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Application of the modified Tobin's q to an uncertain energy-saving project with the real options concept

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ABSTRACT

This paper is to develop a modified Tobin's q evaluation method which successfully combines the evaluation criteria of the traditional Tobin's q and the real options. This study provides flexible thinking for decision making criteria. That is, it clearly provides decision-makers with a reference in choosing enter or exit strategies, such as quantitative indicators references. The proposed model introduces two variables stochastic process in continuous time and explores the impact of the occurrence of unexpected events on the project value, so that, it can more authentically response to the project value. The studied issue deals with the firms that have not established energy-saving equipment yet. It attempts to figure out the optimal timing to adopt an energy-saving investment project when it is beneficial and the optimal timing to terminate it when the continuous operation of that business is unprofitable. The future discounted benefit–cost ratio, Q, follows the geometric Brownian motion with the Poisson jump process and the replacement of investment equipment. Except for the evaluation of energy-saving equipment investment project, the proposed model can be applied to other related project evaluation issues, such as energy-saving, CO_2 emission reduction, or general investment projects.

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1. Introduction

The paper applies the theory of Tobin's q in the 1-dimension (1-D) decision model of Lin and Huang (2010) and extends it into the 2-dimension (2-D) model according to Dixit and Pindyck (1994). The model evaluates an energy-saving investment project and determines the optimal timing to adopt the energy-saving investment project when it is beneficial and the optimal timing to terminate it when the continuous operation of that business is no longer profitable. The optimal entry and exit thresholds for the investment are obtained by using the real options approach (ROA). The 2 variables in the model are the future discounted benefits (B) and the costs (I), which are assumed to follow the geometric Brownian motion due to this investment. The inevitable replacement of the equipment and the occurrence of unexpected events, described by the Poisson process are taken into account while developing the future discounted benefits.

The efforts to coordinate the global action to reduce greenhouse gas (GHG) emissions were initiated by the Kyoto Protocol. The protocol was initially adopted in December 1997 in Kyoto, Japan and entered into force in February 2005. So far in 2009, it has been signed and ratified by 187 states. The Copenhagen accord decided during the United Nations Climate Change Conference (December 7–18, 2009) pledged to keep temperature rises to no more than 2C but did not contain the commitment to emission reduction to achieve that goal. It is a political agreement and the accord has no legal standing. The 2010 World Future Energy Summit was held in Abu Dhabi (January, 18–21), at the Abu Dhabi National Exhibitions Center. Thirty individual conference sessions were planned and more than 200 international influencers addressed future energy strategies, policies, and technologies. The question of appropriate CO_2 emission quantity is connected to the adoption of the optimal energy-saving investment configuration. Deciding how much energy-saving equipment should be an urgent issue as it can result in higher monetary benefits and lower emissions of pollutants. We should reflect on two problems: finding a compromise between the financial economy and the green economy and considering the corporate social responsibility (CSR) in relation with the environmental protection (Blottnitz and Curran, 2007; O'Connor and Spangenberg, 2008; Lloyd and Subbarao, 2009; Mohareb et al., 2008; Train and Ignelzi, 1987; Verdonk et al., 2007).

The consumption of electricity can be directly reduced by adopting energy-saving investments, which indirectly reduces the emissions of CO_2 and other pollutants due to the electricity generation. According to Gupta (2008), the remaining fossil fuels are concentrated in relatively few countries and the governments around the world are trying to reduce the dependency on energy imports. Even if more households and enterprises are installing energy-saving equipment and trying to rely on innovative technologies (Diaf et al., 2008; Gan, 2007; Audenaerta et al., 2008), consumers' readiness to pay more for energy from renewable

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sources is still relatively low (European Commission, 2006). Because the global economy is troubled and green energy is more expensive, consumers and investors are still worried about their return on investment. 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 and showed that the technology-diffusion process was gradual. That paper also explains how alternative policy instruments can hasten the diffusion of energy-conserving technologies.

Tobin (1969) offered to set forth and illustrate a general framework for the monetary analysis. He tried to replace the interest rate with a menu of asset returns. He developed and calculated Tobin's q as the ratio of the market value of capital to its reproduction cost. When Tobin's q is greater than 1.0, the market value is greater than the value of a company's recorded assets. When Tobin's q values are high, companies are induced to invest more in capital because their value is greater than the reinvestment price. Tobin's q has been used by many scholars to control the investment opportunities of a firm (e.g. Hayashi, 1982; Osterberg, 1989). Osterberg (1989) analyzed a general equilibrium q model where the financial structure affects the firm value. In his model, an increase in the corporate tax rate could either raise or lower the steady-state capital stock. Both q and investment could jump in an opposite direction to their steady-state values. Gugler et al. (2004) determined investment and research and development (R&D) equations by using a measure of marginal q, which is more relevant for investment decisions. That paper is using marginal q to identify the existence of cash constraints and managerial discretion. It also presents the evidence confirming the existence of both managerial discretion in some companies and cash constraints in others.

