On Real Options in Ethanol: Producers, Blenders, Valuation and Empirics

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This paper explores the existence and relevance of real options in the ethanol industry. It focuses on the behavior of ethanol producers and blenders in response to government mandates and economic incentives. Through a realistic yet stylized model the authors derive closed form expressions for the ethanol price and industry physical output in terms of gasoline and corn prices. In addition, the value of an ethanol producer is expressed as that of a portfolio of real options on a gasoline-corn spread. These predictions are tested empirically on market and output data for the 2000-2017 period, and by comparison with the market value of the largest ethanol producer in the U.S. Support is found for several implications of the model. The authors conclude that real options are relevant for a quantitative understanding of the ethanol industry.

Introduction

Increased concern about energy security and the environment led to the adoption of the Renewable Fuel Standard (RFS) in 2005 and, two years later, the Energy Independence and Security Act. A very large increase in the demand for ethanol followed, which in turn caused strong growth in ethanol production capacity and physical output. Between 2005 and 2017 the number of ethanol plants in the U.S. roughly tripled and the ethanol blend rate, or proportion of gasoline fuel provided by ethanol, reached 10.0%. According to the Renewable Fuels Association (2017), roughly 30% of U.S. corn output has been recently used as an input by ethanol producers, who sell their output to ethanol blenders for its final use as fuel. The large size of the ethanol market makes it economically significant in the energy landscape. It also has implications for the price of food, for geopolitical and environmental concerns, and for the transportation industry.

In this paper the authors study, through theory and empirical analysis, optimal operation in the ethanol industry and its consequences for ethanol market dynamics. The authors make realistic assumptions for the dynamics of corn and gasoline prices that drive the price of ethanol and take into account the incentives faced by competitive ethanol producers and gasoline blenders under realistic government mandates and capacity constraints. The theoretical model implies explicit formulas for the ethanol price and aggregate physical output, and for the value of an ethanol producer. Predictions are set in terms of the exogenous dynamics of gasoline and corn by focusing on the possible substitution of gasoline by ethanol. The paper also includes empirical testing for the model using aggregate and microeconomic data. Hence, some empirical support is found for a nonlinear pricing mechanism and production rule for ethanol. Then, focusing on firm level data, the share price of a major ethanol producer is found to reflect some essential elements of the model. The paper builds on Ghoddusi (2017) who observed that ethanol may function either as a substitute or a complement for gasoline depending on their relative prices. However, this paper focuses on the substitution effect between ethanol and gasoline in a general setting, derives testable implications and brings them to the data.

Dr. Nicolás Merener, Ph.D., Dean, School of Business, Universidad Torcuato Di Tella, Argentina, presenting at the JPMCC's 3rd Annual International Commodities Symposium, which was held at the University of Colorado Denver Business School in August 2019.

Among the research agendas close to this paper, three stand out. First, there is a large literature devoted to understanding the prices of ethanol, energy sources and corn. Some examples are Mallory *et al*. (2012) on pricing ethanol in terms of futures prices of natural gas and corn, McPhail and Babcock (2012) on the RFS and ethanol prices, and Abbott (2014) on the contributions of ethanol capacity constraints versus ethanol mandates. These mechanisms are also behind our model. Trujillo-Barrera *et al*. (2012) and Serra and Zilberman (2013) studied and reviewed transmission mechanisms between corn and energy markets. Second, it is important to understand the determinants of investment and ethanol physical output. The value of the real option in ethanol production under optimal operation was studied in Kirby and Davison (2010), Schmit *et al*. (2011), Maxwell and Davison (2014) and Ghoddusi (2017) among others. Finally, the optimal operation of commodity firms has been subject of study as well.

The Model

The agents in the model, in the spirit of Ghoddusi (2017) but avoiding certain assumptions therein, are ethanol producers and ethanol blenders operating in a competitive environment. Producers have the real option to turn production on or off depending on the profitability of their operation. This is determined by the market price of ethanol and its cost of production driven by corn. Engineering parameters are as in Irwin (2016). Blenders face a floor on the amount of ethanol they must purchase, set by the government mandate. However, blenders can increase the proportion of ethanol mixed with pure gasoline if it is economically convenient to do so. Hence, the amount of ethanol demanded depends on the relative pricing of gasoline and ethanol. In equilibrium the model holds that:

1) The price of ethanol is a nonlinear function of the prices of corn and gasoline. Specifically, it is the maximum of two affine functions, one in each of these variables. Hence, when gasoline is relatively expensive, ethanol is priced as fuel. When the corn prices are high, ethanol is priced as its cost of production.

