First passage for double exponential jump-diffusion processes in a Markovian environment

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Abstract

Let $Z_t = \{X_t, J_t\}$ be the bivariate Markov process, where J_t is an ergodic finite state space Markov chain with intensity matrix $\mathbf{Q}$ and, conditional on $J_t = k$, component X_t behaves as the following process

$$X_k(t) = a_k t + \sigma_k W(t) + S_k(t),$$

where constants a_k, σ_k are the drift and volatility of the diffusion part, $W(t)$ is a standard Wiener process, $S_k(t)$ are compound Poisson processes with exponentially distributed positive and negative jumps. The process $Z(t)$ is known, for example, in financial mathematics as Kou's model with regime switching and it is the special case of the regime switching Levy model with phase-type jumps.

Using known results on the Wiener-Hopf factorization we investigate first passage time problem for the process X_t. We derive the Laplace transform of the joined distribution of the first passage time and the overshoot. Under the assumption that the eigenvalues of matrix exponents are distinct we give the algorithm for finding the distribution of maximum of X_t under exponential killing. Also we consider numerical examples for the two-regime case.

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