields and corn prices, 2015/16 crop year.

FURTHER WORK: SHARING STOCHASTIC PROJECTIONS WITH FAPRI'S PARTNERS

The US modeling system at the moment is the most comprehensive attempt thus far to incorporate uncertainty into FAPRI models. The discussion and scenario results above clearly show the need to consider stochastic approaches when analyzing renewable fuel policy. Some stochastic elements have been attempted elsewhere, notably as part of the South African modeling system (Strauss and Meyer, 2010). As has been highlighted in the other articles of this volume, one of the common features of the models is that they all take world prices from the FAPRI Global Outlook as exogenous variables in their baselines. It would be desirable to allow some of the advantages of the stochastic results to be incorporated by FAPRI's partners. Given its size and complexity, serious impediments exist for the FAPRI global modeling system to be made stochastic and generate different paths for world prices that way.

As a first-step, farm-level U.S. prices that are generated as part of the stochastic simulation of the US model are simply converted into the prices that are taken as representative of world markets by the partner models. The resulting prices deviate from those that would be generated from a stochastic simulation of the FAPRI Global model in a number of important respects. The U.S. model is necessarily parochial, and the majority of the uncertainty is introduced through varying domestic U.S. variables, such as U.S. yields and exogenous macroeconomic assumptions.

Although some variation is included through the error terms of the U.S. export equations, this approach effectively proxies for the entire rest of the world, which is obviously incomplete. In particular, there is the potential for inconsistencies related to the macroeconomic assumptions in each of the regions. For example, exchange rate fluctuations are presumably responsible for much of the volatility captured in the residuals to the U.S.

trade equations, but these cannot be backed out ex post when transmitting these to partner model markets. The prices that are generated must therefore be viewed as not a complete reflection of global uncertainty of agricultural markets, but rather as a simple way of introducing some of those uncertainties. Using the U.S. model in this way has the advantage of maintaining a link between the oil price and agricultural commodity markets, particularly given that U.S. policy with respect to ethanol is a key driver of the global corn market and thereby of related markets.

Table 2. The Impact of the Elimination of Selected Biofuels Policies on Livestock and Dairy Markets and Incomes, Stochastic Average 2011-2018

	Baseline	No total RFS, no tax credits no tariffs	Absolute difference	Percentage difference
Meat and milk production		(Million metric tons)		
Beef production	12.03	12.05	0.02	0.2%
Pork production	11.19	11.33	0.14	1.3%
Broiler production	17.92	17.91	-0.01	-0.1%
Milk production	90.27	90.46	0.19	0.2%
Livestock and dairy prices		(Dollars per metric ton)		
Steers, Nebraska direct	2,239.85	2,221.91	-17.95	-0.8%
Barrows & gilts, 51-52% lean	1,206.03	1,175.90	-30.13	-2.5%
Broilers, 12-city wholesale	1,900.04	1,895.35	-4.70	-0.2%
All milk	376.17	372.18	-4.00	-1.1%
Farm income		(Billion dollars)		
Crop receipts	188.83	175.92	-12.91	-6.8%
Livestock receipts	156.98	155.96	-1.02	-0.7%
Government payments	13.27	13.79	0.52	3.9%
Feed costs	42.78	40.24	-2.53	-5.9%
Rent to non-operator landlords	12.67	10.15	-2.52	-19.9%
Other production expenses	258.32	255.54	-2.78	-1.1%
Total production expenses	313.77	305.94	-7.84	-2.5%
Other net farm income	50.19	49.75	-0.43	-0.9%
Net farm income	95.49	89.48	-6.01	-6.3%
Farm program outlays		(Billion dollars)		
Net CCC outlays (fiscal year basis)	10.78	11.32	0.54	5.0%
		(Billion dollars)		
Consumer food expenditures	1,395.87	1,391.56	-4.31	-0.3%

The conversion of U.S. prices depends on the commodity, reflecting the flexible approach to modeling outlined above. The U.S. model already generates fob N. Europe dairy prices so these can be used directly. The indicative world price for cereals is the US fob price, so the farm price is transformed in the following way (using corn as an example):

$$COPXDCA_i = a + bPOILRASA_i + cCOPFRM_i$$

where *i* corresponds to the relevant draw, and the parameters of the equation are estimated. For oilseeds, European port prices are used as the indicative world prices. Therefore, instead of oil prices, freight costs are included. The US model only generates farm-level soybean and soybean product prices, so world prices for the rest of the oilseed complex world prices are generated by keeping the relationships between the products constant.

This explanation of how the generation of world prices is accomplished is very crude. However, the generation of stochastic outcomes for the models is a complicated and time-consuming process, and thereby precludes the generation of 500 world price paths from the Global Outlook for the use of FAPRIs partners. Some stochastic element can be added to these models by building on the U.S. model and using a simplistic conversion of the prices generated therein to the world price equivalents used in the partner models. It is hoped that this can provide partner models with the option of incorporating world price volatility, which has been identified as an increasing concern for the agriculture sector. For example, using the analysis undertaken in this model, combined with the simple conversion of prices into their indicative world counterparts, can lead to a database of world prices that could be used to identify the (asymmetric) impacts of changing U.S. energy policies on partner's agricultural sectors.

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IMPACTS OF THE KOREA-U.S. FTA: APPLICATION OF THE KOREA AGRICULTURAL SIMULATION MODEL

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ABSTRACT

Since the Uruguay Round agreement, Korean Agriculture has been changed more rapidly by trade liberalization and structural adjustment. As a result, the government has been trying to reduce the income gap between urban and rural areas. To assist policy makers, KREI constructed an econometric simulation model covering all commodities. The Korea Agricultural Simulation Model (KASMO) contains 67 commodities, macro indices, input price indices and an agricultural total value module, which includes 2,019 equations and formulas using 2,435 variables. Analysis of Korean policy uses a ten- to fifteen-year deterministic baseline projection incorporating the various agricultural policies and specific macro economic assumptions.

JEL codes: Q11, Q17, Q18.

Keywords: Econometric Simulation Model, KASMO, Policy Analysis, Projection, free trade agreement.

Since the Uruguay Round agreement, Korean agriculture has been changed rapidly by agricultural trade liberalization and structural. Furthermore, the upcoming issues in Korean agriculture will come from the circumstances of world trade changes. They should benefit Korea's total economy. However, the impacts will induce structural change and economic redistribution increasing trade volumes in most of the sectors of Korea.

Many macroeconomic theories and research papers have explained that free trade agreement or globalization will induce national economic growth and welfare improvement. However, to understand any trade liberalization proposal, the free trade concept must be

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considered in detail. The economic growth depends on the economies of scale of each country and each industrial sector joined in a trade agreement. The main concern is not efficiency or the optimality of welfare norm, but equity and redistribution in agriculture.

For the economic analysis for Korea agriculture, tools must be constructed to measure the impacts form the policy and regulation changes and provide a way to analyze future policy options. These tools must have the ability to investigate the causality between economic variables capturing the spillover from one sector to other, and performance of targeted policies using simulation and forecasting on the entire Korean agriculture sector.

KOREAN AGRICULTURE REVIEW

The South Korean economy has been growing rapidly for the last few decades and is now placed among the developed economies. With per capita income[1] above that of many European countries and nearing that of Spain, it is comparable to relatively large and high income countries with well-developed food and fiber distribution systems (Lee and Sumner 2007). South Korea is a major target market in world agricultural trade and thus the interest by many countries for a free trade agreement with Korea, such as the Korean-United States Free Trade Agreement(Korus FTA) negotiated by the U.S. Generally, economic growth not only increases gross domestic product or gross national income but also induces significant economic structural change.

Many countries including developing countries have focused on industrialization with economic growth, and economists have thought that the status or importance of agriculture should be decreasing with economic growth. This trend was similar to South Korea. Korean agriculture has increasingly been losing competitiveness. The process of economic growth has focused on industrialization, and citizens have migrated from rural areas to urban areas, especially the young rural population. The rural share of the population and its importance in national economic growth has decreased over time. Agriculture’s contribution to Korea’s economy (measured by Gross Domestic Product) declined from 16.5 percent in 1980 to 4.0 percent in 2007. The ratio of agricultural population to total population also declined from 28.4 percent in 1980 to 6.8 percent in 2007.

The rise and fall of any specific sector depends on the quantity and quality of human capital in that sector. It is certainly true in agriculture. As many of the younger generations have rapidly given up on farming and migrated to urban areas, the share of older generations in rural areas has grown. The mode of age-specific distributions in the South Korean agriculture population has increasingly moved to an older society over time. The mode of age-specific distribution in farming managers has moved to older society as well.

This significant structural change has stemmed not only from globalization but also is a result of changing food demand. Economic growth in Korea has led to an increase in living standards. Income and changes in food consumption patterns have shifted away from traditional Korean foods such as rice and barley and towards meat, dairy products, and wheat-based products. Another pattern is the dramatic growth in the quantity of food consumption. Agricultural production in Korea, however, has not been satisfying these changing consumption patterns, mainly because of the relatively limited availability of arable land and

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[1] Gross National Income per capita was $20,045 in 2007.

competitive pressure for these resources from non-agricultural sectors. With the demand growth for industrial land, roads and housing, arable land available for cultivation has decreased. As a result, Korean food demand is being met increasingly by imports. As the import demand for agricultural commodities increases, tariffs on agricultural imports have been gradually reduced and import quotas have been replaced by tariffs to improve market access.

THEORETICAL BACKGROUND

Agricultural economists have attempted to estimate the true parameters of behavioral equations which derive from economic theories, such as demand, supply and inventory functions. These empirical estimates have been used for evaluating the effects on existing polices, analysis of proposed polices, forecasting, and an improved understanding of the sector in question.

Even though we get the best statistical estimation results by using techniques intended to ensure unbiasedness or consistency and minimum variance, we often find unexpected estimation results that differ from basic economic theories. If estimated coefficients do not match basic economic concepts, misleading results and interpretations of policies and forecasting can occur. It remains imperative that in cases where parameter estimates do not meet prior expectations that there is an understanding of why results are different and what alternative approaches are needed to provide usable estimates.

Researchers are forced to formalize prior knowledge before estimating the model. Economic theories produce useful standards for model specification and the evaluation of parameter estimates; these standards are very useful and helpful in determining the explanatory variables' coefficients and in comparing signs and relative magnitudes.

DEMAND SYSTEM

Demand stems from income growth that has induced agricultural structure change. However, all commodities traded can be either homogenous goods or heterogeneous goods on the demand side but not the supply side, which means that consumers can separate goods as identified by the nationality label put on the goods sold, even though farmers in each country produce the same commodities. We assume symmetric information exists in the Korean agricultural trade market. But if consumers can not clearly identify the nationality of goods to consume, these goods can be homogenous goods in the food market. This case can be applied in the processing food market and the restaurant industry. Imported goods are traded by two types, fresh and processing; and imported fresh type is also separated into fresh usage and processing, feed, and seed usage. This separation is based on not only consumption style but also heterogeneous goods.

In terms of restricted estimation methods, a comparison between the exact restricted estimation (e.g., AIDS) applicable to individual consumer behavior and less restricted or unrestricted estimation at the aggregate market level can be made to find the best method for forecasting and analysis. Neither microeconomics nor econometrics provides the guidelines for this comparison because a trade-off relationship exists between bias and variance. In terms of econometrics or statistics, a highly-restricted estimation method, which is based on microeconomics, may yield more efficient estimates due to predicted low variance. However, these estimates might differ from the unbiased or true estimates. One goal of forecasting is to minimize the mean squared error of the forecasts (MSE)[2]. In small sample forecasting applications, there may be some willingness to accept some bias in exchange for lowering variance. If we get lower variance, the one-step-ahead forecast (Y_{t+1}) is systematically over or under estimated. That means that as long as our estimates are closer to the one-step-ahead forecast than to the average, the high-efficient estimates are very spread out around the true Y_{t+1}.

Brandt and Bessler (1983) note that the difference between simulation performances of unrestricted least squares and exact imposition of the Slutsky condition is quite shocking. They found that the mean absolute error of restricted least squares conforming to the rigorous properties implied by individual demands was, in some cases, thousands of times greater than that of unrestricted ordinary least squares estimates.

In this research, to estimate demands that are consistent with the aggregated demand systems reviewed above, the demand functions were specified by double-log forms. Less restrictive *ad-hoc* restrictions inherited from the individual demands are also imposed on system demand equations' forms as well. Restrictions and assumptions of homogeneity of degree zero, separability, and continuity are applied. Additionally, each commodity's total demand can be separated into fresh-food demand, processing demand, seed, feed, and loss functions to avoid the aggregation bias and capture the structural changes for demand as well. Formally, demand functions' specifications used in this research are shown in the Appendix as table 1.

SUPPLY SYSTEM

The agricultural sector's supply side is more complex and heterogeneous than any other industrial sector. Each supply equation has a very different form depending on the crop or animal type. Therefore, a correct specification for each commodity is needed. A farmer's profit maximization problem or cost minimization problem includes 1) a production equation which is represented by an acreage response function (animal inventory function in case of livestock) and a yield equation per acre or per animal, and 2) a cost equation. Additionally, biological constraints relating to the physical time needed for production can be imposed on the basic economic equations. Agricultural economists have found that applications of simple economic theory on the supply side can have limitations. The biological time lag causes agricultural supply equations to look different from those of many other sectors. These biological constraints introduce the concept of a time table called "crop year" or "marketing year" as opposed to a normal calendar or fiscal year. This has tended to reduce the measurement error problem in variables which can result in biased estimates. Unfortunately,

[2] We can show above trade-off relationship by the mean squared error of W_n as estimator of true θ;

$$E[(W_n-\theta)^2] = E[(W_n - E(W_n) + E(W_n) - \theta)^2] =$$
$$var(W_n) + bias(W_n)^2 + 2E[(W_n - E(W_n))(E(W_n) - \theta)], where\ 2E[(W_n - E(W_n))(E(W_n) - \theta)]$$

it has not been immediately adopted for use in the economic side. Another effect of the use of biological methods is that the supplier's decision making equation can be changed from a static form to a dynamic form, and the supply and demand substitutions are realized by each commodity's specific seasonality, planting time and marketing period. In this research, all agricultural demand and supply tables are made by using the crop year biological component.

Dynamic acreage response function can be derived from Nerlove's (1956) partial adjustment model or Cagan's adaptive expectation model based on Koyck's (1954) geometric distribution lag model. Using the above equations, individual crop acreage equations are specified as a function of the expected net returns for the own crop and expected net returns of competing crops with results shown in table 2 in the Appendix. In addition, Korean livestock model specifications (Han 2009) were based on Brown's (1994) U.S. livestock flow diagram.

The level of ending stocks plays an important role in agricultural demand and supply from one crop year to the next. For storable commodities, it is especially important to correctly describe inventory behavior in order to reflect how the commodity market works (Womack 1976). Additionally, the adjustment of stocks is one of the most important means of accommodating short run volatility in agricultural commodity markets (Williams and Wright 1991) because short run price equilibrium is reached for commodities where consumption or production or both are price inelastic within a given time period.

A major problem in defining and explaining commodity inventory behavior is that inventories have been recorded as being held by one or two groups of market participants, whereas each of these groups contains participants who accumulate inventories for different purposes. Yet a consumer as well as a producer may possess the same motivations.

Inventory accumulations are normally associated with three basic motivations; 1) precaution 2) speculation and 3) transaction demand (Womack 1976). However, in practice, the above theories have not been developed to deal with specific commodity markets due to inadequate or scarce inventory data. Instead, most literatures considered relatively simple empirical relationships by using applications of theory, even though most of them use dynamic approaches including Nerlove's partial adjustment[3] and price expectation model.

MODEL STRUCTURE

Korea Agricultural Simulation Model (KASMO) consists of five sectors that simultaneously interact with each other: 1) macro indices, 2) input price sector, 3) crop sector, 4) livestock sector, and 5) agricultural indicators. The system is a simultaneous, non-spatial, partial equilibrium model for the entire Korean agricultural industry and it is designed primarily for the purpose of policy analysis.

In KASMO, a dynamic simultaneous equation model (SEM) approach is employed pioneered by the Food and Agricultural Policy Research Institute (FAPRI). The main characteristics of KASMO are as follows:

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[3] $(q_t - q_{t-1}) = \delta(q_t^* - q_{t-1})$, subject to $0 < \delta < 1$, $q_t^* = \frac{q_t - q_{t-1} + \delta q_{t-1}}{\delta} = \frac{q_t - (1-\delta)q_{t-1}}{\delta}$
where, q_t: actual supply, δ: adjustment coefficient

1) The market clearing price is determined by the equilibrium condition: total supply equals total demand in each market. The model uses price-independent equations rather than the price-dependent equations. Thurman (1986) interpreted endogeneity test that results in supply and demand systems using the U.S. annual model. While the possibility of simultaneous equations bias is generally acknowledged in the estimation of demand functions, references to it in empirical demand work often are perfunctory. The treatment often consists of an introduction to empirical results that argues for quantity or price being predetermined and, hence for the consistency of ordinary least squares estimates. In the simultaneous equations, a model of demand and supply matters little whether or not price or quantity is placed on the left-hand side in the demand equation. Economic theory accommodates demand price shocks as easily as it does quantity shocks. The choice of dependent variable is crucial to estimation and to economic interpretation. Test for endogeneity proposed by Wu (1973) and later by Hausman (1978) has natural application to the issue of price or quantity endogeneity in demand functions. Thurman (1986) compared Wu-Hausman tests in price-dependent demand equations with those in quantity-dependent equations and concluded that power is not invariant to demand normalization. And he concluded that the test of the predeterminedness of quantity will be more powerful than the test for the predeterminedness of price. Hence a model that assumes prices are predetermined is more consistent and asymptotically efficient.

2) A dynamic estimation method is applied for policy simulation. KASMO is a large-scale system that contains 67 commodities, macroeconomic indices, input price indices and an agricultural total value module. It uses 2,019 equations and formulas and 2,435 variables. It covers more than 95 percent of the total agricultural sector based on the 2007 total production value.

3) KASMO resides in a user-friendly Excel spreadsheet. KASMO outlines the linkages between each commodity sector, input sectors and macroeconomic indices. The behavioral equations are estimated using mostly OLS and 2SLS in some cases. The equations were estimated using annual data from 1980 to 2008. Most of the parameters for the structural equations have economically consistent and statistically significant signs. The broad framework of the Korean agricultural modeling system is depicted by figure 1, which conceptualizes the basic structural model. The top half of figure 1 is a simplified representation of the livestock sector, while the bottom half reflects the crop sector. The left half of Figure 1 stands for demand variables and the right side of the diagram contains the supply variables. The macroeconomic variables driving this system include population, income, and input costs. Technology and policy variables are also included in the system. Analysis of the Korean farm policy uses a ten-year deterministic baseline forecast. It is developed by incorporating the various agricultural policies, specific macro economic assumptions supplied by IHS Global Insight, Inc., and assumes average weather.

DEMAND ELASTICITY

In demand functions, the consumption of each product depends on its own price, the price of substitute products, and income.

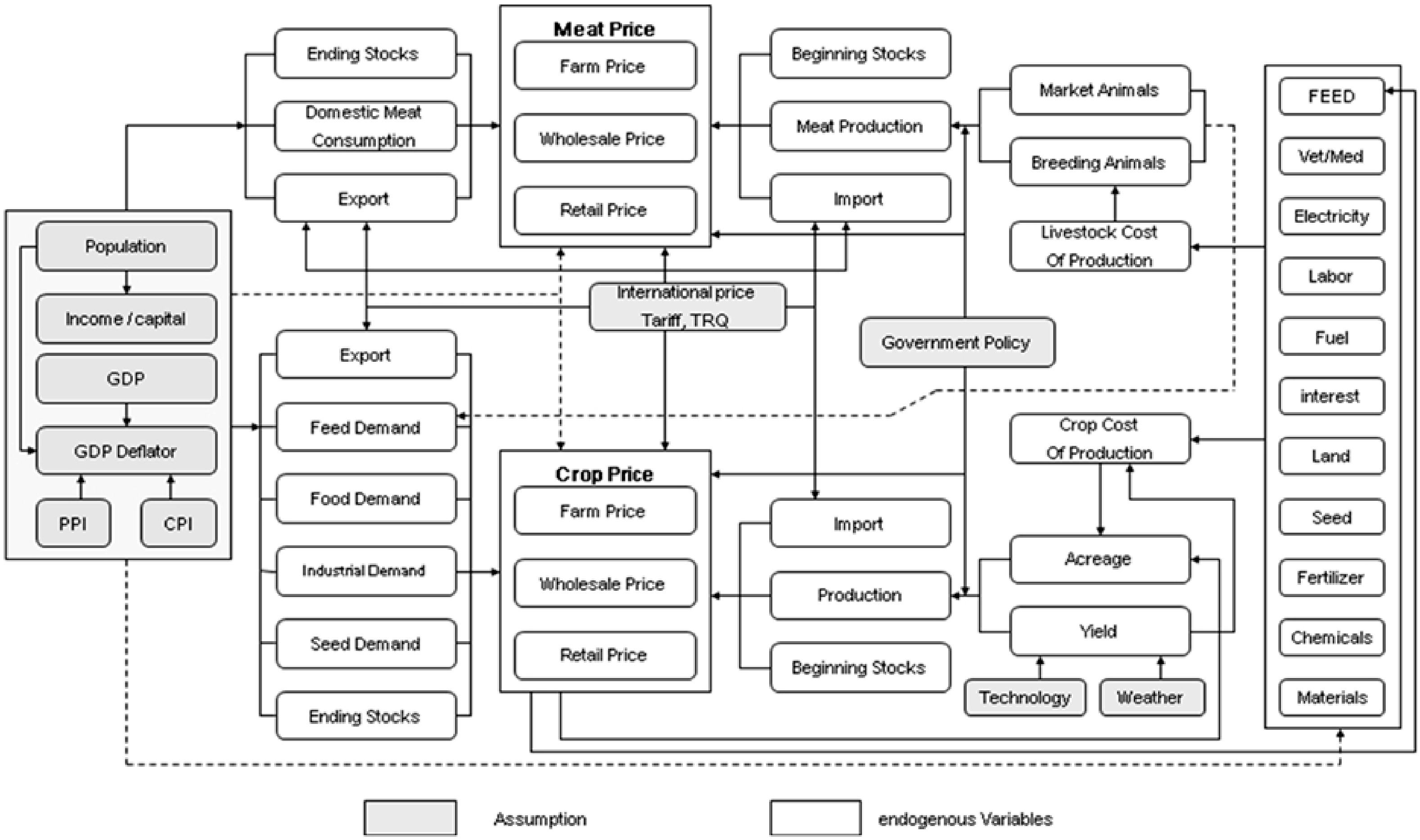

Figure 1. Flow diagram for KASMO.

Since these equations were estimated in double-logarithmic form, the coefficients estimated can be interpreted as elasticities. The demand side of the model remains an unconstrained single equation approach rather than using a constrained system approach because the lack of precision in gathering the data causes difficulties in the systematic approach even though it allows more advanced demand theories to be imposed on the system. However, economic and statistical theories were applied in estimating demand functions. According to Euler's theorem, the magnitude of own price elasticity depends on the magnitude of the cross price elasticity. If there exists no substitute goods in the demand equation, the own price elasticity must equal the income elasticity. Because this modeling was estimated with unconstrained single equations, it was not perfectly in line with Euler's theorem. However, cross versus own price elasticities can be compared.

Own price elasticities were estimated to be from -0.18 to -1.35. By commodity groups, the grains' price elasticity is the lowest in absolute terms and was estimated to be -0.27 and dairy products' price elasticity was the highest in absolute terms and was estimated to be -0.56. The ordering from highest to lowest in absolute terms of the own price elasticities for the commodity groups is; 1) dairy products, 2) fruits, 3) flowering plants, 4) meats, 5) vegetables, 6) oilseeds, and 7) grains. In the case of income elasticities, Korean commodities were estimated to be from 0.1 to 1.18 in this study. By groups, the grains' income elasticity is again the lowest at 0.16 and meats' income elasticity was the highest at 0.70. The ordering from highest to lowest of the own income elasticities is: 1) meats, 2) dairy products, 3) flowering plants, 4) fruits, 5) vegetables, 6) oilseeds, and 7) grains.

SUPPLY ELASTICITY

The supply elasticities for crops with respect to producer net returns were estimated from a dynamic acreage response function. They were derived from Nerlove's (1956) partial adjustment model and Cagan's (1956) adaptive expectation model based on Koyck's (1954) geometric distribution lag model.

In supply functions, the expected acreage of each commodity depends on its own lagged returns and lagged returns of the other substitute commodities in the system. Net returns are calculated by subtracting cost from total revenue. However, in some cases the ratio of total revenue/cost is employed.

The supply elasticities were estimated to be from 0.07 to 0.51. By commodity groups, the supply elasticity for grains is lowest at 0.18 and that of fruit products is the highest at 0.37. The ordering of the supply elasticities from highest to lowest are: 1) fruits, 2) oilseeds, 3) flowering plants, 4) vegetables, and 5) grains.

In the model specification, products are separated by seasons and types. First, products cultivated were separated by two types, winter crops and summer crops, and then divided into green house and open field crops. In the winter season, barley, garlic, and onions are substitutes for each other. In the summer season, however, all crops can be substituted. In open field crops, soybeans, red peppers, corn, and sweet potatoes are substitutes in the summer season. In paddy fields, rice, soybeans, ginseng, and green house vegetables are substitutes for each other.

In the fruit sector, apples, pears and grapes are generally substitutable in planting. Peaches are mainly substitutes for apples. Citrus and sweet persimmons are not included in substitution relationships. Korean citrus crops are cultivated only on Je-Ju Island, and planted on hillsides. Sweet persimmons are also cultivated only in southern areas of Korea.

IMPORT DEMAND ELASTICITY

For analyzing the impacts of the any FTA, the import demand functions are the most important factors in the model. Each commodity's expected import volume was determined from the domestic price and import prices. However, there are many specifications that can be applied in a model such as below:

1. Import = f (domestic price, import price)
2. Import = f (domestic price / import price)
3. Import = f (domestic price – import price)

In this KORUS FTA study, (1) and (2) were the most often employed methods. Separate import demand functions from the U.S. and other countries were developed to analyze the trade conversion and creation effects. Import demand functions were estimated for fresh food, processing, and feed uses to reflect the final tariff schedule. In this section, only summarized coefficients are presented. For example, beef import demand from three groups including the United States, Australia, and other countries were estimated. In the case of pork, the import demands from the U.S., Chile, and other countries were estimated to analyze the trade effects. Where possible, products were separated by HS codes so that the import functions by product end use could be estimated to better examine the implications of different tariff schedules in the KORUS FTA. For grains, the separation included feed and food use. Fruits and vegetables were separated into processing and fresh use. The imports of oranges were separated into two types (March-August, September-February) as specified in the KORUS FTA. According to estimation results, almost all of the own-price import elasticities were over 1.0 and have economically consistent and statistically significant signs.

THE IMPACT OF THE KOREA-U.S. FTA: SIMULATION AND POLICY PERSPECTIVES

On April 2, 2007, South Korea and the United States concluded an historical comprehensive free trade agreement (KORUS FTA) that will eliminate tariffs and other barriers to trade in goods and services, and that is intended to promote economic growth. The agreement followed ten months of hard bargaining, which included eight official negotiation meetings and a high level official meeting. The KORUS FTA will immediately lift 85 percent of each nation's tariffs on industrial goods at first year. However, it has not been approved by either the U.S. Congress or the National Assembly of South Korea.

