

Ethanol Trade Module

US ethanol trade is modeled as a system of three estimated equations (imports, exports and domestic ethanol demand). Exogenous variables include world sugar price and world oil price and US ethanol price. Endogenous variable is corn price.

Shocks enter the module through a change in the baseline situation that would impact corn prices. Corn prices impact imports, exports, and domestic demand, and therefore total demand for corn. Total demand for corn then impacts corn price. The model simultaneously solves until an equilibrium is achieved (figure 1).

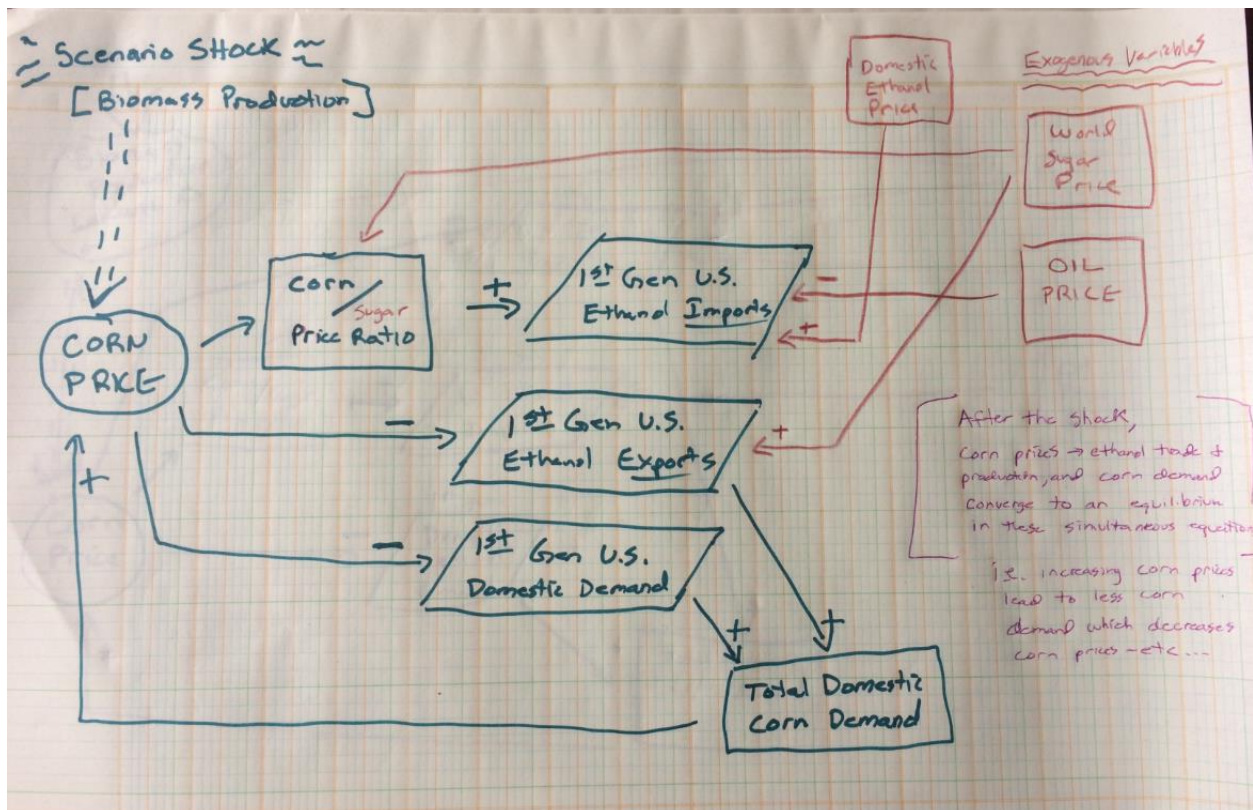


Figure 1: Ethanol Trade Module

$$\text{US Ethanol Exports} = -21825 + (1180) * \text{Sugar Price} + (671.67) * \text{export structural change} \\ + (10.88) * \text{year} + (-72.92) * \text{corn price lag}$$

Where,

export structural change is a dummy variable changed to one in 2009 when ethanol exports went up dramatically. We keep this at 1 for all simulations.

