

Current Status of the U.S. Biodiesel Market: Supply, Demand, and Producers' Profit Margin

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Abstract

The U.S. biodiesel production industry has experienced slow growth despite receiving federal subsidies to produce. The U.S. has fallen below the Renewable Fuel Standard (RFS) in 2010, and it remains questionable if the U.S. can meet the one billion gallon RFS mandate in the coming year. The U.S. biodiesel industry encounters the challenge of feedstock price volatility, high feedstock price diminishes biodiesel producers' profit margin, reducing producers' incentive to produce.

Soybean oil is the most prominent feedstock in the U.S. biodiesel industry. Investigating the main drivers of soybean oil price will be useful for policy and business suggestions aiming to buffer biodiesel producers' profit margin. This study analyzes soybean price through supply and demand factors namely: (1) energy cost of producing soybeans, (2) land use competition, (3) demand of soybean oil from export, (4) demand of soybean oil from the U.S. food industry and (5) demand of soybean oil from the U.S. biodiesel industry. The relative importance of the above mentioned factors are evaluated with Principle Component Analysis and multiple regression analysis using monthly data obtained from the U.S. Census Bureau. Analyses results suggest while supply factors do not significantly affect soybean oil price, soybean oil demand from the biodiesel industry and crude oil price are the main drivers of soybean oil price. Policy solutions should target to protect biodiesel producers' profit margin by paying attention to crude oil price and feedstock demand from the biodiesel industry. Some possible policy solutions include diversifying feedstock, setting a national demand mandate, and implementing a variable subsidy in addition to the RFS mandate.

Table of Contents

Introduction.....	6
Background.....	7
Environmental benefits of biodiesel	8
Status of the U.S. biodiesel market: declining production growth	9
Producers' Profit Margin and Feedstock Cost.....	10
Drivers of Soybean Oil Price: Supply and Demand.....	13
Supply Factors.....	14
Demand	14
Methods.....	15
Data sources	16
Data normalization.....	17
Results.....	17
PCA Results	17
Multiple Regression Analysis Results.....	18
Additional Analysis: Supply Factors	21
Additional Analysis: Demand Factors	23
Food Industry.....	24
Export	24
Biodiesel Demand	26
Discussion	27
Diversify Feedstock.....	29
Demand Mandate	29
Variable Tax Credit.....	30

Conclusion.....	31
References.....	32
Appendix A--Graphs and Tables.....	35
Appendix B-- A Review of Biofuel and Bioenergy from Woody Biomass.....	40
Case Study: Co-producing ethanol and cellulose fiber from Southern Pine	42
Case Study: The Challenges and Opportunities of Simpson Tacoma Kraft's \$100M Biomass Energy Project	44

List of Tables

Table 1--Results of principle component analysis	18
Table 2--Results of multiple regression analysis.....	19
Table 3--Results of power correlation analysis among the four variables.....	36
Table 4-- Breakeven analysis using 60 million gallon capacity plant	38
Table 5-- Breakeven analysis using 30 million gallon capacity plant	38
Table 6--Breakeven analysis using 10 million gallon capacity plant	38
Table 7-- Contents of cellulose, hemicelluloses, and lignin in common lignocellulosic materials.	41
Table 8—Wood consumed and products generated from various cases analyzed in the constant pulp production scenario.	42

List of Figures

Figure 1-- Current U.S. biodiesel mandate, capacity, and actual production.	9
Figure 2-- Average retail price of B99 compared to total production cost of biodiesel with \$1/gallon subsidy from 2005 -2010.	12
Figure 3-- Fitted values over observed values of the regression model.....	20
Figure 4--Soybean production cost breakdown (\$/acre) from 1997- 2009 without government payments.....	23
Figure 5--Soybean oil demand from export, biodiesel industry and food industry from 2004-2009.	27
Figure 6--U.S. soybeans price	28
Figure 7-- U.S. Average Retail Fuel Prices from 2000-2011	35
Figure 8--Soybean price from 2001- 2009	35
Figure 9--Diagnostic plot for multiple regression model.....	36
Figure 10--Acres of corn and soybeans planted in the U.S. from 1990-2010.....	37
Figure 11-- Soybean oil use breakdown in the United States 2009.....	37
Figure 12--Feedstock (soybean oil) to feedstock (crude oil) analysis.....	39

Introduction

High energy prices and environmental concerns associated with petro-based fuel have prompted changes in recent U.S. energy policy. Under the National Renewable Fuel Standard (RFS), the U.S. should meet the goal of producing 1 billion gallons of biomass-based diesel by year 2012. The U.S. federal government is providing a \$1 per gallon fixed subsidy to biodiesel producers to spur growth in the biodiesel production industry. Sufficient biodiesel production capacity exists in the United States; however, it is still unclear if the 2012 biodiesel production mandate can be met. Biodiesel production is related to producers' profit margin. The utilization rate of biodiesel production facilities dropped drastically in 2007 due to high feedstock cost, thus reducing producers' profit margin. As soybean oil is the prominent feedstock in the United States, finding the main drivers of soybean oil price gives insights to additional policy and business solutions aiming at buffering biodiesel producers' profit margin.

This paper explores soybean oil price through factors affecting the supply and demand of soybean oil. Five factors namely, (1) energy cost of producing soybeans, (2) land use competition, (3) demand of soybean oil from export, (4) demand of soybean oil from the U.S. food industry and (5) demand of soybean oil from the U.S. biodiesel industry, are examined to determine the main causes of soybean oil price increase. Analyses results suggest while supply factors do not significantly affect soybean oil price, soybean oil demand from the biodiesel industry and crude oil price are the main drivers of soybean oil price. Both factors have increased rapidly in recent years causing soybean oil price to surge upward which inevitably hinders biodiesel production growth in the United States. A fixed subsidy system does not account for producers' profit margin variability; therefore, alternative producers' incentives in addition to the current

fixed subsidy are needed to reduce biodiesel producers' risks from feedstock price volatility.

Background

The Energy and Security Act of 2007 addresses the importance of moving the United States away from oil dependence. One of the strategies is to create markets for clean domestic transportation fuels. A successful alternative fuel should meet the criteria of yielding more environmental benefits over the fossil fuel it displaces, being economically competitive with fossil fuels, and being producible at commercial scale (Hill et al., 2006). Corn grain ethanol and soybean biodiesel are the two prominent commercial biofuels being developed in the United States. This paper specifically examines the current market and production of biodiesel.

Biodiesel is produced by the transesterification of vegetable oil or animal fat. In short, the transesterification process removes a triglyceride molecule to produce monoalkylesters and glycerin. The purpose of transesterification is to lower the viscosity of biodiesel as the viscosity of biodiesel is 10-20 times higher than that of petroleum diesel's (Dimerbas, 2006). Lowering the viscosity of biodiesel is necessary because high viscosity affects fuel injection accuracy and leads to poorer atomization of fuel spray. Besides having higher viscosity, the main differences in fuel properties between petroleum diesel and biodiesel are, biodiesel blend has higher oxygen content and lower sulfur and aromatic content than diesel. The engine performance of diesel and biodiesel are very similar, no conversion on the engine is necessary for vehicles to use biodiesel blends. Currently, the most popular biodiesel blends are B20 (20% biodiesel, 80% diesel) and B35 (35% biodiesel, 65% diesel) (Wang et al, 2000).

Biodiesel has lower energy content than diesel, in the Annual Energy Outlook 2007(AEO 2007), the U.S. Energy Information Administration (EIA) reported that the energy content of each gallon of diesel is equivalent to 1.03 gallons of B100 (EIA 2007). Note that the energy content is very similar between petroleum diesel and B100, there is less energy content difference between petroleum diesel and B20 as the biodiesel component is less in B20 than that of B100.

Environmental benefits of biodiesel

The environmental benefits of biodiesel are apparent evaluated by the positive net energy balance (NEB), green house gas (GHG) reduction, and air pollutants reduction of replacing diesel with biodiesel. A gallon of biodiesel yields 93% more energy than it is required in its production (Hill et al., 2005). While the life-cycle green house gas reduction of biodiesel use varies widely depending on the study, most studies conclude that biodiesel has a positive impact on green house gas reduction. The National Renewable Energy Laboratory (NREL) stated that biodiesel production can achieve up to 78% green house gas reduction compared to petroleum diesel (USDA & DOE, 1998). In comparison, Hill et al. (2006) calculated a reduction of 41% GHG emissions when using soybean biodiesel to displace diesel at an energy equivalent amount. Moreover, biodiesel has air quality benefits; according to the Environmental Protection Agency report- "A Comprehensive Analysis of Biodiesel Impact on Exhaust Emission", soybean based B20 reduces particulate matter (PM) by 10.1%, hydrocarbons (HC) by 21.2%, and carbon monoxide (CO) by 11.0% increases while it increases nitrogen oxides (NOx) by 2.0%. In addition, toxic emissions also decrease with biodiesel mixed into diesel fuel. More precisely, exhaust emissions associated with biodiesel blends depend on the

feedstock of the biodiesel, how much is blended, and what type of diesel the biodiesel is added on (EPA 2003).

Status of the U.S. biodiesel market: declining production growth

In order for biodiesel to be economically competitive with diesel, biodiesel price has to be competitive with diesel price while the cost of production should be low enough to maintain a profit margin for biodiesel producers. The first step to evaluate if biodiesel can be produced economically at scale is by examining current market trends. Introduced under the Renewable Fuel Standard from Title II (Sec 202) of the Energy and Security Act of 2007, the Clean Air Act was amended to include a production mandate for biofuels. The purpose of the RFS is to promote and develop clean, domestic, alternative transportation fuel in the United States. The U.S. sets the goal of producing 1 billion gallons of biodiesel by 2012.

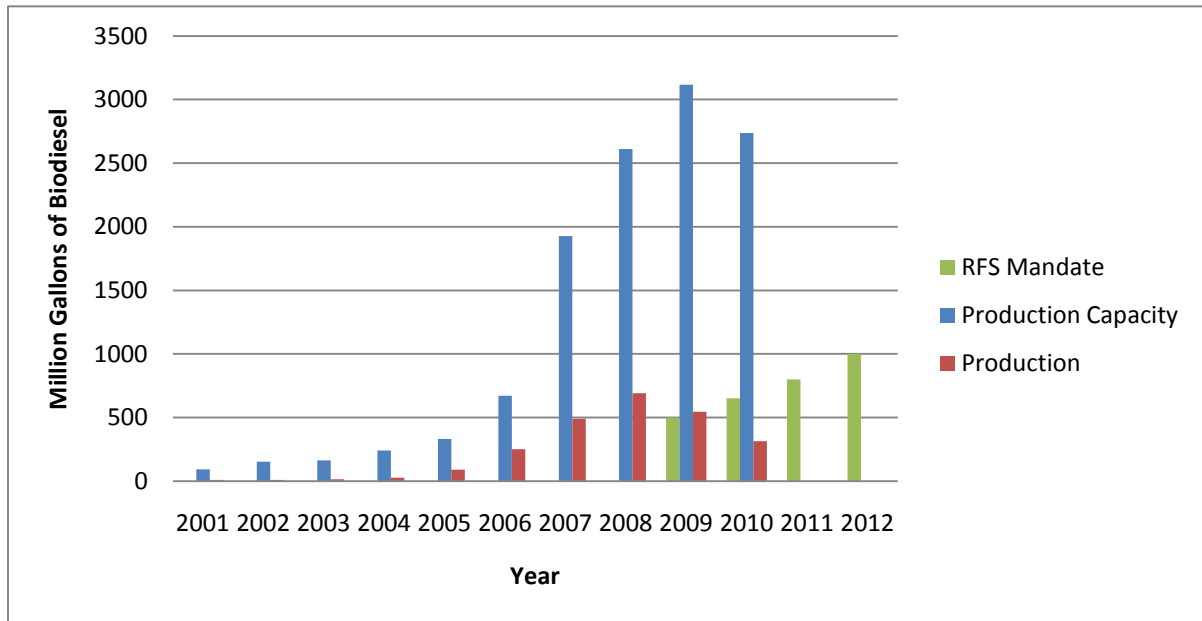


Figure 1--Current U.S. biodiesel mandate, capacity, and actual production. Capacity and production data obtained from the National Biodiesel Board. RFS mandate from Energy and Security Act of 2007.

