Should a lower discount rate be used for evaluating a tolling agreement than used for a renewable energy contract?

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Should a lower discount rate be used for evaluating a tolling agreement than used for a renewable energy contract? The California Energy Commission (CEC) seems to think so. This paper explores this question, concluding that a risk-adjusted discount rate is inappropriate. A correct approach should quantify the effect of risk on a contract’s financial performance, thereby providing useful information for decision making.

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I. INTRODUCTION

The California Energy Commission (CEC) recommends in its 2007 Integrated Energy Policy Report (IEPR) that utilities’ future fuel costs be discounted “at the 3 percent social discount rate used by the Energy Commission in its standard-setting activities, unless the investor-owned utilities can demonstrate that these costs should be assigned to shareholders.”¹ Implementing this recommendation would increase the present-value (PV) cost of natural-gas-fired generation. To see this point, consider a local distribution company (LDC) that procures a long-term (e.g., ten-year) tolling agreement that uses natural gas bought by the LDC to generate electricity to serve its retail customers.² The tolling agreement’s higher PV cost would in turn help justify increasing the state’s renewable portfolio standards (RPS) to be met by the LDC.³

This paper addresses the question: Should a lower discount rate be used for evaluating a tolling agreement than used for a renewable energy contract? We conclude that the use of a risk-adjusted discount rate is inappropriate. The correct approach, rather, is to quantify the effect of risk on a contract’s financial performance, thereby enabling value-at-risk assessments and the development of efficient frontiers that describe a decision maker’s optimal risk-and-return alternatives.

II. WHY A RISK-ADJUSTED DISCOUNT?

Two primary reasons have been advanced to support a lower risk-adjusted discount rate for computing the PV of a tolling agreement’s fuel cost. The first reason is attributable to Shimon Awerbuch.⁴ As the daily percentage change in fuel prices and the daily stock market return are typically negatively correlated, “the nominal empirically
derived discount rates for fossil fuels are on the order of 0% to 2%." Thus, a power contract with fuel-cost risk should attract a lower discount rate than a renewable energy (e.g., solar and wind) contract without fuel-cost risk.

The second reason is risk aversion. A risk-averse decision maker prefers the certainty of a given gain (dollar inflow) to the uncertainty of various possible gains whose expected value equals the certain gain. That is, the uncertain gain’s so-called certainty equivalent (CE) is less than the expected value of the uncertain dollar inflows. Extending this logic, a risk-averse decision maker prefers the certainty of a given cost (dollar outflow) to the uncertainty of various possible costs whose expected cost equals the certain cost. This, some would argue, justifies using a lower discount rate to compute a tolling agreement’s PV of fuel cost, thereby enabling a CE comparison of the tolling agreement with a renewable energy contract that has no fuel cost.

III. IS A RISK-ADJUSTED DISCOUNT RATE VALID?

A. AN EXAMPLE

Consider a hypothetical company whose discount rate is its 10% per year marginal cost of capital. Suppose the company may spend $200 in Year 0 for the three-year rights to produce at zero cost either of two products, A and B. Based on its occasionally imperfect market projections, management believes the following to be the revenue and cost flows over the next three years:

- Year 1. Both products will yield certain revenue of $100.
- Year 2. Product A will yield uncertain revenues: $100 with 0.6 probability and $125 with 0.4 probability. Product B will yield $110 with certainty.
• Year 3. Product A will yield certain revenue of $116. While yielding certain revenue of $125, product B will have a 90% chance of incurring a $10 maintenance cost.

Table 1 shows the PV calculations for the two products. As both products have an *expected* PV of $68.97, a risk-neutral decision maker would be indifferent between them. Product A, however, has a PV variance of $102.45 (= 0.6 * (60.71 - 68.87)^2 + 0.4 * (81.37 - 68.97)^2), while Product B has a PV variance of $5.08 (= 0.1 * (75.73 - 68.87)^2 + 0.9 * (68.22 - 68.97)^2). Letting the PV variance be a proxy for risk/uncertainty, a risk-averse decision maker (i.e., risk avoider) would prefer Product B, while a risk-taking decision maker (i.e., risk taker) might prefer Product A. In the former case, the risk avoider likes the fact that one cannot do worse than a PV of $68.22; in the latter case, the risk taker likes the fact that one might do as well as $81.37. And, in any event, the same 10% discount rate is applied, even though the two products have different revenue and cost flows with different probabilities of realization.

