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Non-transferable non-hedgeable executive stock option pricing

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ABSTRACT

To value non-transferable non-hedgeable (NTNH) contingent claims and price executive stock options (ESOs), we use a replication argument to translate portfolios with NTNH derivatives into portfolios of primary assets (only) with stochastic portfolio constraints. By identifying stochastic discount factors and finding subjective prices of NTNH European and American ESOs, for block and continuous partial exercise, we derive executives' optimal exercise policies, and use these to find objective prices/costs of ESOs to firms. Through numerical simulations, we obtain policy implications regarding ESOs' incentivizing efficiency. For the first time, we demonstrate that, unlike under block exercise, subjective prices under continuous partial exercise may be higher than objective ones. Moreover, volatility regimes and executives' "other wealth" are important in ESO pricing, and are thus essential to empirical executive compensation studies.

1. Introduction

Executive stock options (ESOs) are call options granted by firms to employees as a form of compensation in addition to base salary, bonuses, and retirement savings. ESOs typically become "vested" (exercisable) over time (Murphy, 1999). ESOs are generally non-transferable and non-hedgeable (NTNH) for at least two reasons. First, ESOs incentivize executives by aligning their and the owners' interests, as executives benefit only when firms' stock prices rise, and the NTNH features prevent executives from eliminating this incentive. Second, NTNH features prevent negative signaling to investors. Holders

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of NTNH ESOs cannot transfer the ESOs to third parties at any price, nor are they allowed to hedge their value using positions in underlying assets or other derivatives. ESOs are typically forfeited if executives leave their firms before vesting. In this paper, we introduce a method of valuing NTNH contingent claims and use it to price ESOs.

ESOs have become a major component of corporate compensation (Carpenter et al., 2010). According to Hall and Murphy (2002), in fiscal year 1999, 94 percent of S&P 500 companies granted ESOs, at a value that accounted for 47 percent of total CEOs pay. Cai and Vijh (2005), using Compustat's ExecuComp database, estimated that in 2002 listed firms granted ESOs worth $98 billion based on their Black–Scholes value, representing 1.2 percent of these firms' year-end market value. Due to the extensive use of ESOs,[4] optional reporting of their cost became mandatory by the Financial Accounting Standard Board (FASB) in 2004. Accurate subjective ESO pricing is essential for understanding the incentives they induce.

The relevance and importance of ESO pricing extends over several disciplines: asset pricing, derivative pricing, constrained portfolio optimization, agency theory–incentives design, corporate governance–executive compensation, capital structure, optimal reporting, and optimal accounting. Furthermore, the methods that we introduce here should not only facilitate the pricing of ESOs with additional features, but should also help solve other pricing problems with NTNH constraints, including pensions, human capital, and real estate (Detemple and Sundaresan, 1999). Clearly, the non-hedgeable constraints apply to many real options, including energy.

As arbitrage pricing is not possible for NTNH securities, the state of the art in this area includes two research approaches that are most closely related to this paper: the SDF approach and the utility-based approach. Both approaches originate from constrained portfolio optimization. However, the former employs duality techniques trying to identify SDFs and derive general closed-form pricing formulas, while the latter makes simplifying assumptions and solves problems numerically, giving up a general pricing framework.

Ingersoll (2006) was one of the first to use the SDF approach. He used the duality method of Cvitanić and Karatzas (1992) and Karatzas and Kou (1996) to solve for the optimal constrained portfolio of an undiversified executive. However, his approach includes two restrictive features: the manager is infinitely lived and the value of executives' firm's stocks and options holdings as a fraction of their total personal wealth must remain constant. In the real world, however, the value of this fraction fluctuates stochastically[5] and the corresponding constraints become stochastic intervals. Carmona et al. (2011), within Ingersoll (2006)'s framework, added job termination as a Poisson process. Two comprehensive studies using the utility-based approach are Carpenter et al. (2010) and Leung and Sircar (2009). In these articles, an executive's goal is to maximize the expected utility of terminal wealth by choosing the optimal exercise time and an optimal trading strategy before and after exercise. Traded assets include all the primary assets and some non-transferable options. Solving the free-boundary problem, the authors obtained the executives' continuation region and the critical stock price boundary, above which the option holders exercise and below which they wait. Carpenter et al. (2010) allowed for only a single block exercise of the option, while Leung and Sircar (2009) allowed for a discrete partial exercise. Grasselli and Henderson (2008) studied optimal exercise policies under transaction costs. They concluded that executives should start exercising large blocks of options and over time exercise blocks of decreasing size. The three utility-based models' simplifications include primary assets of only two dimensions and a specific utility form.

Here, we aim to take the merits of both approaches. By using a partial equilibrium approach—constrained portfolio optimization, we show that NTNH constraints break the local co-linearity caused by derivative assets in solving portfolio optimization problems. Thus, we are able to translate portfolios that include NTNH derivatives into portfolios that consist of primary assets only, by replicating derivatives using primary assets and then integrating the NTNH constraints into a single rectangular stochastic constraint. This allows us to study any granting plan of ESOs and optimal ESO exercise policies, which is essential for proper ESO pricing. This is different from Ingersoll (2006) which allowed for only a constant singleton constraint and ESO granting plans which require executives to hold a constant fraction of their wealth in the firm's stock (and stock equivalents of ESOs), not facilitating a careful study of optimal ESO exercise policies.

Solving the constrained portfolio optimization problem identifies a SDF that gives the subjective price of any contingent claim written on the primary assets in this portfolio. Furthermore, by using executives' optimal exercise policies, we derive the objective price of ESOs from the firms' perspectives. We obtain the subjective and objective prices of NTNH American ESOs with both block exercise and continuous partial exercise policies. Early exercise relaxes the NTNH constraints by freeing up cash; it also decreases the total wealth due to a loss in option time value. When partial exercise is allowed, the optimal exercise rate is the one that equates the marginal utility trade-off between those two effects. Also, without NTNH constraints, maximizing the expected utility of terminal wealth and maximizing the option's values induce identical optimal exercise policies. With NTNH constraints, these two different objectives induce different optimal exercise policies. For the first time, we demonstrate that, unlike under the block exercise of European and American ESOs, subjective prices may be higher than objective ones with the continuous partial exercise of American ESOs. Furthermore, under some parameter settings, parameter changes may cause the terminal expected utility and the ESOs' subjective price to change in opposite directions.

[4] Please see Statement of Financial Accounting Standards (SFAS) No. 123 (revised 2004), paragraph B79 and B80. See also International Financial Reporting Standard 3 (IFRS 2), Share-based Payment 3, and Securities Exchange Act of 1934 (as amended through P.L. 111-257, approved October 5, 2010), Sec. 16 (C).

[5] There is no chance, of course, that managers' firm's shares and options holdings value are perfectly correlated with the total value of their personal portfolio.