Figure 1 shows the production mandate, current biodiesel production capacity and actual production in the U.S. since 2001. The United States' biodiesel production capacity far exceeds the production mandate. However, the U.S. has not been fully utilizing the available refining capacity. Most importantly, biodiesel production growth has been slowing down starting from 2007, a decline in production followed, subsequently, the U.S. failed to meet the 2010 production mandate. The U.S. biodiesel market would need a 685 million gallons production growth within the next two years if the U.S. were to meet the 2012 mandate. Achieving a 217% biodiesel production growth rate from now till 2012 seems to be a challenge for the U.S. biodiesel industry. Despite the presence of a mandate and with production capacity to spare, why is the U.S. biodiesel production falling below the RFS mandate?

Producers' Profit Margin and Feedstock Cost

The total biodiesel production capacity amounts to 2.5 billion gallons of biodiesel in 2010 (Fig. 1); the U.S. could have supplied the one billion gallons of mandated biodiesel by 2012 if biodiesel production were to be profitable. Profit margin, defined by selling price minus the cost of production, has to be large enough to incentivize biodiesel producers to make biodiesel. Taking a closer look at the cost of biodiesel production, based on the National Energy Modeling System (NEMS) developed by the EIA (2007), the costs of biodiesel production consist of feedstock cost, capital cost, and operating cost. Since glycerin is a value by-product of biodiesel production, glycerin adds profit to biodiesel production. In addition, under the Volumetric Excise Tax Credit for Biodiesel from EPACT 2005, biodiesel producers in the U.S. are eligible to claim a \$1.00 per gallon subsidy from the federal government for blending agri-biodiesel such as biodiesel using soybean and canola oil as the feedstock.

Feedstock cost is the largest contributor to biodiesel production cost, comprising 80% of the total biodiesel production cost according to the EIA (2009). Hass et.al's research shows that feedstock cost could be as high as 88% of the total biodiesel production cost (2006). In 2009, over 72% of biodiesel produced in the U.S. used soybean oil as the feedstock (EIA 2010). Other types of biodiesel feedstock used in the U.S. includes canola oil, sunflower oil, palm oil, tallow, corn oil, cottonseed oil, animal fat, and poultry oil (EIA 2009). The total demand for soybean oil from the biodiesel industry in 2009 was 1.97 billion pounds; soybean oil has been and will continue to be the most prominent feedstock of the U.S. biodiesel production industry. Since soybean oil is the primary feedstock of biodiesel production in the U.S., an increase in soybean oil price will drive up biodiesel production cost. An analysis of the dependence of production costs on the cost of the feedstock indicated a direct linear relationship between the two, with a change of \$0.075/gal in production cost per \$0.01/lb change in soybean oil cost (Haas 2006).

Figure 2 overlays the selling price and production cost of one gallon of biodiesel using soybean oil as the feedstock from year 2005-2010. Calculations of biodiesel production cost are based on a 30 million gallon capacity biodiesel plant, with an operating cost of \$0.31, a capital interest cost of \$0.076, electricity cost of \$0.36, a profit of \$0.08 per gallon of biodiesel from glycerin, and assuming 7.48 pounds of soybean oil are needed to produce one gallon of biodiesel (NEMS 2007). The average retail price of B99 (99% biodiesel, 1% diesel) represents the market value of a gallon of biodiesel in the United States. The price of biodiesel has always been closely related to the price of diesel since biodiesel is a substitute of diesel (Appendix Fig.7).

As seen in Figure 2, feedstock cost has grown drastically beginning from 2006. When biodiesel production cost goes up, biodiesel producers' profit margin diminishes, leaving fewer incentives for biodiesel producers to continue

making biodiesel. Ultimately, high feedstock cost casts a wide impact on the biodiesel production industry by putting a break on production growth. Average spot price for B99 in 2008 was \$3.8 per gallon, without subsidy, the breakeven feedstock price was approximately \$0.45 per pound of soybean oil, or a total feedstock cost of \$3.36 per gallon of biodiesel. Feedstock cost rose above the \$3.36 per gallon threshold towards the end of year 2007 and continued to climb (Appendix Fig. 8). As feedstock cost exceeded the breakeven threshold, the \$1 per gallon subsidy acted as a buffer to producers' profit margin. If the federal subsidy were not available, biodiesel production would have been economically unviable from year 2007 to 2008. High production cost coupled with recent economic downturn impeded biodiesel production in the United States; as a result, the biodiesel industry struggled to keep up with the RFS mandate.

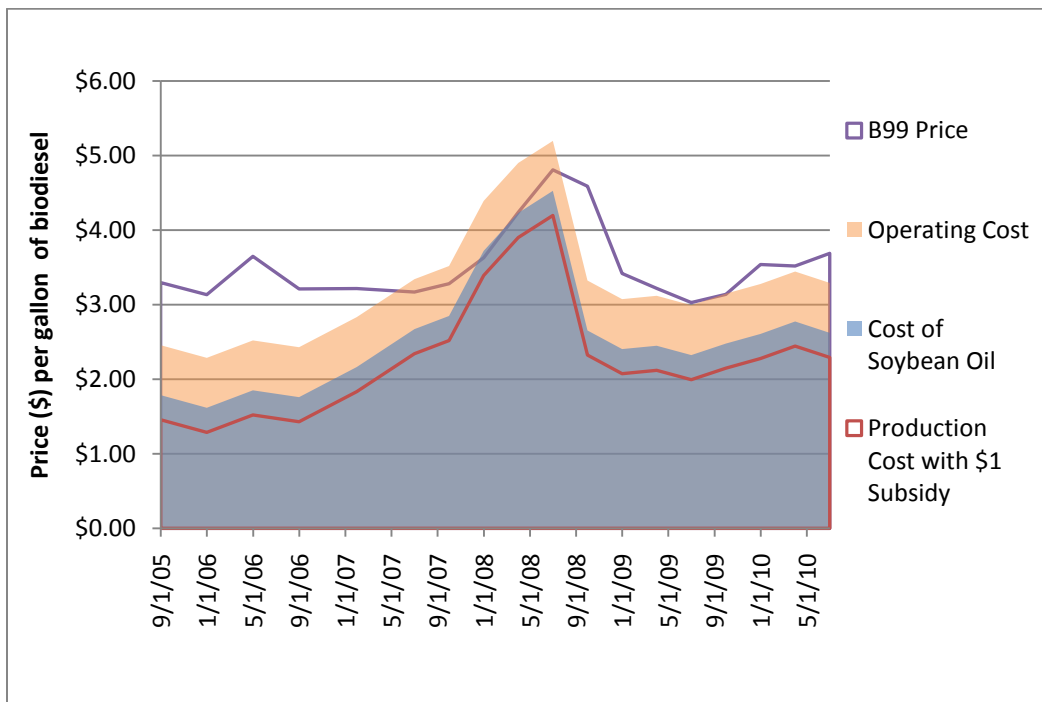


Figure 2-- Average retail price of B99 compared to total production cost of biodiesel with \$1/gallon subsidy from 2005 -2010. Retail price data obtained from U.S. Department of Energy, cost assumption obtained from EIA NEMS.

Drivers of Soybean Oil Price: Supply and Demand

With the understanding that recent biodiesel production in the U.S. has been held back by high soybean oil prices, additional policy or business solutions targeting the rapid increase of feedstock price or buffering producers' profit margin are needed. The price of soybean oil can be explored through the dynamics of supply and demand of soybean oil. Five factors are chosen to analyze the effects of supply and demand on soybean oil prices. Supply factors include energy cost of soybean production and land use competition; demand variables include soybean oil demands from the U.S. biodiesel industry, U.S. food industry, and exports. All of the above factors have possible influence over soybean oil price; the next step is to identify the relative importance of these variables over soybean oil price.

Soybean oil is derived from soybeans, the second most planted crop in the U.S. second to corn. 77.4 million acres of soybeans were planted in 2010, with plantings concentrated in the upper Midwest region of the U.S. as the yields in Midwest regions are higher than other parts of the United States. Almost all soybeans in the U.S. are crushed to extract both soybean oil and soybean meal. According to the Economic Research Service (ERS) of the United States Department of Agriculture (USDA), soybean meal is the most valuable part of the soybean which accounts for 50-75% of the soybean value. 98% soybean meal is used for animal feeds, and the remaining 2% is processed into human food items such as meat substitution and bakery ingredients. On the other hand, soybean oil is mainly used in salad and cooking oil, bakery shortening, and margarine, as well as in a number of industrial applications.

Supply Factors

While there are many causes influencing the supply of soybeans, energy cost of production and land use competition are supply variables that have significantly changed since the bloom of the U.S. biodiesel industry. Crude oil price reached a record high of \$134 per barrel in July, 2008. Though crude oil price dropped significantly towards the end of 2008, crude oil rose above \$100 per barrel since March, 2011 (Appendix Fig.7). Intuitively, energy cost of soybean production increases with rising crude oil price. Direct energy use of soybean production include electricity and farm fuels used for planting seeds and other farm activities such as land preparation, irrigation, fertilizer application, plowing and harvesting. The total average energy input of each bushel of soybean planted is 39, 878 Btu (Pradhan et al, 2009), which translates to \$13- \$20 per acre of soybeans planted between year 2006-2009 (ERS 2010).

With the popularity and high value of oil crops, land use change occurs to accommodate more plantations for oil crops. From 2006-2010, soybean plantation increased by 2 million acres while corn plantation increased by 10 million acres (Appendix Fig. 10). Oil crops and other crops depend on the same inputs: energy, water, and land. Land cost might have increased due to land use competition between crops. With increase in oil price, the fuel value of crops become more than the food value of crops moving the market towards the energy economy and causing the cost of crops production to increase.

