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An entry and exit model on the energy-saving investment strategy with real options

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ABSTRACT

This paper presents an improved decision model based on the real options approach presented by Ansar and Sparks (2009) for the firms that have not yet established energy-saving equipment under the entry and exit strategies. Furthermore, the proposed model takes account of the inevitable equipment renewal and the occurrence of unexpected events under the Poisson jump process. The timing for terminating an investment when continuous operations of that business are unprofitable is also explored to realize the optimal timing of implementing the energy-saving strategy. The future discounted benefit B follows the geometric Brownian motion with the Poisson jump process and the replacement of investment equipment. A numerical analysis is followed by a sensitivity study of various parameters to better realize their impacts on the entry and exit thresholds. The results show that for the jump case, the higher probability of occurrence of unfavorable events will result in a higher entry threshold and lower exit threshold. Investors are forced to request higher benefit thresholds to cover the higher probability of losses brought by unfavorable events.

1. Introduction

The energy-saving issue has become a bigger concern for people as well as for the governments and enterprises. Remaining fossil fuels are concentrated in only a few countries and the governments around the world are trying to reduce the dependency on energy imports (Gupta, 2008). More and more households and enterprises install energy-saving equipment and try to rely on innovative technologies such as photovoltaic panels, LED, frequency conversion appliances, wind power, biomass (Gan, 2007), etc. Diaf et al. (2008) presented a hybrid system combining photovoltaic and wind power. Audenaerta et al. (2008) showed that a low-energy house is the safest choice because its profit is less dependent on future energy prices.

According to Carbon Monitoring for Action, Center for Global Development (CARMA, 2009) and Bureau of Energy, Ministry of Economic Affairs, Taiwan, Energy Supply (Bureau of Energy, 2009), the proportion of fossil energy usage in 2007 is 69% in the US, 80% in China, and 83% in Taiwan. According to the statistics of International Energy Agent (IEA, 2009), the emissions (from fuel combustion only) of CO_2 for 2007 are 5769 Mt in the US, 6028 Mt in China, and 276 Mt in Taiwan. The US, China, and Taiwan are, respectively, ranked the 1st, 2nd and 13th CO_2 emitters in CARMA 2007 due to their huge energy consumption. Therefore, applying the real options model or methodology to deal with the energy-saving issue in these high emitting CO_2 countries is certainly more valuable and with much more utility for its practical effect.

However, consumers' readiness to pay more for energy from renewable sources is still relatively low. For example, in Europe, according to a survey published in 2006 (European Commission, 2006), 59% of the respondents (450 million energy consumers from 25 countries) are not prepared to pay more for "green energy". It represents an increase of 5% compared with the 2005 survey. Consumers and investors are still worried about their return on investment because green energy is more expensive and because the world economy is troubled.

The energy paradox issue—the apparent use of high discounted rates for home-improvement investments—has become a worthy research topic (Hausman, 1979; Dixit and Pindyck, 1994; Metcalf and Hassett, 1999). Jaffe and Stavins (1994) developed a framework concerning the "paradox" of very gradual diffusion of apparently cost-effective energy-conservation technologies. The paper shows that the technology-diffusion process is gradual and explains how alternative policy instruments can hasten the diffusion of energy-conserving technologies.

The net present value (NPV) and the total present value (PV) of a time series of cash flows, can be used for decision-making in

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capital budgeting. The NPV method is considered by Giri and Dohi (2004) as a way to detect the economic manufacturing quantities for an unreliable production system. The NPV of the expected total cost can be retrieved under the general failure and repair time distributions. For Kylaheiko et al. (2002), the main focus is on managing and valuing dynamic capabilities for designing the firm's strategic boundaries in decision-making regarding network relations. The ROA is used to improve the issue of coping with technological and market uncertainty. For both entry and exit projects, the ROA is more conservative than the NPV method in supporting decisions in the face of uncertainty.

One of the strengths of the real options analysis is that it describes ''dynamic'' complexity much better than the classic NPV analysis, which focuses on ''detail'' complexity (Smith, 1999). The NPV method is generally applied in certain and stable conditions or circumstances. Under uncertain situations, the validity of the NPV method will be much more polemical. On the contrary, many studies about the reliability and validity of the real options approach (ROA) have been effectuated and showed evidence about the consistency and robustness of the ROA.

Copeland and Trufano (2004) showed that the true value of a project is generally higher than the NPV and inferior to the real options value. As uncertainty increases, the total project value approaches the option value. Many researches have investigated the role of real options in the planning of operations under uncertainty. Due to the reliability and validity of the ROA, the ROA is now considered in academia and industry (Graham and Harvey, 2001; Alessandri et al., 2004; Smith and McCardle, 1998; Sounderpandian et al., 2008) as one legitimate capital budgeting tool project managers use for the allocation of their resources in the face of uncertainty. Driouchi et al. (2009) developed ''a problem structuring methodology to assess the robustness of real options under alternative possible futures'' and showed how real options thinking and decision-aiding can be combined in order to track investment problems under uncertainty and how decision-makers can deal with their international operations in a robust option-based manner. Mahnovski (2006) identified the investment strategies that are robust against alternative futures and assessed the tradeoffs of various policy instruments.