The role of real options approach (ROA) has been studied by many scholars such as Smith (1999), Copeland and Trufano (2004), Frimpong and Whiting (1997), and Abdel Sabour (1999, 2001). They considered that the ROA could be used to improve the issue of coping with technological and market uncertainty. Samis et al. (2006) demonstrated that the ROA had 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). The ROA is both reliable and valid; as a result, it is now considered in the academia and industry as one legitimate capital budgeting tool project managers use for the allocation of their resources in the face of uncertainty (Alessandri, et al., 2004; Graham and Harvey, 2001; Smith and McCardle, 1998; Sounderpandian, et al., 2008). According to Copeland and Trufano (2004), the true value of a project is inferior to the real options value and higher than the NPV value. Driouchi et al. (2009) and Mahnovski (2006) demonstrated how real options thinking and decision-aiding could be combined to track investment problems under uncertainty. They also showed that decision-makers could deal with their international operations in a robust option-based manner.

The ROA can be used to consider the secondary cost of pollution prevention. Baudry (1999) demonstrated that less pollution diffusion was related to the pollutant threshold by using the ROA. Lin et al. (2007) extended the model of Pindyck (2002) to assess the optimal environmental investment decisions under economic and ecological uncertainty. Keppo and Lu (2003) studied the case of electricity markets and offered a new real options model in order to demonstrate that the price effect of production needed to be considered in the investment analysis: its impact on the assets owned by an energy company and on its investment opportunities is significant.

The real options framework of Dixit and Pindyck (1994) was used by Kjærland (2007) to highlight the consistency between the real options theory and the aggregate investment behavior in Norwegian hydropower. The ROA is helpful in understanding the relation between the price of electricity and the optimal timing for decision makers to implement investment strategies. Fleten et al. (2007) proposed a method for evaluating investments in renewable power generation under price uncertainty. The paper focused on wind power generation for an office building and found out that as high price volatility increases the value of the investment opportunity, it is best to postpone investment until larger units are profitable. Siddiqui and Marnay (2008) studied a California-based microgrid's decision to invest in a distributed generation (DG) unit fuelled by natural gas. That paper shows that greater operational flexibility makes DG investment more attractive for the microgrid and that it is optimal to suspend the DG unit only when the natural gas generation cost is higher or lower than the electricity price. Ansar and Sparks (2009) came up with a new a model which revealed the inclination of households and firms to require very high internal rates of return in order to make energy-saving investments.

Marcus and Modest (1984) investigated the use of futures prices in making production decisions. They derived a preference-independent production rule for firms that faced both demand and production uncertainty. McDonald and Siegel (1985) developed and studied a methodology for valuing risky investment projects, where there was an option to temporarily and costlessly shut down production whenever variable costs exceeded operating revenues. Uncertainty is introduced in that paper by supposing that prices and costs follow a continuous time stochastic process. Dixit and Pindyck (1994) considered a situation where two variables that affected the firm's investment decision – the output price and the investment cost – were both random.

The traditional Tobin's q is the comparison of cash flows between benefits and costs. However, the current research transfers this comparison of cash flows into the potential project value. In the current study, we combine the concept of Tobin's q, the viewpoint of firm value or project value, and the concept of real options to evaluate the feasibility of an investment policy. Numerous academic papers having adopted or applied the theory of Tobin's q and real options can indirectly prove the validity and the robustness of the proposed model in the current research. In this model, the jump events, concerning the energy-saving investment project belong to the external environment. They connect to the green economy and the environmental protection such as the external pressure from the governmental policy to save energy and reduce CO_2 emission. The introduction of new installations can reduce the emission of CO_2 and the treatment of carbonic pollution. The variable cost discussed in the current research is a compromise between the cost of investment equipment and the cost of carbonic pollution treatment. In the internal environment, the variables of benefits and costs in the investment of energy-saving project are controllable from the financial economy viewpoint of entrepreneurs. Both the external and internal environments are under high uncertainty. Thus, we can conclude that the current research concerning the energy-saving issue includes the green economy, the environmental protection, and the financial economy. This paper aims at providing a decision-making reference when an unpredictable external pressure of energy-saving investment happens. There is a high degree of uncertainty when designing energy policies in order to resolve the problems of energy prices, technical innovation of energy-saving equipment, environmental pollution issues, carbon emission reduction or global green economy. Moreover, decision-making thinking is time consuming and as mentioned by Mahnovski (2006), the ROA is more able to handle the strategic assessment related to energy issues.

The decision model in Lin and Huang (2010) evaluated an energy-saving investment project and determined the optimal

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