Demand Factors

The demand for soybean oil can be categorized into three major sources: export, the food industry, the biodiesel industry. Soybean oil demand from all three sectors can potentially drive the price of soybean oil as the demand of

soybean oil from export, the food industry, and the biodiesel industry changed rapidly over the past decade. In 2009, soybean oil demand from the food industry comprised the largest demand for soybean oil at 79% of the total demand. While the demand from export doubled since 2004, soybean oil demand from the biodiesel industry grew five times since 2004 (ERS 2010). Raneses et al (1998) proposed that the increase in demand for soybean oil from the biodiesel industry would raise soybean oil price by as much as 14%, and could raise farm income by 0.3%. A decade of development in the biodiesel industry made Raneses et al.'s predictions obsolete. The price of soybean oil has increased by 144% since 2001 (Appendix Fig. 8), the effect of biodiesel demand on soybean price seemed to be much more than Raneses et al. had predicted.

Methods

To evaluate the relative importance of the supply and demand factors, the significance of energy cost of production, demand from biodiesel industry, demand from food industry, and export on soybean oil price are analyzed with principle component analysis (PCA) and a multiple regression model using the statistical software STATA.

Realizing collinearity (Appendix Table 3) between the variables energy cost of input and soybean oil demand from the biodiesel industry, the function of PCA is to identify the dominant variables without the influence of interactions between the variables. PCA converts the correlated variables into uncorrelated variables called principal components by orthogonal transformation. The model assigns weights to the original variables such that all components are not correlated with one another. The first component explains the most variances amongst the data set, and the subsequent components explain additional variances of the dataset.

The same set of data is evaluated with multiple regression analysis to examine the functional relationship of how the supply and demand variables affect soybean oil price. The multiple regression model explores the significance of each variable as well as conceptualizes how well the variables can predict soybean oil price. Model results from the PCA and multiple regression are used as the first approximation for pinpointing the most important drivers of soybean oil price. The relationships are further scrutinized with observations from past trends of soybean oil production and usage. Note that land use change is not included in the PCA or multiple regression model as land use change data are inappropriate for the analyses. Since farmers commit crop plantings annually, land use data cannot be compared with the other supply and demand variables which are monthly data.

Data sources

The PCA and multiple regression models utilize monthly data of all variables from December 2005 to September 2009 resulting in 46 observations. Monthly data of soybean oil price, energy cost of production, demand from biodiesel industry, food industry, and export are obtained from *Oilseed Crushings and Production, Consumption and Stocks* by the U.S. Census Bureau and Global Agricultural Trade System. The data for monthly energy costs of production are calculated by assuming 39 MJ is needed to produce each bushel of soybeans (Pradhan et al, 2009), and there are 60 pounds of soybeans in each bushel. Soybean oil is 18 percent of a soybean by weight (ERS 2010). The energy input is converted to crude oil requirement using the heating value as the common unit to obtain the cost of energy input by multiplying the crude oil requirement by the monthly crude oil price. Monthly crude oil price data are acquired from the Energy Information Administration (EIA 2010).

Data normalization

All data are normalized by subtracting the mean of the variable from each observation and then dividing the observation by the variable's standard deviation. The purpose of normalizing the data is to put all variables on the same playing field.

Results

PCA Results

The PCA acts as a data exploratory tool by taking out data redundancy within the dataset. The PCA assigns optimal weights to each of the variables such that most variances within the dataset can be explained by fewer variables. Components generated by the PCA are kept when the eigenvalues are above 1. The results of the PCA suggest two components should be kept among the four generated components. Component 1 and component 2 explain 73.8 percent of the total variance within the data set (Table 1). Component 1 of the PCA has high loadings on soybean oil demand from the biodiesel industry and energy cost of input indicating the two factors are the most dominant variables among the four inspected variables. Loadings on soybean oil demand from export and food industry are low on component 1 and higher on component 2. Evidently, the two factors explain less variance within the dataset. Based on the PCA results alone, we cannot dismiss soybean oil demand from the food industry and from export as insignificant variables.

Table 1--Results of principle component analysis

Principal components/correlation Number of obs = 4
 Number of comp. =
 Trace =
 Rotation: (unrotated = principal) Rho = 1.000

Component	Eigenvalue	Difference	Proportion	Cumulative	Variable	Comp1	Comp2
Comp1	1.73376	.517611	0.4334	0.4334	biodiesel	0.6423	0.2124
Comp2	1.21615	.501659	0.3040	0.7375	food	-0.0146	0.7608
Comp3	.714492	.378895	0.1786	0.9161	export	0.3488	-0.6007
Comp4	.335596	.	0.0839	1.0000	energyinput	0.6823	0.1234

Multiple Regression Analysis Results

The multiple regression model assess if the supply and demand variables are significant factors determining soybean oil price. Another function of the multiple regression model is exploring the ability of the variables to predict soybean oil price. The regression model is given by:

$$P_{SBO} = -0.20 + 0.31D_{biodiesel} - 0.05 D_{food} + 0.26D_{export} + 0.39 S_{energy} + .32(D_{biodiesel} * S_{energy}) + \epsilon$$

Simplified model:

$$P_{SBO} = -0.20 + (0.32 D_{biodiesel} + 0.39) S_{energy} - 0.05 D_{food} + 0.26D_{export} + \epsilon$$

Where:

P_{SBO} = Soybean oil price

$D_{biodiesel}$ = Soybean oil demand from biodiesel industry

D_{food} = Soybean oil demand from food industry

D_{export} = Soybean oil demand from export

S_{energy} = Energy cost of soybean production

$D_{biodiesel} * S_{energy}$ = Interaction factor between soybean oil demand from biodiesel industry and energy cost of input

ϵ = error

Table 2—Results of multiple regression analysis. All variables except soybean oil demand from the food industry are significant. The adjusted R-squared value of the model is 0.81 which could be interpreted as: 81% of the variance in soybean oil price can be explained by the significant variables.

Source	SS	df	MS			
Model	37.3961831	5	7.47923663	Number of obs =	46	
Residual	7.6038165	40	.190095413	F(5, 40) =	39.34	
Total	44.9999997	45	.999999992	Prob > F =	0.0000	
				R-squared =	0.8310	
				Adj R-squared =	0.8099	
				Root MSE =	.436	

soybeanoil~e	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
biodiesel	.3077942	.091983	3.35	0.002	.1218896	.4936988
food	-.0514927	.0707086	-0.73	0.471	-.1944001	.0914147
export	.2639717	.0710741	3.71	0.001	.1203256	.4076177
energyinput	.3936116	.1171558	3.36	0.002	.1568309	.6303922
int_biodie~y	.3197643	.0930572	3.44	0.001	.1316886	.5078399
_cons	-.1989249	.0865092	-2.30	0.027	-.3737666	-.0240832

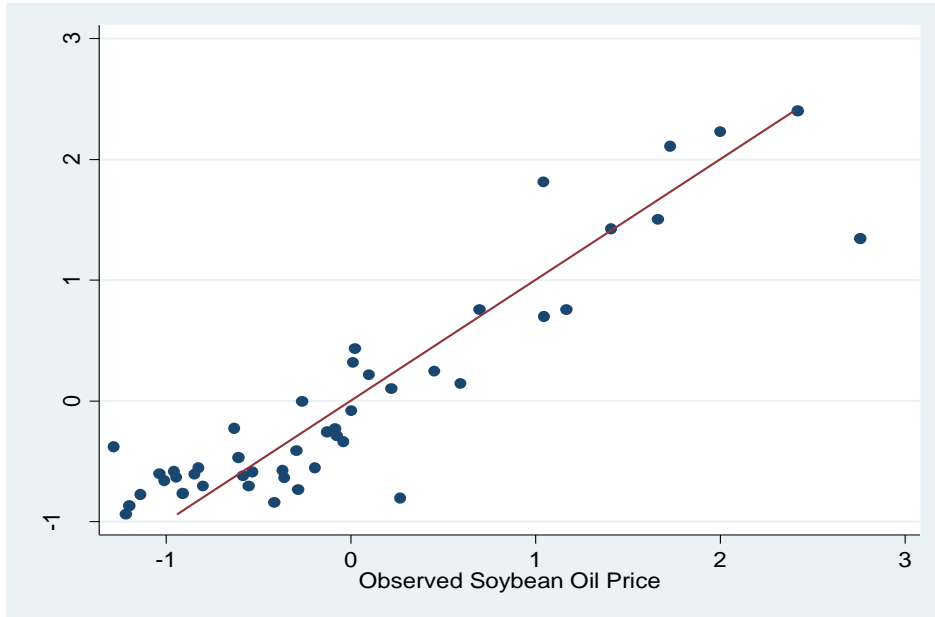


Figure 3-- This graph shows the fitted values over observed values of the regression model. The line represents when fitted values exactly match observed values.

Note that an interaction variable has been introduced to the model so as to address collinearity between the energy cost of soybean production and soybean oil demand from the biodiesel industry. The interaction variable is created by multiplying the two correlated variables together to allow the effects (or slopes) of the two variables to change according to one another. The correlation (R-value) of the model is 0.90. The R-squared value, also known as the coefficient of determination, is a value between 0 and 1 that shows the model fit. The higher the value, the better is the fit of the model. The adjusted R-squared value only accounts for the variances explained by the significant variables. Our model has an adjusted R-squared value of 0.81 (Table 2) which can be interpreted as 81 percent of the variances in soybean price is explained by all the significant variables in the model. Figure 3 shows the fit of observations over the regression model. The regression model indicates only soybean oil from food industry is not a significant factor predicting soybean oil price. All other

variables have a p-value of <0.05 , thus, are good predictors of soybean oil prices (Table 2).

Based on the results of the regression model, soybean oil demand from the biodiesel industry and cost of energy input are the two most important variables explaining soybean oil price trends, the soybean oil demand from export is also a significant variable though might not have as much effect on soybean oil price.

Additional Analysis: Supply Factors

To verify the results of the PCA and multiple regression model, it is important to gauge the model results in context of the soybean oil market. Energy cost of soybean production seems to be one of the two most important drivers of soybean oil price as suggested by the PCA and multiple regression analysis. However, in light of the total soybean production cost (Fig.4), energy cost makes up a small fraction (4 percent) of the total soybean production cost. Yield improvements in soybean farming means higher energy efficiency in soybean production which might have compensated the increased cost of energy (ERS 2010). The significance of energy cost is a result of the effect of crude oil price change since the data have been normalized. Crude oil price is a good predictor of commodity prices as it affects energy prices and the cost of a wide range of services and goods (Huntington, 1998). Nevertheless, rising energy cost of soybean production did not cause recent soybean oil price swells. The interaction effect between the energy cost variable and demand from biodiesel industry variable is linked by crude oil price. As crude oil price surges, alternative fuel in the transportation sector becomes popular and more attractive to investors. As a result, demand for energy crops from the biofuel industry intensifies and ultimately drives up energy crops prices. As Hayes et al. (2009) has pointed out, a "tight linkage" exists between energy and the

agricultural sector where agricultural commodities prices depend on energy price. Higher oil price provides a price floor for biofuel and its feedstock which helps the development of the biofuel markets.

Another interesting observation from Figure 4 is the trend of opportunity cost of land which is the biggest component of soybean production cost, making up 30 percent of the total production cost. Defined by the USDA, "land is valued according to the average cash rental rate for land producing the commodity in the particular area", and land rent is the payment that ensures the right to the use of land. The opportunity cost of land stands as a proxy for the impact of direct competition for land. The opportunity cost of land in the U.S. within the past decade has been staying relatively constant despite the increase demand for land to grow energy crops. As mentioned earlier in the paper, plantings of corn and soybeans have been steadily increasing since the late 90's (Appendix Fig. 10). If land use competition is a significant driver of soybean oil price, the effect cannot be captured by directly measuring land rent. The effect of land use competition is more indirect and dynamic than this study can depict.