There is a high degree of uncertainty in order to design the energy policies that will resolve the problems of energy prices, technical innovation of energy-saving equipment, environmental pollution issues, carbon emission reduction or global green economy. In addition, the decision-making thinking is time consuming. Mahnovski (2006) mentioned that the ROA is more able to handle the strategic assessment related to energy issues.

Many papers focus on the real options approach (ROA) because of its ability to manage the flexibility inherent in natural resource assets, notably Frimpong and Whiting (1997), and Abdel Sabour (1999, 2001). Baudry (1999) used the ROA and showed that less pollution diffusion is related to pollutant threshold. However, a pollution diffusion tax in a period of dire crisis will neither be welcome nor efficient. It also becomes useless in the absence of accurate pollution forecasting. Lin et al. (2007) assessed the optimal environmental investment decisions under the economic and ecological uncertainty by extending the model of Pindyck (2002). A real options approach is used to consider the secondary cost of pollution prevention. Keppo and Lu (2003) proposed a new real options model using the case of electricity markets. They showed that the price effect of production has to be considered in the investment analysis because it has an influence on the assets owned by the energy company and on its investment opportunities.

Samis et al. (2006) showed that the real options approach has the ability to account for the effect of cash flow uncertainty on asset value in a more precise way than the cost benefit analysis (CBA). Kjærland (2007) used the conceptual real options framework of Dixit and Pindyck (1994) and showed the consistency between the real options theory and the aggregate investment behaviour in Norwegian hydropower. The real options theory is applied to estimate the value of investment opportunities and to figure out the relation between the price of electricity and the optimal timing for decision makers to implement investment strategies. Sandsmark (2009) analyzed the development in the regional electricity market in Central Norway, a region that has been known for a strong demand growth over the last 7 years. Central Norway has different options for new supplies, but the investments in generation capacity have not matched the demand growth. The paper discusses the challenges of arriving at the long-term capacity adequacy in deregulated electricity markets.

Ansar and Sparks (2009) developed a model to explain the inclination of households and firms to require very high internal rates of return in order to make energy-saving investments. The real options approach presented in Ansar and Sparks (2009) does not take into consideration that the equipment bought will surely decay and will need to be replaced and that the agent (household, firm or investor) will sometimes be forced to terminate the investment which is no longer profitable. In general, the equipment warranty does not exceed a few years. As the costs of installation are obviously underestimated, the hurdle rate must be superior to the result obtained in Ansar and Sparks (2009).

The adoption of energy-saving investment can directly reduce the consumption of electricity and indirectly reduce the emissions of CO_2 and other pollutants due to the electricity generation. Under the restriction of the total emissions of CO_2 such as the Kyoto Protocol in December 1997, the government departments of most countries who signed the accord develop a variety of policies and norms to respond in order to maintain their national images. Therefore, the excess emissions of CO_2 will not only result in the extra investment cost, but also erode an enterprise's final benefit, social image, and social responsibility. The issue of appropriate CO_2 emission quantity is linked to the adoption of the optimal energy-saving investment configuration, which can result in higher monetary benefits and lower the emissions of pollutants. Hence, to decide how much energy-saving equipment should be installed is nowadays a pressing issue.

We have to find a compromise and a balance between the financial economy and the green economy and consider the corporate social responsibility (CSR) concerning the environmental protection (O'Connor and Spangenberg, 2008; Blottnitz and Curran, 2007; Verdonk et al., 2007; Lloyd and Subbarao, 2009; Mohareb et al., 2008; Train and Ignelzi, 1987). The principal concept of this study, installing energy-saving equipment and renewing it every n years, is suitable in the whole energy strategy and green economy issues. The application of the ROA to determine the adequate timing to adopt the energy-saving investment strategy or to terminate this investment can consequently directly bring monetary benefits to enterprises and indirectly hit the target of the contribution to the environmental protection.

This paper presents an improved decision model for the firms that have not yet established energy-saving equipment and examines the timing for terminating an investment when continuous operations of that business are unprofitable. The model takes into account the inevitable replacement of the equipment every n years and the occurrence of unexpected events. The future discounted benefits B owing to this investment are assumed to follow the geometric Brownian motion with the Poisson process. The optimal entry and exit benefit thresholds for the investment is obtained by using the ROA to help decision-makers avoid the uncertain risk associated with the energy-saving