And 'year' is a time trend equal to the 4 digit year.

The AUTOREG Procedure					
Ordinary Least Squares Estimates					
SSE	139072.59	DFE		18	
MSE	7726	Root MSE		87.89912	
SBC	281.215557	AIC		275.538086	
MAE	58.0968875	AICC		279.067497	
MAPE	73.5478546	HQC		276.965954	
Durbin-Watson	2.2011	Regress R-Square		0.9593	
		Total R-Square		0.9593	
Parameter Estimates					
Variable	DF	Estimate	Standard Error	t Value	Approx Pr > t
Intercept	1	-21825	8874	-2.46	0.0243
sugarprice	1	1180	252.6923	4.67	0.0002
ExportStructChang	1	671.6749	75.6538	8.88	<.0001
year	1	10.8794	4.4410	2.45	0.0248
cornpricelag	1	-72.9173	24.7072	-2.95	0.0085

$$\text{US Ethanol Imports} = -789.38 + (17.88) * \text{corn to sugar price ratio} + (-5.05) * \text{oil price} \\ + (580.14) * \text{domestic ethanol price}$$

We also wanted to make domestic ethanol demand change as corn prices changed. To figure the baseline, domestic ethanol demand is simply total ethanol demand minus export ethanol demand, but in simulations;

$$\text{Corn grain demand of US Domestic Ethanol Demand} = \text{Baseline corn grain demand of Domestic ethanol demand} * (1.0 + \text{elasticity of corn grain demand} * \% \text{ change in corn price})$$

Where,

Elasticity of corn grain demand = -0.35

The AUTOREG Procedure

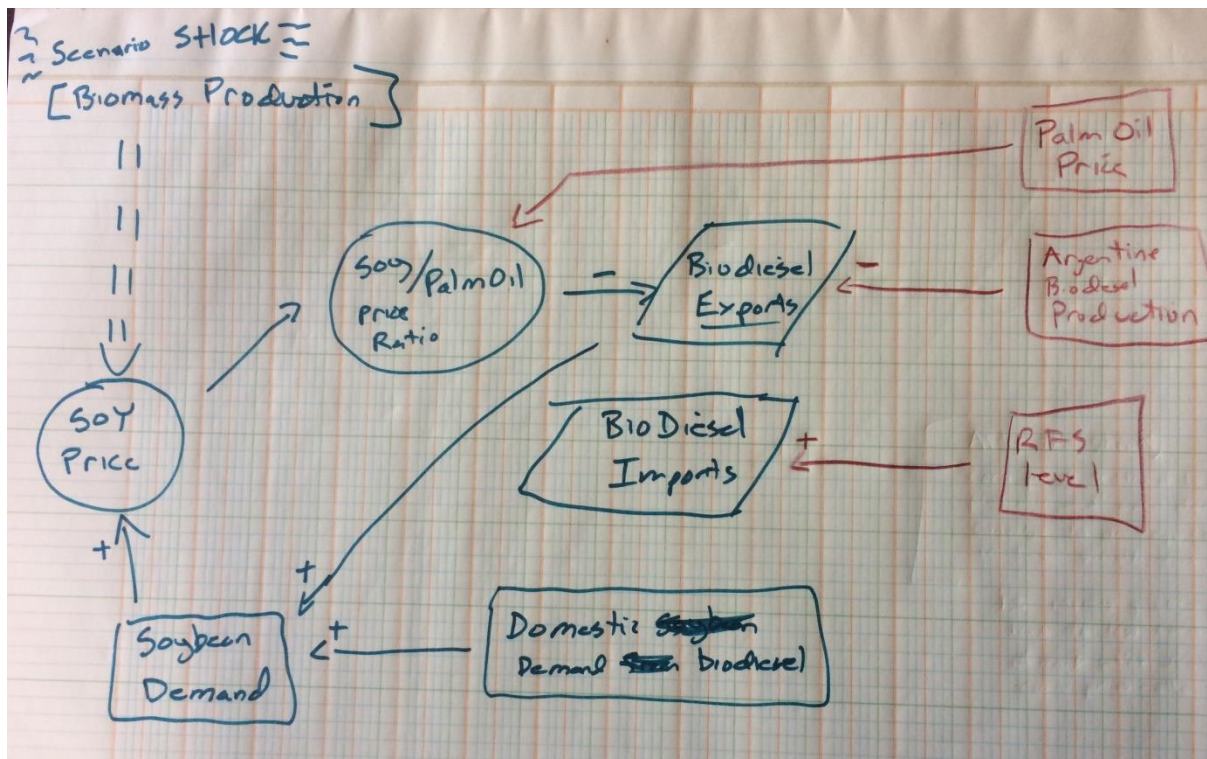
Ordinary Least Squares Estimates			
SSE	266514.533	DFE	20
MSE	13326	Root MSE	115.43711
SBC	304.38439	AIC	299.672175
MAE	81.9768641	AICC	301.777438
MAPE	455.098062	HQC	300.922327
Durbin-Watson	2.1338	Regress R-Square	0.7323
		Total R-Square	0.7323

