Effects of Recent Fossil Energy Market Developments on US Ethanol

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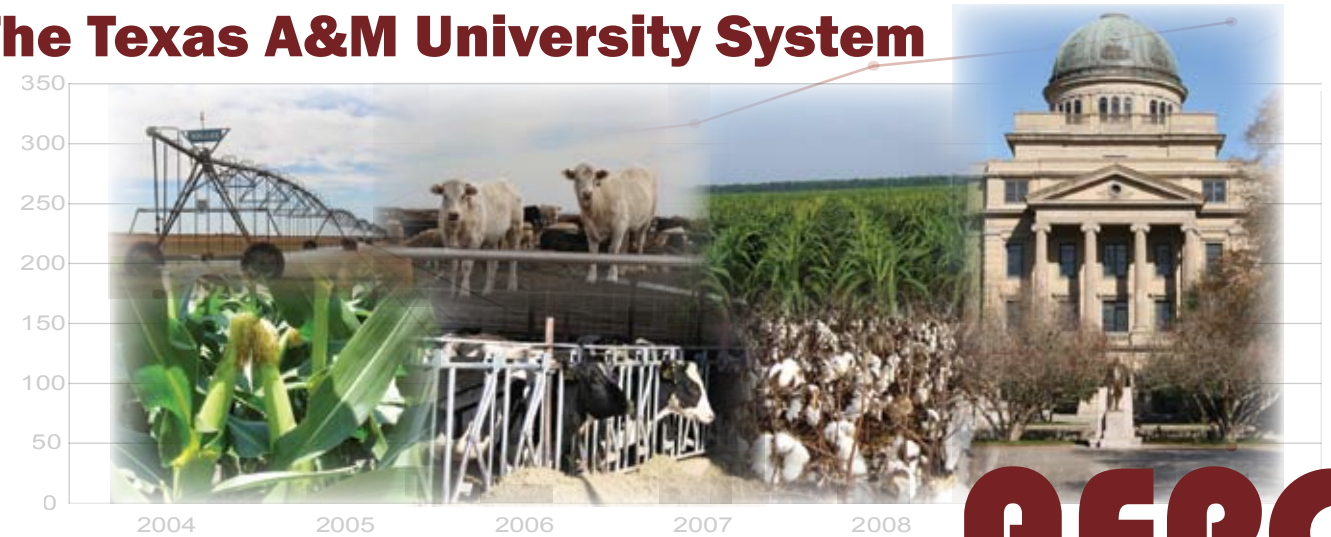

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Executive Summary

Background:

- After several months of increases, fossil fuel prices decreased substantially in August and September of 2006 (figures 1 and 2).
- Crude oil prices directly affect gasoline prices, which are an important determinant of ethanol demand. Natural gas prices are an important cost of ethanol production.
- This briefing paper provides projections of ethanol and corn prices, production, and use, given recent developments in fossil fuel markets.

Data and Methods:

- This study utilizes a stochastic simulation model with three main components, representing fossil energy, agriculture and renewable fuels markets.
- Fossil energy prices are taken as exogenous to the other two model components. Futures and options contract prices observed at the New York Mercantile Exchange are use to simulate possible future paths for fossil energy prices.
- Agricultural markets are represented by a large scale econometric model maintained by the Food and Agricultural Policy Research Institute (FAPRI).
- Equilibrium displacement methods are used to model the response of agricultural markets to varying levels of activity in renewable fuels markets.
- Renewable fuels markets are modeled using four representative production technologies: ethanol produced by wet corn milling, ethanol produced by dry grain milling, biodiesel produced using virgin oil, and biodiesel produced from yellow grease. Throughput use and costs for these four technologies have been assembled from numerous sources.
- Renewable fuels' demand is based on imputed fuel substitution value (taking relative energy content in to account), government use mandates, and minimum levels of use for oxygenating gasoline and enhancing the lubricity of ultra-low sulfur petroleum diesel fuel.

