Production of Biomass in the Louisiana Sugarcane Belt: What could it mean for the sugar industry?

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Introduction

As the United States and the rest of the world continue to expand renewable sources of energy there is going to be increased competition for land for the production energy and food crops. The explosion of first generation ethanol has contributed to shift in the American agricultural crop mix, specifically the increase of corn production at the expense of cotton production in the Mississippi Delta (Figure 1). Further changes in this crop mix are potentially on the way now with the ratification of the Energy Independence and Security Act of 2007. This policy mandates that at least 36 billion gallons of biofuels be used by 2022 and in particular 16 billion gallons of cellulosic ethanol be produced (OPS, 2007). In order for this mandate to be achieved each state within the United States should produce the energy crop(s) for which they have a competitive advantage of biofuel production. There are a multitude of potential feedstocks (e.g. switchgrass, hybrid poplar, energy cane, miscanthus, etc.) that could be used in the production of cellulosic ethanol.

The focus area of this research is the sugar market and in particular the introduction of energy crops into the sugarcane belt of Louisiana. Potential crops being considered for this area are: energy cane, switchgrass, mischanthus, sweet sorghum, etc. Energy cane is a type of sugarcane that produces higher levels of fiber and lower levels of sucrose than are desired by sugar mills for use in sugar production. Within this region many producers are struggling to continue operating due to stagnate prices and rising input costs. Furthermore, yields in this region are lower relative to other sugarcane producing area because Louisiana has the shortest growing season of four sugarcane producing states. A number of the producers in this area especially on the periphery of the region are considering a switch to energy crop production for use in the production of cellulosic ethanol. A loss of sugarcane acreage in this area could have significant impacts on the domestic sugar market. This impact could be exacerbated if the sale of 180,000 acres of sugarcane land owned by U.S. Sugar is actually sold to the state of Florida to be turned back into Everglades (Cahn and Reid, 2008). Florida and Louisiana together accounted for 90 percent of harvested acres of sugarcane acres in the US, shown in figure 2 (NASS, 2009). In Louisiana alone since 2002 the harvested acres of sugarcane has decreased by 18 percent or 85,000 acres (NASS, 2009). Some contributing factors to this decrease in sugarcane acreages are increased transportation costs and a decreasing number of sugar mills operating in the state. Since 2000, the number of sugar mills in the state has decreased by 33 percent to just 12 remaining mills and the majority of them are located in the heart of the sugarcane belt (ALCS, 2009).

The objectives of this study threefold. First, estimate the supply and demand for domestic sugar. Second, a scenario analysis is constructed using the supply and demand estimates to analyze different levels of harvested sugarcane acreages and its impact on domestic sugar price. Third, examine how decreases in sugarcane acreages could potentially impact TRQ.

Methodology

In order to examine the impact on domestic sugar and ethanol prices a simultaneous equations system is employed. Within this system supply and demand for sugar within the US is estimated. Furthermore, in this system, some of the explanatory variables are endogenous which requires the implementation of instrumental variables. Thus, three stage least squares estimation is applied allowing for asymptotically efficient estimators achieved through the use of an efficient weighting matrix and given that appropriate instruments are selected.

The equations for this estimation are adopted from Benirschka, Koo, and Lou (1996). The conceptual model for the estimation is broken down into sugar supply, demand, and imports.

Furthermore, behavioral equations for harvested area, yield, production, consumption, and ending stocks are added.

Sugar Supply

Sugar in the US is produced from either sugarcane or sugar beets. Traditionally, the majority of sugar produced in the US comes from sugar beet production which accounts for on average 54 percent of US production over our dataset. Total sugar supply is a function of harvested acres and yield.