Parameter Estimates					
Variable	DF	Estimate	Standard Error	t Value	Approx Pr > t
Intercept	1	-789.3809	170.6343	-4.63	0.0002
CornToSug	1	17.8812	9.4254	1.90	0.0723
OilPrice	1	-5.0472	2.0790	-2.43	0.0248
ethanolprice	1	580.1438	128.5774	4.51	0.0002

Biodiesel Trade Module

US biodiesel trade is modeled as a system of two equations (US exports, US imports), with 3 exogenous variables (palm oil price, Argentine Biodiesel production, RFS level of biodiesel), and one endogenous variable (soybean price).

Shocks enter the module through a change in the baseline situation that would impact soybean prices. Soybean prices impact imports, exports, and therefore total demand for soybeans. Total demand for soybeans then impacts soybean price. The model simultaneously solves until an equilibrium is achieved (figure 1).



$$\begin{aligned} \text{US Biodiesel Exports} = & 1100 + (-0.00023) * \text{argentine biodiesel production} \\ & + (-29316) * \text{soybean to palm oil price ratio} \end{aligned}$$

The SAS System

The AUTOREG Procedure

Ordinary Least Squares Estimates			
SSE	77290.6779	DFE	6
MSE	12882	Root MSE	113.49793
SBC	113.655504	AIC	113.06383
MAE	82.8555618	AICC	117.86383
MAPE	64.721378	HQC	111.787
Durbin-Watson	2.1969	Regress R-Square	0.7610
		Total R-Square	0.7610

Parameter Estimates					
Variable	DF	Estimate	Standard Error	t Value	Approx Pr > t
Intercept	1	1100	361.3031	3.04	0.0227
Argentina_biod_prod	1	-0.000231	0.0000628	-3.68	0.0104
soytopalmpriamelag	1	-29316	24254	-1.21	0.2722

US Biodiesel Imports = -207.77 + 368.4707 * RFS Biodiesel level

The SAS System

The AUTOREG Procedure

Ordinary Least Squares Estimates			
SSE	141431.686	DFE	6
MSE	23572	Root MSE	153.53159
SBC	105.102944	AIC	104.944061
MAE	112.24199	AICC	107.344061
MAPE	104.174124	HQC	103.872458
Durbin-Watson	1.9755	Regress R-Square	0.6301
		Total R-Square	0.6301

Parameter Estimates					
Variable	DF	Estimate	Standard Error	t Value	Approx Pr > t
Intercept	1	-207.7702	144.2915	-1.44	0.2000
RFS_biodiesel	1	368.4707	115.2517	3.20	0.0187

Programming

There are three new subscripts added to POLYSYS for the Biofuel trade module;

Setethtrade.for, which is 'called' from **setusda.for**. This reads in the exogenous variables from the **ethtrade.txt** file. To change exogenous variables read in the baseline, change here.

Baseline given exogenous variables entered in the input file : /input/bio/ethtrade.txt

Ethtrade.for, which is called from **grains.for**. This has the equations for both the baseline and simulation runs for ethanol trade.

