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Optimal stopping with a discontinuous and time-dependent reward function

We consider a financial derivative with early exercise whose reward function is time-dependent, unbounded and presents a discontinuity at maturity. In this context, the regularity conditions required to apply the results and techniques used in the American option literature are not satisfied. We confirm the existence of an optimal stopping time, and show that our problem admits a trivial optimal stopping time under certain conditions. We show that the value function admits another representation in terms of a continuous reward function, which allows us to express the price of our derivative as a free boundary value problem. We also present an integral expression for the early exercise premium and an application of our results to the problem of optimal surrender in variable annuities.