

Derivatives Pricing with Market Impact and Limit Order Book *

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Abstract

This paper investigates derivatives pricing under existence of liquidity costs and market impacts for the underlying asset in continuous time. Firstly, we formulate the charge for the liquidity cost and the market impact on the derivatives prices through a stochastic control problem that aims to maximize the mark-to-market value of the portfolio less the quadratic hedging error during the hedging period and the liquidation cost at maturity. Then, we obtain the derivatives price by reduction of this charge from the premium in the Bachelier model. Next, we solve a second order semilinear partial differential equation (PDE) of parabolic type reduced from the Hamilton-Jacobi-Bellman (HJB) equation for the control problem, which is analytically solved or approximated by an asymptotic expansion around a solution to an explicitly solvable nonlinear PDE. We also present numerical examples of the pricing for a quadratic payoff and a European call payoff in different settlement types, and show comparative static analyses.

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