REx Incentives: PBR Choices that Reflect Firms' Performance Expectations

A class of incentive menus, called revealed expectations incentives, are structured so that it is in the self-interest of a regulated firm to choose the incentive option that reveals the firm's own performance expectation.

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Incentive regulation (also referred to as performance-based ratemaking, or PBR) is increasingly popular with public utility regulators as a substitute for traditional cost-of-service regulation and as a tool to facilitate the transition to more competitive markets. In restructured utility industries, PBR is becoming the most prevalent mode of regulation in industry segments where competition remains weak or absent (e.g., transmission and distribution). Incentive regulation implemented in the United States and the United Kingdom has employed a variety of approaches such as price caps, rate case moratoria, earnings sharing mechanisms, rate-of-return adjustments, and other performance-based schemes.[1]

Incentive regulation rewards (or penalizes) regulated firms for performance relative to specific targets. For example, under price cap regulation, a utility may realize an increase in its earnings if it can reduce costs relative to the indexed price cap;[2] however, one of the challenges regulators often face with PBR is the selection of appropriate performance targets given incomplete information about the regulated firm and its likely future performance. In response, the concept of providing firms with a menu of "incentive options" has gained some

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support. Sappington and Weisman, for example, explain that by offering regulated firms a choice among two or more incentive plans, regulators can increase consumer welfare by implementing more demanding incentive systems for some firms without raising concerns about causing financial distress in others.[3]

This article discusses a specific class of incentive options designed to reveal the expectations of the regulated firms. These incentive options are structured so that it is in the self-interest of the regulated firm to choose the option that reveals the firm's own performance expectation. In lieu of an established descriptive term, we refer to these incentive systems as *revealed expectations* (REx) incentives.[4] In addition to actual rewards that increase with a regulated firm's actual performance, REx incentives maximize expected rewards for the firm's choice of the incentive option that corresponds to the firm's expected performance. As a result, the selection of the highest realistically *achievable* performance target—a target consistent with public interests—also coincides with the firm's self-interest. This coincidence of private and public interests is a highly desirable feature that is not generally achieved by traditional regulatory practice.

In the remainder of this article we discuss the challenges faced in the implementation of performance-based regulation, summarize the benefits that REx incentives can offer, lay out the design of REx incentives, and review examples of REx incentives and other incentive options.

I. Challenges in the Implementation of PBR

The primary challenge in designing incentive plans is to set realistic performance targets. Information asymmetries between regulators and the firms they regulate make it difficult for regulators and regulated firms to agree on the necessary parameters for use in both incentive regulation and traditional cost-of-service regulation. For instance, the desirability of price caps depends in part on the likelihood that reasonably unbiased estimates of expected productivity gains can be obtained. Similarly, cost-of-service regulation often requires accurate estimates of a company's expected costs to set rates that are fair to the company and its customers. The situation also arises in the context of deregulation, where estimating companies' stranded cost exposure requires a significant amount of company-specific knowledge.

Incremental performance improvements may be more difficult for firms that are already efficient.

Without properly structured incentives, opposing parties in rate cases can be expected to provide cost estimates which are most beneficial to their respective interests and which, therefore, may be biased. If such estimates are overstated, high rates will be costly to customers. If they are understated, the firm may find itself in financial distress—a situation that, ultimately, will also harm customers.

The administrative challenge in implementing performance-based regulation can also be considerable, because regulators often are responsible for regulating many firms with very different cost structures and different potentials for productivity gains. For example, costs may vary considerably across otherwise similar firms simply because of vintage differences in the firms' assets or because of differences in customer mix.[5] Also, incremental performance improvements may be more difficult for already efficient firms than for firms that are still relatively inefficient. As a result, a one-size-fits-all approach to incentive regulation frequently is unfair and undesirable. However, the obvious alternative, implementing company-specific incentive structures, will be unattractive if regulating each firm individually imposes considerable administrative burdens on regulators.