Biodiestrad.for, which is called from **grains.for**. This has the equations for both the baseline and simulation for biodiesel trade.

Baseline calculations given exogenous variable values currently in ethtrade.txt. These can be changed, and actually should be changed to projected estimates found in FAO, EIA, IEA, etc.

There are 2 new index switches in SIM.INS for the biotrade module, indices [101] and [102]:

```
2<- 0 IF NO CHANGE FROM BASELINE; 1 IF ALLOW DOMESTIC CORN DEMAND FOR ETHANOL TO FALL UNDER HIGH PRICES; 2 IF USE NEW BIOENERGY TRADE MODULE[101]
0<- 0 IF READ IN BASELINE EXPORTS/IMPORTS IN BIOTRADE MODULE; 1 IF ALLOW BIOTRADE MODULE TO COMPUTE[102]
```

US Ethanol Exports

		intercept -21825	sugarprice 1180	exportstructurechange 671.6749	year 10.8794	cornpricelag -72.9173
	corn price	corntosug	year	sugarpice		EXPORTS
2016	3.3	8.800294	2016	0.4		1010.92
2017	3.23	8.613621	2017	0.4		1021.80
2018	3.27	8.720291	2018	0.4		1037.78
2019	3.26	8.693623	2019	0.4		1045.74
2020	3.36	8.960299	2020	0.4		1057.35
2021	3.4	9.066969	2021	0.4		1060.94
2022	3.46	9.226974	2022	0.4		1068.90
2023	3.51	9.360312	2023	0.4		1075.41
2024	3.56	9.49365	2024	0.4		1082.64
2025	3.55	9.466982	2025	0.4		1089.87
2026	3.6	9.60032	2026	0.4		1101.48
2027	3.58	9.546985	2027	0.4		1108.72
2028	3.56	9.49365	2028	0.4		1121.05
2029	3.54	9.440315	2029	0.4		1133.39
2030	3.52	9.38698	2030	0.4		1145.73
2031	3.49	9.306977	2031	0.4		1158.07
2032	3.46	9.226974	2032	0.4		1171.13
2033	3.44	9.173639	2033	0.4		1184.20
2034	3.42	9.120304	2034	0.4		1196.54
2035	3.39	9.040302	2035	0.4		1208.88
2036	3.37	8.986966	2036	0.4		1221.94
2037	3.35	8.933631	2037	0.4		1234.28
2038	3.33	8.880296	2038	0.4		1246.62
2039	3.3	8.800294	2039	0.4		1258.96
2040	3.28	8.746958	2040	0.4		1272.02

US Ethanol Imports

intercept	corntosug	oilprice	ethanolprice	
-789.381	17.8812	-5.0472	580.1438	
	corntosug	oilprice	ethprice	IMPORTS
2016	8.800294	44.05	1.6	73.88
2017	8.613621	44.05	1.6	70.54
2018	8.720291	44.05	1.6	72.45
2019	8.693623	44.05	1.6	71.97
2020	8.960299	44.05	1.6	76.74
2021	9.066969	44.05	1.6	78.65
2022	9.226974	44.05	1.6	81.51
2023	9.360312	44.05	1.6	83.89
2024	9.49365	44.05	1.6	86.28
2025	9.466982	44.05	1.6	85.80
2026	9.60032	44.05	1.6	88.19
2027	9.546985	44.05	1.6	87.23
2028	9.49365	44.05	1.6	86.28
2029	9.440315	44.05	1.6	85.32
2030	9.38698	44.05	1.6	84.37
2031	9.306977	44.05	1.6	82.94
2032	9.226974	44.05	1.6	81.51
2033	9.173639	44.05	1.6	80.56
2034	9.120304	44.05	1.6	79.60
2035	9.040302	44.05	1.6	78.17
2036	8.986966	44.05	1.6	77.22
2037	8.933631	44.05	1.6	76.26
2038	8.880296	44.05	1.6	75.31
2039	8.800294	44.05	1.6	73.88
2040	8.746958	44.05	1.6	72.93