**B. LITERATURE REVIEW**

The preceding example highlights that a risk-adjusted discount rate has been found to be invalid for project evaluation. “Discounting is employed to assess projects whose benefits and costs stretch over many years. Frequently (and quite naturally) these yearly payoffs, particularly those further in the future, will be highly uncertain. It is occasionally proposed that the discount rate should be adjusted upward to compensate for this element of risk. That approach is now widely agreed to be not only incorrect conceptually, but also likely to result in significantly inferior choices. Raising the discount rate in effect changes the tradeoff rate between payoffs in different periods, yet
there is no inherent reason why uncertainties about the amounts of future payoffs should affect the way we are willing to trade off one year’s payoff against the following year’s. The correct analytical approach is to separate the question of risk-free discount rate from the question of how we value risky outcomes.”

Affirming the above point are the following statements. ”[I]n general it is not theoretically correct to adjust for risk by adjusting the discount rate used in capital budgeting decisions. This is true for public sector benefit-cost analyses and for private sector capital budgeting decisions.” And “[w]hat is being argued here is not that uncertainty and risk are irrelevant to the decision-guiding rule, but that their presence should not be handled by adjustments to the discount rate, for such adjustments imply a particular behaviour for the risk premium which is hard to justify.”

Moreover, “if the returns from any particular investment are independent of other components of national income, then the present value of this investment equals the sum of expected returns discounted by a rate appropriate for investments yielding certain returns. This result holds for both private and public investments.” Indeed, “[c]onclusions regarding the attractiveness of proposed investments can be badly distorted by applying two or more interest rates simultaneously.”

C. BENEFIT-COST ANALYSIS

The CEC’s recommendation is not based on a benefit-cost analysis, a necessary step to justify contract implementation from either a private or social perspective. Failure to take this step leads to a misguided view of risk. To see this point, consider a generation technology (e.g., wind or solar) with a zero per MWH fuel cost. This
technology does not necessarily have a stable per MWH profit margin because the margin's variance is primarily driven by the highly volatile spot electricity market price. In contrast, if a generation technology (e.g., natural gas) has a per MWH fuel cost that positively correlates with the electricity spot price, the technology's per MWH profit margin is more stable than the spot electricity price.\textsuperscript{11} If one were to adopt a risk-adjusted discounting approach, the renewable energy contract with no fuel-cost risk would attract a \textit{higher} discount rate than the tolling agreement with fuel-cost risk.

To show that a renewable energy contract is more risky than a tolling agreement, consider, for example, a one MW geothermal energy contract. For simplicity, assume that the contract has a constant output level of one MWH per hour. Thus the contract has a fixed take-or-pay $F$/MWH capacity price (= fixed per MW-year payment ÷ 8670 hours per year) but not a volumetric charge. How should this contract be assessed in a benefit-cost framework? There are two answers that differ in their empirical computations but not in their theoretical underpinnings.

The first answer is from a private perspective. The contract’s physical benefit is its output, which can be monetized at the spot-market price of $P$/MWH, where $P$ is also the marginal private benefit of consumption. Thus, the per MWH net benefit is the contract’s profit of $\pi = P - F$. In an uncertain spot market, however, $P$ is random with an expected price of $E(P)$ and a variance of $\sigma_p^2 > 0$. Hence, the per MWH profit is also random with an expected profit of $E(\pi)$ and a variance of $\nu(\pi) = \sigma_p^2$. Under risk-neutral decision making, the contract should be implemented if $E(\pi) > 0$.

The second answer is from a social perspective. The contract’s output is valued at $B$, the marginal social benefit of consumption. As $B$ contains the uncertain private benefit
$P$, $B$ is random. Hence the net social benefit of $\beta = (B - F)$ is also random with a variance of $v(\beta) = \sigma_B^2$. If $E(\beta) > 0$, the contract should be implemented under risk-neutral decision making.

Now, consider a tolling agreement with a heat rate of $H$ MMBTU/MWH and a fixed capacity payment of $\$T$/MWH. The net benefit of the tolling agreement from a private perspective is the per MWH profit of $\theta = (P - X) - T$, where $X = \min(P, HG) =$ per MWH cost when the agreement is economically dispatched at the spot natural-gas price $G$ against the spot electricity price $P$. Under risk-neutral decision making the contract should be implemented if $E(\theta) > 0$.

The implementation decision becomes more complicated, however, when those making the decisions in our uncertain world take risk into account, in which case the variance is often brought into play as a proxy measure of a project’s risk.