II. Benefits of REx Incentives

REx incentives can overcome these frequently faced challenges. REx incentives can be used both to obtain unbiased performance estimates (e.g., cost estimates) from regulated firms and to recognize inherent differences in the cost structure and performance potential within groups of regulated firms. For example, REx incentives can give regulators a tool to obtain from the regulated firm unbiased estimates of capital expenditures, for the purpose of cost-of-service regulation, or expected productivity gains, for use in price caps. REx incentives can also be used to encourage utilities to reveal their true estimates of stranded cost exposure and, at the same time, provide incentives to minimize such exposure.

Even in applications where "up-front" revelation of expected performance is of little explicit value, the range of internally consistent incentive options in a REx system allows regulators to encourage firms, on a voluntary basis, to select more aggressive, yet achievable, performance targets. Furthermore, offering incentive options on a voluntary basis is likely to reduce the litigious nature of many regulatory proceedings, thereby reducing administrative costs.

REx incentive systems are not limited to regulatory applications. REx incentives can provide similar benefits for performance-based compensation in commercial settings, such as commercial contracts or employee compensation. For example, obtaining unbiased estimates of expected sales from salespeople (who tend to be most familiar with the specific characteristics of their likely performance within a particular market area), allows the firm to improve budgeting, production planning, and inventory management. Similarly, obtaining un-biased forecasts from employees can also be very valuable for project management.

III. Design of REx Incentive Systems

To realize these benefits, REx incentive systems present regulated firms with a menu of performance-reward options that cover a range of performance targets. Such a menu is structured to achieve two goals. First, each menu choice provides firms with strong incentives to achieve and exceed their performance targets. Second, the choice of an incentive option from the menu will cause firms to reveal their unbiased performance expectation because expected rewards will be maximized for the incentive option that corresponds to the firm's own best estimate of expected performance. This is achieved by making it attractive for firms with higher incremental performance potential to choose the incentive options with more demanding performance targets.

The choice of an incentive option will cause firms to reveal their unbiased performance expectations.

REx incentive systems can be simple incentive options, as shown with examples and applications in the next section. These incentive options, however, must be structured to meet three conditions that relate to rewards for both expected (ex ante) performance and actually achieved (ex post) performance.[6]

First, each incentive option must offer rewards that increase with achieved performance. This is simply the general rule for performance-based ratemaking. Firms need to have the continuing incentive to improve actual performance, regardless of which incentive option they may have chosen. If X is the firm's actual performance, and $R(E_i,X)$ is the reward offered by incentive option i (which corresponds to the firm's estimate of expected performance E_i), then this condition can be summarized as

$$R(E_i,X_2) > R(E_i,X_1) \text{ for all } E_i \text{ and all } X_2 > X_1.$$

Of course, as with any other PBR plan, the incremental rewards offered by each incentive option must not exceed the value of incremental performance. This simply assures that a win–win situation is created for both the regulated firm's shareholders and its customers.[7]

Second, firms that choose and achieve higher performance targets must realize higher rewards. If $R(E_i,E_i)$ represents the reward for incentive option i where the actual

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performance X is equal to the initial estimate of performance E_i, then this condition can be summarized[8] as

$$R(E_2,E_2) > R(E_1,E_1), \text{ for all } E_2 > E_1.$$

Third, expected rewards must be maximized for the incentive option that corresponds to the firm's estimate of expected performance. This will give a firm the incentive to choose the menu option with the performance target that corresponds most closely to the firm's unbiased estimate of expected performance. For example, suppose that a firm is given the choice of two incentive options $R(E_1,X)$ and $R(E_2,X)$. If the firm expects to achieve a level of performance X equal to E_2, then the firm must *expect* to earn a greater reward from choosing $R(E_2,X)$ than from choosing $R(E_1,X)$. This condition can be summarized[9] as

$$R(E_2,E_2) > R(E_1,E_2), \text{ for all } E_2 \neq E_1.$$

IV. Examples and Applications

Table 1 provides an example of a REx incentive system to reward performance for capital project investments. This REx system can, of course, be applied to any PBR application that rewards cost reductions. It consists of five incentive options, A through E, that reveal a firm's cost expectation while rewarding the minimization of project cost. These rewards (or penalties, if negative) are provided to the firm in addition to the full recovery of actual project costs (including the recovery of, and a fair return on, investment).

