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Biodiesel investment in a disruptive tax-credit policy environment

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ABSTRACT

An investigation of Poisson type policy jumps on biodiesel investment considers the theory of investment under uncertainty. The analysis studies the probability of implementing a policy if it is not in effect and the probability of withdrawal if it is in effect. An application models the policy-switching regime of the discontinuous U.S. federal tax credit of $1.00 per gallon on biodiesel. Results support that time inconsistent government policies do lead to market uncertainty. The analysis reveals a pronounced negative impact on decisions to invest in a biodiesel refinery. Results do indicate a consistent policy-switching regime may not be that disruptive to the emerging biodiesel industry. It is policy uncertainty that drives the option-pricing thresholds and a consistent policy switching does not increase the uncertainty.

1. Introduction

Sound government policy is predicated on the 3-Ts of effective policy development: type, timing, and transience. Policy type, such as a standard, subsidy, or tax, generally receives the most attention such as Fera et al. (2014), del Rio (2014), and Yi and Feiock (2014). Another form of policy type is government-sponsored technology development including smart grids designed to respond to time-sensitive consumer demand (Fera et al., 2016; Partovi et al., 2011). Recent literature reviews on biodiesel-technical policy are Hajjari et al. (2017), Naylor and Higgins (2017), and Živković et al. (2017). Considerably less research has addressed the timing of when a policy should be instigated. More than a decade ago, Pindyck (2002) considered timing of policy adoption in environmental economics. In terms of alternative energy adoption, Xian et al. (2015) addressed the timing of a U.S. wood-pellet subsidy. In contrast, the literature is quite limited focusing on the third leg of effective renewable energy policy, transience. Transience is concerned with the length and consistency of a policy. As a first attempt at filling this policy-transience void in alternative energy adoption, empirical results are presented demonstrating the importance of consistent (nondisruptive) policies. Specifically, the U.S. production of biodiesel is investigated under shifting, on and off again, federal biodiesel tax credits.

This on and off policy started with the American Jobs Creation Act of 2004, which established a biodiesel tax credit of $1.00 per gallon in 2005. The credit was then extended by the Energy Policy Act of 2005 and amended by the Energy Improvement and Extension Act of 2008. The tax credit temporarily lapsed in 2010 before it was extended again by the Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act of 2010 (Yacobucci, 2012). The credit was allowed to expire at the end of 2011 before the American Taxpayer Relief Act of 2012 retroactively extended the tax credit through December 31, 2013 (U.S. Department of Energy, 2014). The credit was then allowed to expire in 2014, but was reestablish in 2015, extended to 2016, but allowed to expire in 2017. The U.S. Congress is currently considering extending the credit through 2020. Table 1 lists the on and off biodiesel tax credit from 2005 through 2017. The history of governmental policy uncertainty does not provide a stable policy platform for a young and maturing biodiesel industry. Theory would then hypothesize such disruptive policies would lead to market uncertainty, which have a pronounced impact on decisions to invest in a biodiesel refinery. Instead of providing a stable price regime, it is hypothesized policies would lead to price volatility.

For investigating this hypothesis, a real options analysis is developed, which considers the likelihood of a tax-credit policy shift. The analysis considers the probability of a policy being implemented if it is not in effect and the probability of the credit being withdrawn if it is in effect. Results support the hypothesis that inconsistent tax credits lead to market uncertainty. Specifically, it is not a policy-switching regime that affects investment per se. Instead, it is policy uncertainty. A known consistent policy-switching regime does not increase investment uncertainty. For policy analysis and implementation, it is important to make a distinction between policy uncertainty and known policy switching.

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Table 1
U.S. biodiesel tax credit.

Year	Tax Credit Existence ($1.00 per gallon)
2005	Yes
2006	Yes
2007	Yes
2008	Yes
2009	Yes
2010	No
2011	Yes
2012	No
2013	Yes
2014	No
2015	Yes
2016	Yes
2017	No

The remaining sections are organized as follows. The following section presents the relevant literature, Section 2. This literature review provides a foundation for the methodology in Section 3. Data and data analysis are next, in Section 4, which is followed by results and discussion, Section 5. The results and discussion are partitioned into subsections on nondisruptive and disruptive tax-credit policy along with the probability rates of tax-credit enactment and removal. As an aid to determining the influence of variables on adoption, sensitively analysis is presented, which naturally leads to the final section, Conclusion and Policy Implications, Section 6.

