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Investment timing under uncertain renewable energy policy: An empirical study of small hydropower projects

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ABSTRACT

Policy uncertainty can be a powerful deterrent to immediate investments. Based on panel data of 214 licenses to construct small run-of-the-river hydropower plants, we examine whether the prospect of a common Swedish–Norwegian market for green certificates (i.e., a renewable portfolio standard scheme) affected the timing of investments. Our results show that traditional utilities and other professional investors in the energy market acted in accordance with a real options investment rule, and the prospect of possible future subsidies delayed their investment decision. On the other hand, our results do not show that farmers and other non-professional investors incorporated timing considerations in their investment decisions. Rather, our results indicate that these investors behaved as if their investment opportunity is now-or-never, investing if the project is profitable according to a net present value investment rule, ignoring the opportunity to create additional value by waiting. The observed difference in behavior between professional and non-professional investors is interesting given the distributed nature of many renewable energy technologies, and can help planners and policymakers better understand the forces shaping the future market for electricity.

1. Introduction

Political discussion on whether, when, and how to support renewable power projects can be a powerful deterrent to immediate investments because it creates an incentive to wait until a policy decision is made. Based on panel data of 214 licenses to construct small hydropower plants, we examine whether the prospect of a common Swedish–Norwegian market for green certificates affected the timing of investments in Norway from 2001 to 2010. The scheme seeks to fill a quota for renewable power. Certificates are issued to producers in proportion to the volume of renewable power generated and traded. A common term for the concept is renewable portfolio standard. We use real options theory to compare the value of immediate investment with the value of postponing the investment decision and possibly being entitled to sell certificates. The theory's main prediction is that firms will delay investments in long-lived irreversible assets whenever there is sufficient uncertainty that takes time to resolve and/or whenever the project value increases over time [6]. Special attention is paid to whether behavioral responses varied between professional and non-professional investors.

The problem we study is accentuated by the following statement by the International Energy Agency in August 2014: "The expansion of renewable energy will slow over the next five years unless policy uncertainty is diminished."[1] Market responses to such uncertainty may be consistent with real options theory. However, assumptions made by real options theory with respect to investors' preferences, characteristics and behavior may be more realistic for traditional utilities and other professional investors than for small, non-professional investors like farmers. Empirical investigation of whether such differences exist is interesting given the distributed nature of many renewable energy technologies. Solar and wind power, for example, can be installed by small land and homeowners as well as by large corporations. Thus, our study has important implications beyond the narrow case of small hydropower

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[1] The quote is from a press release 28 August 2014 in connection with the publication of IEA's third annual medium-term renewable energy market [accessed 28 August 2014 at: http://www.iea.org/newsroomandevents/pressreleases/2014/august/name-125080-en.html.].

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investments in Norway and can help planners and policymakers better understand the forces shaping the future market for electricity.

Taking the perspective of an energy firm, real options theory has been used to derive the optimal investment and operative decisions under uncertain climate and renewable energy policy conditions. Most studies aim at correctly modeling the market-driven sources of uncertainty under specific policy schemes, like the EU emission trading scheme (e.g. Refs. [14,26,28–30]). Some studies acknowledge that policy uncertainty could be modeled more drastically. This can be done by including stochastic jumps in the prices of policy instruments reflecting sudden changes in the policy target (e.g. Refs. [8,27]), or by modeling the risk that a scheme will be introduced, or that an existing scheme will be replaced (e.g. Ref. [3]) or simply removed (e.g. Ref. [23]). The policy uncertainty examined in our study is similar to the one examined in some early generic real options studies (e.g. Refs. [10,16,20]); those studies show how the prospect of introducing tax incentives to invest raises the threshold revenue at which the firm invests and thereby delays investments.

Few empirical studies have used project-level data to test whether firms time their decisions as predicted by real options models (e.g. Refs. [5,7,18,22,25]). However, predictions by real options models are not tested directly in those studies using such data; rather, in those studies binary discrete-choice models test whether decisions are negatively related to measures of uncertainty. Only [25] consider the issue of policy uncertainty. They estimate hazard rates for new power plant projects across states with different regulatory regimes and find that, as predicted by real options theory, regulatory uncertainty significantly affects the pattern of development in the electric power industry.