Table 1: Menu of REx Incentive Options

Realized Costs (After Project Is Completed)	Rewards Offered after Project Is Completed (Incentive Options A–E Are Chosen by Company Before Project Start)				
	A	B	C	D	E
$ 50.00	17.00	15.50	13.00	9.50	5.00
60.00	**$12.00**	11.50	10.00	7.50	4.00
70.00	7.00	**$ 7.50**	7.00	5.50	3.00
80.00	2.00	3.50	**$ 4.00**	3.50	2.00
90.00	−3.00	−0.50	1.00	**$1.50**	1.00
100.00	−8.00	−4.50	−2.00	−0.50	**$0.00**
110.00	−13.00	−8.50	−5.00	−2.50	−1.00

Note: Boldface indicates highest expected reward for each level of expected costs.

The example shows that for each of the incentive options A through E, lower costs yield higher rewards. In addition, expected rewards are highest for the incentive option that corresponds to the firm's expected performance. The incentive system is structured so that Option A offers the maximum reward for expected costs of $60 and Option B for $70; Options C, D, and E offer maximum expected rewards for expected costs of $80, $90, and $100, respectively. If a company expects it could complete a project for a total cost of $80, then Option C will offer the highest reward, equal to $4, if the project actually can be completed for $80. Importantly, once Option C is chosen, the firm will continue to have the incentive to exceed its ex ante performance estimate and avoid cost overruns relative to this initial projection—the firm's rewards increase if costs can be reduced below $80 while, symmetrically, the firm's rewards decrease if costs end up above the initial projection of $80.

REx incentive systems or similar menus of incentive options have been implemented in a variety of settings. REx incentives have been applied in a pilot project in Germany concerning defense procurement contracts and by IBM to provide incentives to its sales force. As we discuss some of these applications below, we will also show that different functional forms can achieve all of the above REx properties. We then discuss REx-like incentive options that were implemented by the Federal Communications Commission for the price cap regulation of local access charges and by the U.K. regulator for the regulation of the National Grid Company. In addition, a number of REx incentive systems have been proposed for gas pipeline capital expenditures, generation plant investments, and the restructuring of purchased power contracts. A REx incentive system is also used by the authors' firm, The Brattle Group, to compensate its partners.

A. Application: Government Procurement Contracts

The REx incentive system illustrated in Table 1 is based on a functional form first proposed by Stefan Reichelstein and Kent Osband in 1984 for application to government procurement contracts.[10] The authors posited the following specification, with R(E,E) convex over E, and R(E,X) linear in X:

$$R(E,X) = a(E) + b(E) \times (X - E)$$
$$\text{with } a'(E) = b(E) \text{ and } b'(E) > 0.$$

The general shape of this REx incentive is illustrated in **Figure 1** for two incentive options, $R(E_1,X)$ and $R(E_2,X)$. Note that rewards increase with performance (both before and after selection of a particular incentive option) and that expected rewards will be maximized if the chosen incentive option reflects the true estimate of expected performance. For example, if a firm's expected performance is equal to E_2, the firm will maximize its expected rewards by selecting the incentive option $R(E_2,X)$. If, however, a firm expects to be able to achieve the higher performance target, E_1, then the firm (and its consumers) will be better off by selecting the more demanding incentive option, $R(E_1,X)$.

Reichelstein (1992) discusses the application of this incentive system in a pilot project for defense procurement contracts of the German Department of Defense, a setting similar to capital investment incentives.[11] According to the author, however, the pilot project failed in part due to the regulator's inability to commit to the agreed-upon structure. We identified other shortcomings. For instance, the structure of incentive payments had poor intertemporal properties. In particular, it included an "up-front" payment prior to the start of the project, followed by a "reward" payment for achieved performance relative to the initial estimate, to be paid at the time of completion. Compared to the up-front payments, the present value of the "reward" payments declined with a project's increasing delay, thus diminishing and distorting the intended incentives. This problem, however, can be avoided if, as in the example of Table 1, incentive payments are not separated into two such parts.