Based on the finalized agreement, KASMO was used to analyze the implications of the FTA for Korean agriculture. The model represents the entire Korean agricultural sector including rice and grains, fruits and vegetables, livestock products, and other commodities for the analysis. In particular, import demand functions are reformulated for the imports from the U.S. and other countries separately so that the trade conversion and creation effects from an FTA with the U.S. can be analyzed directly. Basically, the analysis focuses only on the tariff reductions and TRQs resulting from in the FTA negotiation. In addition, the model analyzes a baseline that represents the current Korean agricultural situation without the FTA and then analyzes an FTA scenario with the final tariff reduction agreed in the FTA negotiation by both countries. The comparison between the baseline and the scenario represents the estimated impacts of the FTA in the years ahead. Since most of the tariffs will be zero by 2025, the analysis compares the baseline and FTA scenario over 16 years from 2010 to 2025. The final tariff schedule and other factors such as TRQs, safe guards on specific commodities, and tariff rates are treated exogenously.

The KORUS FTA is predicted to result in a big reduction in Korean agriculture production value. As seen in table 5, Reductions in production value will be 1,367 billion won in 5 years, 2,531 billion won in 10 years, and 4,237 billion won in 15 years. Hence, an accumulated loss of production value from 2010 to 2025 will be 36,243 billion won, which is larger than Korean total production value on the agriculture industry in 2007 (34,685 billion won).

Korean agriculture value added will also be heavily impacted. Reductions of value added will be 1,084 billion won in 5 years, 1,612 billion won in 10 years, and 2,440 billion won in 15 years. The accumulated loss will be 23,175 billion won by 2025. The loss of agriculture total income will be 978 billion won in 5 years, 1,487 billion won in 10 years, and 2,263 billion won in 15 years. The accumulated loss will be 21,299 billion won through 2025.

The ratio of agricultural production value per GDP under the KORUS FTA will change by -8.5 percent in 2025. In normal percentage levels, the ratio of production value per GDP will decrease from 3.8 percent in 2007 to 1.9 percent in 2025.

At the farm household level, income per farm household will decline from -0.3 percent in 2010 to -2.9 percent in 2025 even though non-farm income will increase as a result of transfer income (government payments). With income loss at the farm level, the agricultural population will decrease from 3,187 thousand persons in 2008 to 2,050 thousand persons in 2025. Employment in agriculture will decrease from 1,633 thousand persons in 2008 to 1,094 thousand persons in 2025. The model predicts that 71 thousand persons will lose or give up their jobs by 2025 year due to the KOURUS FTA.

Utilized acreage will decrease by one percentage annually (-1.3 percent change in 2025 year). In terms of percentage change, the orchard sector will be impacted the most due to the imports of fresh juices and processing fruits, oranges and tropical fruits. In addition, imports of fruit-bearing vegetables[12] such as watermelon, other melons, strawberries, and tomatoes, will lead to decreases in those prices. These comprehensive effects will impact the fruits side the most. It will decrease acreage by an average of 1.7 percent (-2.1 thousand ha). However, the percent change for all fruit acreage will not decrease during the FTA compared to the baseline. Peach and pear acreage will increase slightly due to substitution effects. The marketing period for peaches is only 2 months long (July, August). As a result of this short

[12] Korean fruit bearing vegetables' marketing period has been long due to green house cultivation and out of season demand. In the 1980s, they were sold in late spring and summer. However, beginning in the 1990s they have been sold continually during the year.

marketing period, domestic peach production will not be impacted much by the FTA. Apple and grape acreage will mainly be transferred to peaches. Pear acreage has increased until recently. This current reduction in pear acreage has shifted to apples and grapes. Because apples and grapes will be heavily impacted by the FTA, the pear acreage reduction will turn around.

Grains will have the largest impact in terms of acreage reduction, an average -5.5 thousand hectares by 2025. These reductions do not include rice, which was excluded from the KORUS FTA. Rice acreage will slightly increase compared to the baseline due to substitution effects. Vegetable acreage will decrease by an average of -0.7 thousand hectares due to the strong ASG for peppers, garlic, and onions. However, the percent change is almost identical to that of grains. According to the tariff schedule, the tariff reduction for special crops such as sesame, peanuts and ginseng is the largest. However, the impact will be not as large. Their imports will not exceed the ASG levels because the ASG tariffs under the FTA are the same as the 2008 tariffs.

In the livestock sector, the percentage change of total animal inventory will start with a -0.02 percent change in 2010, and end with a -1.5 percent change in 2025. The beef sector faces the largest loss (an average of -4.3 percent), with the pork sector (an average of -1.9 percent) following in terms of percentage change.

The total farm price will change by an average of -4.3 percent during the same period (ranging from -0.9 to -6.8). The percentage change in crop prices will be -1.0 in 2010 and -6.6 in 2025. In the case of livestock, the percentage change will be -0.4 in 2010, and -7.1 in 2025. The aggregated retail price will also change by an average of -4.4 percent during the same period (ranging from -0.8 to -7.3). The percentage change in crop prices will be -1.1 in 2010 and -6.3 in 2025. In the case of livestock, the percentage change will be -0.2 in 2010, and -8.8 in 2025.

Under the KORUS FTA, trade deficits in agriculture will increase by an average of 3.1 percent (9,452 million dollars) during the same period. However, import quantities will decrease from 2017 due to grain feed import’s reduction. These Korean losses will be benefits to the U.S. in agriculture trade. Through the KORUS FTA, the Korean self-sufficiency ratio will decrease from 80.0 percent in 2008 to 74.4 percent in 2025, an average decline of 0.8 percent (ranging from -0.2 to -1.6) compared to the baseline.

From a policy perspective, the Korean government will need to consider actions which to minimize the negative impacts from the FTA, including major structural reform, improvement of competitiveness, and a safety net for the agricultural income. For structural reform, policies to reduce and eventually eliminate inefficient operations will be needed, while efficient operations are maintained and promoted. Similar to what was adopted for the FTA between Chile and Korea, the "exiting-farms" as well as the "commodity-replacing-farms" could be offered assistance based on efficiency and competitiveness of the imports from the United States.

Because the Korean competitiveness in prices of agricultural products has been much lower than that of the U.S., policy for the Korean agricultural industry will need to focus on the sharp and rapid improvements in competitiveness based on quality, with the objective of encouraging domestic consumers to increase the market share for Korean products compared to the lower priced imports from the United States and other countries. Moreover, the policy strategies for the future should be based on building the trust of domestic consumers and their needs to complement the efforts in production agriculture to efficiently offer safe, high quality, fresh products. In this case, the consumer markets for domestic products and imported products would be separated so that the competitiveness of Korean products is based on known and accepted local and national attributes rather than product price alone. Prices would be no longer taken into account in the market.

Policies for an income safety net will need to be considered to allow orderly adjustment to absorb the negative impacts from the FTA since domestic agricultural prices and agricultural incomes would. Therefore, the policies for the income safety net will need to be based on objective analyses to design transition adjustment programs while farmers adapt their production structure and planning to the new agricultural situation caused by the FTA between Korea and the United States.

CONCLUDING REMARKS

KASMO was originally developed at the same time in both Korea Rural Economic Institute (KREI) and FAPRI. The KREI collected necessary information on the Korean agricultural industry and shared them with FAPRI and selected stable results from both institutes for the model in 2008. Moreover, since then, KASMO has been continuously re-estimated and re-specified to reflect changes in the structure of the Korean agricultural industry.

KASMO was constructed to be used as a Korean agricultural policy analysis tool for such issues as FTA, Doha Development Agenda (DDA), exchange rates, oil price, and other changes. Therefore, the model's structure reflects a variety of policy programs that influence the production decision for the commodities included in the model. To date, the model has been used to analyze many different policy issues, including the effects on the agricultural industry stemming from climate change and climate policy changes, government regulations, and market conditions.

Even though KASMO is generally used as a tool to conduct impact analyses resulted from external shocks, the model has also been used to forecast future prices and quantitative volume of the commodities included in the model. The information has served as input into a country-wide process to establish the official KREI baseline presented at the annual agricultural outlook forum held at the beginning of each year in Korea.

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APPENDIX

Table 1. Demand and Supply Model Specifications

Demand model specification

$$\frac{Fresh\ Demand_{it}}{population_t} = f\left(\frac{Price_{it}}{CPI_t}, \frac{Price_{jt}}{CPI_t}, \frac{Income_t}{CPI_t}\right),\ j = 1,\cdots n \quad (1)$$

$$\frac{Processing\ Demand_{it}}{population_t} = f\left(\frac{Price_{it}}{CPI_t}, \frac{Price_{jt}}{CPI_t}, \frac{Income_t}{CPI_t}\right),\ j = 1,\cdots n \quad (2)$$

$$Feed\ Demand_{\ it} = f\left(\frac{Price_{it}}{PPI_t}, \frac{Price_{jt}}{PPI_t}, Production\ of\ livestock_{\ kt}\right),\ j,k = 1,\cdots n \quad (3)$$

$$Seed\ Demand_{\ it} = f\left(E\left[\frac{Price_{it+1}}{PPI_{t+1}}\right], E\left[\frac{Price_{jt+1}}{PPI_{t+1}}\right], production_{\ it}\right) \quad (4)$$

$$Loss_{\ it} = f\left(\frac{Price_{it}}{CPI_t}, production\ of\ crop_{\ it}\right) \quad (5)$$

$$Import_{\ it} = f\left(\frac{Domestic\ Price_{it}}{CPI_t}, \frac{Exch \times import\ Price_{jt} \times (1.1 + tariff)}{CPI_t}\right),\ j = 1,\cdots n \quad (6)$$

$$Export_{\ it} = f(Domestic\ Price_{it}, international\ Price_{it}) \quad (7)$$

Supply model specification

$$Acreage_{i,t} = f\left[Acreage_{i,t-1}, \frac{E(Net_{Returns\ i,t})}{E(Deflator_t)}, \frac{E(Net_{Returns\ j,t})}{E(Deflator_t)}\right] \quad (8)$$

(9)

$$E(Net_{Returns\ i,t}) = (price_{i,t-1} + policy_{i,t}) \times \left(moving\ average_{Yield_{i,t}}\right) - Cost_{i,t} \quad (10)$$

$Yield_{i,t} = f(\sum_{j=1}^{n} \beta_j \cdot weather_{j,t}, trend)$, weather= Sunshine hours, rainfall, wind-speed, (11)

temperature, number of typhoon (12)

(13)

$$Production_{i,t} = Acreage_{i,t} \times Yield_{i,t} \quad (14)$$

$$Cost_{i,t} = f(\sum_{j=1}^{n}\sum_{k=1}^{m} \delta_j \cdot input_k),\ \delta_j = weight \quad (15)$$

(16)

$$Fruit\ bearing\ tree_t = f(Fruit\ bearing\ tree_{t-1}, Young\ tree_{t-1}, Net_{Return_{t-1}})$$

$$New\ planting\ tree_t = f(New\ planting\ tree_{t-1}, Net_{Return_{t-1}})$$

$$Young\ tree_{\ t} = f(Young\ tree_{t-1}, \sum_{i=1}^{j} Net_{Return_{t-i}} / j)$$

Table 2. Demand Elasticity

	Price Elasticity	Income Elasticity		Price Elasticity	Income Elasticity
Grains	-0.27	0.16	*Vegetables*	-0.33	0.30
Rice	-0.30	0.20	Garlic	-0.34	0.33
Barley	-0.30	0.12	Onion	-0.43	0.49
Wheat	-0.19	0.14	Red Pepper	-0.26	0.25
Soybeans	-0.23	0.22	Green Onion(Welsh)	-0.21	0.19
Corn	-0.33	0.14	Green Onion(Wakegi)	-0.23	0.19
Potatoes(spring)	-0.30	0.10	Fresh Pepper	-0.53	0.60
Potatoes(summer)	-0.29	0.10	Cabbage	-0.33	0.29
Potatoes(fall)	-0.36	0.27	Carrot	-0.13	0.10
Sweet Potato	-0.85	0.16	Cucumber	-0.25	0.47
Meats	-0.36	0.70	Pumpkin	-0.61	0.53
Beef	-0.51	1.01	Eggplant	-0.36	0.54
Pork	-0.33	0.56	Chinese Cabbage (spring)	-0.74	0.21
Chicken	-0.23	0.54	Chinese Cabbage(summer)	-0.18	0.26
Dairy Products	-0.56	0.64	Chinese Cabbage(fall)	-0.41	0.14
Fluid Milk	-0.22	0.23	Chinese Cabbage(winter)	-0.22	0.16
Whole Milk Powder	-0.64	0.83	Radish (spring)	-0.24	0.12
Skim Milk Powder	-0.42	0.32	Radish (summer)	-0.20	0.26
Cheese	-1.02	0.86	Radish (fall)	-0.27	0.30
Butter	-0.35	0.75	Radish (winter)	-0.24	0.29
Fermented Milk	-0.71	1.03	*Oil seeds*	-0.33	0.20
Concentrated Milk	-0.60	0.45	Sesame	-0.39	0.15
Fruits	-0.50	0.31	Perilla Seed	-0.22	0.22
Apples	-0.40	0.23	Peanuts	-0.37	0.24
Asian Pears	-0.72	0.14	*Flowering Plants*	-0.41	0.61
Grapes	-0.49	0.38	Cut Flower	-0.64	0.76
Peaches	-0.43	0.27	Potting Flower	-0.30	0.57
Tangerine	-0.55	0.26	Others	-0.28	0.51
Persimmon	-0.40	0.21	*Others*		
Water Melon	-0.66	0.38	Ginseng	-1.35	1.02
Melon (Cham-wei)	-0.68	0.37	Mushroom (agriculture)	-0.14	0.76
Tomato	-0.37	0.34	Mushroom (forest)	-0.45	1.09
Strawberry	-0.22	0.19	Green Tea	-0.51	1.18
Melon	-0.54	0.68	Egg	-0.18	0.26

Table 3. Supply Elasticity

	Lag dependent	Net return Elasticity (short-run)	Net return Elasticity (long-run)
Grains	0.55	0.18	0.41
Rice	0.76	0.07	0.29
Barleys	0.73	0.23	0.88
Wheat	0.43	0.19	0.32
Soybeans	0.42	0.28	0.48
Corn	0.79	0.13	0.61

	Lag dependent	Net return Elasticity (short-run)	Net return Elasticity (long-run)
W. Potatoes(spring)	0.59	0.24	0.59
W. Potatoes(summer)	0.22	0.14	0.18
W. Potatoes(fall)	0.78	0.28	1.23
Sweet Potato	0.27	0.07	0.10
Vegetables	0.55	0.21	0.47
Garlic	0.85	0.18	1.16
Onion	0.18	0.30	0.36
Red Pepper	0.61	0.34	0.87
Welsh	0.25	0.09	0.12
Wakegi	0.54	0.17	0.38
Fresh Pepper	0.51	0.19	0.39
Cabbage	0.52	0.37	0.77
Carrot	0.72	0.31	1.10
Water Melon	0.82	0.12	0.68
Cham-wei	0.44	0.26	0.46
Tomato	0.29	0.24	0.34
Strawberry	0.61	0.14	0.34
Melon	0.72	0.07	0.24
Cucumber	0.75	0.14	0.57
Pumpkin	0.70	0.47	1.58
Eggplant	0.30	0.21	0.29
C. Cabbage(spring)	0.52	0.15	0.31
C. Cabbage(summer)	0.62	0.24	0.64
C. Cabbage(fall)	0.28	0.20	0.28
C. Cabbage(winter)	0.44	0.27	0.47
W. Radish (spring)	0.60	0.11	0.27
W. Radish (summer)	0.23	0.20	0.26
W. Radish (fall)	0.88	0.15	1.30
W. Radish (winter)	0.86	0.10	0.75
Fruits	0.72	0.37	1.33
Apples	0.71	0.49	1.70
Asian Pears	0.40	0.38	0.63
Grapes	0.85	0.36	2.45
Peaches	0.53	0.32	0.68
Tangerine	0.95	0.33	6.88
S. Persimmon	0.88	0.17	1.42
Oil crops	0.52	0.29	0.61
Sesame	0.47	0.27	0.50
Perilla Seed	0.28	0.10	0.13
Peanuts	0.82	0.51	2.84
Flowering Plants	0.39	0.25	0.41
Cut Flower	0.49	0.25	0.48
Potting Flower	0.35	0.32	0.49
Others	0.32	0.19	0.28
Ginseng	0.77	0.35	1.48
Mushroom	0.44	0.14	0.25
Green Tea	0.88	0.13	1.09

Table 4. Import Demand Elasticity of Meats and Grains

Model Specification = Domestic price/ Import price

	Beef_US	Beef_AU	Beef_RE
Beef_US	1.04	-0.18	-0.04
Beef_AU	-0.14	1.05	-0.32
Beef_RE	-0.01	-1.33	2.19

	Pork_US	Pork_CH	Pork_RE
Pork_US	2.40	-0.16	-0.48
Pork_CH	-1.05	2.87	-1.70
Pork_RE	-1.06	-0.72	2.10

	Egg_US	Egg_RE
Egg_US	1.62	-0.09
Egg_RE	-0.34	0.47

Model Specification = Domestic price, Import price

	Domestic	Broiler_US	Broiler_RE
Broiler_US	5.72	-2.75	1.27
Broiler_RE	0.79	0.47	-1.89

Model Specification = Domestic price / Import price

	Barleys_US	Barleys_RE
Barleys_US	6.55	-5.54
Barleys_RE	-0.08	1.34

(Food)	Corn_US	Corn_RE
Corn_US	1.04	-1.35
Corn_RE	-1.02	1.19

	Production of Livestock	Import
Corn_Feed	0.83	-0.44

Model Specification = Domestic price, Import price

	Domestic	Wheat_US	Wheat_RE
Wheat_US	0.03	-0.57	0.57
Wheat_RE	0.45	0.83	-0.73

	Domestic	Import	Production of Livestock
Soybean_Food	0.51	-0.51	
Soybean_Feed	0.25	-0.43	0.27

Note: US = United States, AU = Australia, CH = Chile, and RE = others.

Table 5. Import Demand Elasticity of Others

Model Specification = Domestic price, Import price or Domestic/Import price			
	Fruits	Vegetables	Import
Orange_38	0.09	0.13	-0.82
Orange_92	0.26	0.15	-0.47
	Domestic	Grape_US	Grape_CH
Grape_US	3.35	-5.32	-
Grape_CH	1.19	-	-0.97
	Domestic	Import	
Garlic_Fresh	5.76	-5.76	
Garlic_processing	1.09	-1.09	
Onion_Fresh	1.69	-1.69	
Onion_Processing	1.39	-2.53	
Pepper_Fresh	3.36	-2.39	
Pepper_Processing	0.35	-0.58	
Whole milk powder	8.93	-8.93	
Skim milk powder	0.35	-0.73	
Infant milk powder	0.37	-0.37	
Cheese	1.19	-1.37	
Butter	4.40	-4.40	
Fermented Milk	0.35	-0.35	
Concentrated Milk	0.55	-0.37	
White Potatoes	0.23	-2.01	
Green Onion (Welsh)_Fresh	3.99	-3.99	
Green Onion (Welsh)_Processing	0.10	-0.10	
Green Onion (Wakegi)	0.41	-0.41	
Cabbage	5.92	-4.68	
Carrot	0.37	-0.37	
Apples_Processing	0.95	-0.90	
Pears_Processing	0.41	-2.70	
Peaches_Processing	0.14	-0.39	
Citrus	0.46	-0.87	
Sweet Persimmon	1.83	-1.28	
Cucumber	0.67	-0.67	
Pumpkin	0.57	-0.49	
Tomatoes	0.14	-0.14	
Strawberry	1.08	-1.08	
Seasam	0.66	-0.66	
Perilla Seed	0.45	-0.45	
Peanuts	0.16	-0.16	
Giseng_Red	0.00	-2.15	
Giseng_White	1.49	-2.21	
Green Tea_Fresh	1.08	-1.08	
Green Tea_Processing	0.32	-0.32	
Flowering Plant_Cut	0.69	-0.84	
Flowering Plant_Pot	0.79	-0.49	
Flowering Plant_Others	0.45	-0.53	
Mushrooms_Agriculture	0.31	-0.31	
Mushrooms_Forest	0.38	-0.38	

Note: US = United States, AU = Australia, CH = Chile, and RE = others.

Table 6. KORUS FTA Impacts Relative to the Baseline (percent change)

Year	2010	2015	2020	2025
Agricultural Total Income				
Total Production Value	-0.6	-4.0	-6.0	-8.5
-Crops	-0.8	-3.7	-4.8	-6.2
-Livestock	-0.1	-4.5	-7.7	-11.2
Total Value-Added	-0.9	-5.0	-6.6	-8.7
-Crops	-1.1	-4.5	-5.7	-7.4
-Livestock	-0.2	-7.0	-9.4	-12.6
Total Income	-1.2	-6.4	-8.6	-11.6
-Crops	-1.5	-6.1	-8.1	-10.9
-Livestock	-0.2	-7.5	-9.9	-13.0
Total Value-Added per ag_capita	-0.9	-4.6	-5.9	-7.9
Total Income per ag_capita	-1.2	-6.1	-8.0	-10.7
Real Total Income per ag_capita	-1.2	-6.1	-8.0	-10.7
Total Production Value / GDP (%)	-0.6	-4.0	-6.0	-8.5
Total Value-Added / GNI (%)	-0.9	-5.0	-6.6	-8.7
Income per Household				
Total Income per household	-0.3	-1.6	-2.2	-2.9
Farm Gross Receipts	-0.6	-3.7	-5.6	-7.9
Farm Expenses	-0.2	-2.4	-4.2	-6.4
Farm Income	-1.2	-6.1	-8.1	-10.9
Rural Population				
Agricultural Population	0.0	-0.4	-0.7	-0.9
Economically Active Population	0.0	-0.2	-0.4	-0.6
Employment in Agriculture	0.0	-0.2	-0.5	-0.7
Number of Household	0.0	-0.2	-0.4	-0.6
Total Farm Price (Normal)	-0.9	-4.0	-5.2	-6.8
-Crops	-1.0	-4.0	-5.1	-6.6
-Livestock	-0.4	-4.2	-5.4	-7.1
Total Acreage	0.0	-0.2	-0.4	-0.5
Total Utilized Acreage	0.0	-0.2	-0.8	-1.3
-Grains	0.0	-0.1	-0.7	-1.5
-Vegetables	0.1	-0.3	-0.5	-1.1
-Special crops	0.0	-0.6	-0.9	-1.0
-Orchards	0.0	-0.9	-2.7	-3.0
-Others (Green House)	0.0	-0.1	-0.1	0.0
Utilized Acreage ratio (%)	0.0	0.0	-0.4	-0.8
Acreage per Farm household (unit: ha)	0.0	0.0	0.1	0.1
Acreage per capita (unit: a)	0.0	-0.2	-0.4	-0.5
Acreage per Farmer (unit: a)	0.0	0.2	0.3	0.5
Total Animal Invetory	0.0	-0.4	-1.0	-1.5
-Cattle	0.0	-1.8	-6.0	-10.7
-Milkcow	0.0	-0.3	-0.5	-0.8
-Hog	0.0	-0.9	-2.8	-4.3

Year	2010	2015	2020	2025
-Broiler	0.0	-0.7	-1.5	-2.1
-Hen	0.0	0.0	0.0	-0.1
Trade Balance				
-Trade deficits	1.4	2.9	3.7	3.9
-Imports	1.2	2.4	3.0	3.2
-Exports	0.0	0.2	0.3	0.3
Self-sufficient Ratio	-0.2	-0.5	-1.1	-1.6
Grains (Fresh+Processing)	-0.1	-0.3	-1.1	-2.0
Meats	0.0	-1.3	-3.4	-5.5
Spice and Culinary	-0.2	-0.5	-0.8	-1.0

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COMBINING STOCHASTIC MODELING TECHNIQUES WITH SCENARIO THINKING FOR STRATEGIC AND POLICY DECISIONS IN AGRICULTURE

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ABSTRACT

In order to make decisions in either normal (risk) or abnormal (uncertainty) conditions, decision makers have to make use of tools to assist in attempting to make a good decision. The simultaneous application of two methods, scenario thinking and stochastic modeling, facilitates a more complete understanding of the risks and uncertainties pertaining to policy and strategic business decisions in agricultural commodity markets. This is likely to facilitate better decision making in an increasingly turbulent and uncertain environment. Results of such an analysis are generated within the BFAP analytical systems, which incorporates a direct link to the global FAPRI modeling system.

JEL classification: Q11, Q17, Q18.

Keywords: risk, uncertainty, decision making, stochastic modeling, scenario thinking, partial equilibrium model.

In 1985, Pierre Wack, arguably the father of modern scenario thinking, wrote the following: “Forecasts often work because the world does not always change. But sooner or later forecasts will fail when they are needed most: in anticipating major shifts…” (Wack, 1985: 73). The truth of this statement has again become apparent, first as the “food price crisis” played out during 2007 and 2008, and secondly as the current financial and economic crisis is playing out. Respected market commentators and analysts, both internationally and

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within South Africa, made all sorts of "informed predictions" on topics ranging from oil prices, interest rates, and economic growth rates to input costs and food prices. The problem is that hardly any of these "respected views" and "informed predictions and estimates" became true within the period that was assigned to these predictions. In fact, just the opposite occurred: the unexpected implosion of the global economy and hence commodity markets.

Against this background researchers at the Bureau for Food and Agricultural Policy (BFAP) have attempted to design and formalize a framework that involves the simultaneous application of two very familiar methods, scenario thinking and stochastic modeling, to facilitate a more complete understanding of the risks and uncertainties pertaining to policy and strategic business decisions in agricultural commodity markets. This application is based on the analytical capacity that was established within BFAP through the collaborative efforts with FAPRI at the University of Missouri since 2002. Scenario thinking and stochastic modeling are the two most frequently applied methods by BFAP to analyze and project the possible behavior of commodity markets. Scenario thinking will be discussed in greater detail in the following section of this article. The BFAP modeling framework (figure 1) has been designed for FAPRI to provide global long term projections of agricultural markets that feed into the BFAP sector model. The international level gives the BFAP system the ability to simulate the effect of world market changes or changes in any specific countries that are included in the FAPRI global model on South African industries and farms.

The BFAP sector model can be classified as a multi-sector commodity level partial equilibrium model that incorporates a world-first automated regime switching technique. This technique provides the model with the ability to switch dynamically between different market regimes and model closures as market conditions change. The model is therefore highly suitable to conduct trade and policy analysis as well as handle real-world exogenous shocks like dramatic changes in weather patterns.

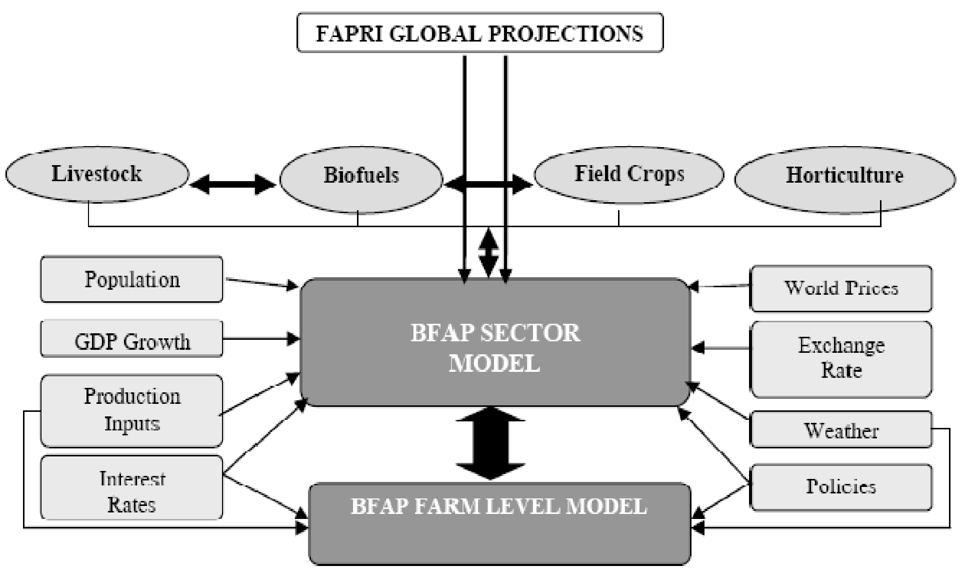

Figure 1. The BFAP modeling framework.

