A Partial Equilibrium of the Sorghum Markets in US, Mexico, and Japan

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Introduction

Grain sorghum is a major feed grain. The United States is the largest grain sorghum producer in the world, though its contribution decreased from 33% to 17% from 1969 to 2013. Nonetheless, the international market share of US grain sorghum expanded over that time. This indicates that US grain sorghum industry has increased its reliance on foreign markets. Major importers of US grain sorghum includes Mexico, Japan, and China. Mexican imports have expanded because Mexican poultry production has grown over the last 10 years. On the other hand, Japanese imports of US grain sorghum have diminished over the same period, and Australian grain sorghum now has the top share in the Japanese market. Chinese imports of US grain sorghum have increased suddenly over the last 2 years because Chinese poultry production has grown in recent years at a rapid rate.

The purpose of this research is to develop a partial equilibrium model of international trade in grain sorghum to illustrate its production-utilization-trade process. This model has 23 equations, which include equations for the demands and supplies of grain sorghum in Japan, Mexico, and the United States, as well as price transmission equations. We estimated the parameters of this model and forecasted the endogenous variables from 2014 to 2018. Nowadays, Chinese imports of grain sorghum are an important factor in the international trade. We assumed three scenarios of Chinese imports of US grain sorghum from 2014 to 2018, and then, conducted a forecast of this model taking into account these scenarios.

Sorghum Model

1) Demand of Sorghum in USA

$$Ln(feed) = ud0 + ud1 * Ln(SorghumPrice) + ud2 * Ln(PoultryProductionRevenue) + ud3 * TimeTrend$$
$$Demand = Feed + other + Ending + ExportsRow$$

2) Stock of Sorghum in USA

$$Stock = End0 + End1 * SorghumPrice + End2 * Crp + End3 * Crp * SorghumPrice$$

3) Supply of Sorghum in USA

$$Ln(TxPlanted) = ts0 + ts1 * Ln\big(lag(SorghumPrice)\big) + ts2 * Ln\big(lag(TxPlanted)\big) + ts3 * Ln(TxCottonSorghumPriceRatio) + ts4 * Ln(\frac{SorghumPrice}{CornPrice})$$
$$Ln(KsPlanted) = ks0 + ks1 * Ln\big(lag(SorghumPrice)\big) + ks2 * Ln\big(lag(KsPlanted)\big) + ks3 * Ln(\frac{SorghumPrice}{CornPrice})$$
$$Ln(OtherStatesPlanted) = os0 + os1 * Ln\big(lag(SorghumPrice)\big) + os2 * Ln\big(lag(OtherStatesPlanted)\big)$$
$$Ln(HarvestTx) = HarvT0 + HarvT1 * Ln(TxPlanted)$$
$$Ln(HarvestKs) = HarvK0 + HarvK1 * Ln(KsPlanted)$$
$$Ln(HarvestOtherStates) = HarvOth0 + HarvOth1 * Ln(OtherStatesPlanted)$$
$$Harvested = HarvestTx + HarvestKs + HarvestOtherStates$$
$$Production = Harvested * yield$$
$$Supply = Production + lag(Stock)$$
$$ExcessSupply = Supply - Demand$$

4) Demand of Sorghum in Mexico

$$Ln(MexicoSorghumPrice) = p0 + p1 * Ln(SorghumPrice)$$
$$Ln(MexicoFeed) = udo0 + udo1 * Ln(SorghumPrice) + udo2 * Ln(MexicoCornPrice) + udo3 * Ln(PoultryProduction) + ud04 * deval$$
$$MexicoDemand = MeixcoFeed + MeixcoOther + MeixcoStock$$

5) Supply of Sorghum in Mexico

$$Ln(MexicoPlanted) = mo0 + mo1 * Ln(SorghumPrice) + mo2 * eighty + mo3 * liber + mo4 * deval$$
$$Ln(MexicoHarvested) = Cos0 + Cos1 * Ln(MexicoPlanted)$$
$$MexicoProduction = MexicoHarvested * MexicoYield$$
$$MexicoSupply = MexicoProduction + lag(MexicoStock) + MexicImportsfromRow$$

