Investment in Cellulosic Biofuel Refineries: Does the Waivable Mandate Matter?

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Introduction

The Renewable Fuel Standard (RFS) in the U.S. Energy Independence and Security Act (EISA) mandates U.S. consumption of 16 billion gallons of cellulosic biofuel by 2022, starting at 0.1 billion gallons in 2010 (Figure 1). However, due to uncompetitive costs, as of February 2010 no commercial scale cellulosic biofuel refinery is operating (Renewable Fuels Association, 2/25/10).

Tradable Renewable Identification Numbers (RINs) is the market mechanism by which the mandates are to be met. But the RFS allows for a waiver of the mandates. Our study shows that under certain conditions, even a waivable mandate can stimulate investments in cellulosic biofuel refineries. A waivable mandate always increases the expected profit of low cost refineries.

Model

In a two-period world, potential investors in the cellulosic biofuels industry have the same fixed cost, f, but different marginal cost, c. Figure 2 shows an investor's decision tree.

The respective discounted profits from investing (I) or not investing (NI) in period one are:

$$B(I) = p_1 - c - f + \beta \int_0^{\infty} \max[p_2 + p^{RIN} - c, 0] dJ(p_2),$$

$$B(NI) = \beta \int_0^{\infty} \max[p_2 + p^{RIN} - c - f, 0] dJ(p_2).$$

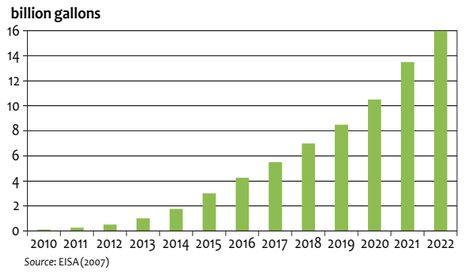

Figure 1. Mandates for Cellulosic Biofuel in EISA (2007)

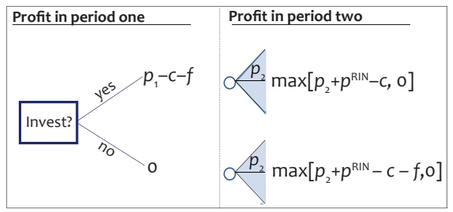

Figure 2. An Investor's Decision Tree

Here β is discount factor; p_1 and p_2 are the prices of cellulosic biofuel in periods one and two, respectively; p^{RIN} is the price of RINs in period two. The distribution of p_2 is $J(p_2)$. Define $\Delta(c) \equiv B(I) - B(NI)$. Let c^* denote the marginal cost of investors who are indifferent between I or NI in period one. Hence $\Delta(c^*) = 0$. We show that $c^* = p_1 - (1-\beta)f$.

Baseline Scenario: *Laissez-faire*

In this scenario $p^{RIN} = 0$ and hence c^* is determined by

$$\Delta(c) = p_1 - c - (1-\beta)f - \beta \int_c^{c+f} J(p_2) dp_2 = 0, \quad (1)$$

which implies:

Finding 1. If almost surely every realization of p_2 is sufficiently high, then RINs will not affect the first period investment level.

Waivable-Mandate Scenario

In this scenario p^{RIN} can be expressed as:

$$p^{RIN} = \begin{cases} \max\{G^{-1}(X_1) - p_2, 0\} \text{ if } X_1 \le M; \\ \max\{G^{-1}(M) - p_2, 0\} \text{ if } X_1 > M; \end{cases}$$

Where $G(\bullet)$ is the distribution function of c, X_1 is the realized aggregate capacity in period one, M is the mandate level in period two. We show that c^* in this setting is also implicitly determined by (1) above, implying :

Finding 2. The period-one investment level in the waivable-mandate scenario is the same as in the baseline scenario if the marginal cost of each refinery is constant.

Waivable Mandate Increase the Expected Profit of Low Cost Refineries

Suppose one state of p_2 is p^l under which $p^{RIN} > 0$. In the baseline scenario, the aggregate operating profit of running plants is area A in Figure 3.

In the waivable-mandate scenario, however, every available plant will be kept running with revenue fixed at c^*. For plants with $c \le p^l$ and plants with $c \in (p^l, c^*)$, the increased profit by the policy is area B and C, respectively, implying:

Finding 3. Relative to laissez-faire, low cost cellulosic biofuel firms expect to profit from a waivable mandate.

Increasing Marginal Costs

In this case, RINs will drive cellulosic biofuel price to a level higher than the shut-down price to keep a plant running at its full capacity. This makes investing in period one more preferable. Figure 4 depicts this effect. Hence:

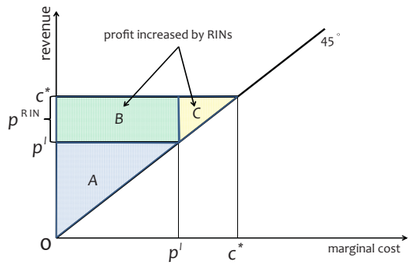

Figure 3. Profit Effect on RIN Policy when $p_2 = p^l$

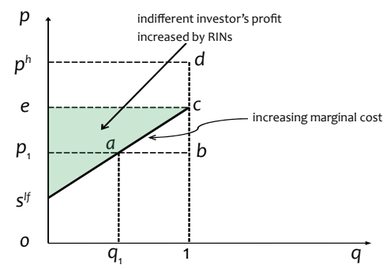

Figure 4. Profit Effect under Increasing Marginal Cost

Finding 4. When investors' marginal cost is increasing, then even a waivable mandate has a positive effect on investment level in period one.

Conclusions

1. RINs will not affect the first period investment level if: a) almost surely every realization of p_2 is sufficiently high; or b) the marginal cost of each refinery is constant.

2. A waivable mandate increases, at least weakly, the expected profit of investors who invest in the first period.

3. If investors' marginal costs are strictly increasing, then a waivable mandate can stimulate the period-one investment level.

4. To precisely measure the investment impact of the waivable mandate policy, empirical research on estimating the price distribution and the cost functions is needed.