Area Harvested

Harvested acres are a function of expected sugar prices and alternative crops. As in the original formulation lagged prices are included as proxies for price expectations. The acreage equation also includes a lagged acreage and time trend variable. Equation 1 is:

(1) $$ah_t^s = f(ah_{t-1}^s, p_{t-1}^s, p_{t-1}^c)$$

where ah^s is area harvested for sugarcane or sugar beets, p^s is domestic raw sugar price, p^s alternative crop prices. The alternative crop considered for sugar beets is wheat and for sugarcane it is soybeans. As compared to the original formulation of the model soybeans we substituted in for cotton because little or no cotton or wheat is substituted into a sugarcane crop rotation. It is expected that the signs on variables will be positive except for price of alternative crop which will be negative. This should especially be true for sugarcane because it is a perennial crop and it is not easily typically financially feasible convert sugarcane acreage to alternative crops.

Yield

Yields for sugarcane and sugar beets follow the original formulation with lagged yields and time trend:

(2) $$y_t^s = f(y_{t-1}^s, t)$$

where y^s is sugarcane or sugar beet yield and t is a time trend. Both lagged yield and the time trend are expected to be positive for sugar beets. However, for sugar cane the time trend is expected to be negative because of the nature of the crop cycle and the yields for sugarcane tend to have a bell shape pattern with peak yields taking place in year two or three of the production cycle depending upon variety (Salassi and Breaux, 2001).

Production

The total production of sugar follows the original formulation and is the sum of sugarcane and beet production:

(3) $$qp_t^s = ah_t^{sc} * y_t^{sc} * er_t^{sc} + ah_t^{sb} * y_t^{sc} * er_t^{sc}$$

where qp^s is the total quantity of sugar produced, er^{sc} is the extraction rate for cane sugar, and er^{sb} is the extraction rate for beet sugar. The sugar extraction rates for this model are exogenous. Extraction rated can be calculated for each by taking the ratio of sugar produced and the yield in tons per acre for both sugarcane and sugar beets.

Sugar Demand

The demand for sugar is made up of domestic consumption, ending stocks, and net exports. Behavioral equations are added to the model for domestic consumption, ending stocks, and net exports is comprised of

Domestic Consumption

Domestic consumption is determined by using per capita consumption of sugar which is a function of the price of sugar, income, and a time trend.

(4) $$cpd_t^s = f(p_t^s, p_t^a, cy_t, t)$$

In equation four cpd_t^s is per capita consumption of sugar, p^s is the price of sugar, p^a is the price of substitutes, *cy* is per capita income, and *t* is a time trend. In this case the price of substitutes is a weighted average of the price of substitutes (i.e. high fructose corn syrup 42, glucose, and dextrose) based on their market share (Leu, Schmitz, and Knutson, 1987). It is expected price of sugar will be native and all other variables will be positive.

<u>Ending Stocks</u>

Ending stocks provide a safe net for unanticipated supply shortfalls due to weather, disease, natural disasters, etc. Benirschka, Koo, and Lou (1996) point out that these ending stocks are probably related to domestic consumption; however, there is an opportunity cost inherent in hold a sugar stock which is impacted by the price of sugar.

As in the original formulation ending stocks are a function of beginning stocks, sugar demand, and sugar price.

(5) $$qs_t^s = f(qs_{t-1}^s, qd_t^s, p_t^s)$$

where qs^s is ending stock, qd^s is sugar demand, and p^s is sugar price. It is expected that all variables except for the price of sugar will be positive because as the price of sugar rises it increases the opportunity cost of holding sugar stocks.

<u>Net Imports</u>

In the original formulation this was computed as net exports but the U.S. is a net importer of sugar so this equation has been modified. Net imports are total quantity demanded plus ending stocks minus quantity produced minus beginning stocks.

