Field to flight: A techno-economic analysis of the corn stover to aviation biofuels supply chain

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Abstract

This analysis focuses on aviation biofuel production using fast pyrolysis from corn stover. Cellulosic biofuels carry a lot of risk, because conversion technology is expensive. As a result, incentives are needed to reduce the risk for private investors. The issue is choosing which policy will provide the most reduction in risk, while providing a lowest cost to the government. Uncertainty is added in benefit-cost analysis to fuel price and four technical variables: capital cost, final fuel yield, hydrogen cost, and feedstock cost. We look at the impact of two policies: reverse auction and capital subsidy. For the reverse auction and capital subsidy, we used contract lengths of 5, 10, and 15 years to see the impact a longer contract could have on probability of loss. A reverse auction reduced more risk of investment. As the contract length increased, the probability of loss and coefficient of variation in net present value were reduced substantially. When fuel price increased stochastically and a contract length of 15 years was used, probability of loss was reduced to 18.4 percent.

Introduction

Aviation Biofuels

Aviation biofuels can help to reduce GHG emissions, meet the Renewable Fuel Standard for cellulosic biofuels, and improve U.S. energy security.

Corn Stover

- Corn stover is a relatively inexpensive cellulosic feedstock.
- There is an abundance of supply.
- Corn stover results in little to no induced land use change.

Fast Pyrolysis

- It is a thermal process.
- Higher yields of liquids compared to other types of pyrolysis.
- Versatility, improved efficiency, and environmental acceptability.

Policy options

- Reverse auction

In a reverse auction a prospective purchaser would request bids for a contract with government to supply aviation biofuels. Private investors would place bids on the price per gallon of fuel. The lowest unique bidder wins the bid.

- Capital subsidy

A capital subsidy involves government paying a portion of capital cost and can take many forms. Here we used a simple form in which the government just pays a fraction of total capital cost.

In order to compare the two policies, we modeled the level of the capital subsidy to have the same cost to government as the reverse auction cases.

Material and Methods

Data

- *Techno-economic analysis data sources: the Iowa State University studies by Wright et al. (2010) and Brown et al. (2013). Base year: 2011.*
- *We recreated their analysis using a discounted rate of return cash flow model (Fig 1).*

Uncertainty

- *Technical uncertainty: capital cost, final fuel yield, hydrogen cost, and feedstock cost. The parameter distributions are estimated based on literature studies.*
- *Fuel price uncertainty: Geometric Brownian Motion is used for future price projection. Two price projections are applied, 1) stochastic fuel price with no drift 2) stochastic fuel price that increases over time at EPA projected growth rate.*