The large difference between the gross value and cost of soybean production reveals that supply factors do not play important roles governing soybean oil price. The main reason being, the rising soybean value compensates soybean production cost increase. The cost of production has persistently increased starting from year 2000 as the value of soybeans goes up simultaneously (Fig 4). Before government subsidy, the value of soybean less total production cost, or farmers' profit margin, was negative from 1998- 2003. Farmers barely broke even from 2003-2006. From 2007 onwards, profit for farmers drastically increased to \$58/acre, \$110/acre, and \$79/acre in year 2007, 2008, and 2009 respectively (Fig 4). Farmers are profiting from higher soybean price as the rate of increase in cost of soybean production is slower than the rate of

increase in soybean price. As suggested by Carriquiry and Babcock (2008), the one billion gallon biodiesel mandate benefits farmers as the subsidy for biodiesel production are passed on from biodiesel producers to farmers through feedstock payments. In summary, evidence does not support the hypothesis of supply variables causing soybean price surges.

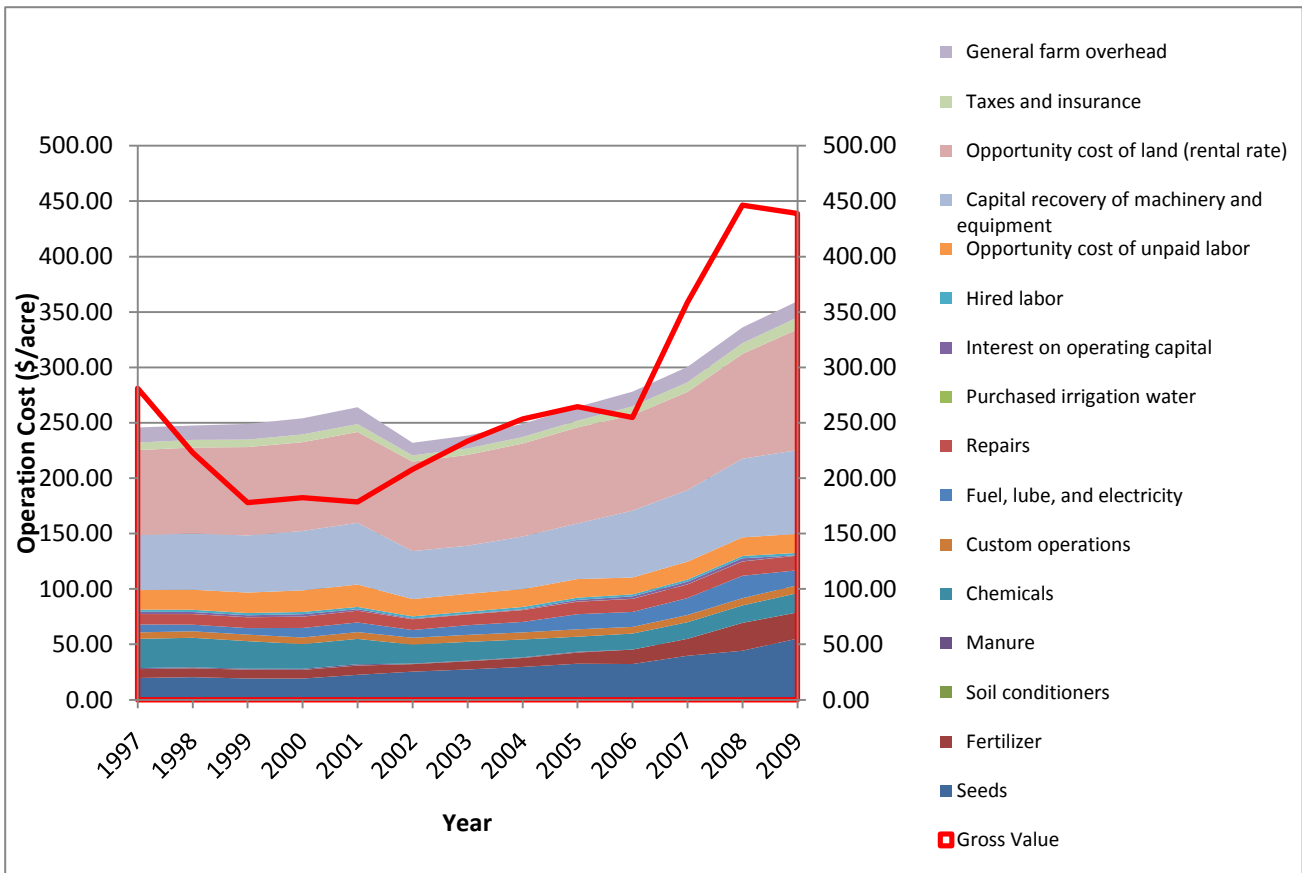


Figure 4—Soybean production cost breakdown (\$/acre) from 1997- 2009 without government payments. Data obtained from Energy Research Service of the USDA.

Additional Analysis: Demand Factors

After ruling out supply factors, it becomes more apparent that demand factors have major influences over soybean oil price. Suggested by the PCA and multiple regression results, soybean oil demand from the biodiesel industry is

the more salient factor prevailing over soybean oil price. Demand from export is also a significant factor though having less influence over soybean oil price than demand from the biodiesel industry. Soybean oil quantity demanded from export and biodiesel industry were very similar in 2009. Export and biodiesel industry made up 11.5 percent and 10.0 percent of total U.S. soybean oil demand respectively. The rest of the soybean oil demand came from the food industry (Appendix Fig. 11).

Food Industry

Although the food industry has been the biggest consumer of soybean oil, using 78% of the total soybean oil produced in the U.S., soybean oil demand from food industry has been declining over the past 3 to 4 years. Soybean oil comprises 55-65 percent of vegetable oils and animal fats consumed in the United States. Until 2005, soybean oil has been the most popular source of vegetable oil in the world. The food industry recently favors low trans-fatty acid oil reducing the food industry's demand for soybean oil. Palm oil has replaced soybean oil as the largest vegetable oil produced in the world. Production of palm oil and canola oil are expected to continue growing which implies more soybean oil will be substituted by palm oil and canola oil (ERS 2010). The reducing soybean oil demand from the food industry confirms that food industry demand for soybean oil is not responsible for recent soybean oil price increase.

Export

Soybean oil demand from export more than doubled between 2004 and 2009 (Figure 5). The change in demand from export might have contributed to the change in soybean oil price as remarked by results of the multiple regression analysis. The main soybean oil export destinations of the U.S. include China, the EU, Japan, Mexico, and Taiwan. The United States is the largest soybean

producer and exporter in the world. Other main soybean producers in the world are: Brazil, Argentina, and China (ERS 2010). While soybean oil export expanded by a billion pounds in year 2007 -2008, curiously, soybean oil demand from export dropped by 800 million pounds in the following year. The rapid change in soybean oil demand from export can be attributed to the change in soybean oil demand from the EU from year 2007 to 2009. The EU is the third largest soybean oil importer of the world, EU's soybean oil import dropped from 1040 thousand tons to 793 thousand tons in years 2007-2008 and 2008-2009 respectively (Foreign Agricultural Services, USDA). The declining trend of EU's soybean oil import is contributed by EU's increasing biodiesel import. Since one of EU's major uses for soybean oil is to produce biodiesel, it is more cost-effective for the EU to directly import biodiesel than to import soybean oil and produce their own biodiesel.

According to the EIA Short-Term Energy Outlook 2009, export of biodiesel from the U.S. to the EU increased from 237 million gallons of biodiesel to 646 million gallons of biodiesel from year 2007 to year 2008. In fact, most of the biodiesel produced in the U.S. were exported to the EU. In 2008, biodiesel exported to EU were over 90 percent of United States' biodiesel production. As mentioned earlier in this paper, under the Volumetric Excise Tax Credit for Biodiesel from EPACT 2005, U.S. biodiesel producers received a \$1 subsidy by blending a gallon of biodiesel to diesel. The subsidy was available to biodiesel producers regardless of where the biodiesel was produced or where the blend was consumed. This created a "loophole" for the U.S. biodiesel producers to export most of their subsidized biodiesel to foreign countries. The exploitation of the policy loophole was called "splash and dash". Biodiesel producer in the U.S. mixed B100 (100% biodiesel) with a small amount of diesel creating B99 (splash) which was then exported into the EU (dash).

EU biodiesel producers were not able to compete with the relatively inexpensive biodiesel imported from the United States. In March 2009, the EU imposed an anti-dumping tariff of up to 29 percent and an anti-subsidy duty up to 41 percent on all biodiesel produced in the United States.

Biodiesel Demand

Synthesizing all analyses results, biodiesel demand is most likely the factor driving up feedstock cost. Soybean oil demand from the biodiesel industry increased from 424 million pounds in years 2004-2005 to 3245 million pounds in years 2007-2008 (Fig. 5). Soybean oil demand from the biodiesel industry dropped in years 2008-2009 which coincided with the biodiesel production decrease in year 2009 (Fig. 1). The dynamic relationship between biodiesel demand and energy cost was briefly discussed in the supply factors section. Higher crude oil price raise prices of energy related products including diesel. As biodiesel and diesel price are closely related, higher diesel price also means higher biodiesel price which makes the market of biodiesel more attractive to biodiesel producers. The increase biodiesel demand inevitably pulls up soybean oil price. Recall that high soybean oil price diminishes producers' profit margin choking the biodiesel production industry in the U.S., the dynamic interaction among crude oil price, soybean oil demand from the biodiesel industry, and soybean oil price controls the boom and bust of the U.S. biodiesel industry. Counter intuitively, the clean alternative transportation fuel market cannot experience growth when crude oil price skyrockets.

