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Investors' reaction to the government credibility problem: A real option analysis of emission permit policy risk

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ABSTRACT

In relation to creating a CO_2 emission permit market, there are two types of climate change policy risks: (1) It is uncertain whether and when a cap-and-trade system will be implemented; and (2) once a policy is in place, there may be government credibility issues. This paper examines the effect of these policy risks on real option decisions of electric power plant investment. To model both an investment decision and generation flexibility, this study evaluates an exotic compound American option on multiple strips of European spread options through the implementation of least squares Monte Carlo simulation. Government credibility risk leads to more investment in "less green" resources and induces additional cash flow variation, which increases the average time to investment (value of waiting). However, in an extreme case, government credibility can actually hasten investment because the risk may be more favorable to electric power companies. Furthermore, if emission trading is planned to be implemented in the future (e.g., 2020), and the market believes that the probability of successful implementation is low, firms will build a "less green" plant early to benefit from the period before the green rule is applied.

1. Introduction

Because humankind must reduce its greenhouse gas emissions (Stern, 2007), governments are responsible for making and enforcing appropriate climate change policies. Carbon dioxide (hereafter, CO_2) emission permit trading is a market-based carbon pollution reduction scheme that has been implemented by the European Union[2] (see, e.g., Boomsma et al., 2012; Lee and Shih, 2010; Szolgayova et al., 2008; Chao and Wilson, 1993). Specifically, in the summer of 2003, the European Union parliament passed a law to initiate the European Union Emission Trading Scheme (hereafter, EU ETS); since January 2005, Europeans have been trading CO_2 emission permits on EU ETS (Benz and Trück, 2009). In the United States, such a cap-and-trade system is still under discussion. Wilson et al. (2012) predict that the U.S. congress may pass a law on the federal-level cap-and-trade system by 2017 and implement the system by around 2020.

Two types of political uncertainty are related to the creation of such a market. First, it is uncertain whether and when a cap-and-trade system will be implemented. Second, as Helm et al. (2003) argue, the ex ante commitment of a government to preserve the initial quantity of emission permits is important to achieving policy goals. Without strong political commitment, private firms may expect that the government will increase the quantity as demand for emission permits increases. Then, the firms, which can make a choice between different carbon-emitting technologies, are more likely to invest in a more profitable resource that might be emitting more CO_2, and the government may fail to accomplish its green policy goal. In economics, such a problem is called the government credibility problem or the time inconsistency problem. In this paper, we study a timely question of how an investor, who can delay the investment, reacts to the aforementioned two types of political uncertainties. Specifically, this paper studies the decision of an electric utility which can invest in either a relatively "green" natural gas-fired electric power plant or a relatively "less green" coal-fired plant as a new incremental base-load resource.[3] This problem is particularly interesting because, according to Szolgayova et al. (2008), the electricity sector accounts for more than 40% of CO_2 emission.

We make four contributions to the literature. First, this article demonstrates how to extend the real option approach proposed by Dixit and Pindyck (1994), Majd and Pindyck (1987), McDonald and Siegel (1986), and Brennan and Schwartz (1985) to more realistic

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[2] Other carbon pollution reduction schemes include production tax credits, feed-in tariffs, and renewable portfolio standards.

[3] Likewise, Fleten and Näsäkkälä (2010) consider a natural gas plant as a candidate for a base-load resource.

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settings, in which we analyze the real option decision under government policy risk. We implement the least squares Monte Carlo (hereafter, LSMC) method of Longstaff and Schwartz (2001) because of the complexity of real option decisions of interest. The value of a power plant is a *strip* of spread options because of its operational flexibilities.[4] Furthermore, for electric utilities, the real option is a choice between more than one *strip* of spread options because a request for proposals (hereafter, RFP) is solicited to choose among *various* resources or a market purchase. While papers such as Fleten and Näsäkkälä's (2010) assume an infinite life of a plant to obtain a closed-form solution, we assume a finite useful life. Our assumption is more realistic given that nearing the end of its life, an electric utility will solicit another RFP. To our knowledge, the LSMC is the only way to model such a complex compound American option on multiple *strips* of spread options.

Yang et al. (2008) and Fuss et al. (2008) study the effect of political uncertainty on power plant investment decision making, and conclude that a firm expecting climate policy uncertainty should wait until the uncertainty is resolved. Differently from them, we explicitly consider the aforementioned exotic American compound option nature of an investment opportunity, and find that their conclusion of deferring an investment decision until resolution of political uncertainty may not always be true. Specifically, if a green rule is planned for a future application (e.g., 2020), and the market believes that the probability of successful implementation is low, firms will build a "less green" plant early to benefit from the period before the green rule is applied without too much exposure to CO_2 cost risk.