The BFAP sector model consists of a system of equations for grain, livestock, wine, fruit, sugar, vegetable industries, ethanol, biodiesel, and dried distillers grain (DDG) that are modeled in a complete simultaneous system of equations. Table 1 presents the commodities that are currently included in the model.

Apart from the fact that the BFAP sector model is used annually to generate a baseline that provides a 10-year outlook of the commodities listed in table 1, BFAP is frequently involved in scenario thinking sessions with a number of private companies. Over the years a methodology was developed that incorporates the simultaneous application of scenario thinking and stochastic modeling techniques. This paper presents a formalized framework of this methodology and, henceforth, has the following aims:

1. First; to explore the foundations of risk and uncertainty and their analyzes in agricultural economics in order to point out a fundamental weakness in the way that uncertainty is addressed in agricultural economics.
2. Second; to identify and discuss a technique, namely intuitive logic scenario thinking, which is suitable to analyze uncertainty and which can be used in conjunction with an existing technique common in the agricultural economic literature, namely stochastic econometric modeling.
3. Third; to present a framework in which intuitive logic scenario thinking and stochastic econometric modeling can be applied in conjunction in order to analyze risk and uncertainty simultaneously in a technically correct manner.
4. Fourth; to present a case study whereby the proposed framework is applied in order to indicate the success that has been achieved by applying it.

Table 1. Commodities Included In The BFAP Sector Level Model

Cereals	Oilseeds	Livestock	Dairy	Horticulture& Viticulture	Other
White Maize	Sunflower	Chicken	Milk	Wine	Petrol
Yellow Maize	Sunfl cake & oil	Beef	Cheese	Table Grapes	Diesel
Wheat	Soya beans	Lamb	Butter	Apples	Bio-ethanol
Sorghum	Soya cake & oil	Wool	Skim Milk	Potatoes	Biodiesel
Barley	Canola	Pork	Whole Milk	Sugar	DDG
		Eggs			

CONTRASTING RISK AND UNCERTAINTY

The concept of risk, derived from the Italian word *risicare* which means “to dare,” was not well understood until approximately 1654 when the Theory of Probability was finally grasped (Bernstein, 1998: 3, 8). Bernstein views the Theory of Probability as the mathematical foundation of the concept of risk (Bernstein, 1998: 3). In contemporary literature, risk is generally defined as a situation in which probabilities (different possible outcomes) of a system or factor are known and can be calculated. Hardaker, *et al.* (2004: 5) argue that this definition of risk is not useful, since objective probabilities are seldom known, and subjective probabilities therefore need to be calculated. As a result, they define risk as "uncertain consequences." Bowles (2004: 101) defines risk as being more finite: when the outcome of an action in the individual's choice set is a set of possible outcomes to which known probabilities can be attached. Valsamakis, Vivian and Du Toit (1996: 23) argue wider on the definition of risk, and write: *"In his effort to understand or minimise uncertainty, man has attempted to determine causation, unfold patterns and give meaning to unexplained events, possibly in terms of a controlling power."* Ilbury and Sunter (2003: 42), although not referring directly to risk, also argue along this line of thought, and write about the 'rule of law' (or causality) and the motivation of people to analyze and understand cause-and-effect in order to quantify it.

To understand risk and its impact and thereby make good decisions, causality between various factors, events, actions and resulting potential outcomes need to be understood and be quantifiable to some extent. *The fact that causality is determinable and quantifiable, leads to the possibility of calculating and assigning probabilities (either objective or subjective) to the occurrence of events.* Based on the ability to quantify the probability of the occurrence of events, a decision-maker can begin to think and calculate the magnitude of potential consequences should a specific event occur. The insight gained by the decision-maker through this process, leads to the understanding of the risks faced, and hence partially assists the decision-maker in making a good and informed decision.

However, from these arguments on the definition and analysis of risk, a dilemma arises. The dilemma arises when causality or the 'rule of law', whether determined objectively or subjectively, breaks down.

In such situations it becomes difficult to form a perspective on the cause-and-effect relationships in a system, and therefore on objective or subjective probabilities of the occurrence of potential events. Frank Knight, in his seminal work 'Risk, Uncertainty and Profit,' discussed this dilemma (Knight, 1921: 224). Knight indicated that a scheme can be set up for classifying three different 'probability' situations, detailed below:

a) *A priori* probability: these are probability situations that can be calculated using homogenous classification of instances that are completely similar except for really indeterminate factors. These types of probabilities are typically mathematical probabilities. An example of such a probability is the flipping of a coin, wherein the only indeterminate factor is whether the coin is "loaded" and whether the person follows exactly the same action each time the coin is flipped.
b) The second type of probability situation is called *statistical probability*. Here he refers to the situation wherein probabilities (objective or subjective) can be calculated based on observed data or empirical classification of instances.
c) The third probability situation is called *estimates* by Knight. This he defines as the situation wherein *no valid basis exists of any kind for classifying instances*. The implication is that no probability (objective or subjective), can hence be attached to an outcome in such a situation, and hence he defines it as "*true uncertainty.*" Knight argues that in such a case it is fundamentally not possible to even assign a probability of making an error in judgement, hence rendering it meaningless to assign a probability, since the decision-maker does not have the slightest idea whether the

decision would be correct or not. Thus, to speak about probability assignment in this type of probability situation, is actually irrelevant.

Based on Knight's original arguments and his distinction between risk and uncertainty, subsequent authors such as Bowles (2004: 101) define uncertainty as a situation when no probabilities, whether objective or subjective, can be assigned to an outcome. Bernstein (1998: 133) also argues along similar lines, and defines uncertainty as unknown probabilities. Uncertainty stems from two underlying problems.

The first problem is the task of calculating accurate and realistic probabilities in order to quantify risk, which is difficult to do because correlations between factors change. Correlations between factors change as a result of a change in the cause-and-effect relationship between factors. Since the accurate calculation of probabilities is dependent on correlations between factors, probability distributions are due to change should correlations between factors change. However, in many instances, knowledge or data is not available to estimate 'new' correlations.

The second problem stems from the fact that, as a result of structural changes in a system, different factors come into play that drive and shape the system. The implication is that a 'new' rule of law (Ilbury and Sunter, 2003) appears.

In many instances these 'new' factors are either difficult to understand or to quantify. Thus, the 'new' factors influencing the system, along with the difficulty to either understand or quantify these factors, make it very difficult to accurately calculate probabilities and so quantify and understand risk and uncertainty.

Pierre Wack (1985: 73) writes about the dilemma that arises when events result in a breakdown of causality. He describes such "causality-breaking" events as discontinuities. He defines discontinuities as "*...major shifts in the business environment that make whole strategies obsolete.*" Grossmann (2007: 878) follows his argument, and writes that discontinuities can be organised into three categories:

a) A temporary or permanent break within one condition or field.
b) A significant change occurring without a break in any particular condition through the combined influence of several trends in different fields – all of which may be unspectacular by themselves.
c) A significant change due to a gradual, long-term process of change.

Volume two of Ecosystems and Human Wellbeing (Millennium Ecosystem Assessment, 2005: 39), attributes the source of discontinuities to indeterminacy, which is caused by ignorance, surprise, and volition. Ignorance refers to limited knowledge, resulting in a lack of knowledge about systems and causality within these systems.

A change in the causality of the system can therefore lead to unexpected outcomes due to a lack of knowledge. Surprise is defined as uncertainty arising from the inherent indeterminism of complex systems, while volition is defined as uncertainty that arises from human actions embedded in the system that extensively influences the system.

RISK AND UNCERTAINTY ANALYZES IN AGRICULTURAL ECONOMICS

Formal risk and uncertainty analysis techniques have been developed and adopted by agricultural economists in order to study the problems, challenges, and consequences risk and uncertainty creates, or as stated by Hardaker *et al.* (2004:23): "to try to rationalize and assist choice in an uncertain world." These techniques mostly utilize probabilities, whether objective or subjective, to include in the analysis in order to capture and communicate the potential effect and outcome of risk and uncertainty. Examples in the literature where these techniques have been applied include the work of Budd and McCarl (2005: 434), Binfield *et al*. (2002), and Westhoff, Brown and Hart (2005)[1]. These studies do indicate the importance of taking risk or probabilities into account when analyzing decision-making factors – whether it's a policy, production or another type of decision. However, discontinuities in endogenous and exogenous variables included in the modeling framework might cause the probabilities presented (or assumed) in these studies to be either over- or underestimated. Therefore, the main shortcoming with regards to these research results is that uncertainty (by definition, it includes possible discontinuities) is not explicitly accounted for. This point is confirmed in the writing of Binfield *et al.* (p. 7): "*By no means, however, have all possible sources of variability been captured. It would be a mistake to conclude that the extreme values achieved in this analysis represent the absolute extremes that are possible in the future.*"

In this point, therefore, lies the major weakness of these techniques and models: it is based on the hypothesis that *the future is likely to be like the past and present*. Based on the arguments on the definition of uncertainty, it becomes clear that it is not possible and logically does not make sense to assign probabilities in the case of the presence of uncertainty.

Interestingly, Knight (1921: 231) pointed out this exact shortcoming as far back as 1921 when he stated that: *"It is this third type of probability or uncertainty which has been neglected in economic theory, and which we propose to put in its rightful place."* Sadly, it appears that this type of probability situation, namely uncertainty, has not been put in its rightful place by subsequent agricultural economics researchers in the field of risk and uncertainty, as evidenced by the arguments of Just (2001) and Taylor (2002).

As indicated in the opening paragraph of this article, during some stages in time, systems change rapidly and unexpectedly, rendering any analysis based on the assumption that the future will be like the past and present, to be useless. The reason is that due to the occurrence of discontinuities, a system experiences rapid and unexpected change.

This result becomes useless in a new form of causality which implies correlations and probabilities as calculated based on the historical structure of the system. Hence, during such stages in time, current models and techniques in terms of analyzing and communicating risk and uncertainty becomes worthless and the application of it might even result in spurious decision making. This implies that during such times, it is important to have an alternative approach to decision making that works with an alternative hypothesis: *the hypothesis that the future is NOT like the past OR present.*

[1] In both the South African and international agricultural economic literature, many more examples exist where risk and uncertainty techniques have been applied.

INTUITIVE LOGIC SCENARIO THINKING

One technique that offers the ability to work with the hypothesis that the future is NOT like the past or present, is intuitive logic scenario thinking. In agricultural economic literature, the word "scenario" is often used to describe a projection about the future. This however constitutes a misunderstanding and in actual fact abuse of the concept of a scenario. The aim of this section is to introduce intuitive scenario thinking in order to hopefully prevent the misuse and abuse of scenarios in agricultural economics in future, to indicate how scenarios should be structured and set up under the intuitive scenario thinking methodology, what value scenarios offer in terms of working with the hypotheses that the future is not like the past or present, and lastly the fundamental difference between intuitive scenario thinking and stochastic modeling. These arguments will point out why the two techniques can't be combined, but can only be used in conjunction, as proposed by the framework presented in this article.

The use of scenarios originated in military planning in the USA (Bradfield et al., 2005), Segal, (2007). After World War II, facing various *uncertainties*, the US Department of Defence had to make decisions on which weapons development programmes to fund. To make these decisions, they developed various techniques, including scenario thinking. Based on their initial work, Herman Kahn at the RAND Corporation used scenarios to inform decisions in considering a large scale early warning missile system. Afterwards, Kahn started the Hudson Institute, where he continued to use scenarios for social projections as well as to inform public policy. Following the initial work of Kahn, mainly three different approaches to scenario thinking emerged, namely, intuitive logic scenario thinking, probabilistic modified trends approach, and La Prospective thinking. The weakness of the two latter approaches was that it included probabilities in terms of setting up and presenting the scenarios, which in fact constituted analyzing risk instead of uncertainty. As a result, intuitive scenario thinking became the "gold standard" of scenario thinking techniques, and is used today extensively in both business strategy and policy development. The two best known examples of where the intuitive logic scenario thinking approach have been used is the "Mont Fleur" scenarios developed and used for the transition period in South Africa, as well as the "High Road, Low Road" scenarios developed by Anglo American in cooperation with Pierre Wack, and presented by Clem Sunter during the late 1980's in South Africa.

Under the intuitive logic scenario thinking approach, various definitions of a scenario exist. Ilbury and Sunter (2003: 87) describe a scenario as not being a single forecast but rather a plausible story or pathway into an unknown future. Shell (2003) describes a scenario as being a story that portrays a potential future. The story normally consists of a combination of momentous events, players who influence the story through their motivations, as well as an underlying assumption about the functioning of the world within the story. The scenario is not a view based on consensus; neither is it a prediction or forecast. It rather conveys a potential milieu and how it could change. Glen (2006: 2) defines a scenario as follows: "*A scenario is a story with plausible cause and effect links that connect a future condition with the present, while illustrating key decisions, events, and consequences throughout the narrative.*" In Davis-Floyd (1998), Betty Sue Flowers, the editor of the 1992 and 1995 Shell scenarios, describes a scenario as a coherent story that leads you to understand relationships and therefore causation.

Wack (1985a) defines two different types of scenarios, namely, "*first generation*" scenarios and *"second generation*" scenarios, or "*decision scenarios."* He writes that in many instances people think scenarios merely quantify alternative outcomes of obvious uncertainties e.g., different exchange rate projections or different oil price projections hence "more of the same". Wack defines these types of scenarios as "first generation" scenarios and describes them as being simple combinations of obvious uncertainties. He argues that first generation scenarios are needed in the planning process, since they tend to improve the understanding of reality, and therefore lead one to question perceptions and to search for the true underlying forces and interactions that drive a system. However, first generation scenarios do not help much with actual decision-making since they tend to lead the decision-maker to fairly straightforward and often conflicting strategic solutions (Wack, 1985a: 76).Therefore, they do not provide the decision-maker with any sound basis on which to exercise his or her judgement.

The improvement on first generation scenarios offered by Wack, namely decision scenarios, are scenarios that are structured around predetermined and uncertain factors (Wack, 1985b: 140). Wack defines predetermined elements as being events already in the pipeline or that are certain to occur, of which the consequences have yet to unfold. According to him, predetermined elements can be viewed as interdependencies within the system, breaks in trends, or the "impossible". The foundation of decision scenarios lies in exploring and expanding these predetermined elements, along with key uncertainties, and through that process develops an understanding for the impossible and therefore the possible. Wack (1985a: 74) describes the process of scenario development: "*by carefully studying some uncertainties, we gain a deeper understanding of their interplay, which, paradoxically, leads us to learn what was certain and inevitable and what was not."* He describes the process of sorting out which factors or elements are predetermined and which are key uncertainties. The key uncertainties are the factors or events that are plausible but to which *no probability* can be attached. Therefore, the scenario thinking process can be described as a process that entails thinking about the unthinkable. Or, as a process entailing pursuing ends, often unrelated and contradicting, in order to sort possible from the impossible, and controllable from the uncontrollable (Ilbury and Sunter, 2003: 21, 23, 29, 31).

Wack (1985b: 140) describes the purpose of scenarios and the intuitive scenario thinking process as follows*: "Scenarios must help decision makers develop their own feel for the nature of the system, the forces at work within it, the uncertainties that underlie the alternative scenarios, and the concepts useful for interpreting key data."* By sifting and separating the probable and plausible, one develops a better understanding of the unthinkable or the known unknowns and unknown unknowns (Ilbury and Sunter, 2003: 83). Furthermore, scenarios serve the purpose of signaling changes in predetermined factors and key uncertainties, in order to facilitate better understanding of the possible occurrence and the impact of discontinuities (Wack, 1985a: 74). Important to note is that the incorporation of the intuitive logics scenario thinking technique does not involve the mere plugging in of a range of values e.g., inputting different exchange rates into a model, as often happens in agricultural economic literature. Instead, it implies that the possible occurrence of discontinuities, and therefore uncertainty, is also taken into consideration in the decision problem. Scenarios should not simply consist of quantified alternative outcomes because the decision-maker needs to be able to deduce from the scenario why a specific event or chain of events could potentially occur, and based on that, exercise their judgement in making a decision (Davis-

Floyd, 1998). This is neatly stated by Wack (1985b:149) when he touches on Roberta Wohlstetter's reference to the Pearl Harbour attack, in which early warning radio signals did appear but weren't correctly interpreted. He writes: *"To discriminate significant sounds against this background of noise, one has to be listening for something or for one of several things… one needs not only an ear but a variety of hypotheses that guide observation."* Therefore, according to Wack (1985b:146), decision scenarios also serve the purpose of assisting decision-makers in anticipating and understanding risk, as well as discovering entrepreneurial opportunities.

Ilbury and Sunter have published two works (Ilbury and Sunter, 2003 and 2005) describing a scenario development technique. These two publications culminated in their most recent work, published in 2007 (Ilbury and Sunter, 2007). Their tried-and-tested approach is mostly based on Socratic methodology. It essentially entails asking critical questions in order to eliminate hypotheses. This leads to re-thinking previously held beliefs, which eventually leads to a better understanding of reality and how uncertainty impacts decisions and actions. Decision-makers therefore know which decisions and resulting actions are most likely to lead to desired outcomes. The approach they present consists of ten questions, each structured in such a way that it connects to all the other questions and leads to a process of "re-perceiving reality", as coined by Wack (1985b:150). Other approaches to developing scenarios by means of the intuitive logic scenario thinking approach are those by Wack (1985), Van Der Heijden (1996), Scwartz (1991), and Shell (2003).

A Proposed Framework for Addressing Risk and Uncertainty in Agricultural Decision-Making with Respect to Business Strategy and Policy

The problem is that a decision maker never knows when to work with which hypotheses: will the future be LIKE the past and present, or will the future NOT be like the past and present. This implies that for the alternative approach to add value in terms of analyzing risk and uncertainty, the approach needs to include both hypotheses simultaneously. This will offer the decision maker a process whereby both hypotheses are included when formulating policy or business strategy. Such an approach will offer the decision maker the possibility to discard one of the hypotheses at a stage when enough information and events have occurred to be able to know whether the future is like the past and present, or the future is NOT like the past and present.

The framework proposed by this article, in which both hypotheses are captured and tested simultaneously during the decision making process, is presented in Figure 2.

In essence, the proposed framework stipulates that the steps that make up the respective two techniques (intuitive scenario thinking and stochastic modeling) are applied separately but in conjunction. This ensures cross pollination in the sense that ideas are shared between the two techniques and hence learning takes place, and that the two fundamentally different techniques are not adjusted or combined, but rather applied separately and technically in the most correct way. This ensures that the strengths of both techniques are kept as part of the decision process, namely, that both risk and uncertainty are analyzed and included in a technically correct manner.

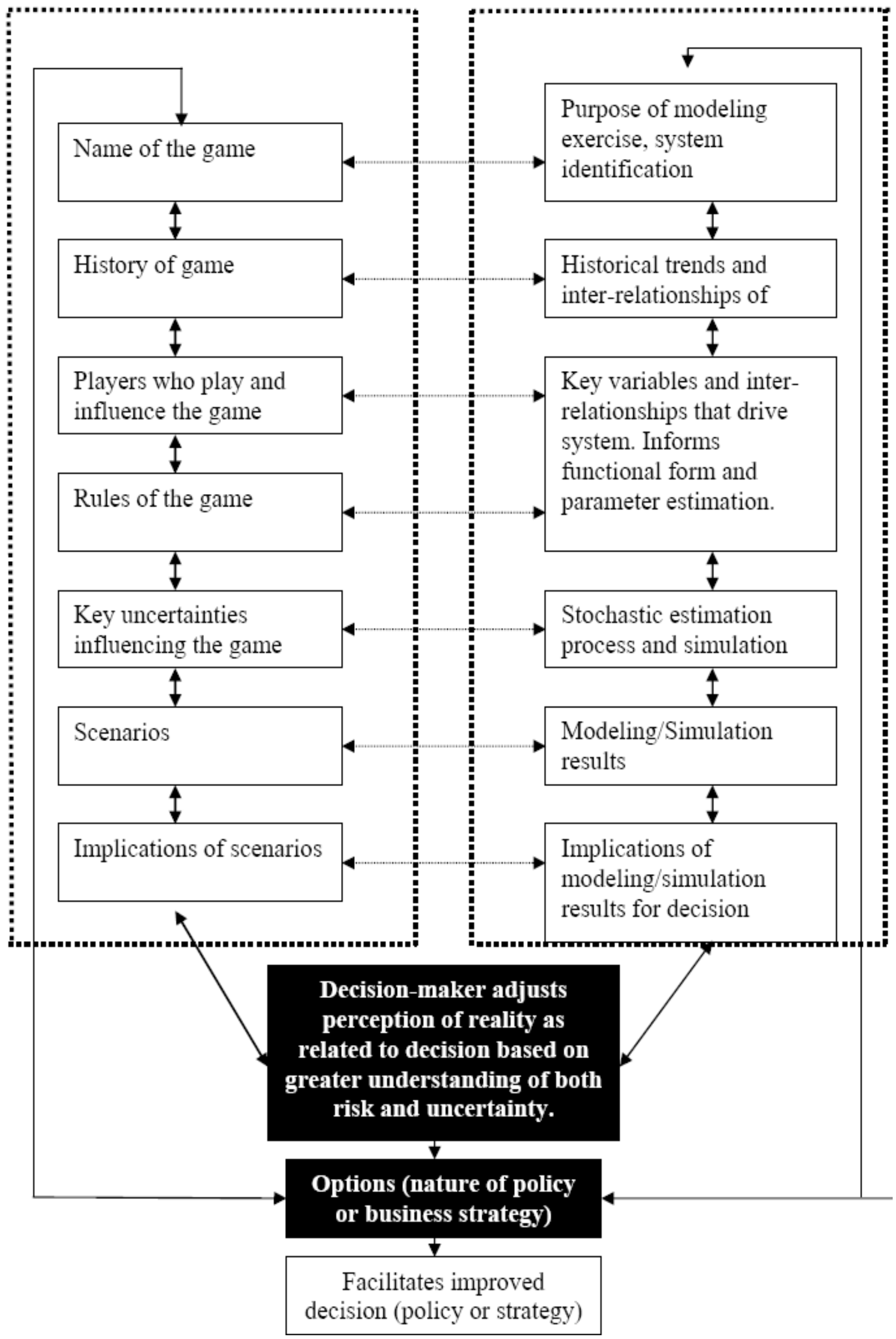

Figure 2. Proposed framework for addressing risk and uncertainty.

This also implies that the weaknesses of one technique are covered by the strength of the opposite technique. The result of this is that the implications of both the occurrence of risky events and unexpected events will be contemplated, and hence will lead to more robust decisions that are more likely to lead to favourable results in terms of either the policy or business strategy.

The framework thus stipulates that nine different steps are followed in setting up a set of scenarios and applying it, namely: contemplating the name of the game as well as the history of the game; identifying players who play and influence the game; figuring out the rules of the game; identifying key uncertainties that influence the game; setting up the scenarios; deducing implications of scenarios; generating options in terms of either policy or business strategy, and making a decision with respect to which policy or business strategy to implement. Concurrently, while setting up the scenarios, one sets up and applies a stochastic econometric model. This entails the following steps: describing the purpose of the modeling exercise and thereby identifying the system that will be modeled; identifying historical trends and inter-relationships that influence and drive the system; analysing and quantifying key variables and inter-relationships that will drive systems in future; based on the analysis, setting up the mathematical[2] functional forms to use in the model structure; setting up the stochastic simulation process to be followed; running the model; analyzing the modeling results and deducing implications from the results; generating options based on implications in terms of policy or business strategy, and lastly, making a decision with respect to which policy or business strategy to implement.

ARGUMENTS UNDERLYING THE PROPOSED FRAMEWORK

The first argument on why this proposed framework should lead to an improvement in terms of risk and uncertainty analysis in agricultural economics, is based on the following point: in following the two steps of identifying “key uncertainties” during the scenario setup process as well as “setting up stochastic process” as part of the model, a clear distinction takes place within the framework. On the one hand, uncertainty is contemplated and analyzed (scenario thinking), and on the other, risk (stochastic modeling). By simultaneously following two fundamentally different steps, the decision-maker develops a clearer picture on what is probable (i.e., risk) and what is possible and plausible but not necessarily probable (i.e., uncertainty.) The value that is added in terms of the decision making process when following these two steps in conjunction is therefore not a convergence of thinking in terms of structuring the scenarios and setting up the model. Rather it is one of divergent thinking, resulting in multi-hypotheses that take into account both risk and uncertainty simultaneously in a technically sound manner. The divergence in thinking is the crux of using this proposed framework, since it provides a decision-making process that facilitates simultaneous and technically correct thinking on the issues of both risk and uncertainty. It therefore offers a solution to mitigating the weaknesses of the two individual techniques by applying the strengths of each technique simultaneously. By mitigating the weaknesses, the robustness of the decision-making process is improved, and hence the diminished possibility of making a decision that will not be robust enough to withstand the onslaught of either a risky or

[2] With “mathematical,” both econometric functional forms and mathematical functional forms (in the sense of mathematical economics) are included. The reason for this is that both are essentially mathematical equations that are set up by different techniques, namely, empirical estimation through econometric techniques or mathematical techniques.

unexpected event. The conjunctive application of these two steps therefore forces the decision-maker into thinking about events that might be both expected and unexpected, and hence leads the decision-maker to develop options that can deal with both situations.

Apart from the opportunity that it offers the decision maker to simultaneously work with two hypotheses during the decision making process, the other major uniqueness and contribution of this proposed framework toward risk and uncertainty analysis in agricultural economics are as follows: since the two techniques are fundamentally different both in terms of logic and the underlying cognitive developmental process followed by each, the only way to link the two techniques is by using the two different cognitive developmental processes of each technique in a synergetic way in order to assist the decision maker in understanding reality both in terms of risk and uncertainty. Scenario thinking essentially follows an internal organic cognitive developmental process (Wack, 1985b: 140) while modeling essentially follows a cognitive developmental process through "formal instruction" (modeling techniques, statistics, economic theory) as stipulated by Vygotsky (Nelson, 1996: 227). Hence, the synergetic platform provided by the two different cognitive developmental processes provides the opportunity to link the two fundamentally different techniques in an informal way without combining the two techniques. Due to this argument, it implies the two techniques can't be combined since they both are fundamentally different in terms of logic, mechanics, and results, but can be used in conjunction. In this implication, the other major contribution of this article is found. This article argues and proposes a framework that shows that the two techniques can't be combined, but can be used simultaneously in a synergetic way based on the synergies that exist between the different cognitive developmental processes underlying the two techniques.

ILLUSTRATING THE APPLICATION OF THE PROPOSED FRAMEWORK

In order to illustrate the usage of the proposed framework in agricultural commodity markets to analyze risk and uncertainty, a case study is presented in this section whereby a financial institution in South Africa applied the framework in order to make decisions with respect to its agricultural financing strategy for maize production with a view toward the 2008/09 production season.

Two meetings were held with the institution, the first on the 6th of February 2008, and the second during April 2008. Present at these sessions were the risk manager, the head of the department, and a market analyst. The purpose of the first meeting was firstly to determine the initial expectations of the participants with respect to maize prices for the 2008/09 season. Afterwards the framework as presented in this article was applied, and the results were presented to the institution in the form of a report. The purpose of the second meeting, held in April, was to revisit the results presented in the previous report, and make adjustments to the results as was deemed necessary by its decision makers. The results from the second meeting were again presented in the form of a report at the end of April 2008. The strategy for agricultural lending by the institution for the 2008/09 season was based on the second report as well as the lessons that were learnt through applying the proposed framework.

During the first meeting, it was clear that the decision makers expected the same market conditions to prevail as in the beginning of 2008. Hence, in line with many general market expectations and reports, they expected oil prices to increase to levels of close to $200/barrel. Based on this expectation and based on the link between energy prices and agricultural commodities that was quite strong at that time, they expected agricultural commodity prices to remain firm and even increase further due to expected increases in the price of crude oil. However, through the application of the proposed framework during the two sessions, a number of factors were identified which could potentially result in a market outcome significantly and unexpectedly different compared to their initial expectations as well as that of the general market.