(6) $$qx_t^s = qs_{t-1}^s + qp_t^s - qd_t^s - qs_t^s$$

where qx^s are net imports. For the U.S. this is expected to be positive since the U.S. is the fourth largest net import of sugar (ISO, 2009). It is expected that

Scenario Analysis

The introduction of new crops into the available crop for planting could have significant impacts on the crop mix in a region as well as the markets for these commodities. Specifically, the case of Louisiana is examined because a number of producers on the periphery of the Louisiana sugarcane belt are struggling to survive. By already having expertise in the production of sugarcane and how to handle bulky biomass crops this makes the transition to energy crop enterprises an interesting alternative. Within Louisiana just in the past several years sugarcane acres have been trending downward and if cellulosic ethanol becomes a feasible option energy cane could be a significant part because of it biomass production potential. Furthermore, switchgrass could also be appealing but the drawbacks to it are the production learning curve and lack of equipment needed for either plant or harvest. However, for the purposes of this study no distinction made between the plant of energy cane or switchgrass, but only that sugarcane acres are decreased due to the planting of one or the other.

Using the estimates from the supply and demand model above four different scenarios is analyzed. The first scenario examines a 5 percent reduction in Louisiana sugarcane acreages or a 19,000 acre decrease from the 2008 level, while holding the rest variables in the model constant at their mean over the time period of 1980 to 2006. Scenario two examines what happens if Louisiana sugarcane acreage decreases by 15 percent or 57,000 acres from the 2008 level, while holding all other variables constant. Scenarios three and four examine the same decreases as in the previous two scenarios but incorporate the information that 180,000 acres of production will also be removed from Florida production. In scenario four, the total decrease in U.S. sugarcane acreage will be 237,000 acres or 29 percent decrease in total U.S. sugarcane acreage. For the purposes of this study shifts in sugar beet acreages were not considered but will be considered in future work.

Analysis of Tariff Rate Quota

Since the U.S. is a large net importer of sugar it is important to examine how imports may be impacted in additional land in the sugar producing regions is allocated to another crop, specifically bioenergy crops. Using the results from the scenario analysis above the additional sugar imports required to meet demand can be calculated for each of the four different scenarios. The additional imports required to meet demand can then be compared to 99,916 million pounds of additional sugar that could be imported under the TRQ surplus of sugar that could be imports. Secondly, they are a number of countries from which the U.S. has not imported any sugar from. For example, Madagascar has not imported sugar into the U.S. in past six years and Trinidad-Tobago has only imported sugar in one of the last five years (ERS, 2009). Thirdly, over the past couple of years the difference between the world raw sugar price and the domestic raw sugar price has been shrinking (Figure 2).

Data

U.S. and State Data Quick Stats from the National Agricultural Statistics Service provide data on crop yields, prices, tons/acre produced and prices (USDA, 2009). *Sugar and Sweeteners Yearbook Tables* provided the consumption, raw sugar prices, population, extraction rates, and the price of substitutes used in to determine the demand of domestic sugar (USDA, 2009). Sugar imports, beginning stocks, and ending stocks were collected from Production, Supply, and Demand online. *Consumer Price Index* and *Gross Domestic Product* was collected from the International Financial Statistics. Table 1 shows the variables, definitions, and units for each of the variables used in the estimation.

Results

The results section is broken down into three individual parts. First, are the empirical results for the sugar supply and demand model and the estimation results are in tables 2-11. Second, is the scenario analysis and the results are shown in table 12. Lastly the results for the tariff rate quota analysis are presented.

Sugar Supply and Demand

Supply

Table 2 shows the results for area harvested of sugar beets. For this equation all variables in the model are significant at the 10 percent level or greater. Furthermore, all variables for this equation also have the expected signs. Table 3 shows the results for sugar beet yield which is a function of *ysb1* and a time trend. For this model *ysb1* is not significant and has an unexpected sign of negative, which is contradictory to what Benirschka, Koo, and Lou (1996) found the sign to be. Possible explanations for this is the biennial nature of the crop where the root is harvested for sugar at the end of the first year and secondly it may potentially be a function of the crop with which sugar beets are being rotated. Table 4 shows the results for sugarcane area harvested and all variables are significant at the 10 percent level, except for *rpfsc1*. The insignificance of this could be a function of the sugarcane quota system because prices for sugarcane are almost flat and fluctuate little from one year to the next. Table 5 shows the results for sugarcane yield and all variable are significant and have the expected sign except for the time trend. In the sugarcane industry especially in Louisiana the timeframe for releasing new hybrids can be quite long (e.g. 10-12 years) and during this if one hybrid stands out it becomes the dominate variety planted. Without diversification in sugarcane varieties there can be increase disease and weed pressures that over this long timeframe actually begin to decrease yields. Table 6 shows the model for beet sugar and all variables in this model are highly significant and possess the correct signs. In table