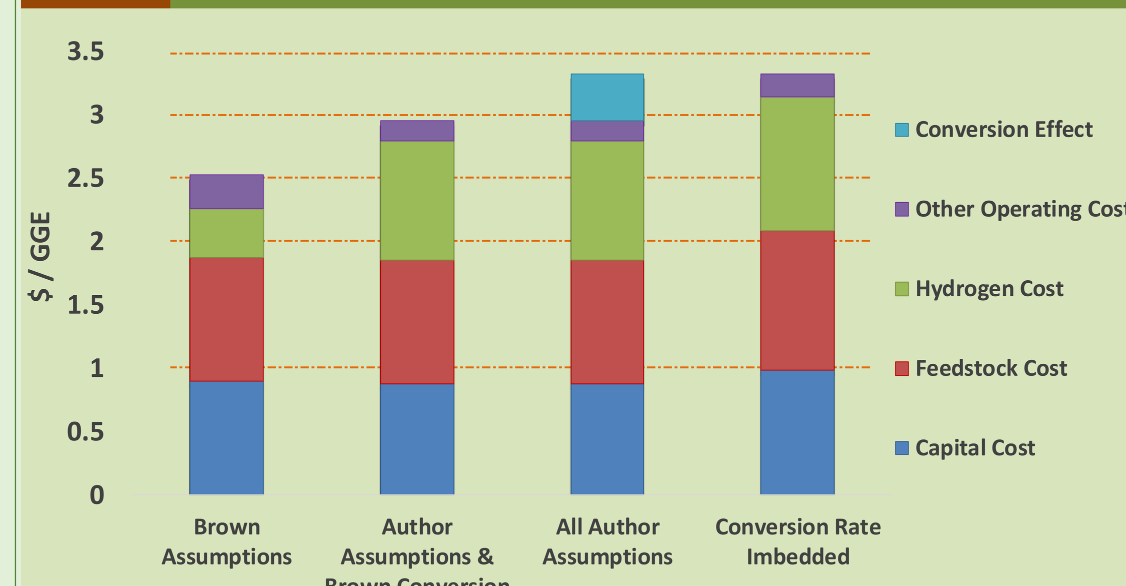
Base results

- *Breakeven fuel prices (Fig 1).*
- *Stochastic base results with steady stochastic fuel price and increasing stochastic fuel price (Table 1).*
- *Sensitivity analysis.*

Policies

- *Breakeven price become the point in the probability distribution for which the firm has a 50% chance of earing its stipulated rate of return. For reverse auction, we assume producers will bid a price at which producers will meet 25% probability of loss (Fig. 2).*
- *Three contract lengths are analyzed (Fig. 3), with 42 million gallons per year.*
- *Capital subsidy would have the same cost of government with reverse auction (Fig.4,5).*

Fig. 1 Breakdown of Impact each Parameter has on Breakeven Fuel Prices ($/GGE).



1. With all of the new parameters the fuel price is $3.33 per GGE, $0.76/GGE higher than Brown's.

2. The increase in prices is due primarily to the increase in hydrogen cost and decrease in final fuel yield from the original Brown values.

Table 1 Stochastic Base Results, distribution means for NPV, IRR, and B/C, for both steady and increasing fuel prices.

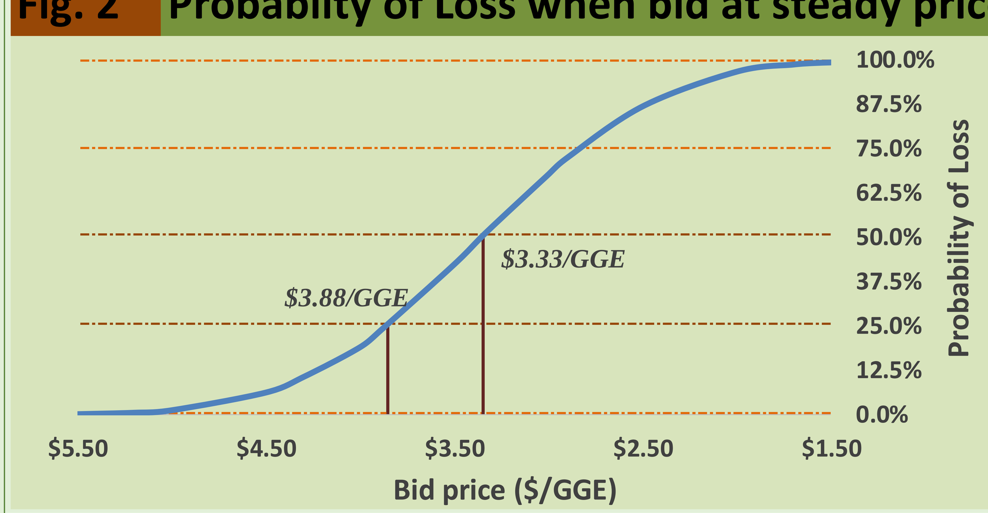
There are errors in IRR calculation in simulations. Negative prices are ruled out in simulations.

	Steady Stochastic Fuel Price			Increasing Stochastic Fuel Price		
	NPV	IRR	B/C	NPV	IRR	B/C
Mean ($	($84.94)	10.30%	0.92	$5.13	13.30%	1
Std dev ($	$215.10	10.20%	0.18	$225.89	10.10%	0.19
Prob. Loss	66.80%			49.70%		

1. With steady prices, Prob. Loss is 66.8%; this Prob. Loss decreased to 49.7% with a increasing price scenario.

2. Overall, there is a lot of risk for an investment in this case. Private investors would be discouraged from making an investment.

Fig. 2 Probablity of Loss when bid at steady prices with no policy.