A number of potential applications for REx incentives based on the above functional form (also referred to as "optimal menus of linear contracts") are discussed extensively by Jean-Jacques Laffont and Jean Tirole.[12] An application of the above system was also proposed by Lorenzo Brown, Michael Einhorn, and Ingo Vogelsang for the regulation of natural gas pipeline capital expenditures.[13] Brown, in testimony before the Federal Energy Regulatory Commission (FERC), proposed such an incentive system for Palisades Generating Company to provide incentives to control costs of capital additions for the company's nuclear power plant,[14] and Paul R. Carpenter proposed this type of incentive system for Florida Gas Transmission Company's capital expenditure incentives.[15]

Osband and Reichelstein[16] proved that, with risk-neutral firms, the conditions specified by the above functional form are both necessary and sufficient to give a firm with any performance distribution (i.e., the distribution of uncertain performance outcomes) the appropriate incentives to reveal its unbiased estimate of expected performance. This benefit, however, is offset by some disadvantages. For example, the fact that more aggressive incentive options will impose more risk on the regulated firm through increasingly "steeper" reward functions (as illustrated by the solid lines in Figure 1), will result in selection bias if firms are risk averse.[17] In addition, this functional form also limits the range of performance targets that incentive options can span. This range is limited because (1) the reward function, R(E,E), must be positively sloped to give

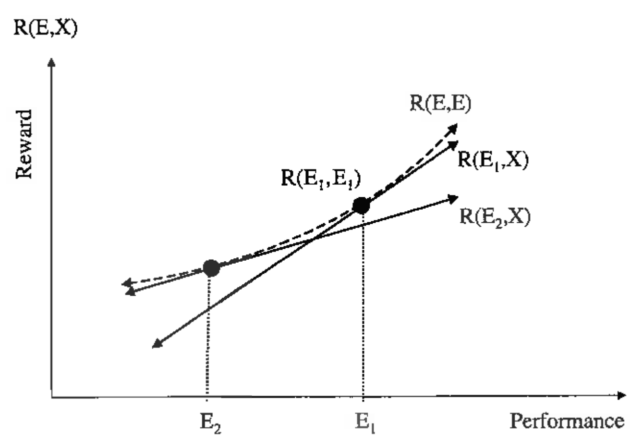


Figure 1: REx System First Proposed for Government Contracts

meaningful performance incentives even for the lowest performance targets, (2) more aggressive performance targets require increasingly steeper slopes, but (3) the maximal slope for the highest performance target is constrained by the requirement that incremental rewards do not exceed the value of incremental performance.

B. Application: Salesperson Compensation

Jacob Gonik describes a REx incentive system used by IBM to reward salespeople for accurate sales forecasts and for giving incentives to exceed their own initial forecasts.[18] Gonik used a menu of incentive options *i* with the following functional form:

$$R(E_i,X) = a \times E_i + (a - b) \times (E_i - X), \text{ with } 1 > a > b > 0 \text{ for } X > E_i,$$

and

$$R(E_i,X) = a \times E_i + (a + c) \times (E_i - X), \text{ with } 1 \geqslant (a + c) > a \text{ for } X < E_i.$$

The general shape of this specification is illustrated in **Figure 2**. Again, the chart shows a choice of two incentive options, $R(E_1,X)$ and $R(E_2,X)$. This application of incentive options is noteworthy because it is one of the few examples that are not based on the previously discussed functional form of linear contracts. As can be seen from Figure 2, however, it nevertheless satisfies all three REx conditions.

This functional form of a REx incentive system has the advantage that (1) the reward curve, R(E,E), does not need to be strictly convex; and (2) each incentive option can have the identical sharing function (i.e., the slopes of the solid lines in Figure 2) relative to the incentive option's target performance. As a result, this specification is not limited in the range of performance targets it can span. Although the asymmetric nature of the sharing function has the disadvantage that it decreases expected rewards for uncertain forecasts of performance, the choice of an incentive option will still appropriately reveal the expected range of a firm's performance.[19] Importantly, the fact that identical sharing functions can be used for each incentive option and performance target avoids the selection bias that the linear specification (Figure 1) exhibits in the presence of risk aversion.