7 are the results for cane sugar where all but *ersc* possess the correct sign and are significant. Total domestic supply of sugar is calculated by adding both beet and cane sugar.

Demand

Table 8 shows the per capita consumption of sugar. All variables in this model have the expected sign and all are significant except for *rgdpp*. One interesting variable of note here though is the time trend variable has a negative sign suggesting that as we move into the future and more substitutes for sugar discovered consumers will diversify their tastes and preferences for sweeteners. Additionally, for this equation an over identification test was performed to test the null hypothesis that instruments used are correlated with the error term. The results of the test fail to reject the null confirm that the instruments are valid. Table 9 contains the results for human domestic consumption. All variables in this model are highly significant and contain the correct signs.

Ending Stocks

Table 10 contains the estimates for ending stocks. All of the variables in the model possess the correct sign; however, none of the variables in the model are significant.

Net Imports

Since the U.S. is a net importer of sugar this equation was altered from its original specification of net exports by Benirschka, Koo, and Lou (1996). Table 11 shows the results for this equation and all variables in this model have the expected sign; however, the intercept and *qssu* are insignificant.

Scenario Analysis

The increased production of energy crops rather than sugarcane decreases the supply of sugar in the US and increasing the need for increased imports assuming that tastes and preferences for sugar remain the same. Table 12 shows the result for the four different scenarios evaluated using the estimates from the sugar supply and demand model. Using the averages over the period from 1980 to 2006 the sugar model predicts that net imports for the U.S. will be 2306 short tons and this is considered the base for the scenario analysis. For the first scenario sugarcane acreages were deceased by 5 percent, which amounts to about 19,000 acres. Incorporating this information into the model increases the net import requirement by approximately 100 short tons or 4 percent. Depending on the elasticity of sugar price event this small shift in sugarcane acreage could significantly impact the domestic sugar market. In scenario two Louisiana sugarcane acreages were reduced by 15 per cent or 57,000 acres. If the biofuel industry is able to convert these 57,000 acres into energy crop production then net imports increase by almost 300 short tons or 12 percent. In scenario three it is assumed that Louisiana sugarcane acres are decreased by 5 percent but in addition to this the sale of 180,000 in Florida also takes place. Under this scenario net imports rise to 3,311 short tons which is 44 percent above the base level. Finally, for the last scenario net imports increase by 52 percent over the base when 57,000 acres of Louisiana sugarcane are converted to energy crop production and 180,000 of Florida's acres are sold to be converted back into Everglades.

Analysis of Tariff Rate Quota

As the demand for cellulosic ethanol rises there will be additional upward pressure on sugar prices because additional sugarcane land could be converted to energy crop production. This in turn could require significant changes be made to the domestic sugar policy. Specifically, it might require an updating of the countries involved in the allocation of import quotas because some countries currently receiving import quota have not delivered sugar to the U.S. in several years. Furthermore, TRQ in the future many not be able to used as it has been in the past as a way to keep domestic sugar prices lower by bring importing sugar at world price because as shown in figure 3 the difference between these two markets ins shrinking.

Summary and Discussion

The estimation of the sugar supply and demand model allows for a unique look into how just small changes in sugar production could have significant impacts on the domestic sugar market. This model can be used to investigate a number of different scenarios depending upon much and how quickly energy crop production is adopted. Furthermore, it allows for an investigation into how policy might need to be changes as the U.S. moves into an era where agriculture is not only responsible for food production but also energy production.