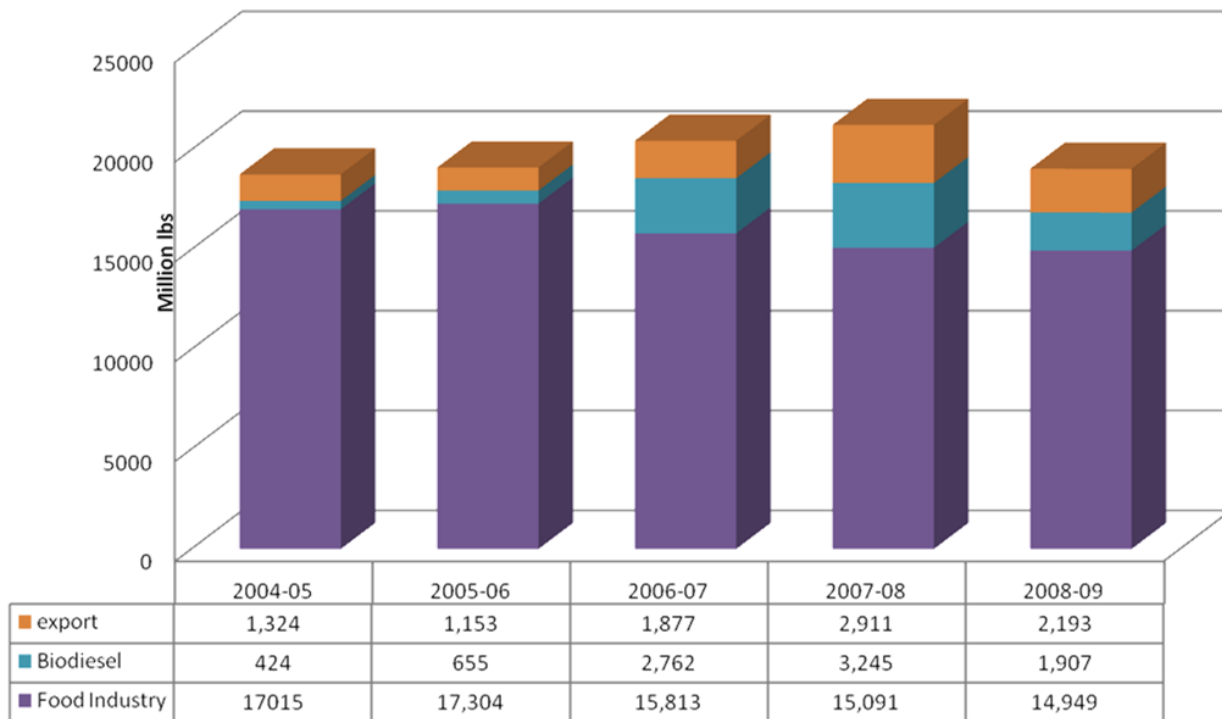


Figure 5—Soybean oil demand from export, biodiesel industry and food industry from 2004-2009. Data obtained from ERS.

Discussion

Whether the United States can meet the RFS mandate next year remains dubious. Understanding that growth in biodiesel production will cause soybean oil price to climb where the current federal subsidy might not be enough to buffer feedstock cost volatility, sudden and rapid biodiesel production growth might not be desirable. Furthermore, recent crude oil price has started to billow along with other commodity prices. The upward soybean price trend in the past year resembles the 2007-2008 soybean price trend (Fig. 6). If the rising energy and commodity prices trigger a repeat of the 2008 episode in the U.S. biodiesel production industry, biodiesel production in the U.S. will be stymied by high feedstock price again. In addition to the risk of high feedstock cost, biodiesel demand for export might be shrinking as the EU has implemented the additional

tariffs on U.S. biodiesel imports. Unless significant changes in the U.S. biodiesel policy occur within this year, it is unlikely that the U.S. will meet the RFS mandate in the coming year.

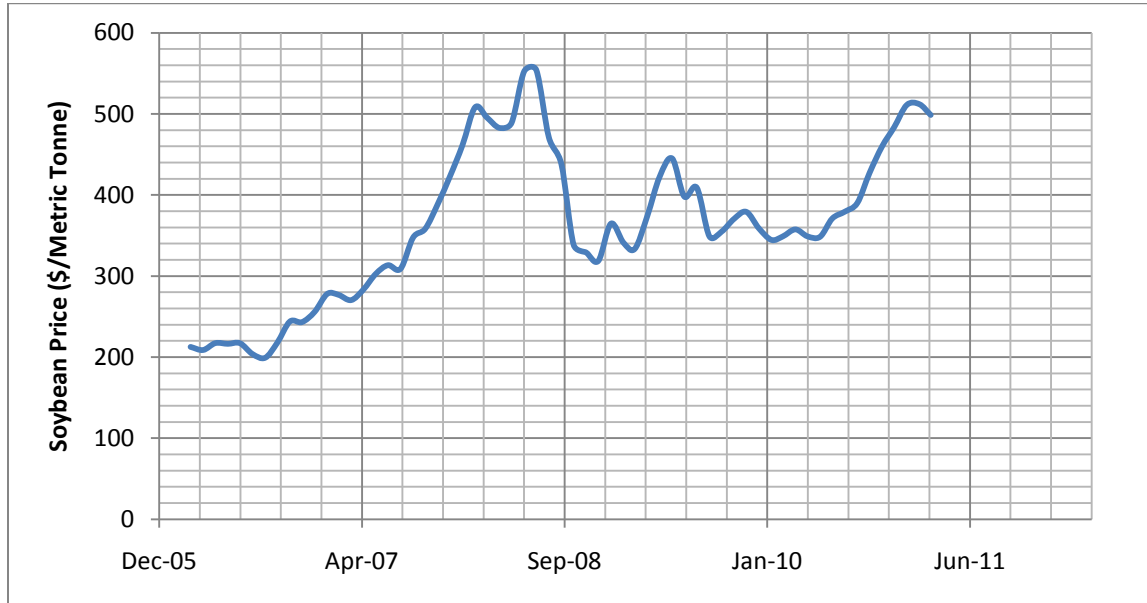


Figure 6— U.S. soybeans, Chicago Soybean futures contract (first contract forward) No. 2 yellow and par in the past 5 years. Data from IndexMundi

Biodiesel is a relatively new product compared to diesel in which the biodiesel production industry is less established than the diesel production industry. It is important to support the development of the biodiesel industry not only for biodiesel's environmental and energy security benefits but also to prepare the market for future generation biodiesel such as lignocellulosic biodiesel from advance technology under development. Government measures aim at promoting biofuel market growth include fuel mandates, tax incentives, and direct funding for capital projects. As suggested by Mabee (2007), successful policy interventions can take many forms. However, success of the biodiesel market will also depend on external factors such as competitive pricing for biodiesel, biomass availability, and investment in the biodiesel industry. Knowing that biodiesel demand and crude oil prices are the main

drivers of soybean oil price, what additional policy or business solutions can the United States invest in to strengthen the biodiesel industry?

Diversify Feedstock

Diversifying biodiesel feedstock can mitigate the rapidly expanding demand of soybean oil from the biodiesel industry. Concentrating on very few crops as the feedstock of biodiesel production can bring detrimental effects in the long-run, therefore, feedstock should be as diversified as possible (Kansedo et al. 2008). Other available biodiesel feedstock candidates include canola oil, sunflower oil, cotton seed oil, tallow, and waste vegetable oil. Many studies have proven the economic feasibility of biodiesel made from non-soybean oil feedstock. Non-edible feedstock such as waste cooking oil is preferred due to issues associated with arable land competition between grain crops and fuel crops. Zhang et al (2004) studied the economic feasibility of biodiesel made from waste cooking oil and found that the price of biodiesel and price of feedstock were the main factors affecting feasibility of making biodiesel from waste cooking oil.

Demand Mandate

The RFS serves as a production mandate; however, there is no national biodiesel use mandate. The environmental benefits of biodiesel should justify a higher selling price for biodiesel. However, without a mandate to use, consumers can choose not to buy biodiesel. Having a biodiesel use mandate can ensure a stable biodiesel demand, giving biodiesel producers the confidence to produce and sell biodiesel at a premium which will improve producers' profit margin adjusting for the high feedstock cost. Several states such as California, Florida, and Montana have started demand mandates to ensure the use of biodiesel within the States. One example of a demand mandate is the Vehicle Acquisition

and Fuel Use Requirements, States, schools and public fleets are required to use alternative fuel vehicles that run on biodiesel, or a certain percentage of biodiesel (DOE 2011).

Variable Tax Credit

Strong long-term government intervention can help buffer volatility in the biodiesel market reducing investment risk and maintaining profitability of biofuel projects (Coyle 2007). While the Volumetric Excise Tax Credit for Biodiesel help biodiesel producers absorb production cost, the fixed subsidy is not sufficient to guarantee a profit margin for producers when feedstock price becomes infeasible. An additional variable tax credit can be implemented when soybean oil price is too high which will buffer biodiesel producer's profit margin. Tyner analyzed the ethanol market with the idea of a variable subsidy in addition to the RFS. Although Tyner only focused on the effect of oil price on ethanol without considering variability in feedstock cost, the idea of achieving a buffer zone for biofuel producers' profit margin with a variable tax credit is applicable to our case. Tyner proposed to have an additional subsidy kicking in only when energy price is too low for ethanol producers to profit. In the case of biodiesel, a tax credit can be implemented based on feedstock price.

Conclusion

Summarizing the key findings of this study:

- The growth of the biodiesel industry depends on the economic feasibility of biodiesel production which is tied to feedstock price.
- High feedstock cost is the main obstacle to the U.S. biodiesel industry growth. Current fixed subsidy does not buffer producers' profit margin when feedstock price spikes.
- The increasing soybean oil price trend in the past few years is not caused by supply factors but mostly demand factors.
- Higher farming efficiency and higher gross value of soybeans offsets the increased cost of soybean production. Farmers benefit from biodiesel production.
- Though the effect of land use competition on feedstock price cannot be captured in this study, it is important for future studies to quantify such effects.
- Both PCA and multiple regression results conclude that soybean oil price is mainly driven by crude oil price and demand from the biodiesel industry. Though not as obvious, demand from export might have also contributed to changes in soybean oil price. Demand from the food industry is the only demand factor that does not have much influence over soybean oil price.
- Without additional policy, the U.S. will continue to have difficulties meeting the RFS mandate.
- Policy solutions should target to protect biodiesel producers' profit margin by paying attention to crude oil price and feedstock demand from the biodiesel industry. Some possible policy solutions include diversifying feedstock, setting a national demand mandate, and implementing a variable subsidy in addition to the RFS mandate.

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Appendix A--Graphs and Tables

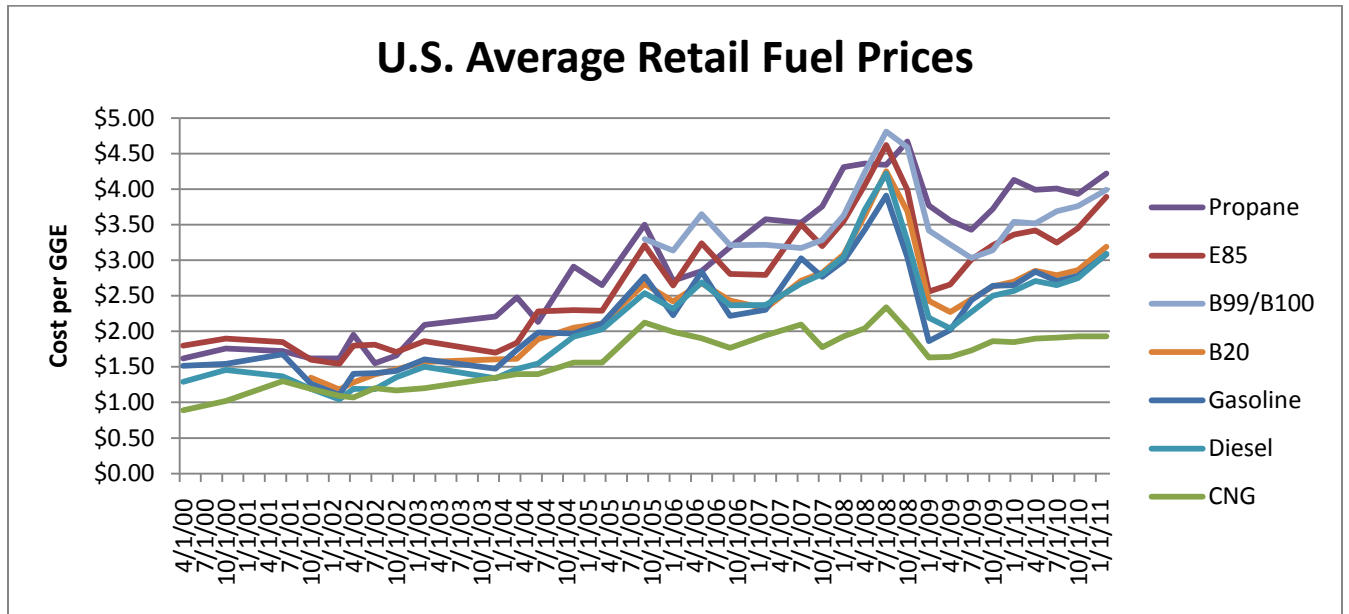


Figure 7-- U.S. Average Retail Fuel Prices from 2000-2011. Available at: www.afdc.energy.gov/afdc/data/