6) Imports of US Sorghum in Mexico

$$MexicoImportsfromUS = MexicoDemand - MexicoSupply$$

7) Imports of US Sorghum in Japan

$$Ln(USSorghumPriceJapan) = jp0 + jp1 * (SorghumPrice) + jp2 * Ln(JapanExchangeRate)$$
$$Ln(JapanImportsfromUS) = id0 + id1 * (USSorghumPriceJapan) + id2 * Ln(JapanGDPPerCapita)]$$
$$JapanDemand = JapanImportsfromUS + JapanImportsfromRow$$

8)Equilibrium Condition

$$Excess\ Supply = JapanImportsfromUS + MexicoImportsfromUS$$

Endogenous Variables:

SorghumPrice, Feed, TxPlanted, KSPlanted, OtherStatesPlanted
HarvestTx, HarvestKs, HarvestOtherStates, Stock, Harvested, Production
Supply, Demand, ExcessSupply, MexicoHarvest, MexicoPlanted,
MexicoProduction, MexicoSupply, MexicoFeed, MexicoDemand,
MexicoImportsfromUS, JapanUSSorghumPrice, JapanImportsfromUS, JapanDemand .

* The dummy variable of liber indicates the years of the protection trade regime, and the variable deval indicates the peso devaluation year.
**The variable Eighty indicates 1980, and the variable crp indicates the conservation program period.

Estimation of the Parameters

Demand of Sorghum in US

UD0	-3.894(6.071)
UD1	-.641(.115)***
UD2	-.056(.004)***
UD3	.556(.254)**

Stock of Sorghum in US

END0	13883.42(2644.8)***
END1	-30981.5(11206.2)***
END2	-12811.8(3189.2)***
END3	34166.56(13660.3)**

Supply of Sorghum in US

TS0	2.934(.991)***
TS1	.496(.117)***
TS2	.708(.112)***
TS3	-.361(.158)**
TS4	3.187(.966)***
KS0	2.604(.654)***
KS1	.17(.05)***
KS2	.683(.086)***
KS3	.831(.46)*
OS0	1.224(.398)***
OS1	.21(.068)***
OS2	.876(.046)***
HarvT0	-.257(.257)
HarvT1	1.014(.035)***
HarvK0	1.257(.291)***
HarvK1	.811(.04)***
HarvO0	-.833(.125)***
HarvO1	1.083(.017)***

Demand of Sorghum in Mexico

P0	2.136(.301)***
P1	1.123(.103)***
P2	.182(.155)
MD0	5.616(.46)***
MD1	-.574(.143)***
MD2	.484(.148)***
MD3	.414(.052)***
MD4	.246(.11)**

Supply of Sorghum in Mexico

MO0	7.208(.094)***
MO1	.144(.075)*
MO2	-.39(.051)***
MO3	-.646(.094)***
MO4	.324(.09)***
cos0	-.185(.206)
cos1	1.009(.028)***

Demand of US Sorghum in Japan

jp0	-.018(.106)
jp1	1(.012)***
jp2	1.002(.02)***
id0	54.958(4.076)***
id1	-.931(.15)***
id2	-4.313(.359)***

Theil Forecast Error Statistics

Endogenous Variable	Bias (UM)	Var (US)	Covar (UC)
Sorghum Price	0.01	0.01	0.98
Feed	0.02	0.05	0.94
TXPlanted	0	0.02	0.98
KSPlanted	0.01	0.02	0.96
OthPlanted	0.02	0	0.98
HarvestTx	0	0.03	0.97
HarvestKx	0.01	0.09	0.9
HarvestOtherStates	0.02	0	0.98
Stock	0	0.25	0.75
Harvested	0.01	0	0.99
Production	0.02	0.03	0.95
Supply	0.01	0.13	0.85
Demand	0.01	0.29	0.71
Excess Supply	0.02	0.06	0.92
Mexico Sorghum Price	0.02	0.07	0.91
Mexico Feed	0	0.05	0.95
Mexico Plant	0.01	0.1	0.89
Mexico Harvest	0.01	0.1	0.89
Mexico Production	0.01	0.02	0.97
Mexico Supply	0.05	0.02	0.93
Mexico Demand	0	0.09	0.9
Mexico Imports from US	0	0.02	0.98
Japan US Sorghum Price	0.01	0.02	0.97
Japan Imports from US	0	0	1
Japan Demand	0	0.05	0.94

Empirical Framework

An Iterated Seemingly Unrelated Regression (ITSUR) was used for the estimation of parameters, and Theils' U was used for the validation of this estimation. Data for this analysis is from 1971 to 2013. The sources of data for this analysis are USDA, FAPRI and the department of agriculture of Mexico. We forecasted the endogenous variables of this model from 2013 to 2018 based on the parameter estimation and the three scenarios of Chinese imports over the same period.