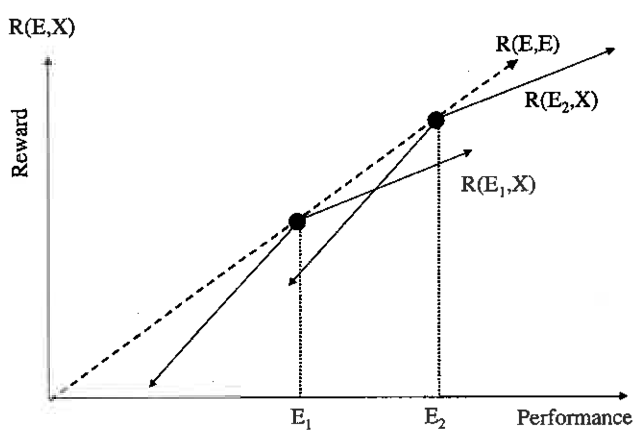


Figure 2: REx System of the Type Used by IBM

C. Other Applications of Incentive Options

Menus of incentive options have been evaluated and implemented in a number of regulatory settings, including the price-cap regulation of U.S. telecommunications carriers and the regulation of the transmission system operator in the United Kingdom. While these incentive systems do not satisfy all of the REx conditions specified above, and thus do not reliably reveal the regulated firms' performance expectations, they nevertheless provide many of the previously discussed benefits.

A system of incentive options was implemented first by the FCC in 1991, and later revised in 1995, in combination with the agency's price cap regulation of interstate access charges by local exchange carriers ("LECs," including the seven Regional Bell Operating Companies and GTE).[20] The LECs were given several choices of X-Factors (two in 1991 and three in 1995), with different sharing arrangements associated with each choice. Companies choosing more aggressive X-factors were allowed to keep a higher proportion of realized savings. The reasons given by the FCC for offering these choices were (1) to encourage LECs to reveal their true X-Factors and (2) to allow for inherent variations in the performance of individual LECs independent of the LECs' efforts. David Sappington and Dennis Weisman describe this experience further and discuss a number of design issues.[21] Although this mechanism was designed with the intent to reveal the LECs' expectations, we found that some of the provided choices were inferior to others irrespective of the companies' true expectations. This is consistent with the fact that the LECs chose only the least and the most aggressive incentive option (but not the middle of the three options) that were provided in the 1995 incentive system.

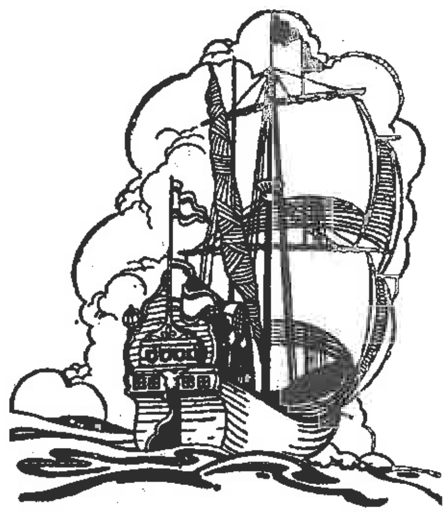
The Australian Competition and Consumer Commission evaluated a similar menu of three price cap options with different productivity targets in its issues paper on the regulation of transmission service providers, recognizing that

> [d]ue to the information asymmetry disadvantage a regulator experiences it may be desirable to offer a menu of options to the owner of a transmission network. . . . For such a regulatory system to work effectively it must be structured so that in selecting from the menu of options NSPs [network service providers] will reveal their true performance expectations. It must also provide NSPs with continuing incentives to exceed their performance expectations.[22]

