SKEW PREFERENCE IN ENERGY COMMODITY OPTION DESIGN

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Overview

The pay-off profiles of an option buyer or seller, indeed the risks they bear, are skewed and asymmetric by design. A poorly designed option has a tendency for inadequate or excessive risk mitigation. Our objective in this paper is to develop an optimisation model for determining the mix and structure of energy commodity options, given alternative levels of skew preference and option premium budgets. Our modelling is particularly suitable to the litigious setting of electric utility regulation involving multiple stakeholders with potentially diverse skew preferences. A regulated electric utility has a fiduciary duty to seek a prudent programme for fuel cost hedging, yet various stakeholders, including the regulator and the consumer advocate, are able to influence its configuration. We implement calibrations and simulations of our model for scenarios pertaining to skew preference, option premium budgets, and a representation of a California regulatory incentive system. We assess the economic consequences of mischaracterising the concept of skew in the design of natural gas options.

Methods

Using a standard formulation in the literature, we conduct a Monte Carlo simulation of a calibrated model of the natural gas forward price at certain transaction and delivery periods. We then formulate and solve an optimisation model with five choice variables: the adder and the subtractor of the call option, and the weights for three instruments: the open position, the collar, and the fixed-for-floating swap. The objective function is a three-moment utility function specifying a hedged portfolio for cost and incorporating variance and skew preferences represented as combinations of 1/0 coefficients (i.e. allowing their effects to be "switched" on or off). One of the key constraints is the collar premiums budget exogenously specified. We study various scenarios pertaining to skew preference, option premium budgets, and a representation of a California regulatory incentive system.

Results

There are four sets of results and implications. Firstly, the introduction of skew preference, altering the portfolio distribution in a favourable manner, leads to the control of the distribution's high or the reduction of its low. The economic damage from tail risk mismanagement could be enormous. Consider an annual natural gas expenditure of $1B, a reasonable figure for a small- or medium-sized electric utility. At a 2% budget, the option premium expense is $20M. The harm associated with the missed opportunity for enjoyment of low prices could be as much as $52M, or more than twice the option premium expense. Secondly, consistent with the literature, skew preference naturally controls "bad" variance. Through the effect of skew, the variance is concentrated in the favourable extreme, and p95 or p01 is lower. Thirdly, the introduction of skew preference leads to meaningful refinements in the mix or structure of instruments. Favourable alterations to the distribution are achieved through granular modifications to the mix or structure of instruments. And fourthly, although there is a similar pattern of results under a 4% budget, doubling the budget from 2% to 4% reduces p01 and increases the portfolio weight of the collar. For a given variance preference, a higher budget increases the ability to pay for the pricey collars required to secure a lower p01. Additional resources for tail risk management are deployed wisely. But having a higher budget per se may not be as important as properly designing the structure or mix of the options. As we have seen above, if the option structure or portfolio weight is sub-optimal, substantial economic harm may result. It is thus crucial for regulatory stakeholders, using a common language, such as our unified modelling framework, to understand, measure, and articulate the economic implications of their risk preferences.

Now, looking at a specific empirical matter, we also study a representation of a regulatory incentive system currently used in California. The regulatory incentive system establishes a schedule of penalties and rewards as a function of whether actual purchase cost exceeds or falls below a benchmark. It is unambiguously intended to steer the hedging behaviour of a regulated electric utility. Our approach to the analysis, using an adjusted specification of our model, is to search for a hedging strategy which achieves the maximum payoff under a representation of the regulatory incentive system. Our objective is to conduct a comparison between, on one hand, the portfolio distribution resulting from the preferences implied by a representation of the regulatory incentive system and, on the other hand, the portfolio distribution articulating skew and variance preferences. Our results indicate an incongruence between articulated and implied preferences. We show that there is a considerable divergence between the portfolio distribution arising from articulated variance and skew preferences and that arising from preferences implied by a representation of the California regulatory incentive system.

Conclusions

Under an adversarial process or an incentive system, regulatory stakeholders could influence the design of an ostensibly prudent hedging programme of a regulated electric utility. The concept of skew preference, the endogenous mix or structure of financial instruments, and the use of option premium budgets, together within a unified modelling framework, assist regulatory stakeholders in evaluating the economic consequences of alternative portfolio distributions. Skew preference not only alters the portfolio distribution in a favourable manner, but also controls “bad” variance. The proper design of the mix or structure of options may be more crucial than a large budget. If the option structure or portfolio weight is sub-optimal, substantial economic harm may result. The portfolio distribution arising from articulated preferences is fundamentally different to the one arising from preferences implied by a representation of a regulatory incentive system in California. It might be interesting to analyse the economic consequences of intricate endogenous structures or quirky option design.