Results:

- Despite recent increases in fossil energy prices, ethanol production is expected to continue to increase as fast as production capacity can expand.
- Ethanol production will increase from around five billion gallons in 2006 to over seventeen billion gallons in 2014 (table 1).
- Ethanol prices are expected to be somewhat lower than previously anticipated, at slightly under $2.50 per gallon for the next few years.
- By the 2014/2015 crop year, ethanol use will account for approximately 53% of corn production (table 2).
- Feed use of corn is expected to decline about 15% from current levels over the next nine years, while exports are expected to decline approximately 29%.
- Corn prices are expected to average $2.42 per bushel in the 2006/2007 crop year, and rise considerably as ethanol bids corn away from competing uses.

Background

Petroleum prices have declined substantially in August and September of 2006 as tensions regarding Iranian nuclear research have eased and the Atlantic hurricane has failed to produce any major storms threatening Gulf of Mexico oil production. The price of crude oil to be delivered in approximately one month on the New York Mercantile Exchange (NYMEX) has declined from around $76 per barrel in early August to around $61 as of September 22 (figure 1). This has resulted in decreased gasoline prices, which directly affects ethanol demand. Similarly, natural gas prices have declined approximately $3 per MMBTU over this period (figure 2). Natural gas is the fuel primarily employed in the drying of distillers' grains, and thus effects the net cost of ethanol production.

Prior to these recent price declines in fossil fuel markets, forecasts called for the cost of production for grain-based ethanol to be below the price of gasoline for the next several years. Consequently, 100% capacity utilization for ethanol production has been expected for the foreseeable future, even as that capacity rapidly expands. Expanding ethanol production has been expected to result in ever greater proportions of the corn crop going to ethanol production, even as yields increase. Exports and feed use of corn have been expected to decline in coming years, both in absolute numbers and as proportions of total use.

This briefing paper provides revised projections of ethanol and corn prices, production and use given recent developments in fossil fuel markets. The results follow a description of the modeling approach.

Modeling Approach and Data

The model used in this analysis is an annual model of the interaction between energy and agricultural markets, with most variables measured as US averages.[1] The model has three major components. The first component reflects fossil energy markets. Raw fossil energy prices are taken as exogenous to the other components of the overall model. Observed prices for NYMEX futures contracts and options on futures are used to develop probabilistic price forecasts for crude oil and natural gas. Future paths of crude oil and natural gas prices are simulated assuming that spot prices evolve following a geometric Brownian motion. The volatility parameter for this evolution is inferred from nearby option premiums using the Black futures option pricing model.[2]

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[1] The model is described in somewhat greater detail in AFPC Research Report 06-3, "US Ethanol Production and Use Under Alternative Policy Scenarios", available at http://www.afpc.tamu.edu/.

[2] Technically, the volatility parameter inferred in this manner is applicable to the nearby futures contract rather than the spot price. The NYMEX contracts considered here have one delivery every month, however, and the nearby contract is thus never far from delivery. Moreover, spot prices for these commodities are often so uncertain that nearby futures prices are generally the best available proxy.

Crude oil and natural gas price forecasts are then used to develop price forecasts for the US average price of premium unleaded gasoline and methanol, respectively. These forecasts are made using simple linear models estimated using annual historical data from 1986 through 2005 for crude oil/gasoline, and 1991 through 2005 for natural gas/methanol. Closing prices for all contracts as of 22 June 2006 are employed.

The second major component of the overall model is the agricultural sector. Probabilistic price and quantity forecasts generated by the large-scale econometric model maintained by the Food and Agricultural Policy Research Institute (FAPRI) at the University of Missouri are employed for this component. This model represents the interrelationships among domestic and international markets for all major agricultural commodities using approximately one thousand equations. Stochastic output representing five hundred possible futures states of the world are generated using the FAPRI model at least once per year.

The output of the FAPRI model is adjusted to reflect activity in renewable fuels markets using equilibrium displacement methods. Some levels of ethanol and biodiesel production will already be reflected in the FAPRI output, and the adjustments are to these levels. Price elasticities of demand (own and cross price) and acreage response measurements have been collected from prior literature and averaged.