US Biodiesel Exports

intercept	arg_biod_prod	soytopalmpricelag	
1100	-0.00023	-29316	
	arg_biod_prod	soyoiltopalm	EXPORTS
2016	2263008	0.012697	205.03
2017	2263008	0.012925	198.33
2018	2263008	0.012911	198.75
2019	2263008	0.012954	197.50
2020	2263008	0.013025	195.40
2021	2263008	0.013039	194.98
2022	2263008	0.013096	193.31
2023	2263008	0.013182	190.80
2024	2263008	0.013182	190.80
2025	2263008	0.013182	190.80
2026	2263008	0.013182	190.80
2027	2263008	0.013254	188.70
2028	2263008	0.013311	187.03
2029	2263008	0.013311	187.03
2030	2263008	0.013282	187.87
2031	2263008	0.013239	189.12
2032	2263008	0.013211	189.96
2033	2263008	0.013182	190.80
2034	2263008	0.013154	191.63
2035	2263008	0.013125	192.47
2036	2263008	0.013096	193.31
2037	2263008	0.013068	194.15
2038	2263008	0.013054	194.56
2039	2263008	0.013025	195.40
2040	2263008	0.012997	196.24

US Biodiesel Imports

intercept	RFS_biodiesel
-207.77	368.4707

	RFS_biodiesel	IMPORTS
2016	1.8	455.48
2017	1.9	492.32
2018	2	529.17
2019	2	529.17
2020	2	529.17
2021	2	529.17
2022	2	529.17
2023	2	529.17
2024	2	529.17
2025	2	529.17
2026	2	529.17
2027	2	529.17
2028	2	529.17
2029	2	529.17
2030	2	529.17
2031	2	529.17
2032	2	529.17
2033	2	529.17
2034	2	529.17
2035	2	529.17
2036	2	529.17
2037	2	529.17
2038	2	529.17
2039	2	529.17
2040	2	529.17

Test Output:

Baseline with values being exogenously read in ethtrad.txt (with index(102)=0)

-----Ethanol-----

Demand(bil gal)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Supply(bil gal)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FEEDSTOCKS													
Corn Stover(mil.dt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wheat Straw(mil.dt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Switchgrass(mil.dt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscanthus(mil.dt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Poplars(mil.dt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Willows(mil.dt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SweetSorgh(mil.dt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E.Cane(mil.dt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRP Harvest(mil.dt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wood Resid (mil.dt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Corn(mil bu)	0	0	0	0	0	0	0	0	0	0	0	0	0
COSTS													
Feedstock Cost(mil\$)	0	0	0	0	0	0	0	0	0	0	0	0	0
Conversion Cost(mil\$)	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Cost(mil\$)	0	0	0	0	0	0	0	0	0	0	0	0	0
Cost per gal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

SIM+BASELINE ETHANOL

Domestic corn(mil bu)	5300.0	5325.0	5359.8	5330.6	5331.4	5279.9	5254.5	5229.7	5179.7	5154.9	5129.5	5161.5	5154.1
Prod for Domestic(bil	13.31	13.41	13.47	13.40	13.40	13.26	13.19	13.12	13.30	13.54	13.78	14.15	14.42
Exported eth(bil gal)	1.000	1.000	1.002	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.005
Imported eth(bil gal)	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
Dom eth Demand(bil gal	13.36	13.46	13.52	13.45	13.45	13.31	13.24	13.17	13.35	13.59	13.83	14.20	14.47
Total eth Prod(bil gal	14.31	14.38	14.47	14.39	14.39	14.26	14.19	14.12	14.30	14.54	14.77	15.17	15.46

-----Bio-Diesel-----

Demand(bil gal)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Supply(bil gal)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FEEDSTOCKS													
Soybeans(mil bu)	0	0	0	0	0	0	0	0	0	0	0	0	0
COSTS													
Feedstock Cost(mil\$)	0	0	0	0	0	0	0	0	0	0	0	0	0
Conversion Cost(mil\$)	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Cost(mil\$)	0	0	0	0	0	0	0	0	0	0	0	0	0
Cost per gal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