In the context of the tolling agreement contract, the per MWH profit variance is $v(\theta) = (\sigma_P^2 - 2\rho_{PX}\sigma_P\sigma_X + \sigma_X^2) = v(\pi) - (2\rho_{PX}\sigma_P - \sigma_X)\sigma_X$, where $\rho_{PX}$ is the correlation between $P$ and $X$. We expect $\rho_{PX} > 0$ because the electricity spot price $P$ moves the tolling agreement's per MWH cost $X = \min(P, HG)$. Past empirical evidence indicates $\rho_{PX} > 0.5$ and $\sigma_P > \sigma_X$, implying $(2\rho_{PX}\sigma_P - \sigma_X) > 0$ and $v(\theta) < v(\pi)$. Based on the Northern California NP-15 market price data, Table 2 confirms that $v(\theta) < v(\pi)$ and that a tolling agreement is less risky than a geothermal contract.

From a social perspective, the net social benefit is $\phi = (B - Z) - T$, where $Z$ is the per MWH cost when the tolling agreement is economically dispatched at the social natural-gas price against the marginal social cost of electricity, which may contain various externality costs (e.g., pollution and global warming). Its variance is $v(\phi) = v(\pi)$ -
(2ρ_{BZ} σ_P - σ_Z) σ_Z. Hence, if 2ρ_{BZ} σ_P > σ_Z, the tolling agreement’s net social benefit is less risky than the geothermal contract’s.

**D. CAPITAL Asset PRICING MODEL (CAPM)**

The CAPM relates an asset’s return to the market return, with the implication that an asset with more risky returns, or a higher variance of returns, should have a higher expected return.\(^{14}\) The risk-return relationship, however, applies to the asset’s return and not to a cost component that only partially determines the asset’s return. Hence, Awerbuch’s reliance on the CAPM to justify a low discount rate for computing fuel cost PV is incorrect in the context of power contract evaluation.

The renewable energy contract’s return is \( r = \pi F \), so that the variance of the contract’s returns is \( \sigma(r) = \sigma(\pi)/F^2 \). The tolling agreement’s return is \( s = \theta T \), so that the variance of the agreement’s returns is \( \sigma(s) = \sigma(\theta)/T^2 \). While \( \sigma(\pi) > \sigma(\theta) \), we expect \( F > T \) because the tolling agreement requires the contract buyer to supply fuel while the renewable energy contract does not. Hence we cannot determine *a priori* if \( \sigma(r) \) is larger or smaller than \( \sigma(s) \). That said, even if one would accept Awerbuch’s discounting approach, it is unclear whether the resulting discount rate for the renewable contract should be higher or lower than that for the tolling agreement.

**E. CROSS HEDGING**

Suppose one accepts the CEC’s view that risky fuel costs should be discounted at the social discount rate (SDR) of 3%, which is much lower than the commonly used rate of around 9% that reflects a utility’s weighted average cost of capital. This view,
however, also implies that reducing the tolling agreement’s fuel-cost risk would lead to the use of a discount rate higher than the SDR. A NYMEX natural-gas futures contract is a particularly effective instrument for cross hedging against the California spot natural-gas price. Moreover, the NYMEX contract is for future delivery in the next 12 years, a sufficiently long enough period of time for hedging a ten-year tolling agreement’s fuel-cost risk. The availability of this effective hedge instrument calls into further question the view’s validity.

F. Social Discount Rate

While it is valid to use the SDR to perform a social benefit-cost analysis, a single identical rate should be used for analyzing the net benefit streams of either a renewable energy contract or a tolling agreement. Selective use of a different discount rate for a particular component of a tolling agreement’s cost stream is arbitrary and inconsistent with the standard practice of a benefit-cost analysis.

IV. Conclusion

The preceding analysis shows that a contract’s fuel-cost risk should not be handled via a risk-adjusted discount rate. This is not to argue, however, that a contract’s financial risk is unimportant. In fact, we advocate using finance theory to develop meaningful information for managerial decision making.

Given a contract’s return (or cost) expectation and variance, we recommend computing the contract’s value-at-risk (VaR), which may be the return floor (or cost ceiling) under normal circumstances. To assist contract selection under uncertainty, we
recommend forming efficient frontiers, based on the contract-specific return (or cost) expectations and variances, which describe the optimal options available to management. When used in conjunction with the risk-return tradeoffs that management is willing to accept, these frontiers facilitate the determination of management’s optimal choice.