The chain of displacements to the FAPRI model output for corn and ethanol are as follows. First, the level of corn use for ethanol production emanating from the renewable fuels component of the overall model (discussed below) is compared to the level reflected in the FAPRI output. The difference in these levels is used, in conjunction with the price elasticity of non-ethanol demand for corn to adjust the price of corn. This price adjustment follows through to affect the levels of feed and export use.[3] Also, the change in price from the FAPRI scenario is carried forward to affect corn and soybean acres in the following year. Soybean displacements due to biodiesel production follow a similar pattern.

The third major component of the overall model represents the renewable fuels markets. For the ethanol market, supply and demand are obtained from the optimizing behavior of producers and consumers. Demand follows two possible regimes. In one regime, a constraint on the minimum level of use is binding. This minimum level is the greater of the RFS (adjusted for biodiesel production) for a particular year. Levels of reformulated gasoline (RFG) used in recent years are linearly extrapolated forward, and imputed minimum levels of ethanol use are calculated, assuming that the finished blended motor fuel will contain 5.7% ethanol by volume (this implies approximately 2% oxygen content by weight).[4] The RFS (and level of biodiesel that is produced) determine the minimum level of ethanol that must be used. The level of biodiesel to be used in future years is currently specified as an assumed proportion (0.5%) of total on-road diesel fuel use in coming years, which is forecast by linearly extrapolating use in recent years. This reflects the common perception that demand for biodiesel is likely to stem largely

[3] Food, seed, and high fructose corn syrup use are assumed to be unaffected.
[4] This reflects the removal of MTBE from use as a fuel oxygenate in the US.

from its ability to enhance the lubricity of newly-required ultra-low sulfur diesel (ULSD) fuel. It is quite possible that greater quantities of biodiesel could be consumed, and this reflects a source of uncertainty regarding the model's results.

The second regime for ethanol demand reflects fuel extension use, whereby ethanol is consumed as a substitute for gasoline. After accounting for differences in energy content, ethanol is nearly a perfect substitute for premium unleaded gasoline.[5] As such, rational consumers will consume ethanol to the extent that its price is less than that of premium gasoline, and the price of gasoline will effectively serve as a floor for ethanol prices (on an energy equivalent basis). Undiluted conventional (i.e., not reformulated or oxygenated) unleaded gasoline contains 125,071 British thermal units (BTU) per US gallon, while fuel ethanol contains 84,262 BTU per US gallon. These values are used in conjunction with per gallon prices for these fuels to calculate per BTU prices.

Supply of ethanol is based on ethanol production technology, throughput prices, the excise tax exemption, and industry structure. The model contains two representative production technologies, wet and dry corn milling. Technical coefficients and unit costs associated with these technologies are based on averages of measurements from numerous sources. Industry structure information consists of the current nationwide production capacity for each of the two technologies. Total current capacity is 4.8 billion gallons per year, of which approximately 1.3 billion gallons is wet mill. Ethanol production capacity for 2006 and 2007 reflects this existing capacity and new capacity that is currently under construction. After 2007, expansion of annual production capacity is assumed to occur at the rate of 1,500 million gallons per year.

The quantity of ethanol produced in each year is determined in sequence, from earliest to latest, with the impacts of renewable fuels production on agricultural markets feeding forward to the following years. For each year, the range of feasible ethanol production quantities is evaluated for possible solutions. If the marginal cost of ethanol production is above its imputed gasoline substitution value (net of the excise tax exemption) for all feasible quantities, then the minimum production constraint is binding (i.e., the quantity required for the RFS will be produced). If the marginal cost of production is below the imputed gasoline substitution value, then the maximum production constraint (based on production capacity) is binding. Finally, there may be an interior solution where some level of production results in a marginal cost that just equals the imputed gasoline substitution value.

The supply schedule is upward sloping in spite of the fixed proportions production technology due to the fact that ethanol production must bid corn away from other uses, which is increasingly expensive as more corn is used. The marginal cost of ethanol production is reduced by the $0.51 per gallon federal excise tax exemption and an assumed average level of state incentives of $0.03 per gallon.

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[5] Premium unleaded gasoline is more like ethanol than regular unleaded gasoline, owing to ethanol's high octane rating.