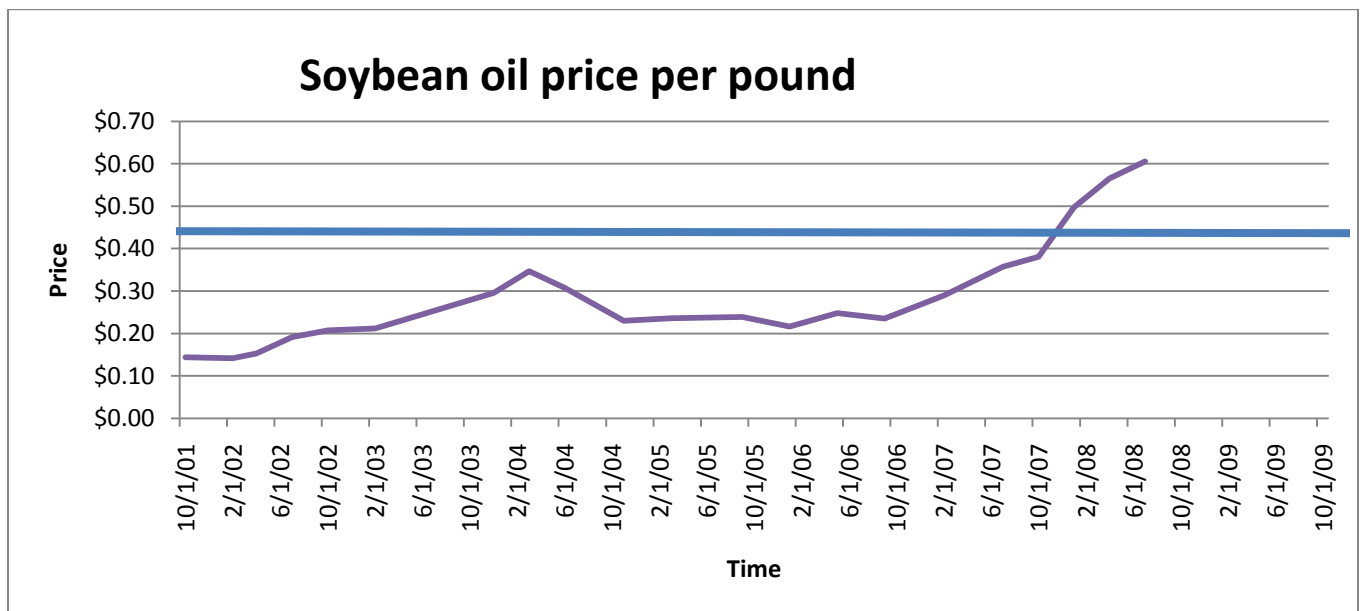


Figure 8— Soybean price from 2001- 2009, units in \$/pound. Soybean oil price exceeded threshold price in 2007.

Table 3—Results of power correlation analysis among the four variables. Only energy input and demand from biodiesel industry showed significant correlation ($p < 0.05$)

```
. pwcorr biodiesel food export energyinput,sig
```

	biodie~1	food	export	energy~t
biodiesel	1.0000			
food	0.0432 0.7758	1.0000		
export	0.1089 0.4712	-0.2444 0.1016	1.0000	
energyinput	0.6359 0.0000	0.0686 0.6507	0.2673 0.0725	1.0000

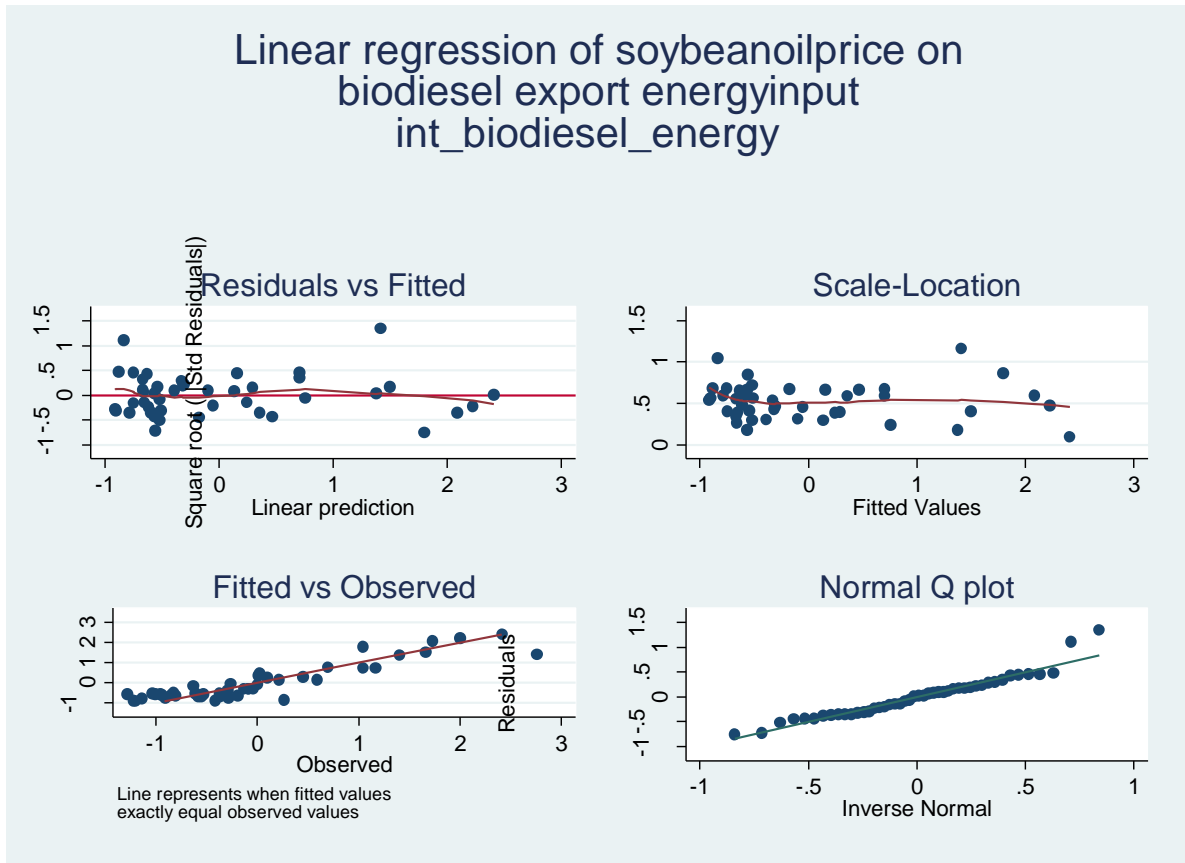


Figure 9— Diagnostic plot for multiple regression model

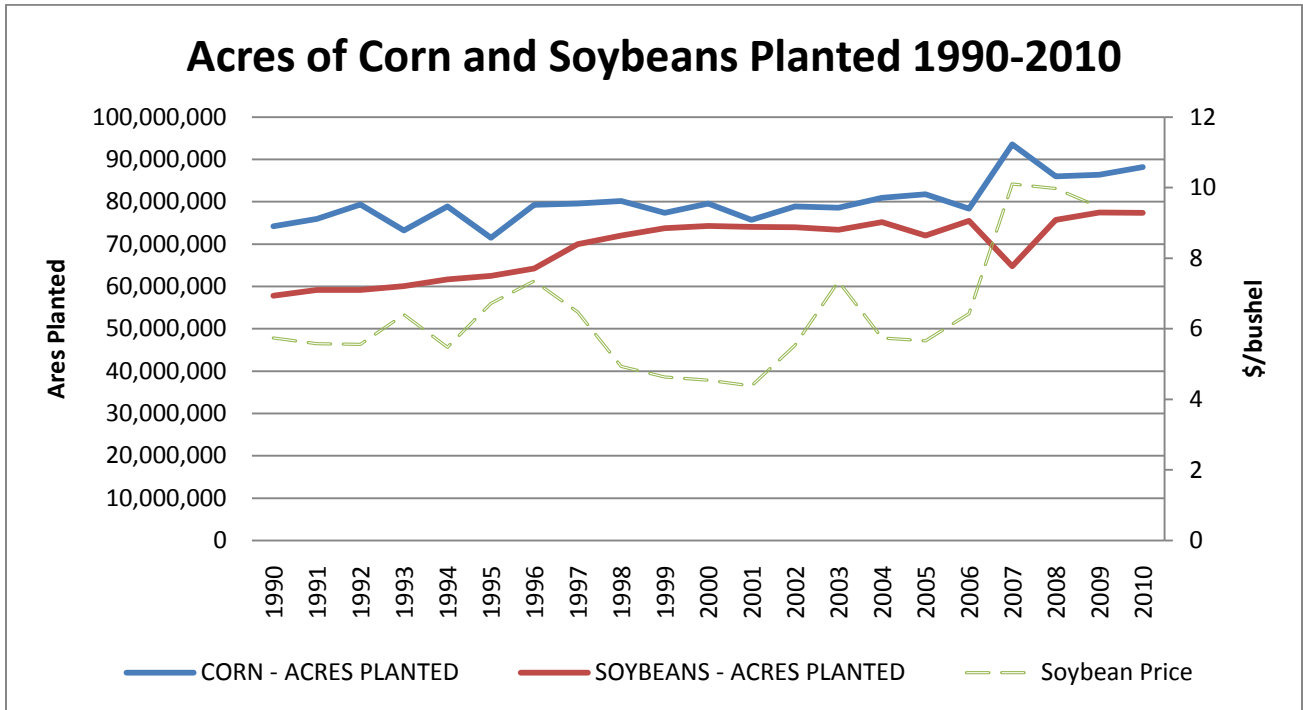


Figure 10—Acres of corn and soybeans planted in the U.S. from 1990-2010. Data obtained from EIA