Most recently, the U.K. Office for Gas and Electricity Markets (Ofgem) issued its final proposal to implement a menu of four incentive options which cover the National Grid Company (NGC) external System Operator (SO) costs.[23] In justifying this menu-based incentive proposal, Ofgem noted that it

> . . . believes that NGC has been unduly pessimistic in its forecast of balancing costs under NETA [the new electricity trading arrangement] and thus that its proposed target for the initial SO incentive scheme under NETA is too high . . . Ofgem recognizes that there is a significant gap between our and NGC's view of possible balancing costs under NETA. In order to bridge this gap, Ofgem proposes four options for NGC's incentive arrangements under NETA.[24]

Each of these four options includes performance targets, sharing arrangements, and caps



and collars to provide a range of performance, risk, and reward options that were designed to mitigate the initial uncertainty faced by NGC under the new electricity trading arrangement. Since the NETA was implemented only in April this year, experience with the SO incentive system is not yet available. Nevertheless, this and the previous examples of incentive options and REx incentive systems clearly show that these forms of incentive regulation can help accomplish a variety of regulatory objectives and offer important advantages over more traditional regulatory approaches.

V. Conclusions

One of the primary challenges in designing incentive regulation systems is the selection of appropriate performance targets given regulators' incomplete information about the regulated firms and their likely future performance. By offering firms a choice of two or more incentive plans that cover a range of performance targets, more demanding incentive options can be provided to some firms without raising concerns about causing financial distress in others. A class of such incentive menus, which we call revealed expectations incentives, are structured so that it is in the self-interest of the regulated firm to choose the incentive option that reveals the firm's own performance expectation. Such REx incentives can be used both to obtain unbiased performance estimates from regulated firms and to recognize inherent differences in the cost structure and performance potential within groups of regulated firms.

REx incentive systems allow regulators to encourage firms, on a voluntary basis, to select more aggressive, yet achievable performance targets. This is realized by making it attractive for a firm with higher performance potential to choose the incentive option that coincides with its own best estimate of likely performance. As a result, REx incentive systems offer the prospect of increased efficiency and consumer welfare, while also rewarding firms for superior performance. Thus, the resulting regulatory regime better approximates

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the results that would be obtained in competitive markets. By offering incentive options on a voluntary basis, REx incentive systems facilitate agreement between regulators and regulated firms on realistic performance targets and, thus, help reduce the litigious nature of many regulatory proceedings. The variety of applications of the incentive options discussed in this article illustrate the potential value of this approach in regulatory as well as commercial settings. ■

Endnotes:

1. For a recent overview of incentive regulation, see David E.M. Sappington, Johannes P. Pfeifenberger, Philip Hanser, and Gregory N. Basheda, *The State of Performance-Based Regulation in the U.S. Electric Utility Industry*, ELEC. J., Oct. 2001, at 71–79.

2. Price cap regulation is often referred to as "RPI-X" regulation. As implemented in the United Kingdom, rates are adjusted annually with changes in the Retail Price Index (RPI, similar to the U.S. Consumer Price Index) minus a productivity offset (X).

3. *Designing Options in Incentive Regulation Plans*, Ch. 6 in DAVID E.M. SAPPINGTON AND DENNIS L. WEISMAN, DESIGNING INCENTIVE REGULATION FOR THE TELECOMMUNICATIONS INDUSTRY (Cambridge, MA: MIT Press, 1996). The firm's choice of options may also include traditional cost-of-service regulation in addition to specific incentive plans.

4. In various settings, similar incentive schemes have been referred to in other ways. David E.M. Sappington, *Designing Incentive Regulation*, 9 REV. INDUS. ORG., 1994, at 258, used the term "optimal incentive plans" and JEAN-JACQUES LAFFONT AND JEAN TIROLE, A THEORY OF INCENTIVES IN PROCUREMENT AND REGULATION, 107 (Cambridge, MA: MIT Press, 1993), used the term "optimal menus of linear contracts."

5. See Edison Electric Institute, *Problems and Limitations of Inter-Company Comparisons of Investor-Owned Electric Utilities*, Washington, DC, 1981.