Adoption of energy crops could potentially change the world agricultural landscape as we know it today. The introduction of these energy crops into the rotation is going to have varying impacts depending upon the region of the world which they are implemented. For example, producers in the Midwest could be impacted quite differently because there are more crop alternatives available for the producer than in the sugarcane belt. Furthermore, each of the different commodity markets will be impacted differently depending upon it structure and trade policies. On a global perspective countries only have a fixed amount of land for which both food and energy crops are competing. Thus, making it ever more important that each country produce the crops with which they have a competitive advantage.

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Figure 1: Historical Acreages of Crops Planted in the Mississippi River Delta

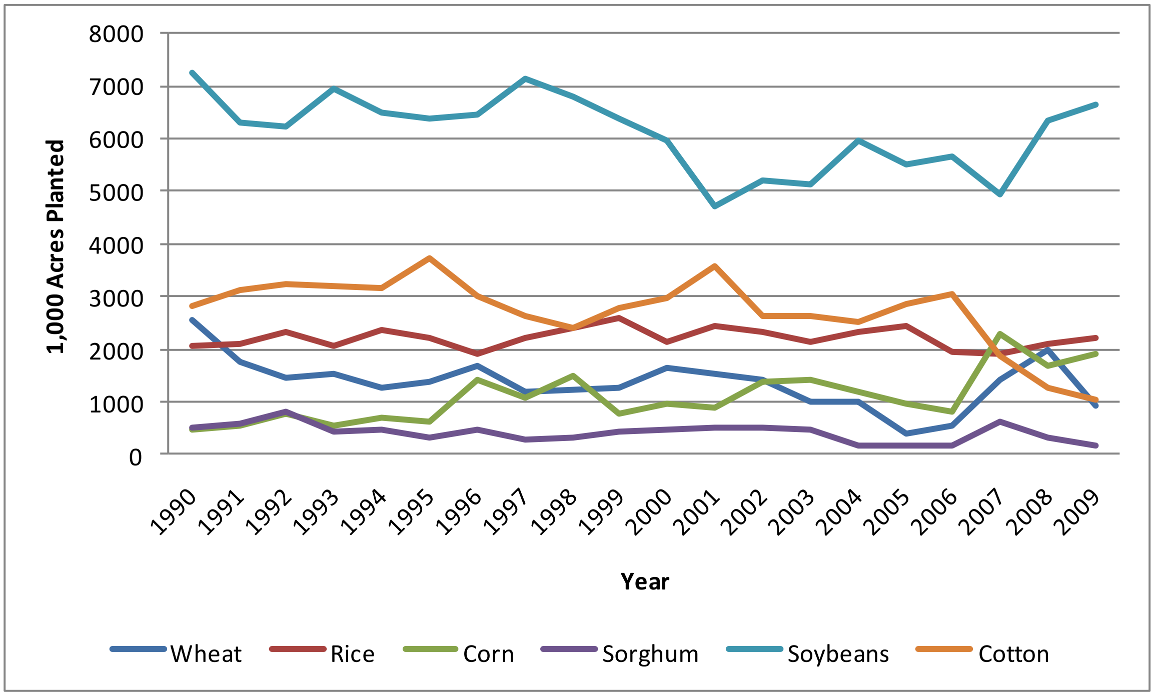
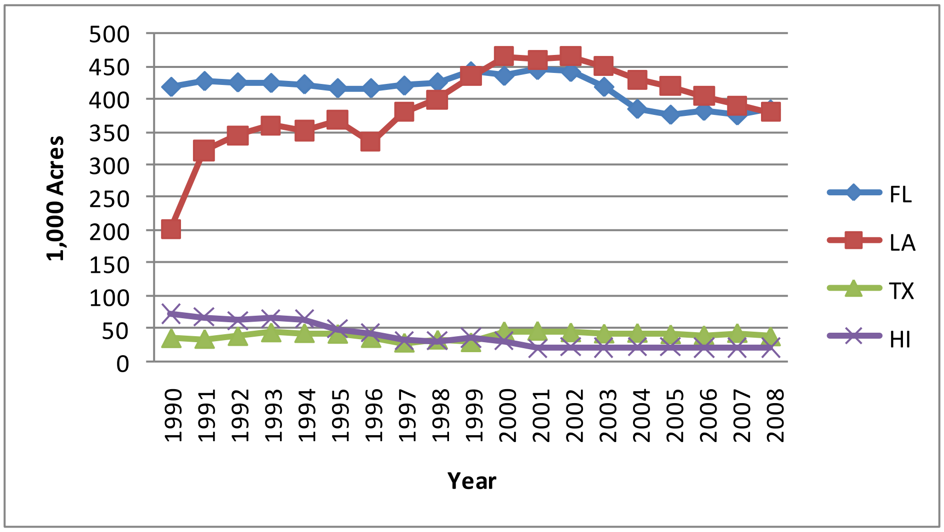
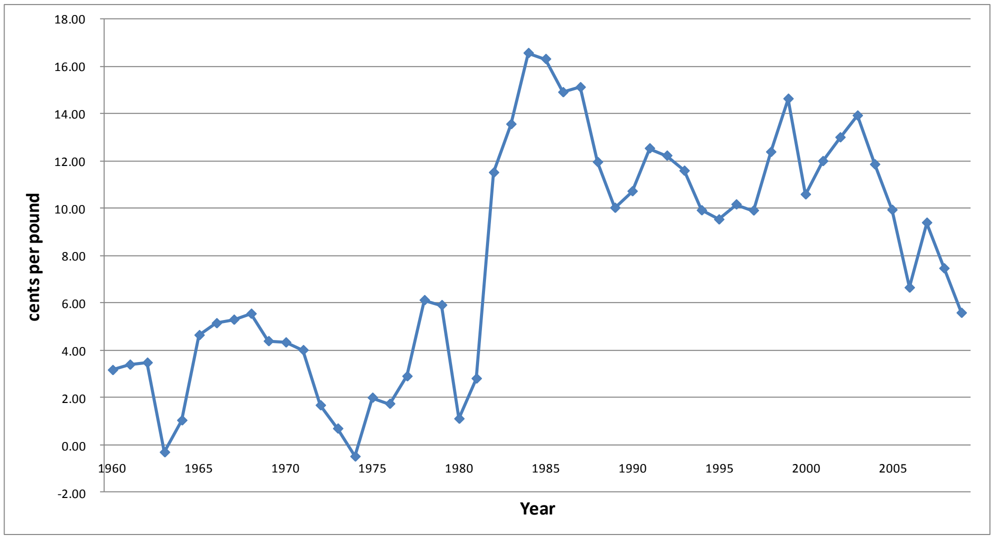