2. Literature review

Real options theory is employed for deriving the optimal investment and operation decisions under uncertain policy conditions. Studies have modeled the market-driven sources of uncertainty under specific policy schemes (Laurikka, 2006; Linnerud et al., 2014). Wang et al. (2014) developed a policy benefit real options model to identify the optimal investment strategy with/without the consideration of revenue from a certified emission reduction. Other studies acknowledge that policy uncertainty should be explicitly considered. They include stochastic jumps in the prices of policy instruments reflecting sudden changes in the policy target. Fuss et al. (2008) and Yang et al. (2008) create stochastic jumps to simulate carbon price shocks under a particular climate policy event. Other efforts in addressing natural-resource policy uncertainty include tradeable permits (Wossink and Gardebroek, 2006), carbon policy (Kettunen et al., 2011), carbon emission credits (Kiriyama and Suzuki, 2004), and green payments (Isik, 2004).

With regard to tax policy uncertainty, the literature indicates how the prospect of introducing tax incentives for investment raises the threshold revenue a firm invests and thereby delays investments. Rodrik (1991) notes that policy reform in developing countries can result in private investors withholding investment until much of the residual uncertainty is eliminated. Mauer and Ott (1995) analyze the effect of tax-policy uncertainty on replacement investment decisions. In the natural-resource literature, carbon-price (tax) uncertainty is addressed by Fuss et al. (2009), Fuss et al. (2012), Reedman et al. (2006), and Zhou et al. (2010). The general conclusion is policy uncertainty is not likely to be captured by a Brownian motion process; it is instead likely to follow a Poisson jump process (Hassett and Metcalf, 1999).

The literature is void in estimating the effect policy shifts (the third leg) have on renewable energy investments and in particular on biodiesel investments. The objective is to fill this gap by incorporating a Poisson process into a real options model. The policy of the discontinuous federal tax credit of $1.00 per gallon of biodiesel is then modeled as a Poisson jump process.

3. Methodology

For modeling the disruptive biodiesel policies, as listed in Table 1, Poisson policy jumps represent the price process. Such jumps are characterized by an upward jump in prices from investing when the tax credit is effective and a downward price shift when the credit lapses. The switches between a tax credit and no credit are Poisson policy processes. The effect of these Poisson policy jumps on biodiesel investment can be investigated through the theory of investment under uncertainty. Let θ represent the federal income tax credit with $\lambda_1\, dt$ denoting the probability it will be implemented in the next interval of time, dt and $\lambda_0\, dt$ the probability it will be withdrawn.

Assume biofuel plants are price takers as long as biofuel production remains a small fraction of total petroleum fuel production (ESMAP, 2006; Maung and Gustafson, 2011). Following closely Dixit and Pindyck (1994) along with Lin and Huang (2010, 2011), the theory assumes a firm is considering becoming an entrant into the biodiesel market. The firm is producing biodiesel with sunk cost of I and an operating cost of v per gallon of biodiesel produced.

Assume the price per gallon of biodiesel, p, follows the geometric Brownian motion

$$dp = \alpha p dt + \sigma p dz, \tag{1}$$

where α is the drift, σ is the variance, and dz is the increment of a Wiener process.

It is further assumed over an interval of low prices, say $(0, p_1)$, a biodiesel refinery will not be initiated regardless if the tax credit is allowed. Over the interval (p_1, p_0) the refinery will be built if the tax credit is allowed, but will wait if the credit is not allowed. By waiting there is a possibility the credit will be established at some future time. Beyond p_0 regardless of the tax policy the biodiesel refinery will be built. As illustrated in Fig. 1, interest is in determining the trigger prices p_1 and p_0 where within this price interval the tax credit is effective in stimulating investments in biodiesel refineries.

Over the range (p_0, ∞), the dominant strategy is to always establish a biodiesel refinery regardless if there is tax credit or not. The investment opportunity is then

$$V_0(p) = \frac{P}{\delta} - \frac{v}{r} - I, \tag{2a}$$

in the absence of a tax credit and

$$V_1(p) = \frac{P}{\delta} - \frac{v - \theta}{r} - I, \tag{2b}$$

with a credit. The prices p and v per period are divided by δ and the discount rate r, respectively for determining the present value of the perpetuity, with $r - \alpha = \delta$.

In contrast, over the range (p_1, p_0), with a tax credit the refinery is established and without it is not. The investment opportunity with a credit is the same as (2b). Without, $V_0(p)$ following Dixit and Pindyck (1994) is

$$V_0(p) = A_1 p^{\beta_1} + A_2 p^{\beta_2} + \frac{\lambda_1 p}{\delta(\delta + \lambda_1)} + \frac{\lambda_1\left(\frac{\theta - v}{r} - I\right)}{r + \lambda_1}, \tag{3}$$

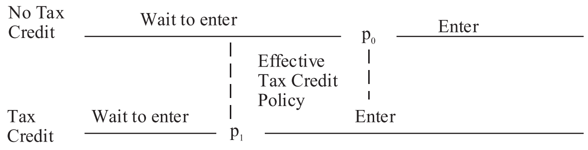

Fig. 1. Price triggers for effective tax-credit policy.