6. Similar conditions are discussed in Stefan Reichelstein and Kent Osband, *Incentives in Government Contracts*, 24 J. PUB. ECON., 1984, at 257–70; Kent Osband and Stefan Reichelstein, *Information-Eliciting Compensation Schemes*, 27, J. PUB. ECON., 1985, at 107–15; and Lorenzo Brown, Michael Einhorn, and Ingo Vogelsang, *Incentive Regulation: A Research Report*, Washington, DC: Federal Energy Regulatory Commission, Office of Economic Policy, 1989.

7. This can be stated as a set of two conditions. Within a menu option, the following should hold: $R(E,X_2) - R(E,X_1) < V(E,X_2) - V(E,X_1)$ for all $X_2 > X_1$ and all E, where E, X, and R(E,X) are defined as before, and V(E,X) represents the value created for consumer interests. Across menu options, the following should hold: $R(E_2,X) - R(E_1,X) < V(E_2,X) - V(E_1,X)$ for all $E_2 > E_1$ and all X.

8. For notational simplicity, we have assumed that the firm knows its achievable performance with certainty. This condition readily generalizes to the case where, a priori, the firm only knows the distribution of achievable performance:

$$\int R(E_2,X)\,f(X)dX\big|_{X\sim(E_2,\cdot)} > \int R(E_1,X)\,f(X)dX\big|_{X\sim(E_1,\cdot)} \quad \text{for all } E_2 > E_1.$$

9. More generally, when the firm only knows the distribution of achievable performance, this condition becomes:

$$\int R(E_2,X)\,f(X)dX\big|_{X\sim(E_2,\cdot)} > \int R(E_1,X)\,f(X)dX\big|_{X\sim(E_2,\cdot)} \quad \text{for all } E_2 \neq E_1.$$

10. Reichelstein and Osband (1984), *supra* note 6.

11. Stefan Reichelstein, *Constructing Incentive Schemes for Government Contracts: An Application of Agency Theory*, 67, ACCT. REV., 1992, at 712–31.

12. Lafont and Tirole, *supra* note 4.

13. Brown, Einhorn, and Vogelsang, *supra* note 6.

14. Prepared Direct Testimony of Dr. Lorenzo Brown, FERC Docket Nos. ER89-256-000, ER90-333-000, and EC89-10-000, filed Oct. 2, 1990.

15. Prepared Direct Testimony of Paul R. Carpenter, FERC Docket Nos. RP-91-187-000 and CP91-2448-000, filed July 9, 1991.

16. See articles by Reichelstein and Osband, *supra* note 6.

17. A risk-averse firm might instead choose a lower performance/reward option due to its lower volatility, even if that option corresponds to a target that is less than that achievable by the firm. Note also that potential problems associated with a firm's risk aversion can be magnified if higher performance targets can be achieved only with new (i.e., riskier) technology. Various measures, however, are available to address risk aversion, including providing appropriate risk premiums or capping possible rewards/penalties to avoid extreme outcomes.

18. See Jacob Gonik, *Tie Salemen's Bonuses to their Forecasts*, HARVARD BUS. REV., May–June 1978, at 116–23.

19. It can be shown that this functional form also results in unbiased revelation of expected (but uncertain) performance if the slopes of the sharing function are designed such that the parameter b is equal to c in the above formula.

20. For a description of the FCC program design, see Federal Communications Commission, *Policy and Rules Concerning Rates for Dominant Carriers*, FCC Docket No. 87–313, FCC Publication No. 90–314, 1990. For a review of the FCC program outcomes, see Federal Communications Commission, *Price Cap Performance Review for Local Exchange Carriers*, FCC Docket No. 94–1, FCC Publication No. 95–132, 1995.

21. *Supra* note 3.

22. Australian Competition and Consumer Commission, *National Electricity Market: Statement of Regulatory Intent for the Regulation of Transmission Revenues*, Issues Paper, May 1998, at 34.

23. Office of Gas and Electricity Markets, *NGC System Operator Price Control and Incentive Schemes under NETA: Final Proposals*, Dec. 2000.

24. *Id.*, at 7.