Figure 2: Distribution of US Sugarcane Acreages



Source: NASS, 2009

Figure 3: Difference between Domestic and World Sugar Prices



Source: ERS, 2009

Table 1: Variable Definitions, Units of Measurement, and Sources for Domestic Sugar Market

Variable	Definition	Unit
ahsb	sugar beet harvested area	1,000 acres
ahsb1	lagged sugar beet harvested area	1,000 acres
ahsc	sugarcane harvested area	1,000 acres
ahsc1	lagged sugarcane harvested area	1,000 acres
cqdsu	per capita sugar consumption	pounds
pfsb	sugar beet farm price	dollars/ short ton
pfsc	sugarcane farm price	dollars/ short ton
pmsu	raw sugar import price, duty paid	cents/pound
tqdsu	sugar consumption	1,000 short tons
qmsu	sugar imports	1,000 short tons
qpwbsu	beet sugar production	1,000 short tons, raw value
qpwcsu	cane sugar production	1,000 short tons, raw value
qssu	sugar ending stocks	1,000 short tons
bst	sugar beginning stocks	1,000 short tons
rpfsb1	lagged real sugar beet farm price	dollars/short ton, 2000 prices
rpfsc1	lagged real sugarcane farm price	dollars/short ton, 2000 prices
rusrsp	real raw sugar import price, duty paid	cents/pound
ysb	sugar beet yield	short tons/acre
ysb1	lagged sugar beet yield	short tons/acre
ysc	sugarcane yield	short tons/acre
ysc1	lagged sugarcane yield	short tons/acre
crgdp	real per capita GDP	1,000 dollars, 2000 prices
ersb	beet sugar extraction rate	percent
ersc	cane sugar extraction rate	percent
pop	population	millions
rpfsoy1	lagged real soybean farm price	dollars/bushel, 2000 prices
rwhp1	lagged real wheat farm price	dollars/ton, 2000 prices
mixcsp	real weighted price of corn sweetener substitutes	cents/lb, dry weight, 2000 prices
t	trend	

Table 2: Results for Acres Harvested Sugar Beets

Variable	Parameter Estimate	P-Value
Intercept	329.4554	0.0647
ahsb1	0.725259	<0.0001
rpfsb1	5.203001	0.0018
rwhp1	-1.59052	0.0015

Table 3: Results for Sugar Beet Yield

Variable	Parameter Estimate	P-Value
Intercept	19.40743	0.0001
ysb1	-0.01317	0.9502
t	0.141580	0.0019

Table 4: Results for Acres Harvested Sugarcane

Variable	Parameter Estimate	P-Value
Intercept	371.9109	0.0074
ahsc1	0.632369	<0.0001
rpfsc1	1.499965	0.2610
rpfsoy1	-14.9071	0.0097

Table 5: Results for Sugarcane Yield

Variable	Parameter Estimate	P-Value
Intercept	27.66084	0.0001
ysc1	0.28571	0.0736
t	-0.18835	0.002

Table 6: Results for Sugar Production from Sugar Beets

Variable	Parameter Estimate	P-Value
Intercept	-6771.31	<0.0001
ahsb	3.669129	<0.0001
ysb	222.7424	<0.0001
ersb	10499.42	0.0247

Table 7: Results for Sugar Production from Sugarcane

Variable	Parameter Estimate	P-Value
Intercept	-3930.34	<0.0001
ahsc	4.920304	<0.0001
ysc	95.33904	<0.0001
ersc	-449.049	0.6976

Table 8: Results for Per Capita Sugar Consumption

Variable	Parameter Estimate	P-Value
Intercept	-314.859	0.0001
rusrsp	-0.72465	0.0788
mixcsp	0.595734	0.0037
rgdpp	0.000059	0.9285
pop	1.777082	<0.0001
t	-5.60145	<0.0001
Overidentifying	F Value (0.7259)	

Table 9: Results for Human Domestic Consumption

Variable	Parameter Estimate	P-Value
Intercept	-7051.52	<0.0001
qdsu	117.2863	<0.0001
pop	29.85004	<0.0001

Table 10: Results for Ending Stock

Variable	Parameter Estimate	P-Value
Intercept	243.0794	0.7726
qssu1	0.172981	0.2085
tqdsu	0.134407	0.1092
rusrsp	-2.63514	0.7722

Table 11: Results for Net Imports

Variable	Parameter Estimate	P-Value
Intercept	684.9085	0.2339
tqdsu	1.216947	<0.0001
qssu	0.176358	0.4732
qpsu	-1.02628	<0.0001
bst	-0.82536	<0.0001

Table 12: Results for Scenario Analysis

	Scenarios				
	Base	1	2	3	4
Net Imports (1,000 short tons)	2306.513	2402.456	2594.341	3311.385	3503.27
Percent Change from Base	-	4%	12%	44%	52%