Results

Despite the recent decreases in fossil energy prices, the cost of producing ethanol is expected to remain below its value as a gasoline substitute for the foreseeable future. Ethanol prices and production levels are presented in Table 1. Ethanol production in the US is still expected to continue at full capacity, even as that capacity rapidly expands. Total production is expected to top five billion gallons in 2006, expanding to over seventeen billion gallons in 2014. Ethanol prices will be somewhat lower than previously anticipated, however, at slightly under $2.50 per gallon for the next few years.

Corn used for ethanol production will be commensurate with the expected high levels of ethanol production. Over 2.3 billion bushels will be used for ethanol production in the 2006/2007 crop year, rising to 6.9 billion bushels in the 2014/2015 crop year. This will represent approximately 53% of 2014 production. Thus ethanol is expected to consume all increases in corn production accruing from yield increases, and still divert corn from feed and export use. Feed use is expected to decline about 15% from current levels over the next nine years, and exports are expected to decline approximately 29%. Average corn prices are expected to increase from $2.42 per bushel in the 2006/2007 crop year to $4.80 per bushel in the 2014/2015 crop year, as ethanol production bids corn away from competing uses.[6] USDA suggests that an additional 10 million acres need to be added to corn plantings to moderate prices. This is expected to dampen the corn prices more than these model results indicate.

[6] The equilibrium displacement methods employed in this model are best-suited to considering marginal changes in markets rather than the large changes to FAPRI's forecasts that are anticipate here. As such, the results presented for later years are offered with the caveat that structural and behavioral change that is outside of the scope of the model renders the quantitative forecasts (e.g., the corn price) highly uncertain.