First of all, the name of the game, as well as the history of the game, was discussed. From this discussion it became clear what the goals of the institution were to minimize the risk of loan defaults while maintaining its market share. Hence, it was important for the institution to finance maize production, but at the same time mitigate the risk of loan defaults. This would be done by following the correct strategy in terms of identifying and analyzing potential clients and also structuring clients' debt correctly by means of using different combinations of finance products. Structuring debt correctly would mean the risk of loan defaults would be minimized since positive cash flow would be improved.

The discussion of the history of the game mainly focused on the maize industry, and historical trends and interrelationships with respect to the maize industry. The reason for only discussing the history of maize was because the institution was reluctant to discuss in detail its exposure to the maize industry in terms of the amount of finance provided as well as its past approach toward financing maize production, since that would have meant disclosing confidential information. From the discussion, it became clear how important the macro-economic situation became in terms of its influence on maize prices, due to the stronger link between fossil fuels and maize as a result of biofuel production.

Moving to the next step, the players influencing the game were discussed in detail. Players that were identified that could significantly influence the macro-economy and therefore the maize industry were global investors, the presidential race in the US (Obama potentially becoming president), the reaction and measures taken by the Federal Reserve Bank of the US should economic conditions turn bad, OPEC and its reaction towards an economic crisis, the ability of Eskom (Main electricity supplier in South Africa) to correct power problems within South Africa and thereby influence investor perceptions positively, and lastly the outcome of the power struggle between the ANC and the government and how that would influence investor perceptions.

Following the discussion on players of the game, the rules of the game were debated. Two key rules were identified that would to a large extent determine the "playing field" on which the game would be played. The first was the rule that investors in general are risk averse. Therefore, should economic problems arise these investors would flee to safe havens in whatever form these safe havens might present itself. It might be commodities, a specific geographic market, or an investment instrument. However it was important that this rule would influence exchange rates, trade patterns, commodity prices and general macro-economic variables such as inflation and interest rates. The second rule was that the US was still the dominant economic power in the world, and therefore if the US would experience severe economic problems, it would mean global economic problems. Some uncertainty however existed in terms of the impact of US economic problems on China, India and the EU. Most market commentators at that stage argued and predicted that these three economic powers would have enough internal economic momentum to sustain economic growth paths regardless of what happened in the US.

Based on the discussions on the history of the game, players of the game, and rules of the game, the key uncertainties were identified and discussed in detail. These were the following factors and players: the US economy going into a recession, and the impact of this event on China, India and the EU.

Following the discussions, each of the factors were divided and presented to the institution in the second report[3] as follows:

Rules of the game:

- *Investors are generally risk averse:* the implication of this driver is that investors will seek havens where the level of risk is in line with the level of potential profit. Hence, in a situation where the world economy is unstable, investors will in general opt for the less risky and stable investment environment.
- *In general, the US economy has a significant impact on the rest of the world's economy:* the implication is that if the US sneezes, the rest of the world gets a cold. Except maybe for China and India?

Key uncertainties:

- *Will the US economy go into a recession?* At this stage nobody is sure of the answer to this question. Some give it a 50% probability, others say it's a given.
- *Should a US recession occur, what will be the macroeconomic impacts specifically on the EU, China and India?* In case the EU, China and India have enough internal momentum to keep their economies growing independently of a US recession, investors will see these economies as a haven. This implies international funds could flow towards these three economies, depending on general risk of the investment environment and the interest rate differentials, leaving the rest of the world economies high and dry. If the EU, China, and India do not have enough internal momentum, implying that a US recession also leads their economies into a recession, investors have very few safe havens left and low risk investments will become an attractive option e.g. gold, money market etc.

Wild Cards and players of the game:

- *If Obama becomes president of the US,* will it have a significant impact on the morale of US citizens leading to optimism and hence influencing investment in the US positively? Also, what will be the impact on the "war against terror" and hence how will it influence key diplomatic relationships e.g., the Middle East, Europe and China. Also, if the stance against the "war on terror" changes significantly, it could

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[3] This part of the article is quoted directly from the report submitted to the institution, to indicate the exact wording and format in which the results of applying the framework were presented to the institution. The report containing this information was presented to the decision makers at the end of April 2008.

have a significant impact on Chinese economic growth since Chinese policies are geared towards an open, free and stable world economy.

- It is unknown if the *drastic monetary policy measures taken recently by the Fed* will swing the US back unto a growth path, and if so, how soon. Hence, will the US economy first go into a shallow recession, or will it stabilize at a very low growth level and then take off again?
- If a US recession does occur, what will be the *reaction of OPEC* in terms of changing production policies? If they increase production or keep it stable to lower oil prices and, therefore, decrease energy costs to jump-start the world economy, the recession might be shorter and shallower than expected. If oil prices remain high and stable, the recession might last long as many fear. This could have a significant negative impact on Chinese economic growth.
- *Will Jacob Zuma become the next president of South Africa?* If he does, will he continue on the current policy paths, or will he drastically change policies in order to create a more social-democratic state driven by more socialist types of policies?

From these factors, a set of three alternative scenarios were written and presented to the institution's decision makers along with the potential implications of each scenario in terms of energy prices and therefore agricultural commodity prices. The potential implications were generated with the help of the BFAP sector model. At that time, the scenarios and implications were presented to the financial institution as follows:

Implications of Scenarios

Scenario 1:

- Rand weakens significantly against the US dollar and the Euro.
- SA inflation generally high due to high world inflation, but follows a declining trend as world economy weakens and global inflation pressure weakens.
- Interest rate, therefore, remains high but also follows a sharper declining trend than expected due to SARB being careful of adjusting interest rates because of frail economy.
- Oil price at first decreases significantly and then moves mostly sideways on the back of slowing demand, and unwillingness from OPEC to adjust production and production capacity.

Scenario 2:

- Oil price remains high since economies in emerging countries continue to grow. US economic problems have less of an impact on these countries' economies.
- Rand weakens against other currencies including the US dollar, because risk averse investors would rather invest in more stable and growing economies.
- Inflation remains high because of stable and high oil price, high international agricultural commodity prices, a depreciating Rand, as well as the inflationary

whiplash of services inflation. Food inflation is a strong driver in this scenario, but the impact does however lessen over time since emerging economies keep growing and hence consumers can afford and get used to higher prices.

- Interest rate, therefore, remains stable but high. SARB does not increase interest rates in fear of seriously damaging already frail economy.

Scenario 3:

- Dollar strengthens against all currencies due to new optimism amongst investors. This causes the Rand to weaken significantly, especially due to political uncertainties in Southern Africa leading to investors becoming risk averse towards SADC investments.
- Oil price increase significantly due to renewed global economic growth. Is $200/barrel of oil possible in this scenario as forecasted by an international institution during the week of 4 May 2008?
- Rand weakness and increasing oil prices lead to significant inflationary pressure in SA.
- Interest rate remains high."

Based on the scenario results, the BFAP sector model (Meyer et. al, 2006) was used to quantify scenario 1 in the report (without including probabilities to ensure that uncertainty is incorporated in a technically correct manner), since the decision makers thought this scenario to be the most critical in terms of developing a robust financing strategy. It is important to note that the global price projections presented by the FAPRI 2009 baseline were applied in the simulation of the results. The following modeling results were presented to the decision makers[4] (although the BFAP sector model covers 36 commodities, for the purpose of this study only the modeling results for white and yellow maize are presented below):

> "The scenario presented below indicates a global economy, which is severely affected by a recession in the US economy as well as overheating due to excessive high fuel and food prices. The assumption is, therefore, that the BRIC countries (Brazil, Russia, India, and China) do not have enough internal momentum to keep their economies growing at rates seen during the past few years, and also that inflationary pressure (due to excessive fuel and food prices) forces the economic growth in these countries to slow down in order to avoid excessive overheating. The macroeconomic assumptions underlying this scenario are presented in Table 2.

Due to a change in the interest rate differential between the EU and the US, the Dollar strengthens, which forces oil prices down. On the back of this, the pressure on the demand for oil slightly weakens since trade and consumption of general goods and commodities slow down. The result is that oil prices drop unexpectedly to levels of around $80 per barrel[5].

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[4] Again this part of the article is quoted directly from the report submitted to the institution, to indicate the exact wording and format in which the results of applying the framework were presented to the institution. The report containing this information was presented to the decision makers at the end of April 2008.

[5] It is important to keep in mind that this was written at a time when market forecasts of reputable institutions indicated a crude oil price of around $150 to $200 by the end of 2008. As a result $80/barrel was seen as a totally unlikely idea! Who would have thought an oil price of $44/barrel on 5/12/2008 was possible?

The impact on the South African economy is a slowdown in economic growth, and a slowdown in inflation, which forces the Reserve bank to decrease interest rates more than expected in an attempt to get the economy back on the targeted growth path. This, however, does not happen and economic growth is generally below the 4% level except in 2010."

As previously mentioned, the outlook of world prices used in the scenario analyzes was derived from FAPRI's Baseline 2008. The projections of the most relevant grain prices for the South African agricultural industry are presented in table 3.

These prices were directly applied in the BFAP sector model and thus established the link between the FAPRI world market outlook and the BFAP sector model. The deterministic outlook of white and yellow maize SAFEX prices under scenario 1 is illustrated in table 4.

"The main trends in the scenario projections can be summarized as follows:

- Due to the general slow down in the economy, world commodity prices decrease rapidly in 2009 and 2010. This does, however, not imply that prices pull back to historical levels. Commodity prices still remain relatively high.
- Commodity prices in the local market are expected to decrease in 2009 and 2010 well below R2000/ton. As a result, farmers will respond to the lower commodity prices by reducing the area planted to field crops, especially on the back of high input costs, which are in general sticky and therefore do not decrease at the same rate as commodity prices. This causes pressure on profit margins and also increases the risk of production significantly. The decrease in area (and supply), causes prices to rise again by 2011."

Table 2. Scenario Projections: Economic Indicators

		2009	2010	2011
Crude Oil Persian Gulf: fob	$/barrel	80.00	79.47	78.39
Exchange Rate	SA c/US$	900.00	945.00	992.25
Interest Rate (Prime)	%	14.00	12.00	10.00

Source: BFAP, 2008.

Table 3. Scenario Projections - World Commodity Prices

		2009	2010	2011
Yellow maize, US No.2, fob, Gulf	US$/t	190.25	160.90	156.51
Wheat US No2 HRW fob (ord) Gulf	US$/t	203.38	172.00	167.30
Sorghum, US No.2, fob, Gulf	US$/t	171.42	149.43	144.82

Source: FAPRI, 2008.

Table 4. Scenario Projections - SA Commodity Price Projections

		2009	2010	2011
White maize (SAFEX)	R/ton	1870.0	1746.8	1877.8
Yellow maize (SAFEX)	R/ton	1885.4	1644.3	1709.7

Source: BFAP Sector Model.

Following the scenario thinking process, the various steps in terms of executing the stochastic modeling process were followed as stipulated by the framework presented in Section 5. During each of these steps, the information and insights gained from the opposing step in the scenario thinking process were used to guide the process on how to set up the model and simulate the maize prices. Concurrently, by going through the modeling steps in terms of quantifying the trends and interrelationships, some objective and quantitative information was added to the thinking process which in turn assisted the institution's decision makers to form more objective perceptions on some of the variables and players thought to influence the market situation.

Interestingly, from the stochastic modeling process probability distributions were generated which indicated that maize prices (both white and yellow) were likely to stay above R2000/ton for the 2008/09 season (Table 2). This concurred to the initial expectations of the bank's decision makers but did not correspond to the deterministic results presented in table 4. By following scenario thinking and stochastic modeling in conjunction, and by comparing the scenario results with the stochastic modeling results it was possible for the institution's decision makers to understand that a situation whereby the global economy could almost implode was quite possible although highly improbable. From the scenario results it was also gathered that should the economy implode, an unexpected decrease in agricultural commodity prices was quite possible and plausible with maize prices dropping below R2000/ton. At the point of developing these scenarios, the possibility for scenario 1 to play out was deemed "unthinkable" since all opinions, views, forecasts, and technical reports pointed to a situation where the market would and "could" only increase from the levels of April 2008. Hence, a meltdown was highly unlikely.

The application of the proposed framework however clearly pointed to such an "unlikely" possibility, and in fact captured most of the dynamics that eventually caused the meltdown quite accurately. Hence, as a result of presenting the scenario results, the decision makers realized that such an unlikely and unthinkable event was quite possible and plausible. This resulted in them starting to question their initial assumptions and therefore expectations, and hence forced them to change their perceptions as to the potential outcome of the market. As a result, the institution's decision makers were in a position to realize that such an event was possible and plausible, and hence re-perceived reality in terms of the actual risks and uncertainties that were faced at the stage of taking a decision. Consequently, the institution decided to adjust their credit provision and management strategy which ultimately enabled them to withstand the onslaught of the eventual risks and unexpected events that led to the current market turmoil. This means they adjusted their approach towards analyzing and financing clients, specifically with respect to the criteria used to analyze a business as well as the type of product used to finance the business[6].

Based on the adjusted credit provision and management strategy, the financial institution thus far appears to be riding out the storm quite successfully. Through making these decisions, based on the results of applying the framework proposed by this paper, the financial institution has been able to limit debt-write-offs as a result of the current financial and economic conditions.

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[6] Due to the confidential nature of credit provision policy and credit provision strategies, no details can be supplied in terms of the exact nature of the changes that occurred with respect to credit provision and management since this might convey, knowingly or unknowingly, sensitive information to competitors in the market.

Table 5. Simulated Maize Price Probability Distributions

Variable	Stochastic model simulation results					
	Unit	Mean	Min	Max	Std Dev	CV
White maize price 2008/09	R/ton	2042	1472	3617	300	14.7
Yellow maize price 2008/09	R/ton	2076	1416	3665	336	16.21

Source: BFAP Sector Model.

Taking the current environment into consideration it shows that the decisions that were made in April 2008 were better than could have been expected using only the econometric methodology. Hence, the institution was able to learn and accurately perceive the true nature of the risks and uncertainties it faced at the beginning of 2008.

Should the financing institution only have used stochastic modeling as is currently used in agricultural economic literature, only the probability distribution results as presented in table 5 would have been available to guide decision making. This would likely have misled the decision makers in expecting higher market prices, resulting in the design of a financing strategy that would likely have been less robust in terms of withstanding the onslaught of the current market conditions.

SUMMARY AND CONCLUSION

This article argues that significant shortcomings currently exist with respect to the analysis of uncertainty within agricultural economics given the possibility that uncertainty is only to increase within the sector in future. The weakness stems from the fact that probabilities (objective or subjective) are used in the analysis of both risk and uncertainty. From the literature on, and theory and definition of uncertainty, it can be argued that probabilities can't be used to analyze and communicate uncertainty, since logically it does not make sense to assign probabilities when uncertainty is present.

Based on this argument, a framework is proposed whereby intuitive logic scenario thinking is applied in conjunction with stochastic econometric modeling in order to mitigate this weakness. Intuitive logic scenario thinking is a technique that was specifically developed in order to analyze and understand the impact of uncertainty.

A case study is presented whereby the proposed framework is applied to show the success of applying the framework given the current turmoil experienced in the general economy as well as in agricultural commodity markets. By means of the case study results and arguments, it is shown that the application of the proposed framework should lead to improved decisions with respect to policy and business strategy in the agricultural sector should risk and uncertainty increase in future.

Additional research that needs to be conducted on the basis of the framework that is proposed in this article is the detailed learning process that takes place when applying this framework in the mind of the decision makers who uses the framework. Furthermore, research needs to be conducted in terms of incorporating game theory and new institutional economics into this framework, since the steps within the framework create the potential to incorporate these fields. This will create a much needed link between the respective fields.

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AGRICULTURAL POLICY CHANGE IN THE EU: ANALYZING THE IMPACT AT MEMBER STATE AND AGGREGATE EU LEVELS

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ABSTRACT

EU policy makers understand that the impact at the Member State level of a proposed change in the Common Agricultural Policy (CAP) can determine its political feasibility. The AGMEMOD Partnership has developed a model to analyze the impact of EU agricultural policy changes at a Member State level of detail. The modeling tool captures the heterogeneity of agricultural systems across the EU Member States, while still maintaining analytical consistency. We use this AGMEMOD 2020 model to simulate a reform of the CAP and then examine the impacts of the policy change for aggregate EU and Member State agricultural commodity markets.

JEL Codes: Q11, Q18.

Keywords: Policy modeling, partial equilibrium model, EU, agricultural policy, CAP reform.

In this article the EU agricultural policy analysis model known as AGMEMOD is described and an application of the model for policy analysis is presented.[1] AGMEMOD was initiated by the economists working within the FAPRI-Ireland Partnership, an initiative between FAPRI at the University of Missouri and Teagasc (Ireland's agricultural research institute) which developed a partial equilibrium agricultural sector model for Ireland in the latter half of the 1990s (see Binfield et al. 2008). In 2001 funding under the European Union's 5th Framework Research Programme supported the creation of a Partnership of 13 institutes from across the EU, with the objective of building a dynamic, partial equilibrium, multi-product econometric-based modeling system for the EU, based on the combination of

[1] AGMEMOD stands for "Agri-food projection for the EU Member States." AGMEMOD has been funded under the EU's 5th and 6th Framework Programmes (FP5 and FP6), by contributions from partners' institutes throughout the EU and through associated projects funded by the Institute for Prospective Technological Studies (IPTS), Seville, part of the European Commission's Joint Research Centre (JRC).

component agricultural sector models for each of the Member States of the EU. Subsequently, in 2003 additional EU research funding allowed the Partnership to expand to include partner institutes from eight of the then accession states from Central and Eastern Europe, so that the enlargement of the EU in 2004 and 2007 could be reflected in the model. In the most recent 6th Framework research project the creation of an affiliate structure within the AGMEMOD Partnership has supported the participation of institutes from EU candidate countries in the Western Balkans region (Croatia and the Former Yugoslav Republic of Macedonia) and from several former Soviet republics and Turkey.

The structure of this article is as follows: the next section provides some background to EU agriculture and EU agricultural policy. The section that follows outlines the structure of the AGMEMOD model. A subsequent section demonstrates an application of the model and the final section provides concluding remarks.

EU Agriculture and EU Agricultural Policy

Following its enlargement on the accession of countries from Central and Eastern Europe and the Mediterranean in 2004 and 2007 (EU10+2), the European Union (EU) now comprises a political entity of 27 Member States. EU enlargement heightened the already significant heterogeneity that exists in terms of the commodity focus, structure, scale and technological development of the EU Member States' agricultural economies. The recent reforms of the EU's Common Agricultural Policy (CAP) have also introduced heterogeneity in the implementation of the CAP across the EU Member States.

The CAP is one of the most important of the EU's *common* policies and over the period 2007 to 2013 will account for close to 40 percent of total EU spending (Gros, 2008). The CAP has undergone periodic reform since its inception in 1957. Over the last two decades the CAP has been reformed on no less than 5 occasions and over that period has become steadily more market orientated.

The MacSharry CAP reforms, agreed in 1992, heralded the beginning of a reduction in the price support provided to some commodities, cereals and beef predominantly, from 1994 onwards (Swinbank and Tanner 1996). Under the reforms, the expected loss in income from the market place, as a result of the lowering of guaranteed support prices, was compensated by an increase in the level of direct income support to producers. The motivation for this reform was largely internal political pressures to control budgetary spending on agriculture and partly the desire to conclude the Uruguay Round of the GATT.

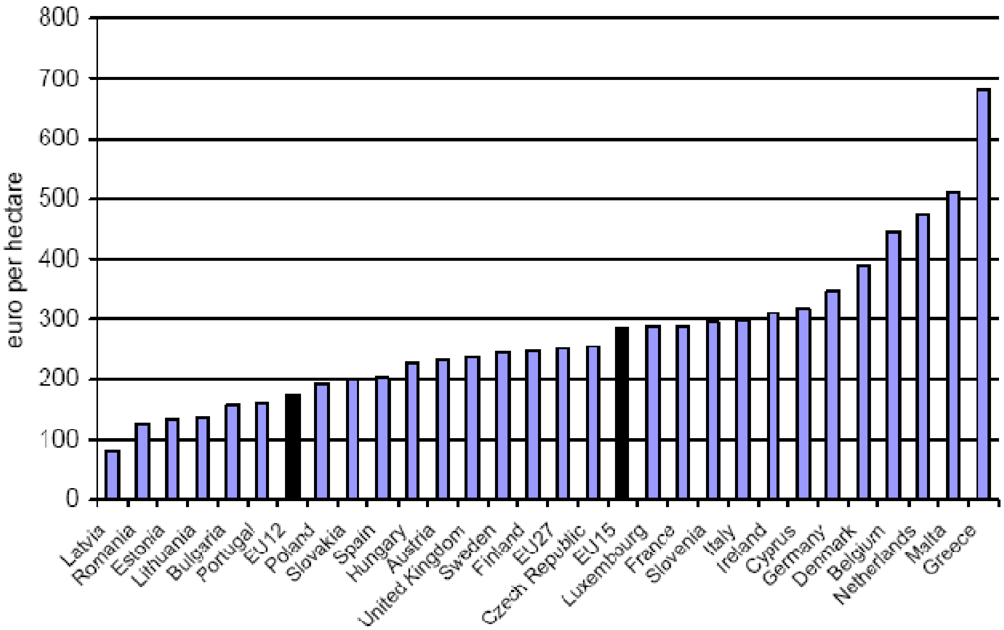
The reform process was extended in the Agenda 2000 CAP reforms agreed in 1999. Cereal and beef support prices were further reduced at that time and a commitment was made to reduce dairy price support by the middle of the following decade, to be compensated through the provision of further direct income support. These reforms were motivated by the desire to control the budgetary cost of the anticipated accession of the countries of Central and Eastern Europe (the so called new Member States) following the collapse of the Soviet Union.

A Mid Term Review of the CAP, known as the Fischler Reforms, was agreed in 2003 and resulted in further changes to the CAP. The main focus of this reform was the introduction of decoupled support payments, breaking the link between the provision of support and the requirement to produce output. Increased spending on rural development policy was also agreed. The main motivations of the Fischler reforms were to increase the market focus of EU agriculture, to better align the CAP for future World Trade Organization (WTO) negotiations, specifically to reduce the extent to which the CAP could be viewed as trade distorting and to accommodate the cost of EU expansion within the EU agriculture budget.

Most recently in 2008, agreement was reached on what was termed the CAP Health Check. Under this reform it was agreed that EU milk quotas (supply controls) would be abolished in 2015, and that there would be successive increases in the EU milk quota in advance of its abolition. In the reform, spending on rural development policy was increased on the basis of a higher rate of modulation of the direct income support payments EU farmers receive. The "modulation" of decoupled direct income payments is the deduction of a percentage of the payment entitlement of the farmer, where payments are over a set threshold. Modulation was introduced in the Fischler CAP reforms of 2003. The funds raised through modulation are used to support rural development and other agricultural policy objectives. Thus the reform in a limited fashion reduced the direct income support provided to European farming. Overall, the key motivation of the CAP Health Check was to increase the market focus of the dairy sector in the EU and to further reduce the cost of agricultural support within the overall EU budget.

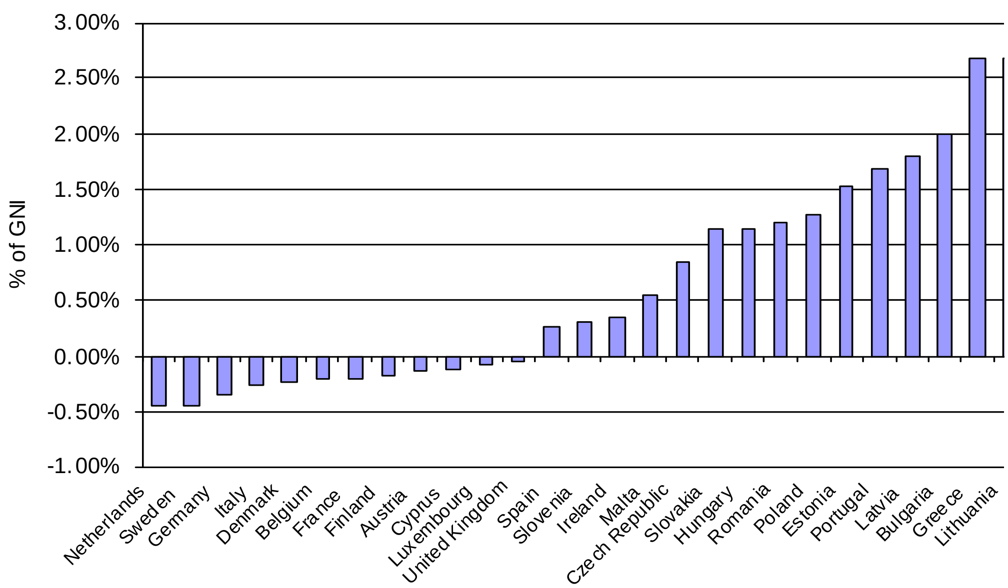
The CAP as currently structured is largely based on protection of the EU market through the imposition of import tariffs and the payment of direct income supports to farmers. While the market price support and direct income support elements of the CAP are financed from a common budget, recent reforms and the expansion of the EU in 2004 and 2007 introduced considerable heterogeneity to the *common* agricultural policy. In the so-called old Member States (EU members prior to 2004), direct income supports are now mostly paid in the form of decoupled direct payments. Among EU15 Member States, a number of different models for determining the level of direct income per hectare are used. These range from models where the coupled payments received by a given farmer in the years 2000-2002 are paid to that farmer (the so-called historical model), to systems where the sum of all payments received in a Member State (or region of a member state) are divided evenly across all hectares of agricultural land (the so-called flat area payment model). Most direct income support payments are decoupled from production; but following the 2008 CAP Health Check, coupled direct payments may still be paid to farmers of beef cows (suckler cow premium) and sheep (ewe premium) in some EU Member States.

In most of the Member States that joined the EU in 2004 and 2007, a flat area payment scheme called the Simplified Area Payment scheme (SAPS) operates. Under the terms of the accession of these countries to the EU, it was agreed that the CAP would be phased in over the period to 2013. Over the CAP phasing in period, EU12 Member States have the freedom to top up the EU budget funded direct income support payments from their national exchequer via complementary national direct payments (CNDP). Despite this, the level of budgetary support (both national and EU) to farm incomes in the newer EU12 Member States, is generally lower per hectare than in the older EU15 Member States. Figure 1 illustrates the large differences in direct income support payments across EU Member States, with support per hectare ranging from €79 per hectare in Latvia, to €681 per hectare in Greece. The large disparities in the direct income support per hectare across the EU are reflected in large differences in aggregate national CAP receipts across EU Member States. These disparities have been a source of considerable controversy in the EU (Begg, 2005).



Source: Commission of the European Communities (2009).

Figure 1. Average direct income support payment per EU Member State (€/hectare).



Source: Commission of the European Communities (2009).

Figure 2. Net operating budgetary balances by EU member state, % GNI, 2008.

Richter (2008) has commented on the “juste retour” attitude, where each EU Member State’s attitude during the policy reform negotiations is to secure the best possible net financial position vis-à-vis the EU budget. Under this approach, the impacts of policy reforms in agriculture are assessed by negotiators, not only on the basis of their impact on agricultural production and agricultural incomes, but also on their impact on the budgetary position of each Member State. Within the EU budget there are distinct groups of Member States that are net payers and net beneficiaries, the pattern of “winners” and “losers” is affected importantly by the CAP and the political success of policy reform proposals is affected by their impact on Member State net balances. Figure 2 presents the net operating balances of the EU Member States as a percentage of Gross National Income. Agricultural policy reforms that dramatically alter the pattern of budgetary flows between Member States are unlikely to succeed given the strong status quo bias of the EU budgetary process (Gros, 2008). The EU Budget Review and the parallel negotiations on the shape of the CAP post 2013 provide an opportunity, perhaps, to remove the link between European agricultural policy and EU budgetary controversies (Bureau and Mahé, 2008)

Given the heterogeneity of agricultural structures across the Member States of the EU, as well as the increased diversity in agricultural policy as implemented in the different Member States, modeling agricultural policy at the EU27 aggregate level does not capture some important country by country differences. These differences are of intrinsic interests to policy makers in the different Member States of the EU and, given the political process through which EU agricultural policy is formed, where Member States still have the primary role in deciding on any changes, these differences are also of interest to policy makers in the EU’s institutions based in Brussels.

