

(Form 1)

Kyoto University	Doctor of Economics	Name	Tomohiro Koike
Thesis Title	A potential-theoretic approach to optimal stopping(ポテンシャル理論を用いた最適停止問題の解法について)		
(Thesis Summary) This Ph. D thesis consists of two parts: an application of optimal stopping problems to energy policy, and new theoretical results of optimal stopping by using potential theory. In Chapter 2, An optimal stopping framework to the design of energy efficiency policies (EEPs) is presented and solved. Policymakers are concerned not only with the environmental impacts of EEPs but also with their effects on household welfare. To address this issue, a general equilibrium model with an optimal stopping problem is formed for determining the optimal timing of EEP implementation that maximizes household utility. The problem is analytically solved. It is shown that a two-sided stopping region (the EEP implementation region) arises when policy costs are in place. The candidate then specifies the energy price by an exponential Ornstein–Uhlenbeck process (to capture cyclicity of energy prices) and conducts a quantitative analysis. The main findings are as follows. First, the additional household utility gained from EEPs becomes larger when energy prices are high; hence EEPs can mitigate welfare losses caused by high energy prices. Second, greater volatility in energy price shocks delay the adoption of EEPs. Third, the relationship between the optimal implementation timing and the persistence of energy price shocks exhibits a U-shape curve. Finally, the effectiveness of EEPs in reducing energy consumption depends on both the average energy price level and the energy intensity of production technology. In Chapter 3, the candidate extends the solution technique of optimal stopping for one-dimensional diffusion process to handle random or negative discounting as well as reflecting, sticky, and skew behaviors of the process. The approach is based on Doob’s h-transform for positive harmonic functions, which enables a reduction of the problem to a problem involving Brownian motion. This is possible because one-dimensional diffusions are fully characterized by a scale function and a speed measure, allowing a transformation into Brownian motion via scale and time changes. The method is demonstrated through several illustrative examples. In Chapter 4, the candidate develops a new approach based on potential-theoretic tools such as the Riesz decomposition and the maximal principle, which help to solve optimal stopping problems of spectrally negative Lévy process. The latter models jumps in the negative direction and is employed in various types of economic problems where sudden downward movement of state process is crucial. The candidate identifies and proves necessary and sufficient optimality conditions that cover a wide class of reward functions and presents a direct and constructive step-by-step procedure by which one can handle complex structure of optimal stopping rules. The candidate illustrates this advantage by solving problems with complex reward function of put- options type.			

(Thesis Evaluation Summary)

The theory and methods developed in this thesis are valuable in solving optimal stopping problems and useful in applying them in real-life problems.

In Chapter 2, optimal stopping is combined with a general equilibrium model for finding an optimal time of the implementation of EEPs. The analysis quantitatively shows, among other things, the size of implementation cost can alter optimality in a significant way. This kind of finding, due to the explicit solutions by the candidate, provides new insight into energy policy.

In Chapter 3, the candidate finds the h-transform technique from potential theory useful in handling various types of boundary behavior of one-dimensional diffusion, reducing complex problems to a simple one. This is a new contribution to the literature. If the boundary is not natural, the harmonic function that appears in the solution must satisfy corresponding boundary conditions. The candidate illustrates several cases in a comprehensive manner.

In Chapter 4, which is the main part of the thesis, optimal stopping problems of spectrally negative Lévy process are solved in a quite general setting. The existence of jumps makes the problem much harder since the reward to be obtained at stopping time is only known as an expected value. The candidate fully utilizes potential theory in identifying necessary conditions and proving sufficient conditions. Furthermore, based on these results, a systematic and direct solution procedure is developed, so that one can solve problems with a wide range of reward functions. Unlike conventional methods in the literature, the candidate's method requires no guesswork in determining solution. Accordingly, even if a problem has complex solution structure including multiple double-sided non-stopping regions, the candidate's method is applicable. The candidate clearly shows the whole procedure with necessary proof. Since negative jumps are extensively used in modeling for option pricing and credit risk, this result is also practically useful.

While this thesis is academically and economically valuable, there is some room for improvement. In Chapter 2, externalities arising from energy-intensive production are not considered. In the present setting, optimal timing of technology switch is decided by a policymaker, which is a little unnatural. In Chapter 3, it would be better if some economic problems with some boundary behaviors are presented. Notwithstanding, however, these points should be understood as future research topics and do not impair the value of this thesis. In fact, the candidate showed some work that addresses the above points.

On January 29th, 2026, the Ph. D thesis oral examination was held. Pursuant to this thesis oral examination, the examination committee hereby concludes that the candidate has passed all of the requirements for the degree of Doctor of Economics.

This dissertation falls under Article 14, Paragraph 2 of the Kyoto University Degree Regulations; therefore, a summary shall be published in lieu of the full text for an indefinite period.

The thesis, thesis summary (Form 1), and thesis evaluation summary (Form 2) will be published through the Kyoto University Research Information Repository. If the thesis cannot be published on the website immediately after the degree is awarded, due to patent application, journal publication constraints, or other reasons, please indicate the earliest date below that the thesis can be published.

(Please note, however, based on Article 8 of the Degree Regulations, that the thesis must be published within three months of the date that the degree is awarded.)

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