Figure 1: New York Mercantile Exchange Nearby Crude Oil Futures Price

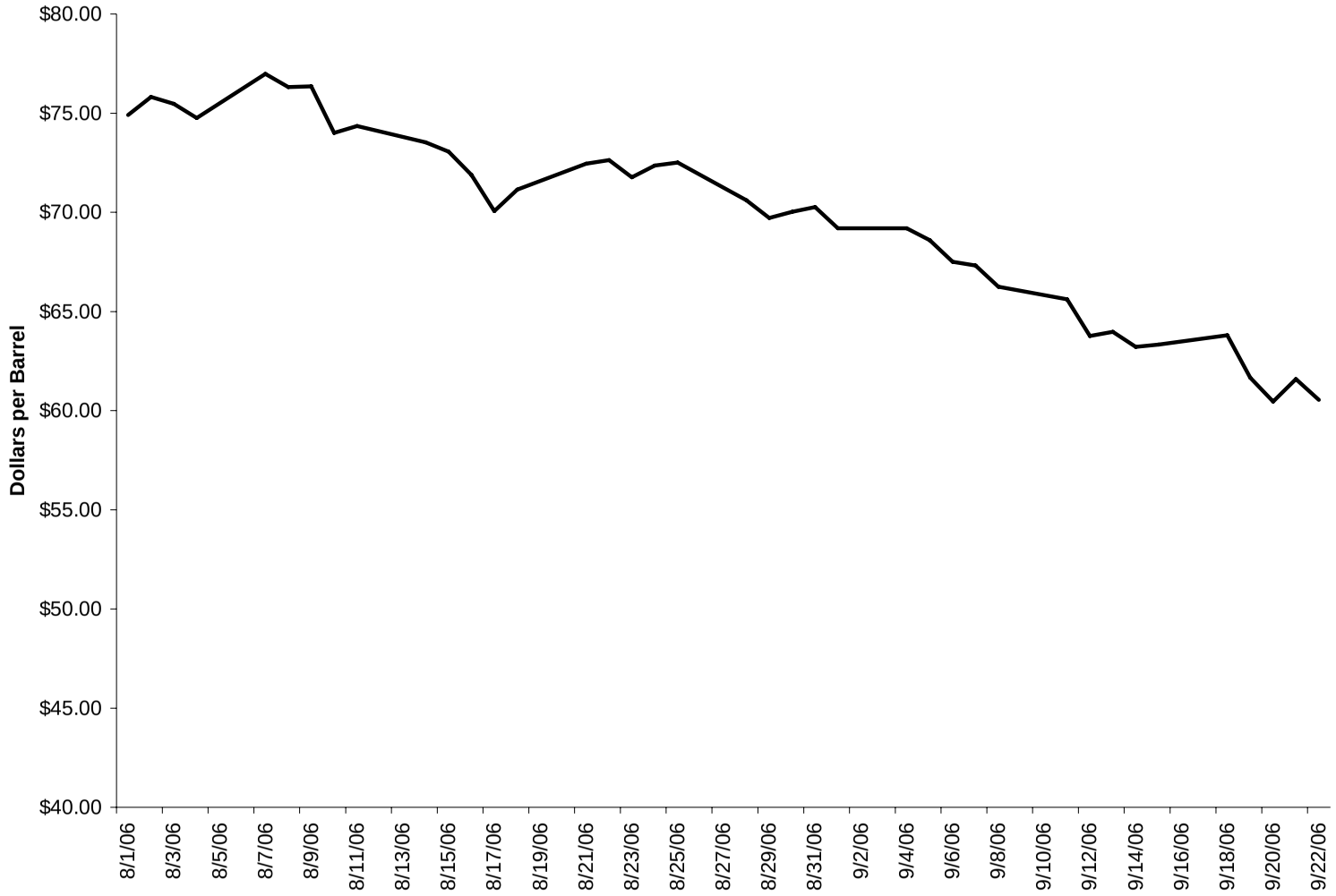

Figure 2. New York Mercantile Exchange Nearby Natural Gas Futures Price

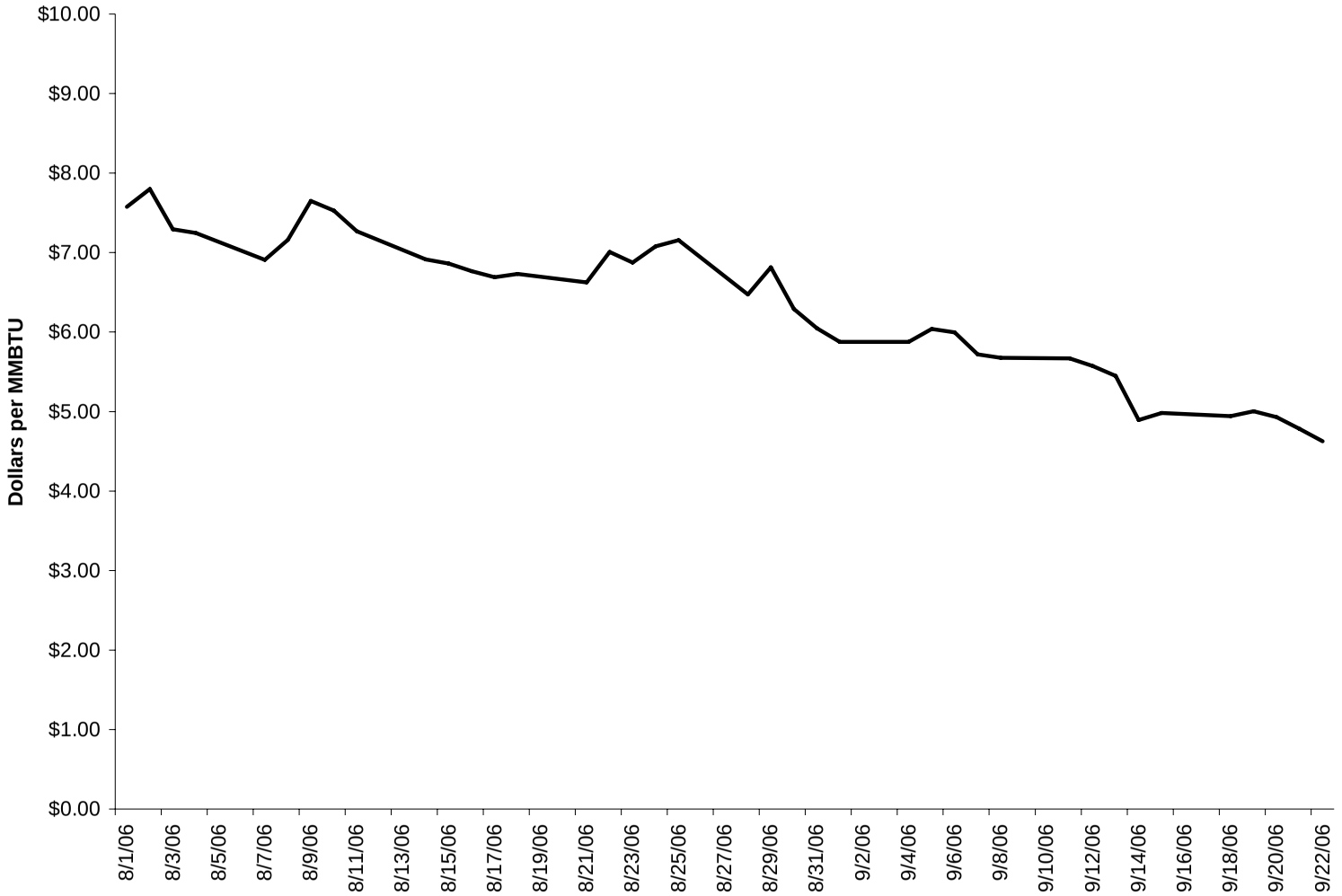

Table 1. Energy Prices and Ethanol Production

	2006	2007	2008	2009	2010	2011	2012	2013	2014
Fossil Energy and Fuel Prices					(Dollars)				
West Texas Intermediate (per barrel), Cushing, OK	64.82	65.90	64.79	63.11	61.69	60.59	59.18	57.77	56.37
Premium Unleaded Gasoline (per gallon), US Ave.	2.96	3.00	2.96	2.90	2.85	2.81	2.76	2.71	2.66
Natural Gas (per MMBTU), Henry Hub, LA	7.290	7.777	7.636	7.494	7.410	7.408	7.405	7.403	7.400
Methanol (per gallon), US Gulf Coast	0.91	0.95	0.94	0.92	0.92	0.92	0.92	0.92	0.92
Ethanol					(Dollars)				
Ethanol Price, U.S. Ave.	2.45	2.46	2.48	2.46	2.41	2.38	2.35	2.32	2.29
					(Million Gallons)				
Wet Mill Production	1247	1247	1247	1247	1247	1247	1247	1247	1247
Dry Mill Production	3834	5496	7123	8623	10123	11623	13123	14623	16123
Total Production	5081	6743	8370	9870	11370	12870	14370	15870	17370
Capacity Utilization	100%	100%	100%	100%	100%	100%	100%	100%	100%
					(Million Tons)				
Grain Used	53.9	71.3	88.4	104.1	119.9	135.6	151.3	167.0	182.8
DGS (dry weight)	12.2	17.5	22.7	27.5	32.2	37.0	41.8	46.6	51.3