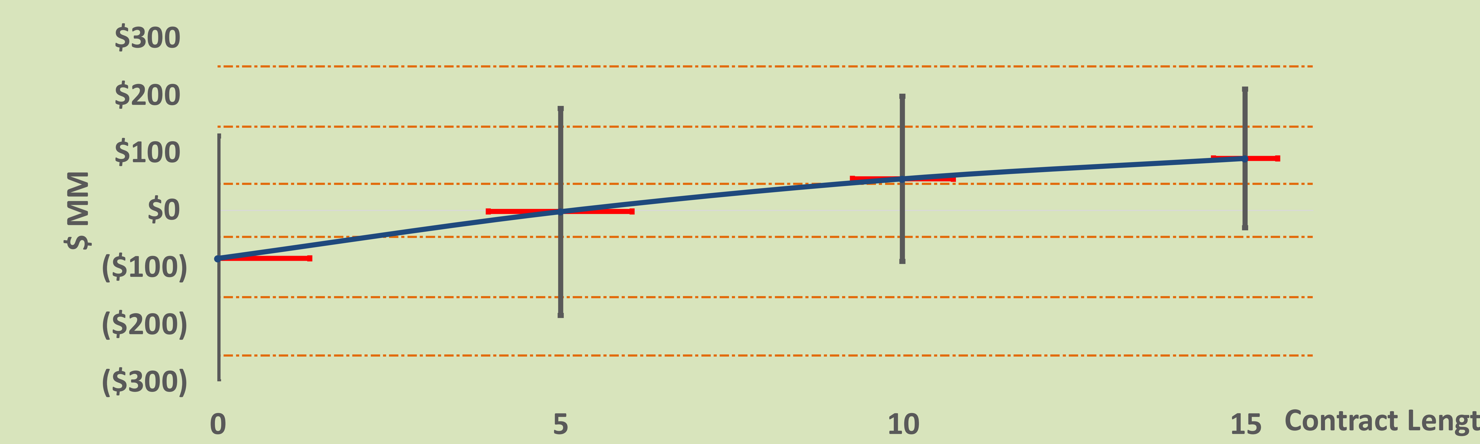


In reverse auction, we assume producers will bid at $3.88/GGE for stead price case, at which producer would face a 25% probability of loss. The level does not matter in regard to policy comparisions in this study.

Results and Discussion

Fig. 3 NPV, Standard Deviation and Probability of loss result from reverse auction (Steady fuel market fuel price).

The line levels indicate NPV means. The vertical error bars indicate standard deviations. The horizontal error bars indicate probability of loss.



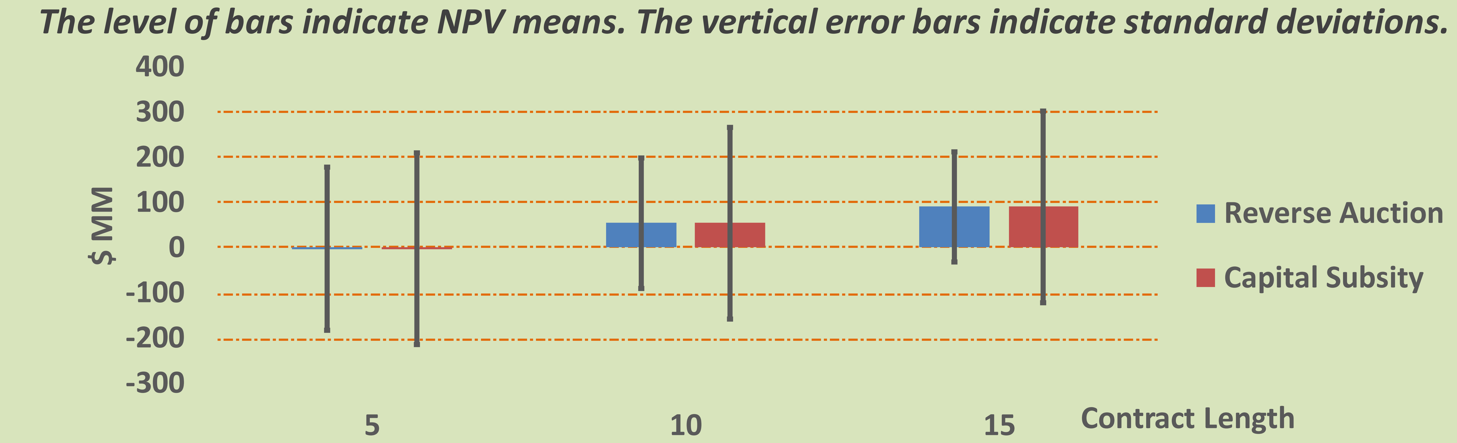
1. The NPV mean become positive when contract length reached 10 years.