AGMEMOD MODEL

The AGMEMOD model is a partial equilibrium model of the agricultural commodity markets of the EU and its constituent Member States that has been developed by the AGMEMOD Partnership with the support of funding from the 5th and 6th EU Framework Programmes. The model is very much in the FAPRI mould in that it is a dynamic, partial equilibrium, multi-product econometric based modeling system that produces 10 year projections of agricultural activity levels (livestock numbers, areas harvested, and yields), agricultural commodity supply and use balance sheets and agricultural commodity prices. The models incorporate a detailed representation of EU agricultural policy instruments that reflects both elements of the CAP that are commonly implemented across all EU Member States and those elements of the CAP where differences in implementation on a Member State by Member State basis are permitted. As with the FAPRI modeling system, projections to a ten year horizon are generated using the AGMEMOD model assuming that current agricultural and trade policy remains unchanged. These Baseline projections are then compared with projections generated using the same model using different exogenous policy data. The impact of the policy change is deduced from the difference in the agricultural activity, supply and use and price projections generated under the alternative policy scenario relative to the Baseline.

The AGMEMOD model was originally conceived as a modeling system that would be based on the structure of the EU GOLD model that was developed by Westhoff. While still close to the spirit of the FAPRI model, the AGMEMOD model now comprises a set of models of agricultural markets in 25 of the 27 EU Member States, as well as models for most of the current EU accession states (see table 1) but also has characteristics which distinguish it from FAPRI type models. The AGMEMOD model is programmed in GAMS (Rosenthal, 2008) and uses a set of model development and analysis tools developed by partners in the project. The development of a country model for Turkey is taking place in 2010 and will be part of the next version of the AGMEMOD model. The set of commodities modeled within the EU AGMEMOD model includes the temperate grain, oilseed, livestock and dairy commodities as well as agricultural commodities that are of importance in Southern Europe. Each country model includes the core set of sub-models for temperate agricultural commodities. Where other commodities such as the Mediterranean crops are important in a given country's agricultural output these are also incorporated in that country model (see table 2).

Table 1. Countries modeled in AGMEMOD

	Countries
EU 15	Austria (AT), Belgium (BE), Denmark (DK), Finland (FI), France (FR), Germany (DE), Greece (EL), Ireland (IE), Italy (IT), Luxembourg (LU), Netherlands (NL), Portugal (PT), Spain (ES), Sweden (SE) and United Kingdom (UK).
EU10+2	Czech Republic (CZ), Estonia (EE), Hungary (HU), Latvia (LV), Lithuania (LH), Poland (PL), Slovak Republic (SK), Slovenia (SI), Bulgaria (BG) and Romania (RO)
Accession States	Croatia (HR), Former Yugoslav Republic of Macedonia (FYROM)
Other countries	Russia (RU), Ukraine (UA)

Note: Luxembourg is combined with Belgium for modeling purposes.

Table 2. Commodities in the AGMEMOD model

	Commodities Modeled
Covered in all country models Grains, oilseeds, livestock and dairy plus root crops and eggs.	Soft wheat, durum wheat, barley, maize, rapeseed, rapeseed oil and meal, soya beans, soya meal and oil, sunflower seed, sunflower seed meal and oil, cattle and beef, pigs and pork, sheep and sheep meat, poultry and poultry meat, milk, cheese, butter, skim milk powder, whole milk powder, casein, cream, other fresh dairy products, potatoes, sugar beet and refined sugar, eggs, bio-ethanol and bio-diesel.
Covered in some country models Fruits, Mediterranean commodities, other grains	Apples, oranges, other tree crops, olives and olive oil, tobacco, cotton, tomatoes and tomato paste, wine, rye, rice, and oats.

Figure 3 is a schematic representation of the AGMEMOD model involving *n* commodities in *m* countries.

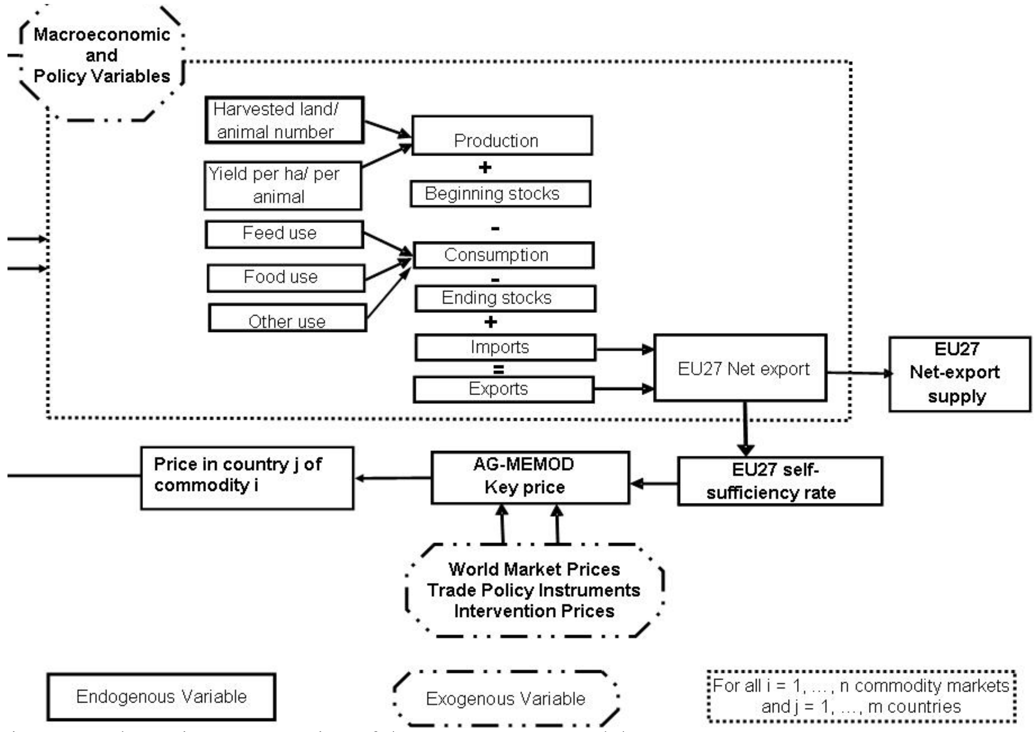


Figure 3. Schematic representation of the AGMEMOD Model.

In a given AGMEMOD country level commodity sub-model, the supply and demand balance is ensured by the designation of one element of the supply and use identity as a closure variable; this variable is usually either the imports or exports of the commodity. For each commodity *i* a given country market is designated as the key price market. Each of the other *m-1* country level market models for that commodity is linked to this key price market. Within the AGMEMOD aggregate model for the whole EU block a closure variable that ensures supply and use balance for each commodity market at the EU level is also needed. In the AGMEMOD model intra and extra EU trade are not distinguished (the model is non-spatial), but given that all intra EU trade flows for a given commodity sum to zero, EU net exports (being the sum of all EU Member State exports less the sum of all EU Member States' imports) is chosen as the closure variable. The key prices for commodities within the AGMEMOD model are modeled as functions of world market prices for the commodities (obtained from the annual FAPRI world market outlook), agricultural policy and agricultural trade policy instruments and the supply and use balance for that commodity within the EU. Thus, within the AGMEMOD model's country level modules, agricultural activity levels, agricultural commodity supply and use balances and agricultural commodity prices are determined endogenously (for fuller expositions of the AGMEMOD model's structure see Chantreuil, Hanrahan and Levert, 2005 and Erjavec and Donnellan, 2005). The key exogenous data used are data on exchange rates, GDP, and economy wide inflation and population, as well as trade and agricultural policy data.

Historical data on agricultural activity levels, commodity supply and use balances and agricultural commodity price data for EU markets are obtained from Eurostat (the EU statistical agency). Agricultural policy and trade policy data are obtained from European Commission publications. Macroeconomic data and projections at the Member State level are obtained from statistical and economic research institutes in each of the Member States. World agricultural commodity prices, US dollar/euro exchange rate data and projections are all taken from the annual FAPRI world market outlook (FAPRI, 2009).

The individual country approach adopted by the AGMEMOD partnership, which involves the development and linking together of country levels models of agricultural commodity markets, was adopted so as to be better able to serve the demands of policy makers at national, as well as EU, levels. The ability of the AGMEMOD model to analyze EU policy reforms at the individual Member State level distinguishes it from some other similar models of EU agriculture, which do not disaggregate the EU by country. The "bottom up" approach adopted within the AGMEMOD Partnership has advantages and disadvantages (Donnellan et al. 2002; Salamon et al. 2008).

The country by country approach allows the individual country models, both through their parameterization and their commodity coverage, to better reflect the diversity in agro-climactic conditions, agricultural structures and agricultural output that exists between EU Member States' agricultural sectors. The central role of modelers based within each EU Member State has also facilitated the development of an interactive review process of the AGMEMOD model's results. This process involves industry and government policy makers and is valuable in improving the usefulness of the analysis. Potential disadvantages of the bottom up approach include the need for careful coordination of model development and database maintenance activities across a very large set of partners (see Salamon et al., 2008).

For each commodity modeled within the AGMEMOD model, a commodity model template was developed and distributed to each of the country level modeling teams. These templates specify the model structure and functional form specification to be used for each of the different commodity models. The use of these templates ensures that, in so far as possible, the structure of country level commodity models is homogeneous, and that differences in the country models' simulated behavior reflect intrinsic difference between the markets modeled, rather than differences in the modeling approach of individual modelers.

As outlined in the previous section, the current CAP allows the agricultural policy as applied in the different Member States, to differ significantly. In most of the Member States that joined the EU since 2004, the Simplified Area Payment System (SAPS) is used, while in other EU Member States the Single Payment System (SPS) is used. In those countries that use the SPS there are different payment models used (historic, flat, static and dynamic hybrid) and differences in whether some direct payments remain coupled to or are decoupled from production. These different country policy settings are reflected in the policy variables that are incorporated in the different AGMEMOD country models. The equations in which policy variables are incorporated is determined by the commodity model templates while the value of the policy variables is determined by a harmonized approach to the representation of policy instruments across each of the country models (Salputra and Miglavs, 2007).

The AGMEMOD model has been used to analyze the impact of the accession to the EU of countries from central and eastern Europe (Erjavec, Donnellan, and Kavcic, 2005; Ivanova et al., 2007; van Leeuwen, Bartova, M'barek, and Erjavec, 2007), to analyze the impact of reforms of the 2003 CAP (Chantreuil, Hanrahan, and Levert, 2005; Chantreuil et al., 2005), reforms of the EU milk sector policy (Chantreuil et al. 2008). Country and commodity specific analyses have been conducted using the AGMEMOD model (van Leeuwen and

Tabeau 2005; Tabeau and van Leeuwen 2008; Gavrilescu, Gavrilescu, and Kervorchian, 2008; Gracia, de Magistris, and Casado, 2008; von Ledebur et al., 2008). Current development is focused on the development of a Turkish AGMEMOD model that will be used to analyze the impact of a future Turkish accession to the EU on agriculture in Turkey and in the EU.

CAP REFORM ANALYSIS

Arguments for the reform of the CAP, for its abolition, and for its retention will inform and be part of the ongoing review of the EU budget and negotiations on the shape of the CAP post 2013 (Council of the European Union, 2005 and 2006). Increasingly there is an acknowledgement of the need to consider what kind of policy for, or about, agriculture is needed for the 21st century (Buckwell 1997; Buckwell 2008; MacMillan and Ritson, 2007; Bureau and Mahé, 2008). The harmonized approach to the incorporation of policy in the AGMEMOD model structure means that the model has the analytical capacity to examine some policy changes that could emerge from the negotiations on the EU budget for the planning period 2014-2020 and the parallel negotiations on the shape of the CAP post-2013. The model also allows us to examine the impact of reforms on each Member State's budgetary receipts from the direct income component of the CAP. In this article we examine the impact, relative to the AGMEMOD 2009 Baseline, of the replacement of current CAP policy with an EU wide flat area payment of €100 per hectare. Such a payment can be interpreted as the Basic Husbandry Payment (BHP) component of the broader contractual payment scheme that Bureau and Mahé (2008) propose as the basis for a reformed CAP.

Under the Baseline, EU agricultural policy as agreed under the CAP Health Check agreement of 2008 is assumed to remain unchanged over the projection period to 2020. Projections of world prices of agricultural commodities are taken from the 2009 FAPRI World Outlook. Macroeconomic projections for each EU Member State date from spring 2009 and reflect the medium term pessimistic outlook for economic growth in Europe. Under the reform scenario analyzed, all remaining coupled direct payments allowed under the CAP are abolished. The wide variety of direct payment systems and models that are allowed under the current CAP are simplified into an EU wide, decoupled, flat area payment of €100 per hectare of eligible agricultural area and modulation is abolished. All other policies that affect agriculture are assumed to remain unchanged. The budgetary funds that under the scenario are no longer spent on supporting agricultural incomes are transferred to other non-agricultural policy areas. The provisions of the Uruguay Round Agreement on Agriculture (URAA) that govern tariffs, trade distorting domestic support and export subsidization remain in place, while the Baseline macroeconomic projections are assumed to remain unchanged.

In this article we present results on the impact of the analyzed reform on a limited sub-set of the commodities and countries modeled and on the impact of the reform on CAP budgetary flows to Member States. It is not possible within the context of this article to present a full set of Baseline and scenario analysis results, see Bartova and M'barek (2008) for fuller country and commodity market details of the AGMEMOD model. We have chosen to concentrate on two commodities soft wheat and beef. These two commodities differ importantly in the extent to which they are affected by agricultural policy under the current CAP and in the degree to which, historically, direct payments were important to production decisions. In some MS direct payments remain coupled to beef production (via the suckler cow premium) whereas all direct payments to cereal farmers have been decoupled from production. Results are presented for the EU27, EU15 and EU12 aggregates as well as for France and Ireland (two of the so-called "old" Member States) and for Poland, Latvia and Slovenia (three so-called "new" Member States).

SOFT WHEAT

Under the current CAP there are no direct payments that are coupled to the production of wheat. Consequently, the key driver of results for wheat are changes in the average level of direct income support to farmers due to the introduction of the EU wide flat area payment of €100 per hectare rather than the decoupling of direct payments.. At the EU27 level the impact of the analyzed reform on EU wheat production is negative, while the volume of net imports increases. The €100 per hectare flat area payment is lower than the average level of decoupled income support per hectare in the EU. Decoupled income support is assumed within the AGMEMOD model to have at least some supply inducing impact on production, and its reduction causes EU27 production of soft wheat to decline by 2.1 percent. The magnitude of the projected reductions in wheat production are greater in the EU15 aggregate than in the EU27 since the reduction in the levels of support per hectare is much larger in the EU15 Member States than in EU12. The impact of the reform differs within the EU15 block. In Ireland, where agricultural land use is dominated by grassland agriculture, the analyzed reform is projected to lead to a 12 percent decline in production of soft wheat. In France, where arable use of land dominates, the reform is projected to lead to a much more limited change in production, with soft wheat production projected to be only 1.4% lower than under the Baseline. The change in soft wheat production in the new Member States is limited reflecting both the smaller change in the level of per hectare income support under the scenario and the dominance of arable agriculture in terms of land use in these countries. In Slovenia, where, compared with Poland and Latvia, grassland agriculture is of greater importance, the soft wheat supply response to the reform is greater.

The changes in domestic use of soft wheat under the scenario are not large, with marginal declines in response to the slightly higher prices that are projected to prevail under the scenario analyzed (see figure 4). Domestic use of cereals also declines in response to the projected declines in cattle and sheep numbers that are projected under the scenario (see below). Under the Baseline EU biofuel policies are projected to lead to a large increase in the domestic use of wheat in the EU (von Ledebur, et al., 2008).

As a result under the Baseline in 2020 the EU is projected to be a net importer of wheat. The impact of the reform scenario is to increase the scale of the EU net imports of wheat by almost 18 percent. This large change in net trade is due to the small scale of projected EU27 imports relative to domestic use and production. Under the Baseline soft wheat net trade in 2020 is equal to approximately 5 percent of domestic use.

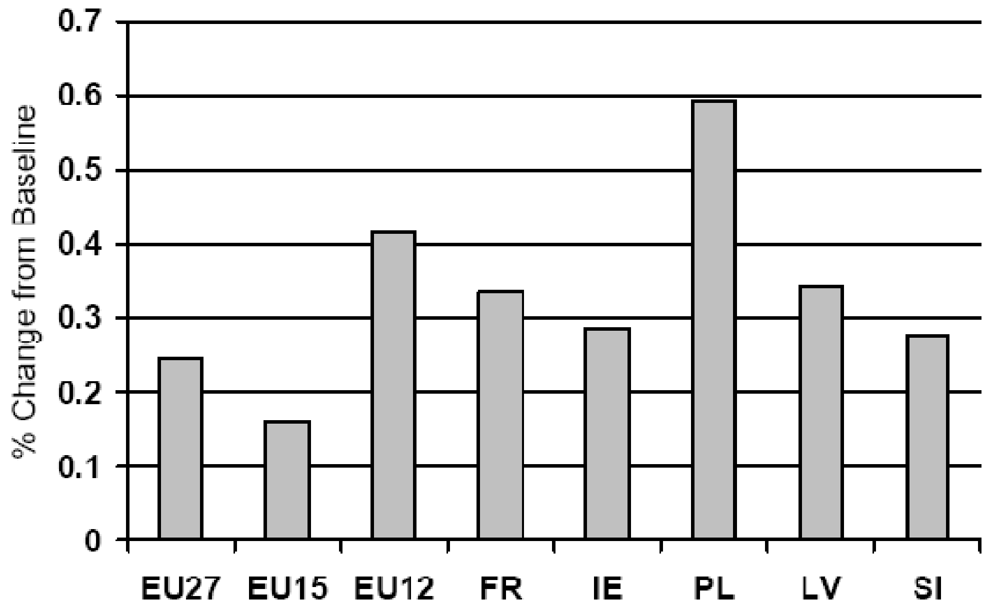


Figure 4. Price impact of CAP reform scenario: soft wheat.

Table 3. Baseline and CAP reform scenario projections: soft wheat

	EU27	EU15	EU12	FR	IE	PL	LV	SI
Production		Thousand tonnes						
Baseline	143,987	104,316	39,671	37,850	1,164	11,562	751	233
Scenario	140,771	101,381	39,391	37,329	1,026	11,431	759	226
% Δ	-2.2	-2.8	-0.7	-1.4	-11.8	-1.1	1.1	-2.9
Domestic Use		Thousand tonnes						
Baseline	161,819	127,048	34,771	26,568	2,143	12,475	590	633
Scenario	161,788	127,048	34,740	26,566	2,139	12,446	591	632
% Δ	0.0	0.0	-0.1	0.0	-0.2	-0.2	0.1%	-0.1

BEEF

In contrast to the relatively limited impact of the reform scenario analyzed on soft wheat markets, the impact on the production of beef in the EU is more appreciable. Again the effects of the reform scenario differ significantly between Member States. Under the Baseline the current freedom to pay coupled direct payments to beef farmers per beef cow farmed (the suckler cow premium) is availed of in a number of EU15 Member States, including France. Other EU Member States, such as Ireland, chose to fully decouple direct payments. In the Member States that acceded to the EU in 2004 and 2007 no production linked direct payments are made under the CAP and, as outlined above, the level of direct income support is lower. Thus, in addition to the impact of the reduced level of direct income support under the scenario, the decoupling of the coupled suckler cow premium also has a negative impact on the level of beef production. The differing importance of specialized beef production systems across the EU is also an important factor in the differential impact of the analyzed reform across EU Members States. In those Member States with a significant suckler cow inventory, the reform has a larger impact on beef production than in those Member States (the majority) where most beef production is from dairy beef. In the EU27 approximately two third of the stock of cows are specialized dairy cows, thus the impact of a given reform on beef cow numbers will differ significantly from the impact on beef production.

Relative to the Baseline, the EU27 inventory of beef cows is projected to decline by 5 percent under the reform scenario. The magnitude of the contraction in beef cow numbers is larger in the EU15 group of Member States than in EU12 group of Member States. This reflects the smaller negative impact of the introduction of the €100 per hectare flat area payments in the EU15 and the absence, under the Baseline, of any coupled payments to beef producers in the EU12 group.

Within the EU15 the impact of the reform analyzed on beef cow numbers also differs. France is one of a number of Member States with an important specialized beef herd. This factor, along with the payment of coupled direct payments to beef farmers in France, explains the larger negative impact of the reform scenario in France when compared with projected response to the reform in the EU15. Under the scenario French beef cow numbers are projected to be over 12 percent lower than under the Baseline. Ireland, like France, has a large specialized beef cow herd. However, unlike France, Ireland fully decoupled all direct payments from production following the 2003 CAP reform. This fact largely explains the smaller, though still negative, impact of the reform in Ireland, where beef cow numbers in 2020 are projected to be 4 percent lower than under the Baseline.

In the new Member States the decoupling of payments is not projected to have any impact on beef cow numbers given the absence of coupled payments under the Baseline. Of greater importance in the new Member States is the introduction of the €100 per hectare flat area payment. On average across the EU12, beef cow numbers decline by 2 percent. In some Member States the decline in cow numbers is significantly larger. These differential responses are largely due to the different adjustments in the value of direct income support per hectare that arise from the introduction of the €100 per hectare flat area payment. In Slovenia and Poland direct income support per hectare under the baseline is in excess of €100 per hectare (see figure 1) and as a result the number of beef cows declines, with the impact on Slovene beef cow numbers being much larger, reflecting the higher level of budgetary support per hectare in Slovenia (€294 per hectare compared to €79 per hectare in Poland). In Latvia the level of direct income support under the Baseline is less than €100 per hectare and under the scenario beef cow numbers are projected to be marginally higher than under the baseline.

The impact of the reform on beef production is smaller than the impact on beef cow numbers. This is a consequence of the dominance of dairy calf based beef production systems in the EU. In the EU27 beef production under the reform scenario is projected to be 2.5 percent lower than under the Baseline in 2020. The impact of the reform at the level of the individual Member States also varies, even after accounting for the differential impact of the reform on beef cow numbers. In France and Slovenia the analyzed reform had similar percentage impacts on beef cow numbers, however the much greater share of beef production that is accounted for by the dairy herd in Slovenia means that the impact of the scenario on beef production is smaller than in France.

The reform scenario analyzed leads to higher cattle prices in the EU, with larger price increases projected in those markets which are projected to experience the largest negative adjustments to beef production (see figure 5). With higher beef prices, domestic use of beef in the EU27 and in individual Member States is projected to decline.

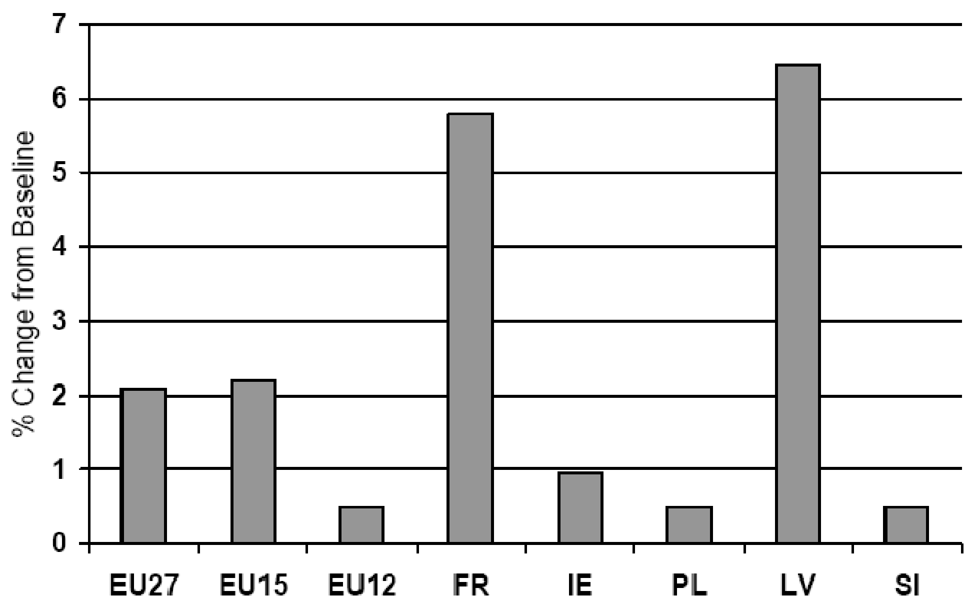


Figure 5. Price impact of CAP reform scenario: cattle.

Table 4. Baseline and CAP reform scenario projections: beef

	EU27	EU15	EU12	FR	IE	PL	LV	SI
Beef Cow Inventory		Thousand head						
Baseline	12,209	11,542	667	4,294	872	89	20	76
Scenario	11,603	10,952	651	3,756	836	89	20	64
% Δ	-5.0	-5.1	-2.3	-12.5	-4.1	-0.4	0.6	-16.4
Dairy cow inventory		Thousand head						
Baseline	21,659	16,587	5,073	3,711	1,015	2,172	131	85
Scenario	21,626	16,544	5,082	3,690	1,015	2,176	131	84
% Δ	-0.2	-0.3	0.2	-0.6	0	0.2	0.4	-0.3
Beef Production		Thousand tonnes						
Baseline	8,266	7,383	883	1,532	475	322	19	49
Scenario	8,061	7,181	879	1,329	464	323	20	46
% Δ	-2.5	-2.7	-0.4	-13.2	-2.4	0.1	4.1	-6.0
Beef domestic use		Thousand tonnes						
Baseline	8,314	7,457	857	1,817	80	204	19	44
Scenario	8,293	7,437	856	1,806	79	203	19	44
% Δ	-0.3	-0.3	-0.2	-0.6	-1.2	-0.3	-0.6	-0.2

Under the scenario the introduction of the €100 per hectare flat area payment has negative impacts on agricultural production in the EU. The impacts differ between EU Member States and between commodities. In general the greater impacts are projected to occur in the EU15 Member States, with the largest impacts arising where, under the Baseline, coupled direct payments had remained as part of the Baseline policy set. As noted earlier the political feasibility of a reform proposal is in part a function of its impact on agricultural production and incomes in the different Member States.

Given that agricultural production is projected to decline in most Member States, it is unlikely that the hypothetical reform analyzed in this paper would receive enough political support to be adopted. However, the reform agreement of 2003, where Member States agreed to decoupled direct payments despite expected negative production impacts suggests that probable negative production impacts do not necessarily doom a reform proposal. The reform analyzed reduces the level of overall spending on the CAP Pillar 1 instruments dramatically and with only one exception (Latvia) leads to reduced expenditure on agricultural incomes support across the EU, see Table 5.

Table 5. Budgetary impact of CAP reform scenario

	Baseline	€100 per hectare flat area payment	Change in Budgetary Envelope
	million euro		%
Austria	744,955	323,985	-56.5%
Belgium	648,856	146,619	-77.4%
Bulgaria	809,585	364,486	-55.0%
Czech R	902,222	356,598	-60.5%
Germany	5,774,254	1,695,100	-70.6%
Denmark	1,030,478	271,676	-73.6%
Estonia	100,900	76,390	-24.3%
Spain	4,840,413	2,538,324	-47.6%
Finland	565,520	229,360	-59.4%
France	8,415,555	2,958,411	-64.8%
Greece	2,178,382	325,405	-85.1%
Hungary	1,313,966	582,734	-55.7%
Ireland	1,340,521	430,489	-67.9%
Italy	4,184,720	1,470,994	-64.8%
Latvia	145,616	173,361	19.1%
Lithuania	377,360	279,070	-26.0%
Netherlands	853,090	194,669	-77.2%
Poland	3,017,407	1,594,148	-47.2%
Portugal	608,827	376,541	-38.2%
Romania	1,777,866	988,592	-44.4%
Slovakia	386,214	193,928	-49.8%
Slovenia	144,110	49,034	-66.0%
Sweden	763,082	320,124	-58.0%
UK	3,975,849	1,676,085	-57.8%

Source: European Council (2009), own calculations.