Scenarios of Chinese Imports of US Sorghum

Chinese imports of US sorghum have increased at the rapid pace. In 2012, they were just 48 thousand metric tons, while by 2013, they had increased to 4,568 thousand metric tons. The growth rate of Chinese imports of US sorghum from the 1st quarter of 2013 to the 1st quarter of 2014 was 218%.

We projected three scenarios of Chinese imports of US sorghum from 2014 to 2018, and then forecasted US sorghum exports to the rest of world during the years.

Scenario 1

Chinese imports of US sorghum will expands by 218% each year

Scenario 2

Chinese imports of US sorghum will stop expanding in 2014, and their amount will be the same in the remaining years

Scenario 3

Chinese imports of US sorghum will increase by 5,390 thousand metric tons

(4,568 thousand metric tons times 1.18) each year

Projections of Endogenous Variables from 2014 to 2018

Scenario 1

	Sorghum Price	Feed	Production	Excess Supply	Mexico Sorghum Price	Mexico Feed	Mexico Production	Japan US Sorghum Price	Japan Imports from US
2014	0.17302	2855.63	11716.75	397.58	1.83131	8402.27	6870.52	21.2456	315.811
2015	0.18563	2646.3	16264.25	-402.53	1.97805	7887.25	7019.2	23.48	261.356
2016	0.20229	2418.43	27469.14	-1034.35	2.17944	7473.59	7153.96	26.0305	216.754
2017	0.21448	2242.23	53068.46	-1517.26	2.33244	7213.38	7260.38	27.9875	187.51
2018	0.22646	2080.54	109811.97	-1885.89	2.487	7035.52	7366.16	29.7154	164.298

Scenario2

	Sorghum Price	Feed	Production	Excess Supply	Mexico Sorghum Price	Mexico Feed	Mexico Production	Japan US Sorghum Price	Japan Imports from US
2014	0.17302	2855.66	11716.4	397.705	1.83127	8402.37	6870.5	21.2452	315.817
2015	0.18563	2646.3	16263.75	-402.535	1.97805	7887.25	7019.2	23.48	261.356
2016	0.16281	2779.89	17072.62	385.627	1.70784	8596.17	6905.15	20.9498	265.344
2017	0.16088	2696.39	17011.34	341.289	1.68884	8681.88	6927.92	20.994	245.098
2018	0.1594	2606.18	16955.52	374.272	1.67657	8822.27	6956.32	20.916	227.87

Scenario3

	Sorghum Price	Feed	Production	Excess Supply	Mexico Sorghum Price	Mexico Feed	Mexico Production	Japan US Sorghum Price	Japan Imports from US
2014	0.17302	2855.63	11716.75	397.58	1.83131	8402.27	6870.52	21.2456	315.811
2015	0.18563	2646.3	16264.25	-402.53	1.97805	7887.25	7019.2	23.48	261.356
2016	0.18253	2583.22	21700.06	-381.886	1.94186	7985.4	7035.09	23.4879	238.531
2017	0.1803	2506.29	27107.92	-428.16	1.91942	8067.04	7057.84	23.5284	220.411
2018	0.17993	2411.29	32523.77	-451.525	1.92094	8159.57	7095.09	23.6102	203.55

Conclusion

Almost of the all parameters of this model are significant. The Theil forecast error statistics show that the forecasted values of the endogenous variables show little difference from the actual values, and capture the actual variance. The model made the projections of the endogenous variables based on three scenarios of Chinese demand of US sorghum. Scenario 1 (the same growth rate over five years) may not be feasible because the excess supply may be negatively large. In this case, China may import sorghum from other countries than US. Scenario 2 and scenario 3 are possible, since the negative amount of excess supply in some years is less than 5% of the total production of US sorghum. This forecast tells us that the impact of Chinese imports of US sorghum on the total production may be large, and it may more than double the production of US sorghum in five years.

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