Our second contribution is to introduce a new type of political uncertainty—government credibility risk—to a real option study of a climate change policy and/or political uncertainty. For example, Maxwell and Davison (2014), Kettunen et al. (2011), Lee and Shih (2010), Szolgayova et al. (2008), Chao and Wilson (1993), and Herbelot (1992) analyze real options under various climate policy instruments; Boomsma et al. (2012), Nishide and Nomi (2009), Yang et al. (2008), Fuss et al. (2008), Pawlina and Kort (2005), and Saphores et al. (2004) increase understanding of political *risk* in the context of real options. Our paper differs from the aforementioned papers by including government credibility issues which may arise once a policy is in place.[5]

Industries affected by a CO_2 reduction policy can put pressure on the government to ease such costs by, for example, hiring a lobbyist and interviewing with the press, so political uncertainty may be interlinked to commodity prices. Differently from Boomsma et al. (2012), who use a Markov chain to investigate the effect of policy risk related to feed-in tariffs and renewable energy certificates on electric power plant decisions, we model the political pressure on a government as a Brownian motion, and the submission of government to such pressure as a first passage time, a logical setting in which to study the government credibility problem because of the potential correlation between commodity prices and the pressure to government. While Pawlina and Kort (2005) use the first passage time of the value of the entire investment project to study investment under uncertainty and policy change, we use a separate stochastic process for which the threshold of the first passage time can be easily calibrated.

Third, we shed light on understanding operational flexibility in the presence of political risk on a climate change policy. We find that if there is no scheduled CO_2 emission permit market implementation, the operational flexibility is almost irrelevant because a coal plant is more profitable than a natural gas plant in most states of world. In the presence of a scheduled CO_2 emission permit market implementation, the incremental costs of emission permits make a coal plant less profitable than a natural gas plant. In that case, removing the operational flexibility does change the relative economics of these two alternatives, preventing management to stop production. Thus, the value of waiting and the time to investment are increased. We find that such an effect of operational flexibility on investment timing matters more when government credibility risk is high.

Fourth, this paper documents a new channel of additional risk hastening investment. While government credibility risk delays investment in power plants under reasonable model parameters, uncertainty about the future implementation of the policy can actually decrease the average time to investment. The literature has documented channels through which additional risk hastens investment. Bar-Ilan and Strange (1996) document that if an investment lag is greater than zero, the increase in volatility may incent a firm to invest earlier because it decreases the value of abandoning a project. Chronopoulos et al. (2011) find that in an incomplete market, the increase in risk aversion may decrease the average time to investment. The new channel documented in this paper is as follows. Uncertainty about the future implementation of the policy and government credibility issues have two effects: first, both increase the variability of the future cash flows of firms, which delays the investment; second, both lead to more positive cash flows, which accelerates the investment. We find that under certain conditions, the latter effect dominates.

To study the optimal investment decision under the government credibility problem, we propose two real option analyses. We first study the value of an investment opportunity for a power plant using a compound exchange option (Carr, 1988) (hereafter, CEO). A firm generating electric power makes a sequence of two separate but related decisions: The first one is whether the firm invests in physical capital; and the second one is whether the firm dispatches the electric power plant. Because an exchange option (Margrabe, 1978) can model the second decision, a compound option on an exchange option (CEO) can model the first decision. Calculating CEO premia, we demonstrate that the emission permit price affects the decision of investing in, or not investing in, a green resource. However, this simple framework does not account for the nature of a compound American option on multiple *strips* of European spread options. So, we implement the LSMC simulation and provide insight into the value of waiting, the investment timing, and investment choice that we glean from the LSMC results.[6]

Within our LSMC simulation, an electric utility has the opportunity to build a new power plant, which will be connected to the electrical grid. The power plant will either use coal or natural gas as fuel. Coal costs less, but emits more CO_2. Natural gas costs more, but emits less CO_2. The power-generating company has the opportunity, not the obligation, to invest in the new power plant. The firm thus has a real option.

We summarize the LSMC results as follows: the presence of a green policy does promote the investment into natural gas plants. When the policy is implemented immediately, the presence of a green policy reduces future cash flow by imposing emission costs, reducing the immediate exercise values of the real option. This slows investment into new power plants. Credibility issues at the government level increase the variance of future cash flows and further slow investment into new power plants. Removing the generation flexibility reduces the immediate exercise value because the management cannot stop production in less favorable situations, and the power plant can incur losses. The lack of generation flexibility delays the investment timing.

[4] For example, Fleten and Näsäkkälä (2010), and Cartea and González-Pedraz (2012) also model a physical asset as a strip of spread options.

[5] Saphores et al. (2004) find that a long and uncertain regulatory process can be costly to the firm. Nishide and Nomi (2009) find political and social instability delays investment, and right before the regime change, investors behave as if the worst case scenario is assumed. We study different aspects of policy risk: the credibility of a policy and whether and when a cap-and-trade system will be implemented.

[6] Our analysis is partly motivated by Schwartz and Trolle (2008), who study the real option under expropriation risk.