SIM+BASELINE BIODIESEL

Domestic soy(mil bu)	541.0	555.0	564.0	568.0	573.0	577.0	577.0	577.0	577.0	577.0	577.0	577.0	577.0
Prod for Domestic(bil	0.56	0.58	0.59	0.60	0.60	0.61	0.61	0.61	0.61	0.61	0.67	0.67	0.67
Exported biod(bil gal)	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
Imported biod(bil gal)	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
Dom biod Demand(bil ga	0.96	0.98	0.99	1.00	1.00	1.01	1.01	1.01	1.01	1.01	1.07	1.07	1.07
Total biod Prod(bil ga	0.76	0.78	0.79	0.80	0.80	0.81	0.81	0.81	0.81	0.81	0.87	0.87	0.87

Simulation BC1080 \$80 biomass price

-----Ethanol-----

Demand(bil gal)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Supply(bil gal)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FEEDSTOCKS													
Corn Stover(mil.dt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wheat Straw(mil.dt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Switchgrass(mil.dt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscanthus(mil.dt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Poplars(mil.dt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Willows(mil.dt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SweetSorgh(mil.dt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E.Cane(mil.dt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRP Harvest(mil.dt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wood Resid (mil.dt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Corn(mil bu)	0	0	0	0	0	0	0	0	0	0	0	0	0
COSTS													
Feedstock Cost(mil\$)	0	0	0	0	0	0	0	0	0	0	0	0	0
Conversion Cost(mil\$)	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Cost(mil\$)	0	0	0	0	0	0	0	0	0	0	0	0	0
Cost per gal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SIM+BASELINE ETHANOL													
Domestic corn(mil bu)	5300.0	5325.0	5363.2	5340.0	5341.0	5281.5	5242.4	5215.9	5165.5	5139.6	5113.7	5146.0	5139.9
Prod for Domestic(bil	13.31	13.41	13.76	13.72	13.69	12.92	12.79	12.71	12.85	13.03	13.28	13.61	13.99
Exported eth(bil gal)	1.000	1.000	1.002	1.016	1.018	1.017	0.982	0.978	0.977	0.975	0.973	0.973	0.976
Imported eth(bil gal)	0.050	0.050	0.041	0.040	0.040	0.061	0.064	0.064	0.066	0.067	0.067	0.068	0.064
Dom eth Demand(bil gal	13.36	13.46	13.80	13.76	13.73	12.98	12.85	12.77	12.92	13.10	13.34	13.68	14.05
Total eth Prod(bil gal	14.31	14.38	14.48	14.42	14.42	14.26	14.15	14.08	14.26	14.49	14.73	15.13	15.42

-----Bio-Diesel-----

Demand(bil gal)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Supply(bil gal)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FEEDSTOCKS													
Soybeans(mil bu)	0	0	0	0	0	0	0	0	0	0	0	0	0
COSTS													
Feedstock Cost(mil\$)	0	0	0	0	0	0	0	0	0	0	0	0	0
Conversion Cost(mil\$)	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Cost(mil\$)	0	0	0	0	0	0	0	0	0	0	0	0	0
Cost per gal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SIM+BASELINE BIODIESEL													
Domestic soy(mil bu)	541.0	555.0	557.4	562.2	568.1	559.9	536.1	524.2	526.1	526.9	528.5	526.1	526.4
Prod for Domestic(bil	0.56	0.58	0.59	0.60	0.60	0.61	0.61	0.61	0.61	0.61	0.67	0.67	0.67
Exported biod(bil gal)	0.200	0.200	0.191	0.192	0.193	0.176	0.143	0.126	0.129	0.130	0.127	0.124	0.124
Imported biod(bil gal)	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
Dom biod Demand(bil ga	0.96	0.98	0.99	1.00	1.00	1.01	1.01	1.01	1.01	1.01	1.07	1.07	1.07
Total biod Prod(bil ga	0.76	0.78	0.78	0.79	0.80	0.78	0.75	0.73	0.74	0.74	0.79	0.79	0.79