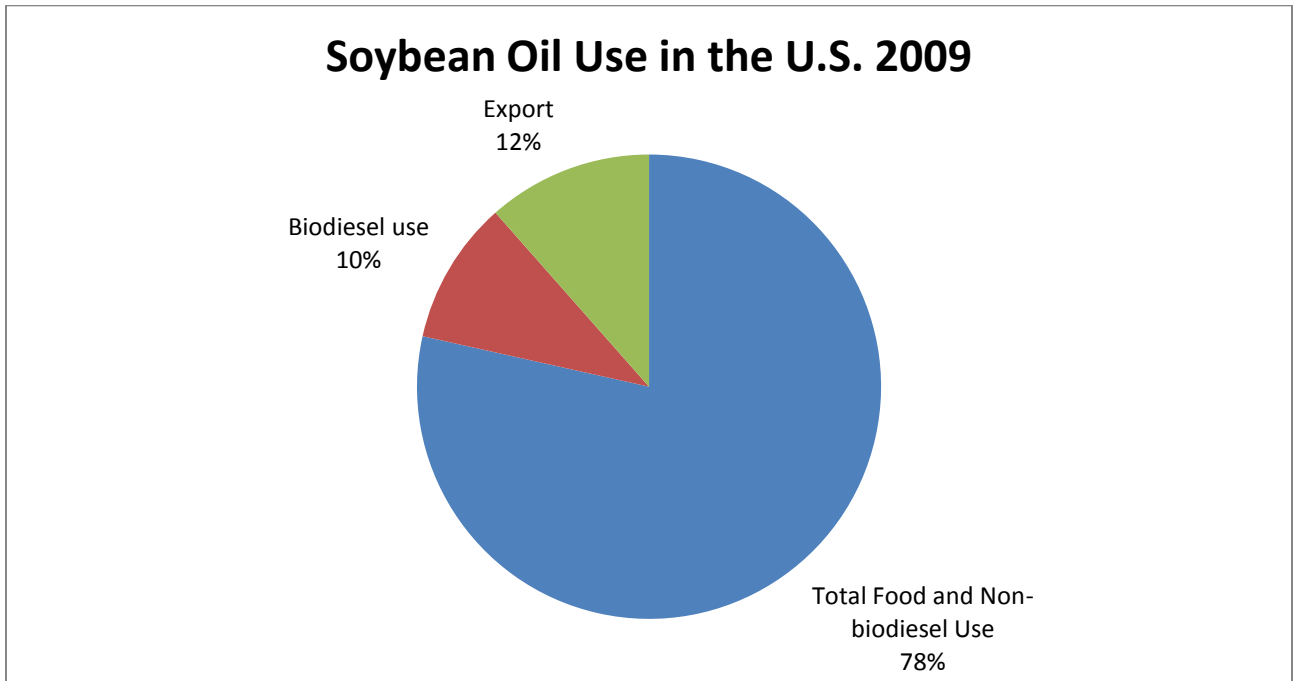


Figure 11-- Soybean oil use breakdown in the United States 2009.

Table 4-- Breakeven analysis using 60 million gallon capacity plant

		Biodiesel Spot price (\$/gallon)										
		2	2.2	2.4	2.6	2.8	3	3.2	3.4	3.6	3.8	4
Feedstock Prices (\$/lb)	0.15	0.23	0.43	0.63	0.83	1.03	1.23	1.43	1.63	1.83	2.03	2.23
	0.2	-0.144	0.056	0.256	0.456	0.656	0.856	1.056	1.256	1.456	1.656	1.856
	0.25	-0.518	-0.318	-0.118	0.082	0.282	0.482	0.682	0.882	1.082	1.282	1.482
	0.3	-0.892	-0.692	-0.492	-0.292	-0.092	0.108	0.308	0.508	0.708	0.908	1.108
	0.35	-1.266	-1.066	-0.866	-0.666	-0.466	-0.266	-0.066	0.134	0.334	0.534	0.734
	0.4	-1.64	-1.44	-1.24	-1.04	-0.84	-0.64	-0.44	-0.24	-0.04	0.16	0.36
	0.45	-2.014	-1.814	-1.614	-1.414	-1.214	-1.014	-0.814	-0.614	-0.414	-0.214	-0.014
	0.5	-2.388	-2.188	-1.988	-1.788	-1.588	-1.388	-1.188	-0.988	-0.788	-0.588	-0.388
Assumptions: 60 million gallon capacity, operating cost 31 cents, capital interest cost \$0.058, energy 36 cents, 7.48 lb feedstock/gal biodiesel, glycerin 8 cents/gal												

Table 5-- Breakeven analysis using 30 million gallon capacity plant

		Biodiesel Spot price (\$/gallon)										
		2	2.2	2.4	2.6	2.8	3	3.2	3.4	3.6	3.8	4
Feedstock Prices (\$/lb)	0.15	0.692	0.892	1.092	1.292	1.492	1.692	1.892	2.092	2.292	2.492	2.692
	0.2	0.318	0.518	0.718	0.918	1.118	1.318	1.518	1.718	1.918	2.118	2.318
	0.25	-0.056	0.144	0.344	0.544	0.744	0.944	1.144	1.344	1.544	1.744	1.944
	0.3	-0.43	-0.23	-0.03	0.17	0.37	0.57	0.77	0.97	1.17	1.37	1.57
	0.35	-0.804	-0.604	-0.404	-0.204	-0.004	0.196	0.396	0.596	0.796	0.996	1.196
	0.4	-1.178	-0.978	-0.778	-0.578	-0.378	-0.178	0.022	0.222	0.422	0.622	0.822
	0.45	-1.552	-1.352	-1.152	-0.952	-0.752	-0.552	-0.352	-0.152	0.048	0.248	0.448
	0.5	-1.926	-1.726	-1.526	-1.326	-1.126	-0.926	-0.726	-0.526	-0.326	-0.126	0.074
Assumptions: 30 million gallon capacity, operating cost 31 cents, capital interest cost \$0.076, electricity 36 cents, 7.48 lb feedstock/gal biodiesel, glycerin 8 cents/gal												

Table 6--Breakeven analysis using 10 million gallon capacity plant

		Biodiesel Spot price (\$/gallon)										
		2	2.2	2.4	2.6	2.8	3	3.2	3.4	3.6	3.8	4
Feedstock Prices (\$/lb)	0.15	0.171	0.371	0.571	0.771	0.971	1.171	1.371	1.571	1.771	1.971	2.171
	0.2	-0.203	-0.003	0.197	0.397	0.597	0.797	0.997	1.197	1.397	1.597	1.797
	0.25	-0.577	-0.377	-0.177	0.023	0.223	0.423	0.623	0.823	1.023	1.223	1.423
	0.3	-0.951	-0.751	-0.551	-0.351	-0.151	0.049	0.249	0.449	0.649	0.849	1.049
	0.35	-1.325	-1.125	-0.925	-0.725	-0.525	-0.325	-0.125	0.075	0.275	0.475	0.675
	0.4	-1.699	-1.499	-1.299	-1.099	-0.899	-0.699	-0.499	-0.299	-0.099	0.101	0.301
	0.45	-2.073	-1.873	-1.673	-1.473	-1.273	-1.073	-0.873	-0.673	-0.473	-0.273	-0.073
	0.5	-2.447	-2.247	-2.047	-1.847	-1.647	-1.447	-1.247	-1.047	-0.847	-0.647	-0.447
Assumptions: 10 million gallon capacity, operating cost 31 cents, capital interest cost \$0.117, electricity 36 cents, 7.48 lb feedstock/gal biodiesel, glycerin 8 cents/gal												

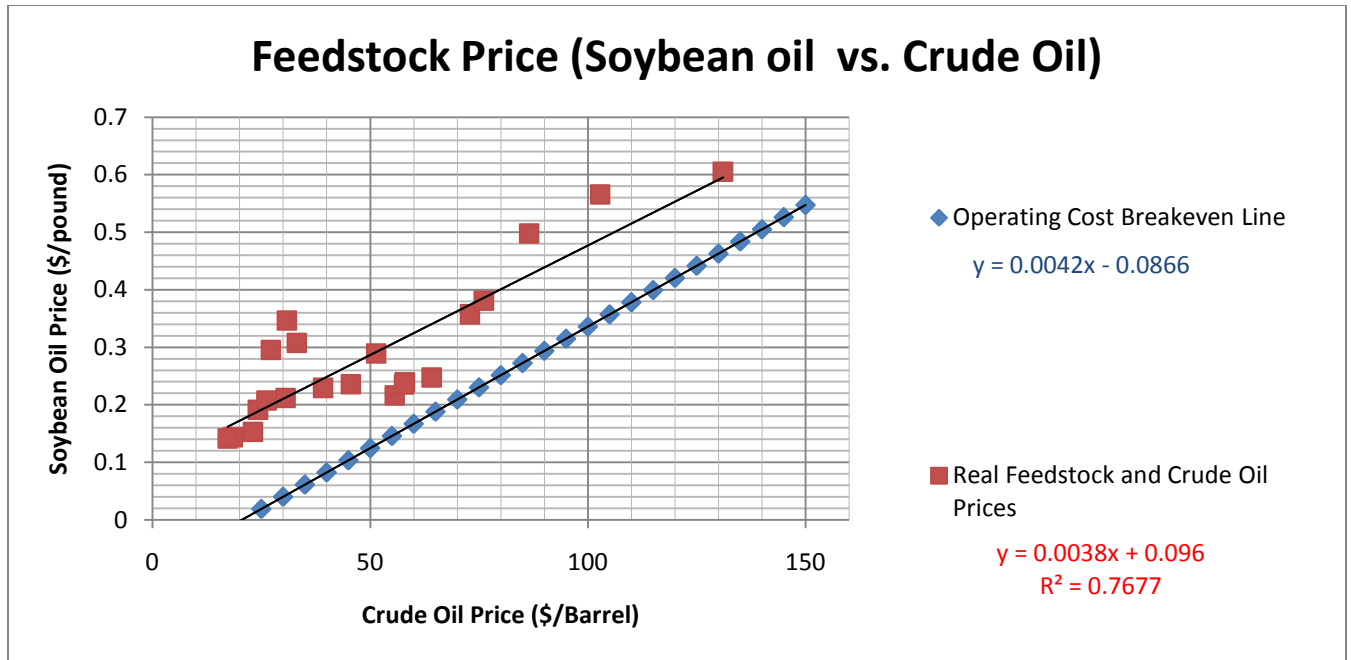


Figure 12—Feedstock (soybean oil) to feedstock (crude oil) analysis comparing biodiesel and diesel, the blue line models the threshold soybean oil price depending on crude oil price at a breakeven scenario before government subsidy. Region to the right produces profit. Data points in red shows real soybean oil and crude oil prices.

Appendix B-- A Review of Biofuel and Bioenergy from Woody Biomass

The major controversy related to corn ethanol and soybean biodiesel is land use competition between food and fuel. To avoid the problem of food versus fuel, non-food base biomass fuel is under development. Cellulosic biofuel is derived from wood, grasses, or non-edible plants. Cellulosic biofuels are also referred as advanced biofuel; current RFS mandate for cellulosic biofuel is set at 1 billion gallons by 2013, and 16 billion gallons by 2022.

Cellulosic- platform bioethanol can be produced from forest residuals such as wood chips. Lignocellulosic materials have high cellulose and hemicelluloses content and can be converted to ethanol by three steps: pretreatment, hydrolysis, and fermentation (Cheng 2010). Lignin, the main component of cell walls, hinders the hydrolysis process and has to be separated from cellulose. The challenges of cellulosic biofuel at present are: cellulosic biofuels are more energy intensive and more expensive to make. However, wood is widely available, and is a cheaper feedstock compare to agri-based feedstock. Biofuel from woody biomass has great potential to become a better clean, domestic, alternative transportation fuel than first generation biofuel.

