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A real option-based model for promoting sustainable energy projects under the clean development mechanism

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HIGHLIGHTS

- This study focused on the risks associated with the uncertainty of future CER value in CDM projects.
- A real option-based model was developed for both parties in CDM to have fair share of profit and risk.
- Key variables and boundary conditions were identified for application of real option to CDM.
- The model allowed both parties to own options, which have an identical value.
- Hydropower plant projects in Indonesia were used to illustrate the implementation of the model.

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ABSTRACT

The clean development mechanism (CDM) provides a way of assisting sustainable development in developing countries for developed countries to reduce greenhouse gas (GHG) emissions. Despite its intended benefits, the primary CDM market decreased from US$5.8 billion in 2006 to US$1.5 billion in 2010. One of the primary reasons for the reduction of market size is that developed countries as investors have a high level of risks caused by the volatility of the market price for certified emission reductions (CERs). Another issue to be resolved is that developing countries as host countries cannot claim any right to the CERs produced on their own land. This paper presents a real option-based model for both parties (developed and developing countries) to have their fair share of profits and risks by controlling the uncertainty associated with the future value of CERs. A case study illustrated that the proposed model can effectively attract investors to CDM projects leading to mitigation of climate change.

1. Introduction

The developed countries belonging to Annex I of the United Nations Frameworks Convention on Climate Change (UNFCCC) have committed to reduce greenhouse gas (GHG) emissions since the Kyoto Protocol came into effect in 2005. The Kyoto Mechanism was proposed to provide financial benefits to countries willing to participate in GHG emission reductions. The Kyoto Mechanism represents three types of flexible trading methodologies for carbon credits: international emission trade (IET), joint implementation (JI), and clean development mechanism (CDM) (Begg, 2002; Kim, 2001). The former two methods are the emission trading systems among the developed countries included in Annex I, whereas the CDM enables emission trading between developed and developing countries. The CDM is different from the other two as it entitles carbon emission rights to the Annex I countries providing the opportunities of GHG reduction and sustainable development in developing countries (UNFCCC, 1998; Haites and Yamin, 2000). Considering the ever-increasing trend of business globalization, developing successful implementation models for CDM is important.

The primary CDM market has gradually decreased despite the importance of CDM. The World Bank reports (Carbon Finance, 2011) that from 2006 to 2010, the primary CDM market has decreased from US$5.8 to US$1.5 billion although the entire carbon trading market has increased from US$31.2 to US$141.9 billion. Three primary reasons exist for the CDM market shrinkage. First, the transaction costs of the approval process and interministerial conflict of host countries were barriers to the implementation of CDM projects (Michaelowa and Jotzo, 2005; Muller, 2007; Luukkanen and Kaivo-oja, 2002). Second, CDM projects may not sufficiently contribute to the sustainable development of host countries considering employment generation, carbon credits revenues, local air quality, and technology transfer (Sutter and Parreno, 2007; Muller, 2007). Third, developed countries tend to hesitate to invest in CDM projects

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due to the risks arising from the low current carbon price and the high level of volatility of the future carbon market (Matsuhashi et al., 2004; Pearson, 2007; Muller, 2007). Among the reasons why the CDM market has shrunk, the third is closely related to the economic feasibility of CDM projects.

Developed countries are willing to invest in CDM projects when the predicted price of carbon credits is high. A prediction of low carbon price will likewise deter developed countries from investing in such CDM opportunities. Since CDM projects such as clean energy systems have a relatively long lifespan exceeding 10 years, the reduction of uncertainty in future carbon price is crucial in terms of attracting potential investors to CDM projects.

The main objective of this study was to propose a CDM model that reduces the uncertainty of future carbon prices for investors and provides fair risk sharing to the contracting parties. The main mechanism used for uncertainty reduction as well as impartial risk distribution engages a real option approach. The remaining part of this paper starts with the review of CDM and real option approaches with a focus on conflicting perspectives of different contracting parties. A real option-based model is then presented, validated, and verified with a case study of Indonesian hydropower plants. An expansion of the proposed model to other clean energy systems is also discussed. The findings and recommendations for future studies conclude this paper.