2) Industry output is set jointly with prices. When the price of gasoline is relatively high, ethanol demand is strong and the capacity utilization ratio reaches 1. On the other hand, low gasoline prices decrease the appetite for ethanol which is then produced solely to satisfy the government mandate. The capacity utilization ratio reflects this through the relative size of the mandate and installed capacity.

3) The profit of an ethanol producer is determined by the spread between gasoline and corn. Hence, the producer can be understood as holding a collection of real call options on such a spread. Closed form solutions for the value of an ethanol producer are derived under the additional assumption of a stochastic process for the spread.

The Data

The paper uses monthly data on gasoline, ethanol and corn spot prices, ethanol production, installed capacity and additional parameters such as extra costs and credits. These are taken from the USDA. Mallory *et al*. (2012) proposed a model for ethanol in terms of futures prices of natural gas and corn. We also work with CME corn futures (4th contract) and ICE NY RBOB gasoline futures (6th contract), which correspond to expiration roughly between 6 and 9 months away from spot. Each year the Renewable Fuel Association publishes a list of ethanol producers. Green Plains satisfied the joint condition of being publicly traded and focused almost exclusively on ethanol, hence a good candidate for testing the predictions of the model regarding the valuation of ethanol producers. As of 2017 Green Plains had an approximate production capacity of 1.5 billion gallons per year, close to 10% of U.S. ethanol production. Yearly data for Green Plains on outstanding number of shares, ethanol production capacity and outstanding debt were obtained from the 10K reports to the U.S. Securities and Exchange Commission.

Empirical Results

Under the model proposed in this paper, the price of ethanol is a nonlinear function of the prices of gasoline and corn. In a direct test of this statement, the formula was implemented empirically on historical prices of gasoline and corn between 2000 and 2017, and then compared with historical ethanol prices. Fitting errors, of the order of 30 cents per gallon of ethanol are shown to be not larger for the theoretical model than for the best-fit linear models with more degrees of freedom. Hence, the nonlinear mechanism proposed in the model seems relevant to explain its performance in reproducing the dynamics of historical ethanol prices to some extent.

The model predicts that the capacity utilization ratio should be an increasing function of the gasoline corn spread. It is then found empirically that between 2008 and 2017 such a relationship was present in the data. For months with a large gasoline corn spread, theoretical and historical utilization ratios were close to 1, while for instances with a small spread, theoretical and historical utilization ratios were close to 0.90.

Finally, according to the model in this paper, the value of an ethanol producer should be that of a portfolio of real call options on the gasoline corn spread. Regardless of the choice of dynamical model for the spread, the producer's value should be increasing on the spread and it should exhibit some positive convexity. These notions were tested on monthly data for Green Plains, a major ethanol producer in the U.S., between 2012 and 2017. Time series regressions were run after controlling for variations in the general level of equity markets and adjusting for installed capacity, outstanding debt and number of shares. The authors find strong statistical and economic significance for the gasoline corn spread in explaining fluctuations in the share price of Green Plains and in its first order sensitivity. Moreover, unrestricted regressions of Green Plains share price against gasoline and corn prices rediscover weightings in line with those predicted by the theoretical model from first principles.

Conclusions

This paper developed, implemented and tested a real option model for the ethanol market. Optionality arises from the interaction between producers and blenders, who respond to incentives. The cost of ethanol production, driven by corn, and the value of ethanol as fuel, driven by the price of gasoline, are the fundamental inputs to the model, which also incorporates engineering settings, industry capacity, government incentives and mandates as external parameters. The model makes precise predictions for the price of ethanol as a nonlinear function of the prices of gasoline and corn, for the magnitude of ethanol physical output in terms of the relative pricing of gasoline and corn, and for the value of an ethanol producer as that of a call option on the spread between gasoline and corn. Empirical tests for each of these predictions found support for the model. However, certain features of the ethanol industry were left outside of the model. In particular, heterogeneity among producers, exit, and entry, seem relevant questions for future research as the story of the ethanol market in the last fifteen years has had firm entry as a main feature. The possibility of ethanol storage is also likely to have an impact on the decision process faced by producers and blenders. This, too, should be explored in the future.

Endnote

Dr. Merener presented on this topic at the JPMCC's 3rd Annual International Commodities Symposium during the "Agricultural Commodity and Freight Markets" session on August 13, 2019. The symposium, in turn, was organized by Professor Jian Yang, Ph.D., CFA, the J.P. Morgan Endowed Chair and JPMCC Research Director at the University of Colorado Denver Business School.

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Dr. Nicolás Merener is a faculty member at the School of Business of Universidad Torcuato Di Tella in Argentina, where he has been serving as Dean since 2016. Prior to joining Di Tella in 2008 he spent six years in Fixed Income Research at Lehman Brothers in New York. He has a Ph.D. in Applied Mathematics from Columbia University. His research focuses on commodity markets, risk management and financial engineering.

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