Our paper contributes to this literature because it (1) focuses on the uncertainty created by shifts in policy regimes, (2) empirically tests the predictions for investment timing given by real options investment rules as compared with net present value investment rules, (3) bases these investment rules on detailed and project-based information about the market value of each underlying asset, and (4) examines whether investment behavior varies systematically across two investor groups.

Our choice of case gives us three advantages. First, the Norwegian government has spent the last 12 years discussing whether, how, and when to introduce a subsidy scheme for renewable power production, a lengthy discussion that provided us with a good case on how uncertainty about policy decisions may affect the timing of investments. Second, by focusing on small hydropower projects, we obtain access to a high number of standardized individual projects that lend themselves more easily to empirical testing than do other real investment projects. Finally, we have access to high-quality data, including the regulator's database on all license applications, interviews with the majority of license holders in our sample, discussions with an expert group representing the stakeholders, and the extensive collection of price data available through Nord Pool Spot and NASDAQ OMX Commodities.

Using a similar approach to that of McDonald and Siegel [17]; we investigate whether a real options investment rule can better explain actual investor behavior than a net present value investment rule can. The investigation is carried out by a numerical simulation to estimate the expected timing of investment decisions, followed by empirical testing using a logistic regression model. As in Moel and Tufano [18] and Walls et al. [25]; we control for other factors affecting the investment decision.

The remainder of the paper is structured as follows. In Sections 2 and 3, we present the real options and the net present value investment rules and examine whether the assumptions of real options theory are realistic for our study. Based on this evaluation we suggest a division into two investor groups to empirically investigate systematic differences in behavior. In Sections 4–6, we present the data we use to model the projects' cash flows, the simulation approach used to estimate the two investment rules, and the regression analysis with which these rules are tested. We offer concluding remarks in Section 7.

2. Theory

According to a naive version of the net present value investment rule, an investor should invest now if the discounted value of future net cash flows, V, is greater than or equal to the investment cost, I [4]:

$$V - I \geq 0. \tag{1}$$

However, assuming that investment expenditures are at least partly irreversible and that investments can be delayed, the investor may value the opportunity to wait for new information to arrive about uncertain market and policy conditions. Hence, according to the real options investment rule, the investor should invest now if the net present value of immediate investment, $V - I$, is greater than or equal to the expected value of postponing the investment decision, which expected value is also called the continuation value, C [6]:

$$V - I \geq C \Leftrightarrow V \geqslant I + C = V^*. \tag{2}$$

Consequently, the value of the opportunity to invest, the option value, can be expressed as:

$$F = \max[V - I, C]. \tag{3}$$

Real options theory allows us to explicitly model different sources of uncertainty affecting the project's cash flows. When cash flows are uncertain, investors will value the opportunity to gain additional information about likely future conditions affecting the project; that is, in order to invest immediately, they will require a threshold project value V^* in Eq. (2) which is strictly greater than the investment cost I. Moreover, the threshold V^* will increase with the volatility in project value and/or as investors get nearer to an information event where future conditions affecting the project may be revealed. Even ignoring uncertainty, there may be value in waiting if the project value increases over time, for instance as a result of a future introduction of green certificates.

The real options investment rule assumes that the neoclassical theory of the firm correctly predicts investors' preferences, characteristics and behavior (e.g. Ref. [13]). This theory assumes that firms have only one objective, maximizing the economic value of the firm, and that they make rational choices based on the same information. These assumptions require, however, that firms, in our case referred to as investors, have the cognitive ability and time to value every choice against every other choice. According to the bounded rationality theory (e.g. Refs. [12,24]), people may use more simplified rules because they lack the cognitive ability or time to arrive at the optimal solution. Thus, they may instead be rational only after having greatly simplified the choices available.[2] The net present value investment rule is an example of such a rule. It treats risk in a simplified manner because it bases project appraisal on expected cash flows and lets project risks be represented by a single risk-adjusted discount rate. And, more importantly, it is based on the assumption that the investment decision must be made now-

[2] The bounded rationality theory was first proposed by Simon [24] and is today widely acknowledged because of the seminal work of Amos Tversky and Daniel Kahneman (see e.g. Ref. [12].