This outcome would suggest that a reform that leads to a CAP that only involves a flat area payment set at €100 per hectare would be politically unacceptable in an EU context. In Bureau and Mahé's proposal the Basic Husbandry payment is an element of a wider policy proposal that involves a scheme of spatially differentiated and targeted direct payments to farmers for the provision of environmental goods and services. Given the non-spatial nature of the AGMEMOD model we have only been able to analyze the basic income support component of their wider proposal. Our results suggest however that a Basic Husbandry payment set at €100 per hectare would have to be augmented by other parallel measures to win the support of the Member States and the European Parliament, which, together under the terms of the Lisbon Treaty, determine EU agricultural policy.

CONCLUSIONS

The AGMEMOD modeling system described in this article is a partial equilibrium model of EU agriculture that both in its use and structure reflects its FAPRI heritage. The FAPRI process of Baseline development, and interactive industry and government peer review and scenario analysis has been followed over the course of the AGMEMOD model's development and use. The model, as illustrated in this article, can be used by members of the AGMEMOD Partnership to analyze the impact of policy changes at the level of individual Member States and at an EU wide level.

Research currently underway involves the development of an AGMEMOD model for Turkey, which will allow for the analysis of the impact of a possible future accession of Turkey to the EU on Turkish and EU agriculture, and analysis of the impact of possible outcomes from the ongoing EU Budget and CAP review on EU agriculture. The current AGMEMOD model takes projections of world prices of agricultural commodities from the annual FAPRI world market outlook and thus it assumes that the EU is in effect a "small country" or price taker in world agricultural markets. This assumption is most likely not a good reflection of the reality of many international agricultural commodity markets and research is seeking to improve this aspect of the AGMEMOD model.

The bottom up, country by country, approach taken in developing the AGMEMOD model has advantages and disadvantages. An important advantage is that it has facilitated the development of technical capacity across all participating institutions. The AGMEMOD approach has also facilitated the development of FAPRI style Baseline review relationships between agricultural economists working on the AGMEMOD model and their peers in industry and government services. The modular, country by country, structure of the model also allows for the relatively straight forward addition of additional countries to the AGMEMOD model and allows the model to examine the impact of the possible future accession of the countries of the Western Balkans and Turkey to the EU. However, it should also be noted that the AGMEMOD approach to modeling EU agriculture also has some important drawbacks. The management and coordination of a large group of institutes, and the maintenance of model databases and updating of model parameters and structures through time poses a formidable set of ongoing challenges. The AGMEMOD model was largely developed with funds provided under the 5th and 6th Framework Programme of the EU, with some ongoing development supported by the Institute for Prospective Technological Studies

(IPTS) of the European Commission. Research funding of this kind, is not available to support the ongoing development and maintenance needs of the AGMEMOD model and the ability of the AGMEMOD Partnership to continue will depend on the willingness of the participating institutes to fund the involvement of their staff in database updating, model development, Baseline and scenario analysis activities.

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FAPRI-UK MODELING: REGIONAL RESPONSES TO EUROPEAN POLICY INITIATIVES

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ABSTRACT

The FAPRI-UK modeling system is used to inform policy makers of how changes in the policy instruments of the European Union's Common Agricultural Policy and rules agreed under the WTO impact the individual agricultural sectors of England, Wales, Scotland and Northern Ireland. The regional focus is required due to differences in farm structure and regionalized agricultural policies due to devolution. The regional differences in farm structure and aspects of policy are incorporated within the modeling framework and an example of the divergence in regional responses is highlighted by analysis of the UK government's long-term 'Vision' of EU agricultural policy.

JEL code: Q11, Q18.

Keywords: Common Agricultural Policy, trade liberalization, United Kingdom.

The European Union's Common Agricultural Policy (CAP) has changed significantly in recent years. Successive reforms have diminished the role of market management tools, increased the market orientation of the CAP and increased remuneration to farmers for the provision of public goods (see preceding article in this journal by Hanrahan, Donnellan and Chantreuil for further details on these reforms). These reforms include the introduction of the decoupled Single Farm Payment (SFP), the abolition of compulsory set-aide and the

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expansion and commitment to eventual abolition of milk quotas. In addition, increased emphasis has been placed on rural development through the transfer of monies from direct payments to farmers to rural development measures, including agri-environmental initiatives.

A collaborative project that began in 1998 between Queen's University Belfast (QUB) and FAPRI at the University of Missouri, and now includes the Northern Ireland Agri-Food and Biosciences Institute (AFBI), has resulted in the FAPRI-UK modeling system, which has been used to assess the implications of these CAP reforms (and further proposed reforms during the negotiation process) on UK agriculture. The ongoing Doha Round World Trade Organization (WTO) negotiations have been a key driving factor for CAP reform. While no final agreement has been reached, the FAPRI-UK modeling system has also provided policy makers with impact assessments of WTO negotiation proposals, including export subsidy elimination and increased market access. Moreover, in response to new policy imperatives the modeling system has been developed to quantify greenhouse gas (GHG) emissions and determine the impact of biofuel policies on agricultural markets.

A key feature of the FAPRI-UK modeling system is its incorporation within the FAPRI EU GOLD model, which is in turn linked to the FAPRI global model. Simulating the system as a whole provides a way of capturing the impact of policy changes and developments in world and EU agriculture on the UK. Moreover, the UK modeling system contains sub-models for England, Wales, Scotland and Northern Ireland and thus allows for the inherent differences in farm structure across the UK. The regional focus is also important due to the discretion given to the devolved administrations in the implementation of the CAP, which has resulted in regionally diverse agricultural policies.

The following paper describes how the modeling framework has been adapted to account for regional differences within the UK and hence permits analysis of the impact of CAP and trade policy changes at the regional level. The role of devolved administrations and structural differences in England, Wales, Scotland and Northern Ireland are discussed. The general modeling framework is outlined, followed by a description of how the model has evolved in recent years. An example of a recent policy analysis highlighting regional results is discussed and finally, conclusions are drawn.

IMPORTANCE OF DEVOLVED ADMINISTRATIONS

The devolution of agricultural issues to the Scottish Parliament (1999), the National Assembly for Wales (1998) and the Northern Ireland Assembly (1999) has, for the first time since the UK's accession to the EU, resulted in significant differences in the implementation of the CAP across the UK. Furthermore, the four ministers with responsibility for agriculture belong to four different political parties, Labour in England, the Scottish National Party in Scotland, Plaid Cymru in Wales and Sinn Féin in Northern Ireland. They are responsible for agricultural policy in each country, or at least that part of the CAP which is open to Member State discretion.

The devolved administrations and political parties espouse differing ideologies regarding the role of the market and government intervention, which in turn influences their attitudes to and objectives for the agricultural sector and rural development. The differing ideologies of the devolved administrations are reflected in the implementation of the 2003 CAP reforms, alternatively known as the Fischler reforms. The main element of these reforms separated financial support from the level of production through the introduction of the decoupled SFP in place of a range of coupled direct payments. In reaching agreement, Member States and devolved countries in the UK were given discretion in the extent to which the SFP replaced the coupled direct payments and over the type of decoupled system (historic, area-based or hybrid). Each of the administrations in the UK opted for full decoupling, rather than continuing to maintain specific coupled direct payments, but chose different decoupled systems. In Wales, the devolved administration opted to limit the redistribution of payments through choosing an historic system, whereby the SFP is calculated on the basis of participation in CAP direct payment schemes in the reference years 2000, 2001 and 2002. The Scottish devolved administration also introduced a historic system but chose to top-slice the SFP using the National Envelope mechanism in order to provide specific direct payments to the beef sector. Payments are directed to beef bred calves produced from the suckler herd with the avowed aim of sustaining quality beef production, support remote and fragile areas, and protect environments dependent on cattle grazing.

The Department for Environment Food and Rural Affairs (Defra) opted to introduce by 2012 a flat rate payment based on the area farmed for England, with a transition period of eight years. During this transitional period the SFP depends upon a combination of historic and regional average payments, with the regional average component increasing each year. Thus, under the English system the distribution of the single farm payment changes over time, with extensive livestock producers, and previously non-supported crops, benefitting and intensive livestock producers losing. In Northern Ireland, the devolved administration opted for a hybrid system based on historical and area components. In contrast to England, the area component in Northern Ireland is relatively small and remains static over time.

The 2003 CAP reforms also introduced compulsory modulation across the EU, which reduces the SFP by a certain percentage each year to fund environmental projects. In addition, the reforms permitted the application of an additional national modulation rate (known as voluntary modulation), if a Member State or devolved administration chose to do so. The devolved administrations in the UK have applied different voluntary modulation rates, with England applying the highest level and Wales the least.

The different political aspirations also became evident in negotiations among the FAPRI-UK project funders regarding the identification of policy scenarios to be analyzed and subsequent interpretation of the conclusions drawn. The project modelers always emphasize their impartial stance to policy options and guard against ever being drawn into what could be construed as an advocacy role.

One final complication arises from Defra in London having ultimate responsibility for all CAP reform negotiations in Brussels and the implementation of agreed CAP policy measures and WTO negotiations in the Doha Development Agenda round of trade liberalization talks. It was within this national role that Defra, together with HM Treasury, published their ‘Vision’ paper for EU agricultural policy for the next 10 to 15 years (HM Treasury and Defra, 2005). The ‘Vision’ paper sets out radical reforms to reward farmers only for producing societal benefits that the market cannot deliver, while making the sector internationally competitive without the need for subsidy or protection. This commitment to remove subsidies and protection is not fully shared by the other devolved administrations in the UK. FAPRI-UK analysis of these proposed reforms is reported later.

DIFFERENT FARM STRUCTURES

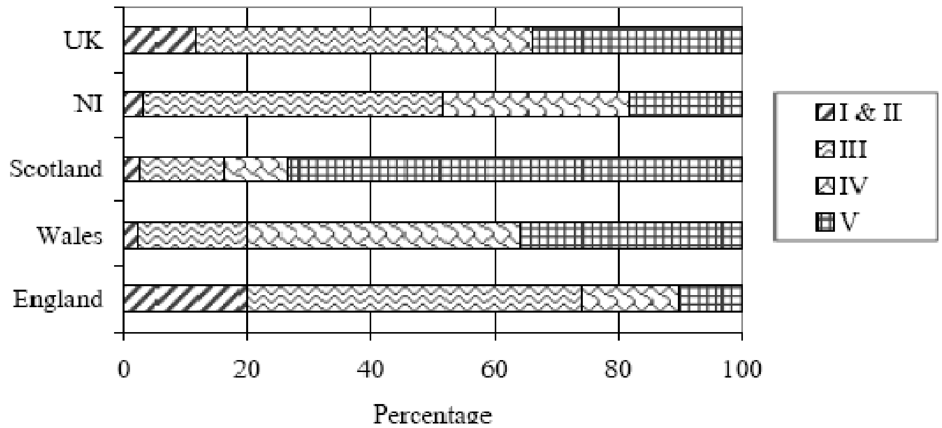
Although subject to the same general CAP policy environment, since UK accession to the EU in 1973, there are significant structural differences across the four constituent countries. In particular, agriculture's contribution to the overall economy varies significantly. In 2008, agriculture's share of total gross value added ranged from 0.3 per cent in Wales to 1.3 per cent in Northern Ireland (Table 1), while in terms of employment agriculture's share was greatest in Northern Ireland (3.1 per cent) and least in England (1.3 per cent).

Table 1. Comparison of Agricultural Data in England, Wales, Scotland and Northern Ireland (2008, unless otherwise stated)

	UK	England	Wales	Scotland	NI
Agric. share of total gross value added (%)	0.5	0.4	0.3	0.8	1.3
Agric. share of employment (%)	1.4	1.3	2.1	1.8	3.1
LFA* (% of total agricultural area)	49	16	81	86	70
Average farm size (ha)	60	44	37	121	39
% of total area on holdings with 100ha and over		68	53	87	31
Livestock (2007 census)					
Dairy cows (No. per ha grassland**)	0.15	0.25	0.16	0.04	0.29
Beef cows (No. per ha grassland**)	0.13	0.15	0.13	0.09	0.28
Cattle (No. per ha grassland**)	0.81	1.12	0.78	0.36	1.68
Sheep (No. per ha grassland**)	2.7	3.1	6.1	1.4	2.1
Pigs (No. per holding)	14.5	18.1	0.6	8.9	15.7

Notes:
* Less Favoured Areas.
** Includes rough grazing.

Agricultural land quality is an important underlying determinant of structural differences across the UK. The distribution of land classification grades in England, Wales, Scotland and Northern Ireland is shown in Figure 1. The quality of land for agriculture is graded on a scale according to the extent limiting factors impinge on the agricultural productivity of the land and include height, slope, climate, soil and drainage. The scale ranges from Grade I, denoting the best quality land, to Grade V, denoting the worst. Compared to the rest of the UK, a high proportion of land in England is classified as land with no or minor physical limitations (20 per cent of the total agricultural land in England is classified as Grades I and II, compared to 3 per cent in Wales, Scotland and Northern Ireland). Conversely, over 80 per cent of agricultural land is classified as poor (Grades IV and V) in Wales and Scotland, compared to 26 per cent in England and 48 per cent in Northern Ireland. Scotland in particular is characterized by extensive areas of poor quality land, with almost three-quarters of all agricultural land classified as Grade V. These distributions in land quality are reflected in the targeted nature of government support, which subdivides the UK into Less Favoured Areas (LFAs) and non-Less Favoured Areas (non-LFAs). LFAs are designated as suffering from difficult farming conditions, with the farms therein eligible for special assistance.



Source: Best (1981).

Figure 1. Distribution of land classification grades.

As shown in Table 1, the percentage of LFA land ranges from 16 per cent in England to 86 per cent in Scotland. The variation in land quality is evident in terms of the structural differences in enterprise mix. As shown in Figure 2, agriculture in England is characterized by a large concentration of crops and a low proportion of rough grazing. The prevalence of poor quality land in the Highlands of Scotland is reflected in the large area of rough grazing in Scotland (accounts for approximately 65 per cent of the total area of agricultural land) and the associated low stocking rates (Table 1). Nonetheless, conditions in certain regions of Scotland are suitable for crop production and tillage crops account for a significant proportion of total agricultural area (10 per cent). Tillage crops are of relatively minor importance in Wales, accounting for just 4 per cent of the total agricultural area. A high proportion of land is devoted to grassland farming systems, but rough grazing is less prevalent than in Scotland. The sheep sector in particular is central to the Welsh agricultural industry, with the number of sheep per hectare of grassland much higher in Wales compared to the rest of the UK (Table 1).

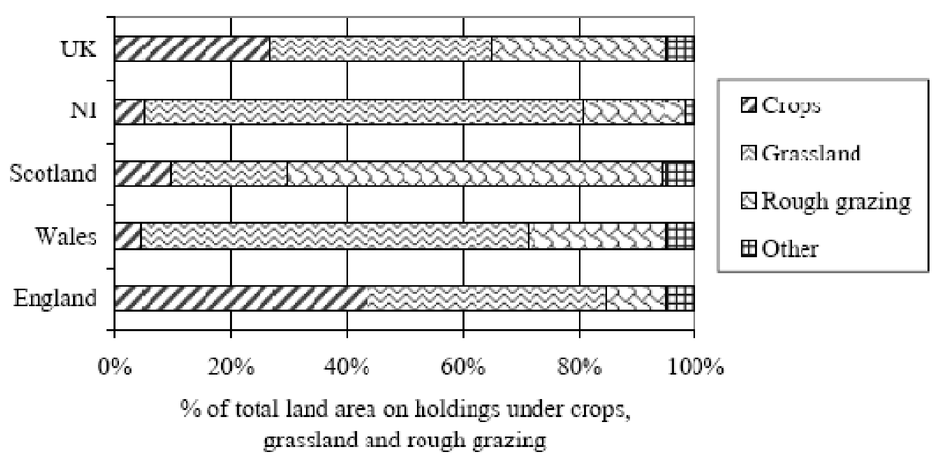


Figure 2. Land use in England, Wales, Scotland and Northern Ireland (2007).

The broad breakdown of land use in Northern Ireland is similar to that in Wales, with conditions favoring grassland farming systems. Agricultural holdings in Northern Ireland, however, are dominated by beef and dairy farming and the number of cattle per hectare of grassland is higher in Northern Ireland compared to elsewhere. The production system typically employed in Northern Ireland differs from the rest of the UK due to the availability of cheap feed in the form of grass. Greater emphasis is placed on forage grazing, e.g. the use of concentrate feeds in Northern Ireland dairy systems averages about two-thirds of the level fed per cow in the rest of the UK (Colman *et al.*, 2002).

There are also important structural differences with regards to farm area. The average area of farm enterprises is much larger in Scotland (121 hectares) compared to elsewhere (44, 39 and 37 hectares in England, Northern Ireland and Wales, respectively). Although the average area of farm enterprises is not dissimilar in England, Wales and Northern Ireland, distributions vary considerably (Table 1). The proportion of total agricultural area accounted for by holdings with 100 hectares and over is much smaller in Northern Ireland (31 per cent), compared to Scotland (87 per cent), England (68 per cent) and Wales (53 per cent). This arises from the differing historical developments in land settlement and tenure in the different countries over the centuries and the inherent regional differences in land quality.

As a result of the above structural differences, the contribution of the SFP as a component of farming income varies markedly across the UK. As shown in Figure 3, the average SFP per hectare is significantly higher in Northern Ireland compared to elsewhere. This reflects the importance of the beef sector to the Northern Irish agricultural economy and the nature of beef production in Northern Ireland, which attracted significant direct headage-based payments under the old policy environment. Given the magnitude of the SFP, farmers in Northern Ireland are particularly dependent on this form of support.

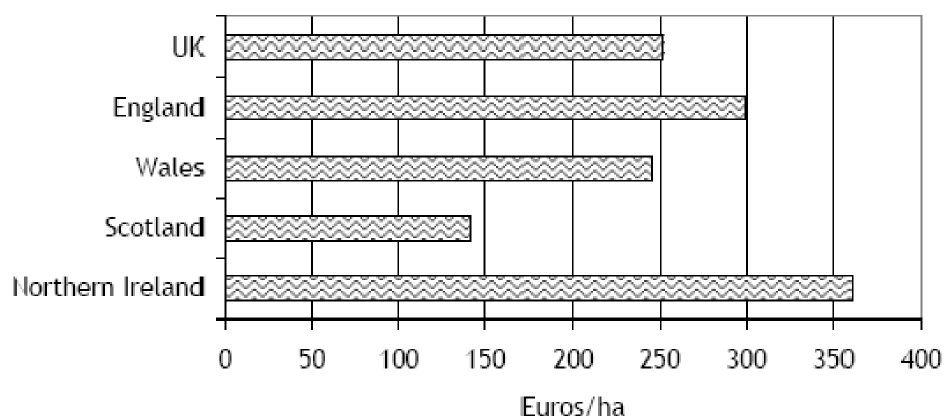


Figure 3. Average SFP per hectare in England, Wales Scotland, Northern Ireland and the UK.

MODELING FRAMEWORK

The FAPRI-UK modeling system (created and maintained by personnel in QUB-AFBI) captures the dynamic interrelationships among the variables affecting supply and demand in the main agricultural sectors of England, Wales, Scotland and Northern Ireland. The model consists of a system of equations covering the dairy, beef, sheep, pigs, poultry, wheat, barley, oats, rapeseed and biofuel sectors. The UK model is fully incorporated within the EU grain, oilseed, livestock and dairy (GOLD) run by FAPRI at the University of Missouri (see Hanrahan (2001)). Consequently, the UK model is not run in isolation but solves simultaneously within the FAPRI integrated partial equilibrium modeling system. It thereby yields UK projections which are consistent with equilibrium at the EU-level.

The models are recalibrated each year by the addition of the most recent year's data. In addition, an important feature of the FAPRI approach is consultation with industry to assess the robustness of projections. Extensive consultation is undertaken with key stakeholders for each of the commodities in each of the countries in the UK. This is invaluable in identifying issues not fully captured by the models, especially regarding "non-market" factors such as capacity constraints, industry restructuring and changes in taste.

In line with the FAPRI approach, the modeling system is firstly simulated to generate Baseline projections based on the assumptions that current policies remain in place, specific macroeconomic projections hold and average weather conditions apply. Baseline projections of key variables for each country in the UK are generated for a ten year period. Baseline projections provide a benchmark against which projections derived from policy scenarios can be compared and interpreted. The modeling system is then further simulated with changes to policy variables and the results are compared against the Baseline to isolate the policy effects across the ten-year projection period.

The UK model consists of submodels for England, Wales, Scotland and Northern Ireland reflecting the areas of responsibility for the devolved administrations. In general, supply is modeled for each of the four constituent countries of the UK, while demand is modeled at the UK level. This yields projections of livestock numbers, slaughter, production, market prices, market receipts, direct payments and selected inputs for each of the UK countries. Commodity production from each of the four constituent UK countries is summed to calculate aggregate UK production. Commodity domestic use, imports and exports are projected at the UK level. In addition, the EU GOLD modeling system generates country specific estimates of supply, utilization, trade and market prices for the other countries in the GOLD model (France, Germany, Ireland, Italy, rest of EU-15, Poland, Hungary, rest of NMS-10 (New Member State), Romania and Bulgaria), as well as estimates of supply and utilization for the total EU.

The commodity submodels close at the European level by ensuring EU export supply equals EU export demand in all markets. The key price in each model is adjusted until equilibrium is attained. Changes in the key price lead to adjustments not only in supply and utilization in the key country, but via price linkage equations to changes in the supply and utilization totals in all the other markets modeled. The iterative equilibrating process continues until all product markets in all years are in equilibrium (net EU export supply equal to net EU export demand). Thus, the UK commodity prices are consistent with equilibrium at the EU-level. Within the Baseline world prices are based on the projections of world prices from the Global FAPRI model generated for the World Outlook. When a policy scenario is undertaken, a reduced form world model is used which mimics FAPRI's Global modeling system's reaction to changes in trade from the EU through representative world prices. Trade for the EU is subject to the constraints of either the agreements made under the Uruguay Round Agreement on Agriculture (URAA) or scenario assumptions.

The UK model covers the following commodities: dairy, beef, sheep, pigs, poultry, wheat, barley, oats, rapeseed and liquid biofuels.

Dairying

The UK dairy model consists of submodels for liquid milk, cheese, butter, skim milk powder and whole milk powder. The model firstly allocates milk to the liquid market and the remainder is allocated to non-liquid uses. The non-liquid milk is converted into fat and protein equivalents. The distribution of milk fats and proteins amongst different dairy products is modeled on the basis of their relative prices. The model projects the producer price of liquid milk for England and Wales, Scotland and Northern Ireland as a weighted function of the prices of the dairy commodities cheese, butter, SMP and WMP (see discussion of results for further details).

Livestock

There are four livestock models in the FAPRI-UK system. The beef, pig and sheep models share a similar structure. The key supply side variable in each of the livestock models is the stock of female breeding animals (cows, sows, and ewes). This stock determines the number of young animals available for fattening and/or slaughter, which in turn determine meat production. Owing to its much shorter production cycle and the lack of CAP policy measures, the poultry model is much simpler. It does not include poultry numbers, but models production directly.

The various livestock models are linked primarily through their demand side specification, which are logarithmic specifications of per capita demand. Per capita meat demand is modeled as a function of the prices of the meat in question and of the other meats, all of which are all assumed to be gross and net substitutes in consumption. All of the meat goods are assumed normal, none is treated as a luxury good. The beef production model is linked with the dairy models via cow slaughter and the calf production from the dairy herd.

Crops

Within the crops model, land is allocated as a two-step process. Firstly, total cereal and oilseed area is projected as a function of weighted returns, where the weight reflects the share of the grain in total grain area. Having determined total cereal and oilseed area, land is distributed across different crops on the basis of expected returns of the crop in question relative to the other crops. Crop yield per hectare is primarily projected as a function of a trend term, which reflects technology change. To a lesser degree, yields are also affected by prices (small positive impact reflecting higher-yielding varieties from induced innovation) and area devoted to crop production (crop yields decline as area increases since additional land tends to be less productive). The supply of oilseed meals and oils is also projected. Production of oil and meal for each of the oilseeds is determined by the quantities crushed times the appropriate extraction rate.

The model incorporates variables representing the major policy instruments associated with the EU Common Agricultural Policy (CAP), as well as external trade commitments made by the EU. These policy variables can be altered to run scenarios for the purposes of policy analysis. In the last three years the FAPRI-UK project has analysed, at the UK level and for England, Wales, Scotland and Northern Ireland a number of different policy scenarios including: proposed CAP Health Check reforms incorporating the increase in and subsequent phasing out of milk quotas; the CAP Health Check agreement; and, the HM Treasury/Defra's Vision for the CAP incorporating potential WTO scenarios.

MODEL EVOLUTION IN RESPONSE TO POLICY REFORMS

Introduction of Single Farm Payment

The modeling system has evolved to capture the successive reforms of the CAP. One of the most radical changes involved the replacement of a range of production coupled direct payments with the decoupled SFP under the 2003 Fischler CAP reforms. Although the SFP is decoupled from production in an administrative sense, it is assumed that this payment exerts a partial influence on production since cross compliance criteria require farmers to "maintain land in good agricultural condition", which implies that at least some production will continue. Moreover, economic theory indicates that decoupled payments influence the production decision since increased wealth allows producers to undertake more risk (Hennessey, 1998). In addition, the provision of guaranteed direct payments may enable producers to expand production since they are more likely to be able to access credit.

Given there is little research evidence on this issue for the EU, in line with the treatment of decoupled payments within the FAPRI US model, it is assumed that the SFP has 30 per cent of the impact of previous direct payments in the GOLD model. In the dairy sector, producers never received coupled direct payments and thus there was no existing production response in place when the SFP was introduced. Consequently, it has been assumed that the production stimulating impact of the SFP in the dairy sector is less than in the other sectors. Specifically, it is assumed that the SFP has a milk production stimulating effect of 10 per cent.

Abolition of the Dairy Milk Quota

The expansion and then eventual abolition of milk quotas under the Health Check reforms also required significant modifications to the modeling system. In the past, the EU GOLD model has functioned as if production were determined by quotas for countries other than the UK. In order to model the expansion and eventual abolition of milk quotas, the modified model allows milk production to fall below quota if movements in prices result in the elimination of quota rent. The quota rents that are used for the model are based on those calculated by Lips and Rieder (2005). [See Patton *et al.* (2008) for further details on the rents used within the modeling framework]. Expanding the milk quota increases milk production, which reduces prices and therefore quota rents. If the expansion in quota is large enough, production can fall below the new quota levels. In the UK, it is clear that the rent associated with quota is minimal, given that production has been below quota in recent years and the corresponding very low price of quota. Milk production in each country in the UK is modeled using separate latent milk output functions for each region based on a scaling function estimation procedure. When projected prices are below a certain level milk production is determined by upward sloping supply functions in each country.

Increasing Importance of Liquid Biofuels

Various state support policies encouraging production and use of biofuels (European Commission (2003) and Department for Transport (2007)) have led to the substantial expansion of the biofuels industry, which has a knock-on impact on the main agricultural sectors. In particular, biofuel production affects the supply and demand of agricultural products used as feedstock for biofuels (primarily wheat and rapeseed in the UK), which in turn affects the prices of these commodities and in turn has a knock-on impact on the beef and dairy sectors through feed demand. In order to capture the impact of this new policy imperative on UK agriculture, liquid biofuel models have recently been incorporated within the UK and EU modeling systems.

