Valuation and Operation of Energy Commodity Storage –paramter effects and extended model

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Abstract

Supply, demand and other exogenous events contribute energy commodity price fluctuations that incur financial risks for energy facility owners and operators. Energy commodity storage is an effective way to mitigate price fluctuation and lower the financial risks.

In previous work we proposed a storage model for the case of a single commodity with stochastic price serving a known and fixed demand. Convenience yield is included in the model. A 2-dimensional (2D) Hamilton-Jacobi-Bellman (HJB) equation was solved to obtain the optimal storage strategy [1]. In this paper the control policy is further investigated. The valuation result is compared with a no control policy and with threshhold control policy [3]. The effects of the convenience yield and the demand are investageted. The problem is further extended by including stochastic demand. A 3-dimentional (3D) HJB equation with embedded optimization problem is formulated and solved. Similar derivation process of the 3D HJB equation can be found in [4], [5], [6], and [7]. First order convergence of of the 3D compuatation is verified numerically.

In 2D problem, the optmial control ends up to be sliding mode control. The chattering can be reduced or elimiated by reducing the amplitude of the signum function or replacing the signum function by a high-slope saturation function [2]. The valuation result with optmical control is much higher than those without any control policy executed and with threshold method. The convenience yield is positively related with the valuation result while the demand is the opposite. That's because the bigger convenience yield is, the more benefit it can bring by storing the enenrgy commodity; the higher the demand, the more cost is spent to satisfy it, and therefore we have lower valuation result. Finite difference method with the first-order accuracy is employed to solve the 3D HJB equation. The calculated numerical convergence order is approximately 1, which is consistent with the numerical scheme order we used to solve the HJB equation. Therefore we say our 3D computation converges.

This extended 3D model can be easily adapted to stochastic convenience yield, stochastic volatility or another stochastic commodity price.

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Proper boundary conditions need to be chosen to solve the corresponding 3D problem.

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