Finally, we acknowledge that VaR and efficient frontiers can vary with the discount rate used in a PV calculation. Hence, we recommend an analysis of the empirical sensitivity of VaR and efficient frontiers to the discount-rate selection. Nonetheless, it remains incorrect to use different discount rates for different financial components of an electricity contract, irrespective of whether the contract is for renewable energy or natural-gas-fired generation.
Table 1: A hypothetical firm's income streams by product and probability of occurrence.

<table>
<thead>
<tr>
<th>Year</th>
<th>Product A</th>
<th></th>
<th>Product B</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Probability = 0.6</td>
<td>Probability = 0.4</td>
<td>Expected value</td>
<td>Probability = 0.1</td>
</tr>
<tr>
<td>0</td>
<td>-200</td>
<td>-200</td>
<td>-200</td>
<td>-200</td>
</tr>
<tr>
<td>1</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td>2</td>
<td>100.00</td>
<td>125.00</td>
<td>110.00</td>
<td>110.00</td>
</tr>
<tr>
<td>3</td>
<td>116.00</td>
<td>116.00</td>
<td>116.00</td>
<td>125.00</td>
</tr>
<tr>
<td>PV</td>
<td>60.71</td>
<td>81.37</td>
<td>68.97</td>
<td>75.73</td>
</tr>
</tbody>
</table>
Table 2: Daily average NP-15 price and per MWH profit of a tolling agreement with heat rate = 8 MMBTU/MWH.

<table>
<thead>
<tr>
<th>Year</th>
<th>NP-15 daily average market price</th>
<th>Agreement’s per MWH profit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean of $P$</td>
<td>Variance of $P = \nu(\pi)$</td>
</tr>
<tr>
<td>2002</td>
<td>28.98</td>
<td>48.80</td>
</tr>
<tr>
<td>2003</td>
<td>43.66</td>
<td>78.91</td>
</tr>
<tr>
<td>2004</td>
<td>49.03</td>
<td>62.60</td>
</tr>
<tr>
<td>2005</td>
<td>64.64</td>
<td>441.51</td>
</tr>
<tr>
<td>2006</td>
<td>52.60</td>
<td>270.64</td>
</tr>
<tr>
<td>2007</td>
<td>58.48</td>
<td>126.26</td>
</tr>
</tbody>
</table>

Note: Dow Jones provides the daily NP-15 electricity on-peak and off-peak prices and daily PG&E Citygate natural-gas prices. The daily average price is $P = (2/3) \times$ on-peak price $+(1/3) \times$ off-peak price (other hours). Sunday on-peak and off-peak prices are identical. The tolling agreement’s per MWH cost is $X = (2/3) \times$ min(on-peak price, heat rate $\times$ PG&E Citygate natural-gas price) $+(1/3) \times$ min(off-peak price, heat rate $\times$ PG&E Citygate natural gas price).
ENDNOTES


3 As of August 2008, California law (Senate Bill 107, 2006) requires that the state’s three investor-owned utilities (PG&E, SCE and SDGE) achieve a 20% RPS by 2010, while publicly-owned utilities (e.g., SMUD and LADWP) are required to set their own targets in keeping with the spirit of the law. In its draft Scoping Plan, the California Air Resources Board recommended increasing this RPS to 33% by 2020, so as to meet the Global Warming Solutions Act (Assembly Bill 32, 2006), which requires that the state reduce its total GHG emissions to 1990 levels by the year 2020.

4 Shimon Awerbuch THE TRUE COST OF FOSSIL-FIRED ELECTRICITY IN THE EU: A CAPM-BASED APPROACH (2003), at http://www.london.edu/assets/documents/PDF/2.3.3.7.10_otm_seminar_true_cost_of_fossil_electricity.pdf

5 Supra note 4 at 8.


7 Robert C. Lind. DISCOUNTING FOR TIME AND RISK IN ENERGY POLICY (Johns Hopkins, 1982) at 23.


10 Eugene Grant, W. Grant Ireson and Richard S. Leavenworth. PRINCIPLES OF ENGINEERING ECONOMY (John Wiley & Sons, 1982) at 611.


12 $B$ may exceed $P$, as access to affordable electricity improves public health and safety.


18 Chi-Keung Woo, Ira Horowitz, Arne Olson, Brian Horii and Carmen Baskette, supra note 12; Chi-Keung Woo, Ira Horowitz, Arne Olson, Brian Horii and Rouslan Karimov. The Efficient Frontier for Spot and Forward Purchases: An Application to Electricity, 55