2. Prob. Loss decreased dramatically from 66.8% with no contract to 23.3% with 15-year contract.

3. The standard deviation decreased significantly with the increase of contract length.

Fig. 4 Comparision of reverse auction and capital subsidy, NPV and Standard Deviation results with steady prices.

The level of bars indicate NPV means. The vertical error bars indicate standard deviations.

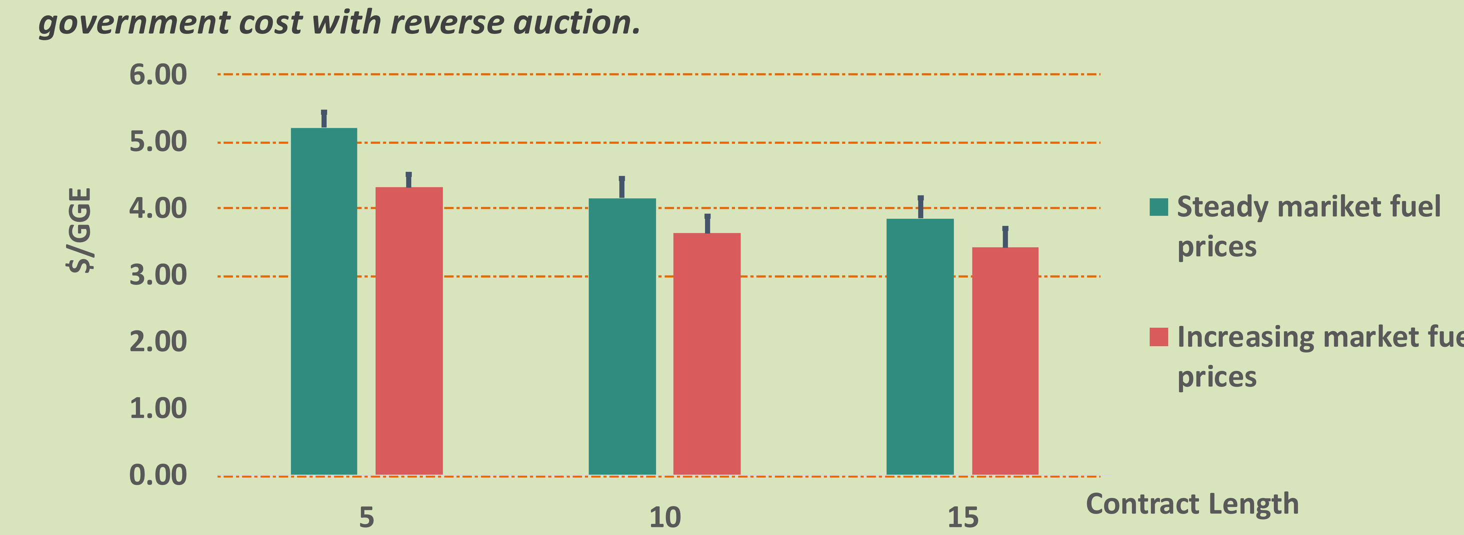


1. Both reverse auction and capital subsidy shifted NPVs to right at the same extent.

2. However, the Std Dev in capital subsidy case will remain unchanged. The Std Dev of reverse auction decreased with contract length.

Fig. 5 Bid prices at 25% probability of loss (with policies) for reverse auction with steady and increasing market fuel prices.

The bar levels indicate bid prices.
The vertical error bars indicate the equivalent bid prices for capical subsidy that has the same government cost with reverse auction.



1. An alternative way to compare the two policies is to compare the bid price at which producers can achieve 25% probability of loss with a policy.

2. Bid prices are decreasing with contract length.

3. Bid prices for capital subsidy are larger than them for reverse auction.

Conclusions

1. The reverse auction reduced risk more than capital subsidy when the costs to the government are the same.
2. More risk would be reduced as reverse auction contract length increases.
3. However, there may be difficulties in securing adequate competition for new processes such as pyrolysis based aviation biofuels.