Stochastic Analysis in Response to Increased Market Orientation

Historically, trade policy measures have, in addition to providing income support, protected EU agricultural commodity markets from the adverse effects of global price volatility. With the reorientation of the CAP from price support to direct-aid payments and moves towards trade liberalization, EU commodity prices have become more closely linked to world prices and hence, are more susceptible to global shocks. Moreover, a successful Doha WTO Round is expected to move EU prices even closer to world prices and thereby increase EU markets exposure to global price volatility.

In order to capture the impact of global price volatility, the conventional UK Baseline is now supplemented with a stochastic Baseline, based on alternative world price projections from the FAPRI-Missouri modeling system which reflect the inherent uncertainty associated with agricultural production systems (see article 4 within this journal). Stochastic world price projections from the FAPRI-Missouri stochastic modeling system are used as input data into the FAPRI EU model, which includes the FAPRI-UK modeling system.

This stochastic approach provides an indication of how variations in world prices are transmitted to EU, and in particular, UK prices. The stochastic methodology is also useful in assessing the role of EU Commission policies that have asymmetric features. Conventional projections derived from a Baseline assuming average weather and normal demand conditions may not be appropriate in examining policies that only come into play under defined adverse conditions. Stochastic analysis facilitates the assessment of how alternative policies respond under different conditions.

Greenhouse Gas Emissions in Response to Climate Change

Increased concerns about the threats posed by climate change have led to the development of radical EU and UK targets to reduce GHG emissions. In the UK, the 2008 Climate Change Act set substantial long-term binding targets to reduce GHGs by at least 34 per cent by 2020 and 80 per cent by 2050, compared with 1990 levels (Department of Energy and Climate Change, 2008). Agriculture is a significant source of emissions and is expected to contribute to these targets; and so it is important to assess the implications of any changes in agricultural or trade polices on GHG emissions. A FAPRI-UK GHG sub-model has recently been developed, which provides projections of methane and nitrous oxide arising from agricultural activity in England, Wales, Scotland and Northern Ireland. Through linking the GHG sub-model to the main FAPRI-UK modeling system, projections of greenhouse gas emissions consistent with equilibrium within the entire modeling system are obtained. These greenhouse gas projections are based on projections of commodity outputs and input usage, which take account of both market and policy developments within the agricultural sector.

EXAMPLE OF POLICY ANALYSIS UNDERTAKEN

The modeling system accounts for differences in farm structure and aspects of policy by modeling supply for each of the four constituent countries. Key differences in the modeling system are highlighted below with reference to recent analysis of the impact on agriculture in the UK of implementing HM Treasury/Defra's Vision for the CAP (Moss *et al.*, 2009). Within the 'Vision' report HM Treasury/Defra proposed that agriculture should be:

- internationally competitive without reliance on subsidy or protection;
- rewarded by the market for its outputs and by the taxpayer only for producing societal benefits that the market cannot deliver;
- environmentally-sensitive, maintaining and enhancing landscape and wildlife and tackling pollution;
- socially responsive to the needs of rural communities;
- producing to high levels of animal health and welfare; and
- non-distorting of international trade and the world economy.

Key proposed policy reforms designed to achieve this vision of sustainability include the alignment of import tariffs for all agricultural sectors with other sectors of the economy and the abolition of production subsidies, price and direct income support measures and export subsidies. Within the modeling system, the following policy changes were simulated:

- phased increase and eventual abolition of milk quotas;
- trade liberalization (elimination of EU export subsidies and reduction of EU import tariffs for all agricultural sectors in line with other sectors of the economy); and
- phased elimination of the SFP.

By solving the UK modeling system in conjunction with the FAPRI-EU model it was possible to capture the impact of CAP reform across the EU and changes to EU trade rules on UK agriculture.

Results of Vision Analysis

Dairy Sector

Within the dairy sector, the policy changes have a depressing impact on producer milk prices and production in the UK. This primarily reflects the impact of the abolition of milk quotas and the elimination of export subsidies. The phased increase and eventual abolition of milk quotas leads to a modest increase in projected EU milk production, which has an upward impact on EU production of cheese, butter, skimmed milk powder and whole milk powder. Projected EU dairy commodity prices, including those in the UK, decline in response to the increases in production. Moreover, the elimination of EU export subsidies exerts a further downward impact on the price of butter.

The fall in commodity prices has a variable impact on producer milk prices across the UK (Figure 4). Within the modeling system the producer milk price in each country is modeled as a weighted function of the prices of the dairy commodities cheese, butter, SMP and WMP, where the weights reflect the milk utilization for production of these commodities. Thus, the projected producer price moves in line with changes in dairy prices and the structure of dairy production in each country.

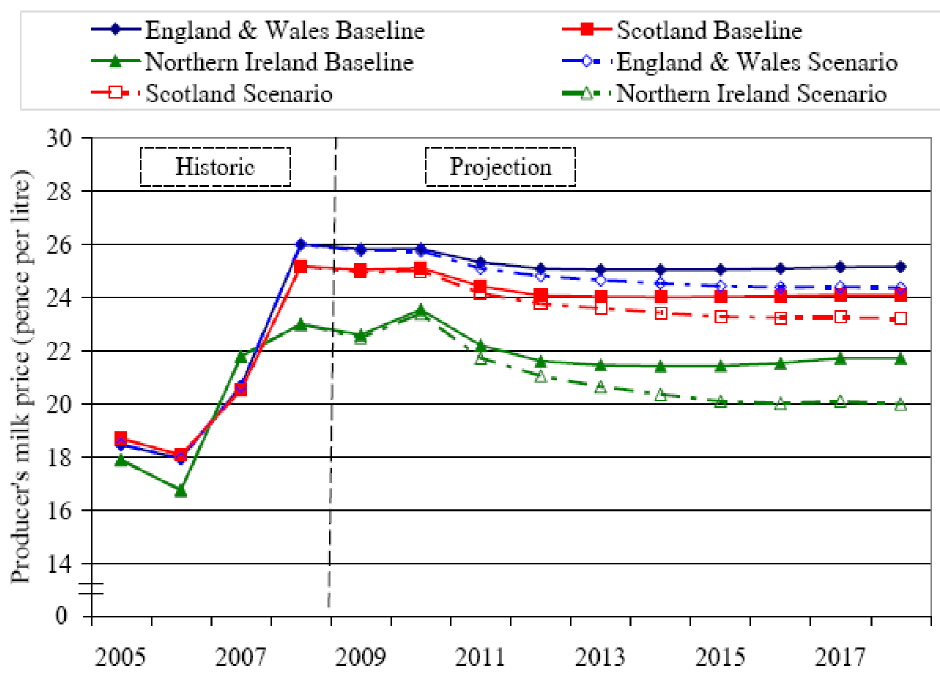


Figure 4. Projected change in producer's milk price in England & Wales, Scotland and Northern Ireland following implementation of 'Vision' reforms.

Additionally, a restriction is imposed on the extent to which changes in the structure of dairy processing and dairy prices affect the producer milk price, based on the amount of milk used for processing. For example, in England about 50 per cent of the milk produced is used for processing, while in Northern Ireland around 85 per cent of total milk production is processed due to the small size of the local population and hence, demand for liquid milk. Consequently, the Northern Ireland producer milk price reacts to a greater extent to dairy commodity price changes than the English producer milk price. Following the 'Vision' policy changes, it is projected that the producer milk price in England and Wales is 3 per cent lower relative to the Baseline at the end of the projection period, while in Scotland it is 4 per cent lower and in Northern Ireland it is 8 per cent lower.

Milk production in the UK falls in response to the decline in producer milk prices. The decline in production is greatest in Northern Ireland (-8 per cent) compared to elsewhere (-3 per cent in England, Wales and Scotland) since Northern Ireland experiences a more pronounced decline in price. Milk production in Northern Ireland is adversely affected by a marked expansion in milk production in the Republic of Ireland that reduces the volume of milk exported from Northern Ireland to its neighbor.

Beef Sector

The impact of the 'Vision' reforms is particularly marked in the UK beef sector. This is attributable to the combined impact of the reduction of EU import tariffs and phased elimination of the SFP. Extensive reductions in over quota tariffs lead to a substantial increase in EU beef imports. Projected internal EU beef prices, including in the UK, decline markedly in response to this large increase in imports. The decline in beef prices reduces the economic incentive to produce beef and exerts a negative impact on UK suckler cow numbers. Elimination of the SFP applies further downward pressure on suckler cow numbers since under the Baseline it is assumed that the decoupled SFP continues to have a modest production stimulating effect.

Overall, following the implementation of 'Vision' reforms projected beef prices in the UK are 25 per cent lower than the Baseline at the end of the projection period. Projected suckler cow numbers are 26 per cent lower in England following the implementation of 'Vision' reforms compared to the Baseline in 2018, while they are 29 per cent lower in Wales, 26 per cent lower in Scotland and 27 per cent lower in Northern Ireland. Although the decline in suckler cow numbers is not dissimilar in England, Wales, Scotland and Northern Ireland, the contribution of underlying factors varies across the UK. For example, the estimated price elasticity for suckler cows within the modeling system is lower in Northern Ireland compared to England and as a consequence, suckler cows are less responsive to price changes in the former. Farm household models support the hypothesis that small scale beef farmers in Northern Ireland pursue wealth maximization and lifestyle objectives, in addition to profit motives, and as a result are less responsive to fluctuating commodity prices (Jack, Moss and Wallace, 2009). In contrast, the elasticity for direct payments within the suckler cow equation for Northern Ireland is greater than that for England since producers in the former have been more dependent on direct payments given the magnitude of the SFP per hectare. As a result, suckler cows in Northern Ireland are more responsive to changes in the level (and ultimately the removal) of direct payments. Moreover, due to different regionalized agricultural policies, the SFP in England is subject to higher levels of voluntary modulation compared to the rest of the UK. Thus, within England monies are transferred from Pillar I to

Pillar II to a greater extent under the Baseline compared to elsewhere and thus, the full phasing out of the SFP under the ‘Vision’ reforms has a smaller impact. Overall, the decline in price and elimination of the SFP following the implementation of the ‘Vision’ reforms result in comparable reductions in suckler cow numbers in the four regions.

The impact of the ‘Vision’ reforms on beef production varies according to the proportion of beef production that is sourced from the dairy herd. For example, a higher proportion of beef animals come from the progeny of the dairy herd in England compared to Scotland. In 2008 dairy cows accounted for 63 per cent of total cows in England, compared to 30 per cent in Scotland. Thus, although the reforms have a similar projected impact on beef and dairy cow numbers in England and Scotland (under the ‘Vision’ policy changes it is projected that beef cow numbers fall by 26 per cent and dairy cow numbers fall by 3 per cent in both regions compared to the Baseline), the decline in overall beef production is more marked in the latter (minus 15 per cent in Scotland and minus 10 per cent in England).

Crop Sector

It is projected that the ‘Vision’ reforms have a marginal impact on the UK crop sector. The cuts in import tariffs do not result in increased non-EU imports since EU prices closely track their world prices. In addition, export subsidies for crop commodities are not required in the Baseline and hence the elimination of this form of support has no impact. In contrast to the rest of the UK, however, it is projected that barley production in Scotland declines by 4 per cent in response to the lower projected livestock numbers since a significant proportion of Scottish barley is of low quality and used for feed purposes.

Total Market Receipts and Retained Direct Payments

Implementation of the ‘Vision’ reforms has a depressing impact on total market receipts in the UK, amounting to £1,384 million (Table 2).

Table 2. Projected Change in Market Receipts and Retained Direct Payments in England, Wales, Scotland and Northern Ireland Under the ‘Vision’ Reforms Compared to the Baseline in 2018*

	England	Wales	Scotland	NI	UK
Total Market Receipts	-11% (-£778m)	-19% (-£156m)	-17% (-£235m)	-20% (-£215)	-13% (-£1,384)
Retained Direct Payments**	-66% (-£959m)	-68% (-£142m)	-67% (-£256m)	-67% (-£149m)	-66% (-1,507m)

Notes:

* Absolute figures in parenthesis.

** Retained Payments defined as (SFP plus agri-environmental funds minus costs associated with agri-environmental measures).

It is projected that the decline is less marked in England compared to Wales, Scotland and Northern Ireland since it is less dependent on the beef and sheep sectors which suffer the greatest fall in market receipts. The transfer of funds from Pillar I to Pillar II under the 'Vision' reforms also significantly reduces, by approximately two-thirds (amounting to £1,507 million at the UK level), the level of direct payments retained by farmers since it is assumed these are switched to agri-environmental measures with associated compliance costs. While these projected changes in market receipts and direct payments are large in terms of total income, it must be recognized that these costs would also be reduced due to lower production levels.

CONCLUSIONS AND SUMMARY

It is highly unlikely that the full 'Vision' proposals would be agreed within an EU context. Despite agreeing the Health Check reforms, with its transition to a more market oriented CAP, many Member States still view the provision of income support and protection as a necessary condition for rural development. While the results outlined above highlight some differences concerning the impact of 'Vision' reforms across the UK, it must be emphasized that the policy changes represent significant departures from existing policies. Econometric approaches, such as that used within the FAPRI-UK model, employ historic data to derive coefficients of demand and supply relationships and therefore reflect existing farm structures. Fundamental changes in farm policy could lead to major structural changes that are difficult to capture from a modeling perspective. As with other quantitative approaches, the FAPRI-UK modeling system provides at best indications of differing impacts across the UK and care should be taken in the interpretation of the projected impacts.

Although addressing the needs of the different devolved funders has proved challenging, it has nonetheless been very rewarding. By undertaking the policy analysis at the regional level it has been possible to highlight differential impacts of policy reforms across the UK, which would not have been evident if the analysis had been undertaken solely at the UK level.

Analysis of future policy changes will undoubtedly be equally demanding. Approaching the second decade of the 21st century, the pressing issues facing UK agriculture and the portfolio of policy instruments within the CAP to deal with these issues is very different from those of the MacSharry era of the early 1990s. With the full implementation of the Health Check Reforms, the days of complex commodity regimes, high levels of protectionism and the underlying imperative of farm income support have been replaced by recognition of the importance of: simplified policy instruments, market mechanisms as a safety net, trade liberalization, food security and, increasingly, the challenge of limiting climate change. Consequently, UK agriculture will have to respond to the necessity of meeting targets for GHG emissions; contributing to the challenges of ensuring global food and energy security; and address global price volatility, at the same time as operating under whatever post-2013 CAP regime and WTO Doha agreement, if any, come into force.

Policy models will need to adapt to these new policy regimes. In anticipation of the possible new policy imperatives, significant methodological developments have been made to the FAPRI-UK models, including the creation of a GHG emission sub-model and stochastic modeling.

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BIOFUEL EFFECTS ON MARKETS AND INDIRECT EFFECTS ON LAND USE AND FOOD

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ABSTRACT

Expanding US biofuel use led to popular discussion about the impact on land use and food availability abroad. Early partial equilibrium analysis simplified biofuel use as exogenous or perfectly elastic and treated some foreign land use effects as recursive to commodity markets. An experimental model of a dozen key countries and country groups suggests: market context is critical, historical relationships are not a reliable guide to all forward-looking analysis, US ethanol demand changes are met in part by changes in Brazilian use, and there is a trade-off between indirect land use effects and food price inflation.

JEL classifications: Q11 - Aggregate Supply and Demand Analysis; Prices. F17 - Trade Forecasting and Simulation. Q42 - Alternative Energy Sources

Keywords: biofuel, ethanol, indirect land use change, food versus fuel.

Biofuel policy has raised the profile of a long-standing question: what are the indirect effects of US policies on people in other countries? Academic investigation to assess the extent of indirect effects on land use abroad was brought into policy making as the Environmental Protection Agency (EPA) adopted indirect land use change in its calculations of lifecycle greenhouse gas emissions. Members of Congress questioned these calculations and some called for them to be deferred to build more scientific consensus on their scale. Another recent question about the effects of US biofuel policies related to the food-versus-fuel trade-off. In non-academic forums, including barbed editorial cartoons, US ethanol was portrayed as a direct substitute for food consumption of the poor. Many readers might have believed that most, or even the entirety, of the food price rise to 2008 could be attributed to support to biofuel production and use in developed countries, particularly the US, ignoring the findings of more refined analysis (Abbott *et al*. 2008, 2009; Dewbre *et al*. 2008; FAO

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2008; Meyers and Meyer 2008; OECD-FAO 2008; Timmer 2008; Trostle 2008; Westhoff 2008).

These questions can be answered using new applications of long-standing methods to assess how policies of one country feed through markets to affect agents in other countries, both producers and consumers. The key new challenges in this application are the specific policies involved, the focus on land use abroad, and the goal of identifying effects on final food consumers. In contrast, FAPRI partial equilibrium models typically do not span these measures. For example, land used in production of specific crops of the model is typically estimated endogenously, but other land uses are not. As for consumer analysis, food use is typically expressed at farm or wholesale levels and without any aggregation to give measures of total food consumption. In the case of the US biofuel policies, a model-building program of research generated sets of equations to represent how the key mechanisms, namely biofuel use mandates (the Renewable Fuel Standard), tax credits, and tariffs on ethanol import, affect specific agents' behavior, and how markets work more broadly (Thompson *et al.* 2008a, 2009). The international effort to identify the indirect effects included collaborative work to assess recursively what changes in crop area caused by a change in US biofuel use means for other land uses based on historical trends in land use change (Searchinger *et al.* 2008) and upper bounds on consumer price effects based on average consumption baskets and calorie data (Elobeid and Hart 2007). The ideal approach would be to represent more directly land use decisions and the steps from commodity to consumer effects in the partial equilibrium models. This ideal, however, presumes that the underlying data and our understanding of the economic relationships support the representation. In fairness, our certainty about supply curves depends at least indirectly on the substitution of land among various uses, whether specified explicitly or not, and commodity demand curves at farm level implicitly represent as well the transmission of price signals between wholesale and consumer levels and final consumer demands.

The modeling effort described here explores the potential to extend the FAPRI-MU partial equilibrium model to address these questions. The model explicitly represents land use change and price links to consumers as simultaneous to the agricultural commodity markets. Our representation is at a national level and we do not embark on the detailed land disaggregation explored in some GTAP applications using a dozen or so agro-ecological zones (Ahammad and Mi 2005; Birur *et al.* 2007; Golub *et al.* 2007; Lee *et al.* 2008). The model also does not achieve the level of policy- and market-specificity that hallmarks many partial equilibrium models, but instead employs a more standardized representation of each country or aggregate. Finally, in contrast to the effort to collect data from sources in each country that provides a foundation of many FAPRI model efforts, the model discussed here is built on FAO and USDA/Foreign Agricultural Service's Production, Supply and Distribution database (PSD) data and general indicator prices for all countries except the US. This approach allows a consistent representation of land allocation over a wider list of uses and tracks feed and food demands based on more systematic approaches. Thus, this representation includes more of the cross effects among commodity supplies and demands than a traditional partial equilibrium model that is built by analysts who focus on a single commodity or set of commodities.

The second section, next, provides a description of the model structure, data, and parameters. The third section describes some model results to highlight its uses. The final section highlights the lessons learned from this exercise and outlines some avenues for further development.

MODEL STRUCTURE, DATA, AND PARAMETERS

The scope of the model in terms of commodities and countries is as follows.

- Commodities: wheat, rice, corn, other grains, soybeans, rapeseed, sunflower, oilseed oil, palm oil, oilseed meal, sugar, beef, pork, and poultry.
- Countries: Argentina, Brazil, Canada, China, the European Union, India, Indonesia, Japan, Malaysia, Mexico, the US, and four developing country aggregates.

The US is represented using the FAPRI-MU stochastic model. Rest of world net trade is represented in a straightforward way as a function of the world price. Models for identified countries have evolved through several stages of improvements. Below, the current version is summarized.

Developing country groups are defined based on shared characteristics other than region, following examples of other researchers (Diaz-Bonilla et al. 2000; OECD 2002). The criteria reflect the purpose of the developing country aggregates, namely to simulate how shocks in biofuel policies in some countries are transmitted to developing countries and if the shock imperils food security in the developing countries.

The question of price transmission is addressed by taking into account the importance of trade to the domestic crop markets. If trade plays a larger role in markets, then the country is assumed to be more integrated with world markets. Sensitivity to changes in food consumption is gauged based on the overall level of food consumption. If consumption in a country is low overall, then a change in consumption caused indirectly by policies of other countries could have more important consequences – namely, more severe human suffering – than for countries with higher initial levels of consumption.

Our developing country groups are based on two measures. First is the average calorie consumption. If a developing country's average national calorie consumption per person exceeded the median of all developing countries in 2003-05 according to FAO data, then it is placed in the "high consumption" groupings. Otherwise, if below median consumption, then it is in a "low consumption" group.

The second measure is the share of trade in the domestic market for grains (the sum of rice, wheat, and coarse grains), measured by two ratios, exports relative to production and imports relative to consumption, based on USDA PSD averages for 2005/06 to 2007/08. If either trade ratio, whether measured by exports or imports, exceeds the median for all developing countries, then the country is placed in the "high trade" groupings.

If both ratios are lower than the median, then the country is in a "low trade" group. Thus, each developing country is allocated to one of four groups: high consumption and high trade, high consumption and low trade, low consumption and high trade, and low consumption and low trade (table 1).

Table 3. Developing Country Groups

Low consumption and low trade	
	Afghanistan, Bangladesh, Bhutan, Burundi, Central African Republic, Chad, Comoros, D.P.R. of Korea, Democratic Republic of the Congo, Equatorial Guinea, Ethiopia, Guinea-Bissau, Laos, Madagascar, Mali, Niger, Rwanda, Solomon Islands, Tajikistan, Timor-Leste, Tuvalu, Tanzania, Uzbekistan, Vanuatu
Low consumption and high trade	
	Armenia, Cape Verde, Eritrea, Gambia, Haiti, Iraq, Kenya, Lesotho, Liberia, Malawi, Mauritania, Mongolia, Mozambique, Sierra Leone, Somalia, Sudan, Swaziland, Togo, Uganda, Yemen, Zambia, Zimbabwe
High consumption and low trade	
	Benin, Burkina Faso, Djibouti, Kiribati, Maldives, Myanmar, Nepal, Samoa, Sao Tome and Principe, Turkmenistan
High consumption and high trade	
	Albania, Angola, Azerbaijan, Belarus, Bosnia and Herzegovina, Cambodia, China, Ecuador, Egypt, Georgia, Guinea, Honduras, India, Indonesia, Kyrgyz Republic, Pakistan, Philippines, Morocco, Nicaragua, Senegal, Syria

Structure

Model equations are standard for the selected countries and developing country aggregates (listed above). Land is allocated in a set of nested branches (figure 1). At the top level, land is divided between the sum of forestry and agricultural uses versus other uses. The second stage is the identification of separate forestry and agricultural uses. The third stage divides agricultural land into palm, sugar, groves, pasture, perennials, and annual crops. A fourth and final stage divides annual crops into the ones modeled here and a residual category for other uses. Land allocation at each stage depends on relative prices to the land use options. (Parameter values are discussed below, but the figure represents as well the use of constant elasticity of transformation at upper stages and different cross-crop elasticities at the lowest stage.) Some of the land use returns are recursively determined from external factors, such as the country's income and deflation or international indicator prices. The prices of land allocated to other uses (not forestry or agriculture) and forestry land price, for example, are recursive in this partial equilibrium model. Most land prices are determined by the real returns to the activity, as is the case for individual annual crops, palm, and sugar. The price of pasture land is uniquely a market-clearing price with supply determined based on the land allocation system and demand determined in the feed demand system.

Rounding out domestic crop supplies, yields are functions of a trend and the moving average of current and recent real crop prices. Beyond that point, there is a divergence in the treatment of grains and oilseeds. For rapeseed, soybeans, and sunflower, stock-holding demand is the only component of demand estimated at the level of each oilseed. Supplies net of any stock change are converted into their oilseed meal and vegetable oil equivalents based on the crush rate for the particular oilseed. These calculations give total domestic supplies of oilseed products. For oilseed meal, the domestic uses are for feed and food, as well as for stocks. Palm oil is added to oilseed oils to estimate total domestic vegetable oil supplies.

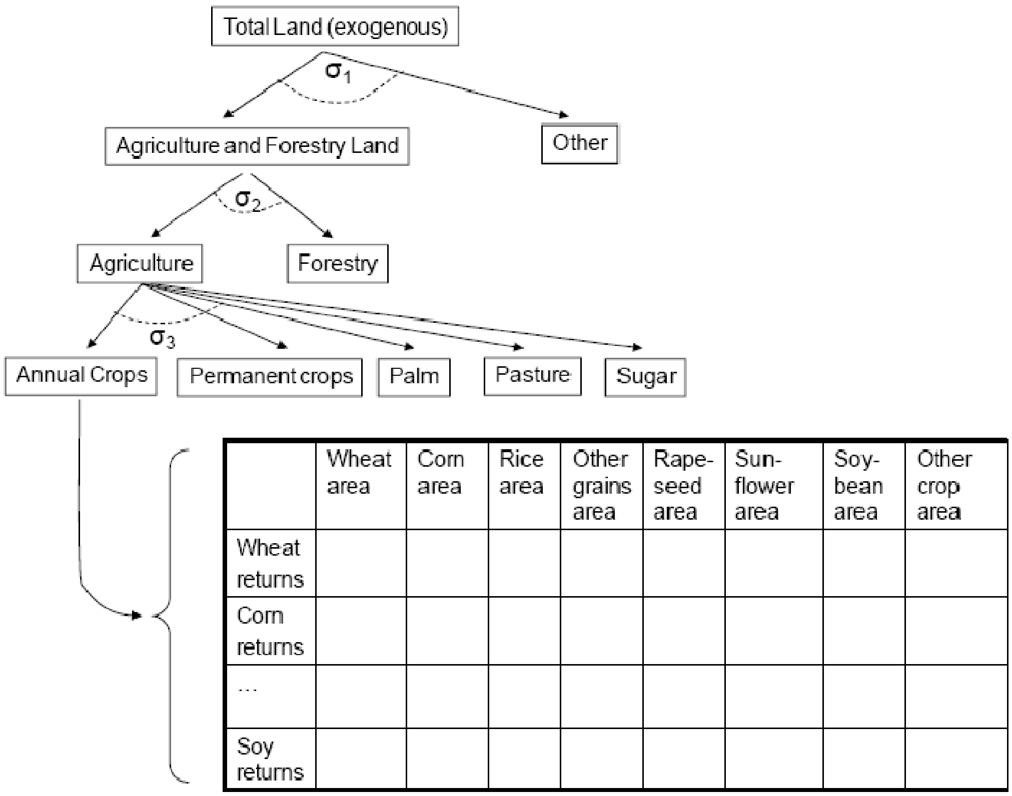


Figure 1. Land allocation system.

Domestic vegetable oil uses are for food or stock-holding. In contrast, the market representation of rice, wheat, corn, and other grains each includes food, feed, and stock uses of that grain. Domestic markets of beef, pork, and poultry are comprised of production, food use, and stocks.

For all commodities, prices are based on world prices times exchange rates. The link to market prices is then buttressed by distinct links to producer prices and consumer prices, both of which depend predominantly on the domestic market price. At all stages, the petroleum price can play a role. Net trade of each commodity is a residual of the domestic market-clearing identity. Commodity markets clear at world levels.

Data

Commodity and land use data are drawn primarily from FAO and USDA. The FAO data on land use are imperfect, with data sometimes surprisingly constant and not entirely up-to-date. Nevertheless, this source spans most of the countries that we represent and the data might be consistent with some of the commodity market data drawn from the same source, namely palm oil. Other commodity quantity data are from USDA/PSD. We accept the risk that commodity market data do not correspond completely with the land use data, leading to us to discount any meaningful interpretation of the residual “other crop” category of annual crop land use. World prices that are consistent with the FAPRI baseline projections are multiplied by exchange rates to give indicator domestic prices over the historical period for purposes of calibration.