Gluten Feed	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Gluten Meal	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7

Table 2: Corn Supply, Utilization, and Price

	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15
Production				(Million Bushels)					
Harvested Acres (millions)	73.0	76.2	77.9	79.9	81.7	83.5	85.1	86.3	87.6
Yield (bushels per acre)	147.0	149.1	150.8	152.8	154.6	156.4	158.6	160.4	162.3
Supply	12,746	13,024	13,207	13,479	13,790	14,128	14,499	14,842	15,202
Beginning Stocks	2,014	1,653	1,446	1,261	1,139	1,051	997	988	964
Production	10722	11361	11751	12207	12641	13066	13492	13844	14228
Imports	10	10	10	10	10	10	10	10	10
Domestic Use	9,417	9,985	10,425	10,887	11,351	11,803	12,237	12,645	13,056
Feed, Residual	5721	5654	5535	5435	5340	5236	5118	4975	4837
Fuel Alcohol	2336	2970	3531	4093	4655	5217	5779	6340	6902
HFCS	510	509	507	505	503	498	493	487	480
Seed	21	21	21	21	21	21	21	21	20
Food, Other	829	831	831	832	832	830	827	822	817
Exports	1676	1593	1520	1453	1388	1328	1274	1233	1193
Total Use	11,093	11,578	11,945	12,340	12,739	13,131	13,511	13,878	14,249
Prices and Returns				(US$ per Bushel)					
Farm Price/bu.	2.42	2.66	2.97	3.25	3.53	3.86	4.16	4.49	4.80

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