2. Theoretical background and research objectives

2.1. Clean development mechanism

The emission reductions of a CDM project should be "real, measurable, and long-term" (UNFCCC, 1998). The industrialized country that wants to invest in a CDM project for carbon credits should propose a CDM project that will gain the approval of the host country. A baseline then has to be established for proving the "additionality" of emission reductions that the CDM project produced (UNFCCC, 2002). The baseline is the amount of GHG emissions from anthropogenic activities in the most plausible future scenario and in the absence of the CDM project. The carbon emissions difference between the CDM project and the baseline is defined as emission reduction, also known as the certified emission reduction or CER (UNCTAD, 2009). The investor or the industrialized country should propose a method that can achieve success of a few processes involved: establishing the baseline, monitoring carbon emissions, calculating the emission reduction, and determining the crediting period for the issuance of CERs.

The contracting parties have different perspectives depending on the investment position in a CDM project. Developing countries need foreign investment to improve the existing infrastructure such as the energy generation facilities. The investment of developed countries then provides the host country with not only the financial means but also the required technologies. On the other hand, developed countries want to obtain carbon allowance at a low price. The investment needed to obtain CERs should be less than the purchase of the same amount of CERs in the carbon trading market so that developed countries may be enticed to embark on CDM projects. Thus, it is important to identify and develop a condition where the two different perspectives are balanced for the CDM to operate in its intended purpose.

2.2. Real option approaches for infrastructure projects

During the past decade, real option approaches provided appropriate contractual platforms for infrastructure projects involving different contracting parties. Some studies used real option analysis to investigate how to quantify the value of alternative strategies. The examples include valuation of flexible design alternatives (Ford et al., 2002; De Neufville et al., 2006; Mayer and Kazakidis, 2007) and determination of optimal investment time (Garvin and Cheah, 2003; Zhao et al., 2004; Hui et al., 2011). Real option analysis was also applied to assessing strategies for clean energy development (Cheng et al., 2011; Kim et al., 2012). Real option theory provided a way to incorporate the managerial flexibility into the traditional decision making process.

Other studies were conducted for evaluating and properly allocating the risk in public–private-partnership (PPP) projects. For risk mitigation of private investors, real option theory was used to determine the suitable level of government supports (Ho and Liu, 2002; Cui et al., 2004; Chiara et al., 2007; Cui et al., 2008; Brandao and Saraiva, 2008). Cheah and Liu (2006), Huang and Chou (2006), Liu and Cheah (2009), and Asuri et al. (2011) attempted to provide a balanced mechanism of risk reduction by counterbalancing the minimum revenue guarantee (MRG) option with the repayment option. In other words, the risk associated with the profit level of private entities were mitigated by the MRG real option, whereas the repayment real option reduced the uncertainty and risk of the government.

The government and private entity in a PPP project can be likened to the developing country (host country) and developed country (investor) in a CDM project, respectively. The government and developing country both need external investment-whether they are from private entities in PPP projects or developed countries in CDM projects-for the project of interest. Likewise, the private entity and developed country both want to engage in a project with low risk and sensible revenue. However, CDM has the characteristics distinct from other infrastructure projects in the establishment process based on the comparison of baseline and CDM project. Most importantly, CDM puts a great emphasis on the value of the CER issued by the project. The need for CER consideration therefore makes it difficult for the previous real option-based methods to be applied in CDM projects.

For a successful implementation of CDM projects, this study now proposes a real option-based model that can possibly attract potential investors with a fair risk-sharing mechanism. Specific objectives are as follows:

(1) Key variables are identified to reflect the important features of CDM projects.
(2) A contractual condition is established to produce sufficient interest of developed countries in CDM projects.
(3) A risk-sharing mechanism is developed such that the contract is fair and reasonable to the developing country (host country) and the developed country (investor).

3. The real option-based model for CDM projects

3.1. Conceptual framework for real option application in CDM projects

From the perspective of developed countries, excessively low prices of CERs is the risk they want to avoid. Low CER prices can invalidate the economic feasibility for developed countries to commit to CDM projects. Developing countries, however, are not in favor of excessively high prices of CERs. They do not want to lose their carbon emission right at a price considered too cheap. An agreement should then be made to appease these two conflicting views so that both parties are willing to enter into the same contract. Thus, the real option approach is utilized in the proposed model to control the fluctuating future price of CERs.

Fig. 1 shows how the proposed model includes two different real options regarding CER prices. Option 1 is designed to be issued by