Parameters

Parameters are typically based on values found in the related literature but adjusted to be consistent with the equation structure. Land allocation parameters are based on GTAP-PEM (OECD, 2008) and Partial Equilibrium Agricultural Trade Simulator (PEATSim) by ERS and researchers at Pennsylvania State University (Stout and Abler 2004). GTAP-PEM uses a similar nested land allocation system (figure 1), so the parameters seem most applicable at the upper stages. However, the crop-specificity of PEATSim was attractive at the lowest stage of allocation to allow for differentiation in the trade-off between different annual crops instead of relying on a single general parameter. For the lowest stage of land allocation, among annual crops, we use the PEATSim elasticities but rescale them to match the overall parameter of the corresponding stage of GTAP-PEM elasticities. This was intended to make the overall responsiveness at the lowest stage (among crops) consistent with other stages of the nested allocation, but retain the potential that some pairings of annual crops would substitute in land use more readily than other pairings. Oilseed elasticities represent an important exception to our borrowed elasticities: zero is used in place of frequently positive cross-price effects among oilseeds on the assumption that there is typically limited direct competition for land and no complementarity among rapeseed, soybeans, and sunflower. Elasticities were calibrated to 2008 data to ensure symmetry and adding up. Homogeneity is imposed in all years. Upper level coefficients were taken directly from GTAP-PEM, but upper level elasticities are assumed not to be more than one-half the value at the next lower stage. For those countries and aggregates that are not represented in PEATSim or OECD-PEM, we estimated elasticities based on countries that are included but the basic relationship is recalibrated to market data (2008) to take into account relative scales of different commodities in overall land use and to ensure symmetry, adding up, and homogeneity hold at each stage.

Food demand is based on a meta-analysis of demand studies for the modeled countries. Sources include published articles and reports relating to a particular country or commodity based on time series or survey data. These studies often apply demand systems, but the elasticities are not adjusted to ensure compatibility. Other sources are large-scale models such as PEATSim or WATSIM, but preference is given to such models that publish own- and cross-price elasticities. General equilibrium model commodity groups are often too aggregated or the structure, which includes use in intermediate products, too dissimilar for their elasticities to be useful. For each study, the elasticity is matched to the income level that corresponds to the mid-point of the data period. This gives a data set that relates the income elasticities and price elasticities to the level of income for each commodity. Using basic regressions, these relationships are projected forward to the income levels prevailing in each country at the start of the projections period. These values are starting values only. The estimated elasticities are then calibrated to elasticities based on a system approach that can be used to force homogeneity, symmetry, and adding up, although in the model applications discussed here only homogeneity is strictly enforced.

Feed inputs in the system are corn, other grains, wheat, rice, oilseed meal, and pasture land. Initial values for grain feed demand elasticities are chosen based on the assumption that a one percent change in relative grain prices can cause one percent of total grain use (measured in corn equivalent) to switch to the relatively cheaper grain.

The initial assumption for oilseed meal feed demand and pasture land demand is that they are far less sensitive to prices in the absence of good substitutes. These initial values are calibrated to elasticities that are consistent with a translog cost function that enforces homogeneity, symmetry, and adding up.

Stock elasticities are typically assumed to be high (in absolute value), with some distinction based on the country's level of development. Average per capita GDP is used as a measure of development. Price transmission parameters also vary with the level of development and the country's trade status. The effect of a given change in world prices on local prices is assumed to be somewhat larger for developed countries than for developing countries. Within-country price transmission from market prices to producer and consumer prices similarly depends in part on the degree of development. As regards price transmission, it is also important to note the assumption that a one percent adjustment in world prices causes a greater proportional change in the market price of a country that exports that good relative to the case of a country that imports the good.

Elasticities are subject to certain bounds to ensure model stability and plausibility. These limits matter to commodities that are a small share of the overall grouping, whether a food commodity or a feed commodity. If a quantity is particularly low, then the elasticities are removed and the variable is determined recursively from general external conditions without regard to simultaneous prices.

RESULTS

Variants of this model have been used to address questions relating to the effects of US policies on markets in the US taking into account trade and international responses, land use effects, and technology variations.

One study addressed directly the potential that changes in US ethanol policy could limit increases in agricultural commodity prices (Thompson, Meyer, Kalaitzandonakes, and Kaufman 2009). Two possible policy options were tested. First, the tariff on most ethanol imports is discontinued, but the mandates are not changed. Second, the tariff remains in place but the biofuel use mandates are rebalanced to encourage more advanced biofuels, namely sugar-based ethanol from Brazil, instead of corn-starch ethanol. It is assumed that 2.5 billion gallons of the mandate are shifted, so the volume of the mandate that can be met by corn starch ethanol in 2012 is 10.7 billion gallons (instead of the 13.2 billion gallon limit of existing legislation) and imported ethanol must be at least 3.0 billion gallons (as opposed to 0.5 billion gallons). Both options will tend to encourage imports, one by reducing the price domestic users must pay for Brazilian ethanol and the other by requiring that more is imported for use despite the tariff. Both options tend to reduce demand for US corn and consequently reduce pressures on US corn markets (ignoring the indirect feedback of higher sugar prices as Brazilian sugar prices rise).

A key result of this study is that the impact on US markets of either policy option depends on the market conditions, with the case in point being the level of the petroleum price. If the petroleum price is high, such as $125 or $160 per barrel, US demand for ethanol is likely to be above the mandated levels of corn starch and imported ethanol. Because the mandates are not binding at least in the near-term future, rebalancing them has very little effect (figure 2, panel A). The shift causes a small increase in imports at $125 petroleum. At the higher price, there is no direct effect from rebalancing mostly irrelevant mandates. If petroleum is less expensive, such as $55 per barrel or perhaps even $90, then the mandates are more likely to be binding so the policy option to rebalance them in favor of imported sugar-based ethanol has effects in the market. The resulting reduction in corn starch ethanol production leads to lower corn prices.

Eliminating the tariff can have an effect on ethanol markets at all the petroleum prices explored here (figure 2, panel B). Mandates require that at least minimum amounts of certain biofuel types are purchased, so the tariff elimination mostly causes a reallocation from domestically produced ethanol to imported ethanol when the mandate is not binding – namely, if the petroleum price is low. The tariff elimination affects markets if the mandates are not binding because buyers can switch among sources to take advantage of cheaper imports. The reduction in the price of imports is passed on to consumers at least in part, encouraging more ethanol use. (In the simulations with $160 per barrel petroleum, ethanol demand is already so strong that the E10 market is saturated in 2012 and further expansion must be in the E85 market. Because it takes time for to develop delivery infrastructure and to change car fleets, E85 use does not respond as quickly to the falling ethanol price.)

The conclusion of this study is that, at least for the near-term future, either the mandates or the ethanol tariff are likely to affect markets, but the circumstances matter. The mandates tend to have a large effect if petroleum prices are low, but no direct effect at high petroleum prices. The tariff matters at all petroleum prices tested but has a larger effect on US production at lower petroleum prices because imports mostly displace domestic production given that ethanol use does not expand. If these levers are used to reduce US corn demand, then the conditioning factors, such as petroleum price, will play a role in determining the effectiveness of the policy.

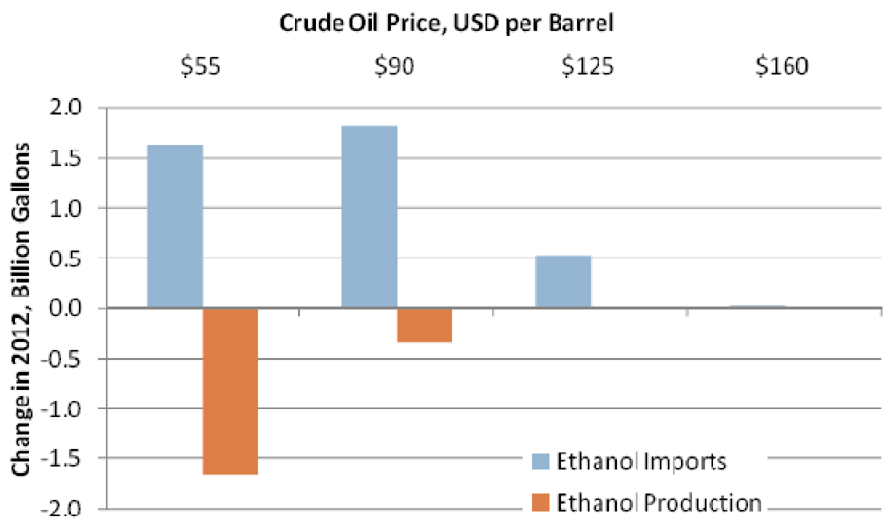
Another study based on this representation suggests that the pace of yield technology improvement interacts with the biofuel use mandate to generate sometimes unexpected results for producers (Kalaitzandonakes *et al*. 2009). This result follows from the basic concept that technology improvements that shift out the supply curve can increase or decrease overall producer returns depending on demand elasticity.

If demand is elastic, then better technologies that shift out supply can lead to more volumes sold with only a slight decrease in the market price so overall returns increase. If demand is inelastic, then the additional volumes only sell at a sharp discount so total returns fall. Historically, corn exports might have been viewed as the most price-sensitive component of US corn demand, with domestic feed and food use typically much less responsive to changes in prices. However, ethanol use has recently been seen by some authors as a nearly perfectly elastic demand for corn (for example, Tyner and Taheripour 2008), making this the most elastic of the major demand categories, in this view, and a growing one at that since ethanol use of corn is now greater than exports.

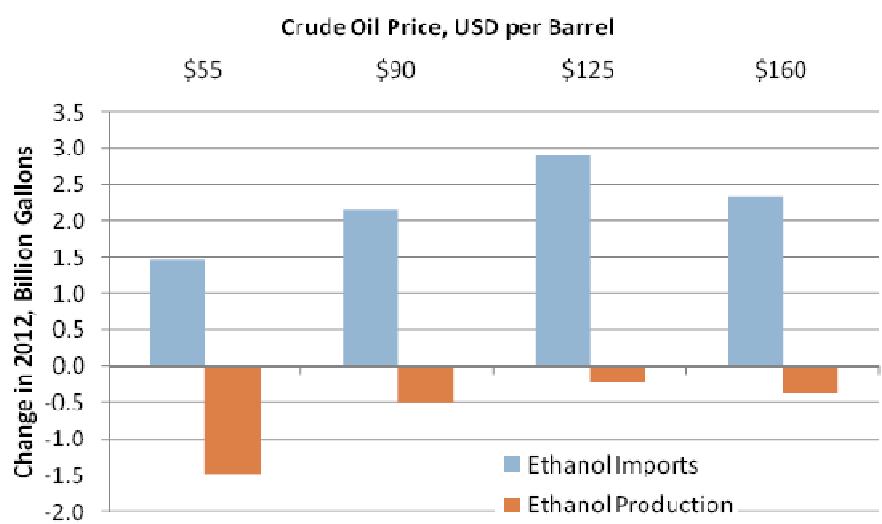
In such a context, better corn production technology such as improved yields might be expected to lead to greater total returns.

Ethanol expansion faces two limits that might reduce elasticity. Neither limit was relevant in the historical period, but both are represented in the forward-looking model.

First, the "blend wall" lies at the natural limit to low-cost ethanol use in the form of E10 or similar fuels that do not require large changes in fuel delivery infrastructure and vehicle fleet. Once the E10 market is saturated, further expansion might require a plummeting ethanol price in order to coax the E85 market to expand. (That point is delayed if E15 or even E20 is permitted.)



Panel A. Effect of changing RFS mandate on U.S. ethanol production and imports.



Panel B. Effect of eliminating the specific ethanol tariff on U.S. ethanol production and imports.

Figure 2. Effect of changing RFS mandate or eliminating ethanol tariff on U.S. ethanol production and imports (Thompson *et al*. 2009).

The second reason to suspect less elasticity in corn use for ethanol is the biofuel use mandate. A binding biofuel use mandate can make ethanol refineries' demand for corn inelastic. For example, without the RFS mandates, higher rates of improvement in corn yield per acre or in ethanol yield would lead to billions of gallons of additional ethanol as corn becomes plentiful and it is more readily converted into ethanol (figure 3). With a binding mandate, however, better technology does not lead to much more ethanol production from corn. In this example, the binding RFS sharply reduces aggregate corn market elasticity. The conclusion of this study is that better corn production technology can lead to lower total returns to the corn producing sector if mandates are binding. In the long-run, negative returns do not persist because corn area falls as land is reallocated to other uses, such as growing soybeans. This study finds that the implications of better ethanol yield from corn for higher ethanol refinery profits also depends on whether or not mandates are binding.

Research also addressed the interaction of US and Brazilian commodity and ethanol markets. The responsiveness of land allocation in Brazil to price signals has implications for agricultural and ethanol markets outcomes (Thompson, Meyer, and Westhoff 2008b). In this exercise, the Brazilian ethanol market is characterized as follows. Ethanol supply response to price changes is very small at first, but it is elastic with the respect to the profitability between ethanol and sugar prices in the long run. Brazilian ethanol demand is very elastic based on widespread use of flexible fuel vehicles. The implications for agricultural markets and land use are assessed for rising US ethanol demand in a context of non-binding mandates. The results are tested for their sensitivity to the speed of land reallocated in Brazil by varying the elasticities of land allocation. Sensitivity testing focuses on the elasticities governing the reallocation of land from forestry or other uses to agriculture.

The higher demand for ethanol in the US leads to more domestic production and imports. For the scales of changes explored, the combination of immediate responsiveness of Brazilian ethanol demand and very elastic medium-term Brazilian supply prove sufficient to meet changing US import needs.

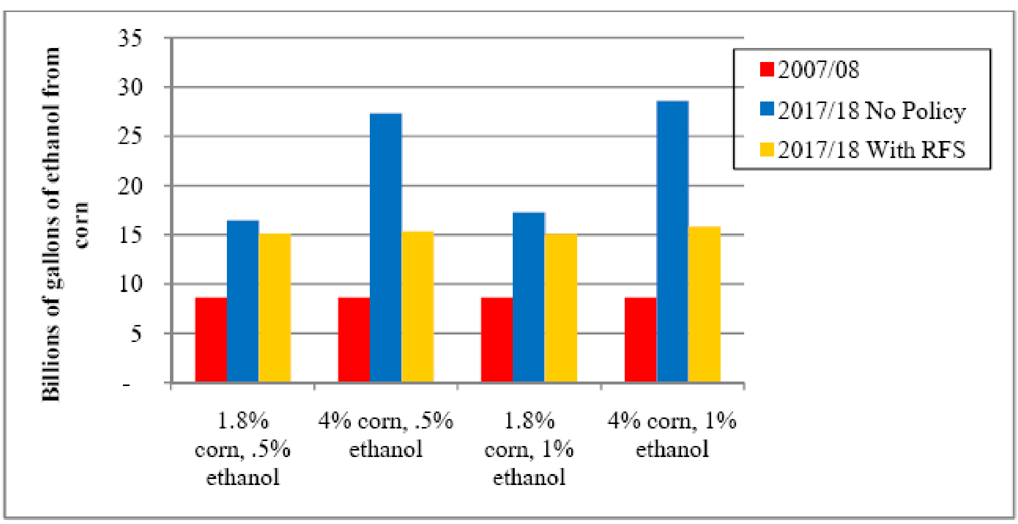


Figure 3. Implications of growth in corn yields and ethanol yields for corn ethanol production (Kalaitzandonakes *et al*. 2009).

If land is converted among uses more readily, then Brazilian ethanol production accounts for a larger share of changes in the US market. One result of this study is that some of the increase in US ethanol use comes at the expense of Brazilian ethanol use. While there are limits to how low Brazilian ethanol use will fall no matter how high the price – and recent events in Brazil suggest that these limits are important now – the modest changes in these simulations did not hit those limits. Thus, one conclusion of this study is that changes in US ethanol use might be achieved in part by changes in Brazilian ethanol use, at least over certain ranges. Policies intending to increase global ethanol use might usefully take into account this potential.

The results of this study have another implication. Land use elasticity in Brazil is important to questions about US ethanol policy's indirect land use and food price effects according to the results of the model. First, consider the case that land reallocation to agriculture is less elastic. As ethanol prices in Brazil rise, sugar prices are bid higher and more land is drawn into sugar production. Less area is used for annual crops, like soybeans, or devoted to some other uses. Because of the assumption that very little land can be switched to agricultural use overall, the production of other commodities in Brazil falls. In this case, world market price effects of the higher US ethanol demand are more pronounced since overall supply response is lower. Next, consider the case that land reallocation from forestry or other uses to agriculture is more elastic. Rising agricultural commodity prices associated with US biofuel support leads to greater crop output from Brazil. The greater responsiveness of overall supply restricts the magnitude of world price increases. From this sensitivity testing, the study draws a second conclusion. Researchers and policy makers should expect a trade-off of sorts between indirect land use effects and food commodity price impacts of greater ethanol use. Expectations of simultaneous large indirect land use effects and large food commodity price increases might be inconsistent.

New work with this model explores additional questions about the effects of biofuel expansion on world agricultural markets and food use. Current research estimates how continued growth in US and EU biofuel feedstock uses of grains and vegetable oil affect greenhouse gas emissions. This research supports the view that yield responses are an important element in determining land use changes and, hence, greenhouse gas emissions (Keeney and Hertel 2009). To that finding, current research supplements a forward-looking component using a method of comparing baseline and scenario projections over a medium-term future simulation period. This process can identify sensitivity to the baseline path.

These experiments also give initial estimates on the effects of discontinuing the trend toward greater biofuel feedstock use in the US and EU. If these purchases were to be discontinued instead of increased, for example, then world demand for grains, vegetable oils, and to a lesser extent sugar would be lower. (Brazilian sugar purchases for ethanol production are not changed.) Simulations suggest that prices of wheat, corn, other coarse grains, and vegetable oil would fall by more than a quarter (table 2). These changes would result in lower rice and sugar prices partly as a consequence of land shifting away from crops with falling prices. Another reason for the falling rice price is lower demand as consumers opt for cheaper foods and feeds where possible. This effect is less pronounced for sugar as there are fewer substitutes. Lower feed costs gradually lead to greater meat output and consequently lower prices, but this effect is still building momentum at the end of the projection period. Even so, the end result for meat prices is likely to differ from the crop prices shown. Largely as a result of its status as a co-product with vegetable oil and the land use changes, the change in the world oilseed meal price is a more modest -7%. This smaller effect is especially relevant for poultry and pork because they are fed more oilseed meal.

Table 4. Effects of Eliminating US and EU Biofuel Feedstock Purchases on Developing Country Food Consumption, 2017/18

		Developing Country Aggregates			
	Changes in World Prices	High food High trade	High food Low trade	Low food High trade	Low food Low trade
Wheat	-27%	7.1%	6.2%	8.7%	7.4%
Rice	-17%	0.6%	0.6%	1.2%	2.0%
Corn	-27%	9.2%	7.1%	11.1%	11.5%
Other grains	-26%	3.0%	2.3%	5.4%	5.4%
Vegetable oil	-30%	7.3%	9.0%	9.5%	9.3%
Sugar	-11%	-0.1%	-0.6%	0.9%	0.6%
Beef	-14%	2.2%	1.1%	2.2%	2.0%
Pork	-16%	2.5%	1.8%	1.6%	0.5%
Poultry	-13%	1.9%	-0.1%	2.2%	2.0%

The implications of the array of falling world prices for each developing country group depends on its link to world markets (see the section on model parameters, above). Interpretation is complicated by the cross-price effects.

A sharp decrease in any individual crop price might lead to a substantial increase in the food use of that crop as consumers substitute to use it. Here, however, the broad decrease in agricultural commodity prices means many of these cross-price effects offset one another. Said differently, our representation implies a low aggregate food demand response to lower food prices overall, even in developing countries. Vegetable oil and sugar are somewhat different because the other commodities listed here are typically less substitutable for these two commodities. As such, the sharp fall in vegetable oil prices leads to a somewhat larger increase in food use than a comparable price change in one of the food grains, wheat or rice.

The changes in corn and other grain food use is not very important in these developing country aggregates as they account for a much smaller share of consumption than the other commodities listed here. Food use effects tend to be larger in countries that have lower food consumption and are consequently more sensitive to price changes. Food use increases also tend to be larger in countries that are better integrated with world markets through greater trade (exports or imports).

To summarize these preliminary estimates, the substantial simulated reductions in world prices cause greater food consumption in developing countries but not sharply higher food use because of the limits to price transmission into these countries and the expectations about partly offsetting cross-price effects.

LESSONS LEARNED

As with any model experiment, there are limitations to this model at present. This work relies on land use data that are not updated as frequently or as reliably as the commodity market data. While the meta-analysis and calibration process to develop model parameters offers some reassurance, results depend on coefficients about which there is some degree of uncertainty. The model is still in development; new work using this model studies the implications of various biofuel policy or production paths on land use, greenhouse gas emissions, and food consumption in key producing countries and in developing countries.

Key results of this model that have already been published indicate that market results of US biofuel policies are sensitive to the baseline levels and the mandates. Forward-looking analysis should take into account the rising volumes that must be used to meet the mandates (unless waived) and the conditioning factors, such as petroleum prices and corn yields, that determine whether or not the mandates are binding. Moreover, the distinction among types of feedstocks in the mandates interacts with other US biofuel policies, namely the tariff, such that the consequences of one element of policy are dependent on the influence of another.

Results are also sensitive to the parameters representing underlying economic and technical constraints on such decisions as the allocation of land among various uses and the ability of consumers to substitute ethanol for gasoline. US policy and short-term obstacles to market adjustment reduce the responsiveness of ethanol use to price signals and consequently can affect overall US corn demand elasticity in the near term, leading to the expectation that corn sector technological improvements can reduce overall returns in the near-term future. Conversely, backward-looking analysis or studies that assume perfect substitutability between gasoline and ethanol can be used to drive the corn price as a function of the gasoline price could suggest the opposite result. More generally, the elasticity of US corn markets is in question, with these two perspectives leading to very different views about how shocks to supply or other demands would affect prices, producers, and consumers. Another lesson is that US biofuel policy initiatives might be better informed if they recognize that changes on world ethanol use in the US is likely to have an opposite but smaller effect on the quantity demanded abroad, particularly in Brazil. Finally, policy and popular debate should recognize that greater indirect land use change would imply higher elasticity and smaller increases on food commodity prices for a given change in US ethanol use, whereas a sharper rise in food commodity prices owing to the same change in US ethanol use is consistent with lower supply response and a smaller indirect land use change.

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THE FAPRI APPROACH: A FEW KEY PRINCIPLES

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ABSTRACT

The papers in this volume highlight the diverse ways that the FAPRI modeling approach has been applied to the differing needs of different countries and policy settings. Some common principles guide FAPRI-affiliated researchers: good analysis requires both good analytical tools and good analysts; cookie-cutter approaches rarely succeed; baselines matter; bigger models are better, to a point; and understanding the audience is as important as understanding markets and policies.

JEL codes: Q11, Q18, C52.

Keywords: policy analysis, policy modeling, FAPRI approach.

The articles in this volume have shown different applications of the FAPRI approach to modeling agricultural markets and policy. These applications all use common baseline projections for world agricultural markets as a point of departure, and they apply a common set of principles to analyzing a wide range of policy and other issues in very diverse settings.

Meyers, Westhoff, Fabiosa and Hayes describe the basic modeling approach used by FAPRI analysts and summarize the world baseline projections used in the other papers. Meyer, Binfield and Westhoff extend the basic FAPRI model to investigate the relationship between energy and agricultural markets in a stochastic framework. Han and Lee develop a model of South Korean agricultural markets that is used to evaluate impacts of a U.S.-South Korean free trade agreement for an exhaustive list of food commodities. Strauss and Meyer combine stochastic analysis with business strategy methods to analyze South African agricultural policy choices. Hanrahan, Donnellan and Chantreuil use a model developed jointly by analysts from across Europe to examine national and EU-wide impacts of changes in the European Union's Common Agricultural Policy (CAP). Moss, Patton, Binfield, Zhang

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and Kim also examine issues related to the CAP, but using a model that allows them to estimate impacts on different regions within the United Kingdom. Finally, Thompson links the FAPRI U.S. model to a model of world markets to investigate the global food security and land use impacts of U.S. biofuel policies.

That FAPRI-affiliated researchers have used a variety of approaches to examine a wide range of market, policy and other issues has been made clear by the papers in this volume. This diversity makes it hard to provide a succinct description of “the FAPRI approach” to market and policy analysis. A few key principles guide and are a hallmark of FAPRI-affiliated researchers and their analytical reports.

First, good analysis requires both good analytical tools and good analysts. FAPRI has stressed the importance of building and maintaining models that reflect the most important aspects of agricultural markets and policies. Even the best model, however, is of limited value if it is not operated by a skilled analyst. All models have limitations since by design they are approximations of reality, and no model is suited to address every question. Good analysts understand both the power and the limits of the models they use. They also have taken the time to understand the nuances of specific markets and policies, both so that they can develop the best possible analytical tools and so that they can recognize results that are somehow flawed.

Second, cookie-cutter approaches are unlikely to succeed. It is helpful to have standard ways to represent certain types of relationships in a model, but there has to be room for tailoring model specifications to different types of market and policy issues. For example, equations determining the feed use of grain tend to share a common set of explanatory variables, but crop supply equations may need to be quite diverse. No single approach can capture all the ways that government policies affect producer supply decisions and the market; analysts must have the flexibility to modify standard specifications to better match the reality of markets and policies in particular places at particular times.

Third, baselines matter. Even when the primary objective is to estimate the impacts of policy alternatives, it is a mistake to assume that the point of reference is unimportant. Policy makers and other non-economists are less likely to find analysis credible when the scenarios are evaluated relative to a baseline that is out of date or otherwise considered inconsistent with current reality or future expectations. Furthermore, there are many cases where the impacts of policy changes are baseline-dependent. Many policies have asymmetric effects. Some policy changes may have very large impacts under some circumstances and little or no impact under other circumstances. For example, biofuel use mandates may be very important when oil prices are low and biofuel use is otherwise unattractive, but they are far less relevant when high oil prices provide strong incentives for biofuel use.

Fourth, bigger models are better, to a point. A model that is too narrow, that focuses only on a particular commodity or country, is likely to miss many issues of great importance. Something that causes a shift in domestic corn supply or demand will not only affect domestic corn prices, but corn supply and demand in other countries, the supplies of competing crops, and the livestock sector. The resulting changes in corn trade, the prices of competing crops and livestock production, in turn, have important effects on the domestic corn market. A good model must be able to capture the salient relationships among these closely related markets. However, it is not always better to expand the size and scope of a model. The bigger the model, the more time and resources it takes to build and maintain and the greater opportunity for modeling error. Judgments must be made about what is truly important and what is not.

Fifth, understanding the audience is as important as understanding markets and policies. FAPRI researchers communicate regularly with policy makers and other users of FAPRI analysis. Not only does this help identify the issues of greatest interest, but it also clarifies the type of information most likely to be of value to end users. Quite often, the target audience may know a great deal about the policy or market issue but have little training in economics, so it is important to report indicators to which they can relate. For example, discussing effects on producer and consumer surplus may be very meaningful to fellow economists, but policy makers may prefer to see estimates of impacts on net farm income, the consumer price index for food, and federal budgetary outlays on a fiscal year basis. This attention to the audience also means understanding the time frame in which decisions are made—even the best analysis is of little value if delivered the day after the vote is taken or the agreement signed.

FAPRI has maintained these basic principles throughout its 25-year history. While the principles have stayed the same, the models are revised constantly to better reflect developments in theory, markets and policy. Experienced FAPRI analysts leave our group to take on new challenges at other institutions and new analysts join the team and provide new perspectives. The models provide useful tools, but the future success of the FAPRI approach will continue to depend primarily on the skill and judgment of FAPRI analysts.

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