Woody biomass has advantages over herbaceous biomass because of higher ethanol yield and availability (Table 7). Woody biomass is denser than herbaceous biomass making transportation of woody biomass the cheaper choice. Furthermore, wood waste from forest operations such as thinning and chipping can be diverted from the waste stream for biofuel production. The main downside of woody biomass is it is relatively difficult to extract cellulose from woody biomass compared to herbaceous biomass.

Table 7-- Contents of cellulose, hemicelluloses, and lignin in common lignocellulosic materials.

Lignocellulosic Materials	Cellulose, %	Hemicellulose, %	Lignin, %
Hardwoods stems	40-55	24-40	18-25
Softwood stems	45-50	25-35	25-35
Switch grass	45	31.4	12-20
<i>Miscanthus</i>	40	18	25
Coastal Bermuda grass	25	35.7	9-18
Corn stover	35-40	17-35	7-18
Wheat straw	30	50	15
Rice straw	36-47	19-25	10-24
Cotton seed hairs	80-95	5-20	0
Newspaper	40-55	25-40	18-30
White paper	85-99	0	0-15

Lignocellulosic ethanol production is entering commercialization stage. Current research and development efforts focus on reducing cost of the cellulase enzyme and improving treatment processes and feedstock research. The production cost of lignocellulosic ethanol is still too high compare with gasoline and corn ethanol due to the more complicated production processes. Extra cost is associated with the extra pre-treatment process necessary for lignocellulosic ethanol production.

Several pilot lignocellulosic ethanol production facilities are built, including a 100-300 liter per day capacity plant in Irvine, California. The Irvine plant processes mixed wood chips. The cellulose conversion efficiency reaches an average of 70 percent in the Irvine plant.

Reference

Cheng, Jay. *Advanced Biofuel Technologies: Status and Barriers*. WPS5411 Vol. World Bank, 2010. Web. April 29, 2011.

Case Study: Co-producing ethanol and cellulose fiber from Southern Pine

This case study is based on a research done by Frederick et al. (2008) on the technical and economical feasibility of producing both cellulosic ethanol and cellulose fiber from Southern Pine. The U.S. pulp and paper industry uses 30 percent of the harvested wood for fiber products, the rest of the materials are turned into fuel, generating electricity for the pulp and paper mills. Frederick et al. explored the possibility of producing cellulosic ethanol with the 70 percent remaining materials as opposed to using the materials solely for electricity generation.

The basis of the study is an ethanol plant integrated with a kraft pulp mill. The products of the plant are ethanol, cellulose fiber, and power. The feedstock of the plant is Southern Pine in which by content, has 65% cellulose and hemicellulose, and 27% lignin. Acid prehydrolysis is the process chosen for hemicellulose extraction. The aqueous residual from the ethanol extraction process is collected and used as a fuel for electricity generation. Table 8 summarizes the amount of ethanol output by varying wood consumption:

Table 8—Wood consumed and products generated from various cases analyzed in the constant pulp production scenario.

Bark-free wood extracted for ethanol production (%)	0	6	10	14	18	71.2
Wood purchased (dry, bark-free basis) (t a ⁻¹)	915,818	983,691	1,066,425	1,169,122	1,302,899	915,818
Ethanol produced (t a ⁻¹)	0	18,930	34,377	52,571	74,881	219,918
Unbleached fiber produced (t a ⁻¹)	426,640	426,640	426,640	426,640	426,640	0
Gypsum produced (t a ⁻¹)	0	8297	8995	9870	10,975	83,680
Exportable power (MWe)	19.4	30.3	32.4	34.8	38.0	-7.0
Exportable biomass fuel (t a ⁻¹)	88,060	1691	36,660	83,245	144,147	209,622

The efficiency of ethanol extraction decreases as wood consumption increases. The pre-extraction process causes cellulose loss, more cellulose is lost when the pre-extraction process becomes more extensive. The higher rate of cellulose loss results in higher ethanol extraction costs because more wood has to be purchased to compensate for the cellulose loss. Since cost of wood is the main

factor affecting the feasibility of cellulosic ethanol production, production cost becomes significantly higher when ethanol extraction efficiency is low. Frederic et al. concludes that ethanol production from the co-production process is not economically competitive with corn ethanol at present stage. Reducing cellulose loss from the ethanol extraction process is the key to making cellulosic ethanol production economically viable in pulp and paper mills.

Reference

Frederick Jr., W. J., et al. "Co-Production of Ethanol and Cellulose Fiber from Southern Pine: A Technical and Economic Assessment." *Biomass and Bioenergy* 32.12 (2008): 1293-302. Web.

Case Study: The Challenges and Opportunities of Simpson Tacoma Kraft's \$100M Biomass Energy Project

Simpson Tacoma Kraft Co., LLC, a timber product company in Washington, invested \$100 million to a biomass project in its pulp and paper mill in Tacoma. According to the USA Biomass Producers Alliances, the project is the largest cogeneration renewable energy project in the U.S. of the decade. The capacity of the cogeneration plant is 55 megawatts which generates enough electricity to power 40,000 homes¹. Simpson is selling the power outputs to PPM which is a wind energy provider in Oregon. The biomass power from Simpson is available for utilities customers in the West Coast.

Energy and steam are generated by wood residuals from the pulp and paper mill as well as using black liquor, a liquid chemical resulting from the process of converting wood into wood pulp. The renovated boiler of Simpson's pulp and paper mill has a steam turbine to support cogeneration. Cogeneration, also known as Combine Heat and Power (CHP), is a technology used for generating electricity and useful heat (e.g. steam) simultaneously; the main advantage of cogeneration is energy efficiency. The renovation project was completed in August 2009, since then, the plant had been in commercial operations.

Investment in expensive new technologies has its associated risks; however, Simpson views the investment in the biomass project as a long term investment that makes business and environmental sense. The electricity generated by biomass will supply the pulp and paper mill with power as well as extra electricity that creates a new stream of revenue for Simpson. Every month, Simpson sells approximately 27,500 Mwh of electricity which creates enough revenue to give the project a 5-8 year payback period². The environmental

¹ <http://biomassmagazine.com/articles/1628/simpson-tacoma-kraft-co.-to-cogenerate-biomass-power/>

² <http://chpcenternw.org/NwChpDocs/Simpson%20Tacoma%20Kraft-pp011811.pdf>

benefits of the project includes saving 300,000 tons of carbon dioxide emission per year, reducing NOx emissions, as well as providing energy savings from energy efficiency improvements.

Challenges: Capacity and Biomass Availability

Simpson's investment in the biomass project is based on a sound demand for renewable energy, however long-term challenges remain in which the major concerns are future renewable energy price and biomass supply. The Department of Ecology of the State of Washington produced a report addressing the current and potential bioenergy production in pulp and paper mills in the State of Washington. In reference to the report, the State of Washington has to meet a 15% renewable electricity requirement by 2020 under Initiative I-937. Currently, the State of Washington uses hydropower as its main renewable energy source. The report concludes that the pulp and paper industry has been under utilized as a source of renewable electricity. The pulp and paper industry is estimated to have a 520 MW capacity of electricity generation if all boilers were to be upgraded to state-of-the-art boilers technology.

There are 11 pulp and paper mills in the State of Washington, the capacity of the pulp and paper mills range from 60,000 tons to a million tons of paper and market pulp per year. The pulp and paper processing industry is energy intensive, contributing to 12% of the total energy use in the U.S. manufacturing sectors. In the State of Washington, if the pulp and paper mills were to depend their power sources from biomass alone, the sector needed 280,000 tons of biomass per year in addition to the 1.4 million tons of biomass being used currently. The total available amount of biomass from the pulp and paper industry is assessed to be 5.3 million tons which exceeds the need of biomass if all pulp and paper mills were to be powered by biomass.

To become a significant renewable energy source, pulp and paper mills should expand to the potential 520 MW electric generation capacity with cogeneration. An additional supply of 3.8 million tons of biomass is needed for the pulp and paper mills to reach the potential capacity. The total biomass needed is approximately the same amount as the available biomass from all pulp and paper mills from the State of Washington. Forest residuals from thinning and timber harvesting operations may supplement an extra 3 million tons of biomass for bioenergy. However, the biggest challenge is to transport the biomass at a reasonable cost. At current stage, the price for woody biomass does not justify such operation.

Since Simpson Tacoma is one of the largest pulp and paper mills in Washington and a leader in cogeneration in the Washington market, there are no short-term constraints in biomass supply or cost for the Simpson cogeneration. The main concern remains as the security of reasonable price for renewable energy. Renewable energy usually sells for a premium price to offset higher capital cost of generation which could make renewable energy less cost-effective than energy derived from fossil fuel. Simpson encountered the challenge of finding the right buyer for its bioenergy when the project first initiated. Tacoma Public Utilities, the local municipal of Tacoma, refused to buy Simpsons' bio-electricity as the municipal did not have the immediate need to buy expensive renewable power as hydroelectricity was much cheaper than bioenergy.³ Fortunately, California needs more renewable energy to meet its renewable electricity standard and is willing pay for the relatively expensive bioenergy from Simpson. California import electricity from Simpson through PPM in Oregon. Since electricity price in California is higher than that of Washington's, the relatively expensive bioenergy from Simpson is still cost-effective for California.

³ <http://www.timberbuysell.com/Community/DisplayNews.asp?id=3476>

After almost two years of operations, Simpson reported that there are minor difficulties with the biomass project. The power output is slightly less than the contracted amount and significantly less than what Simpson has anticipated. The cogeneration does not seamlessly work with the rest of the mill resulting in less efficiency in steam flow. Simpson is currently working on improving the system process, besides the small hiccups, the cogeneration technology is working.

Opportunities: Environmental Benefits and

The Renewable Electricity Standard (RES), a federal mandate, requires the U.S. to meet the goal of having 10% electricity generated from renewable energy sources excluding hydropower by 2020. In the State of California, the three biggest utilities are required to produce 33% of their electricity from renewable energy sources by 2020. The ambitious standard will stimulate renewable energy generation technology development in the West Coast. The market for Simpson is optimistic because the demand for renewable energy exists. As long as the cost of biomass electricity generation remains affordable, Simpson should not have any problem continuing the bioenergy operation.

Simpson also has the advantage for being a first mover in the biomass electricity market. While other pulp and paper mills in the State of Washington are still exploring the biomass market, Simpson already has its operation running. At the current stage, Simpson does not encounter other bioenergy competition in the market. Besides diversifying income, biomass energy production coincides with Simpson's commitment to responsible environmental and natural resource stewardship. Simpson is marketing bio-electricity as a green product that reduces carbon dioxide emissions. At the same time, bioenergy cuts down manufacturing waste: waste from the pulp and paper production process could be reused for electricity generation.

Lessons learned

Strong market and long-term secured pricing for renewable electricity are paramount for the success of biomass electricity because of the high capital cost associated with building infrastructures. When investing in a cogeneration project, investors have to plan for long-term revenue. There are uncertainties associated with future biomass supply availability and renewable electricity price. Government policy or regulations is necessary as they provide investors with more predictability of the energy market.