Cost Savings from Nuclear Regulatory Reform: Reply

I. Introduction

Since economics advances slowly, if at all, one econometric test at a time, the comment on our article [1] is especially welcome. Dismukes employs a data base that is similar to—or, at least, overlapping with—ours. Moreover, he clearly states what he has accomplished. The dramatic contrast in sample design and empirical testing enhances the comparison. Having said this, we reassert the utility of our approach and the reliability of our findings.

Dismukes levels two charges against our modeling: first, that we failed to recognize that "the construction cost data . . . has an unequal number of nuclear plants being constructed in an unequal number of years"; second, that we incorrectly used "construction costs on a 'per-project' rather than 'per-plant' basis." The claimed defects supposedly lead to two problems: irrelevance of the cumulative NRC regulations variable, since it is "perfectly correlated with time," and doubts concerning our finding of significant economies of scale.

Obviously, we know that the industry constructed an unequal number of nuclear plants in an unequal number of years. In turn, the non-linearity in the distribution of project completion dates in a cross-sectional data base minimizes the effect of any "collinearity with time" of cumulative Nuclear Regulatory Commission (NRC) regulations. Though substantial correlation exists between the log of cumulative regulations and time ($R^2 = .837$, not 1.00), the critical issues are (1) whether, in a cross-sectional data base, the log of regulations is highly correlated with commercial operation start dates, and (2) whether the model otherwise controls for time. Figure 1 is a scattergram of the log of cumulative regulations and commercial start dates from our sample. It shows that the two variables are quite distinct; they do not trace a smooth semi-log pattern. Furthermore, time enters our model as duration for each project; this controls econometrically for any residual effect of time. Finally, no significant multicollearity exists in our Model A.

II. Nuclear Projects, Cathedrals, and Time

As to economies of scale, Dismukes estimates a coefficient for *individual plants* of $-.304964$ compared with our estimates for *projects* of -0.512734 in Model A and -0.474663 in Model B. Using a model similar to Dismukes', but for coal-burning generation, Joskow and Rose [3], cited approvingly by Dismukes, also find quantitatively and statistically significant economies. That is, these authors find significant economies of scale despite loading the dice against them by separating projects into smaller units. Unsurprisingly, in Dismukes, the first plant is more costly by a value of 0.163435. As Dismukes suggests, ". . . multi-unit projects tend to 'front-load' a significant amount of common costs onto the first unit."

This disproportionate accounting practice, which is apparently Dismukes' rationale for using a "first plant" variable, is one reason why we prefer to study the cost of entire projects. Each utility project involves a collection of common attributes that cannot be arbitrarily severed at the

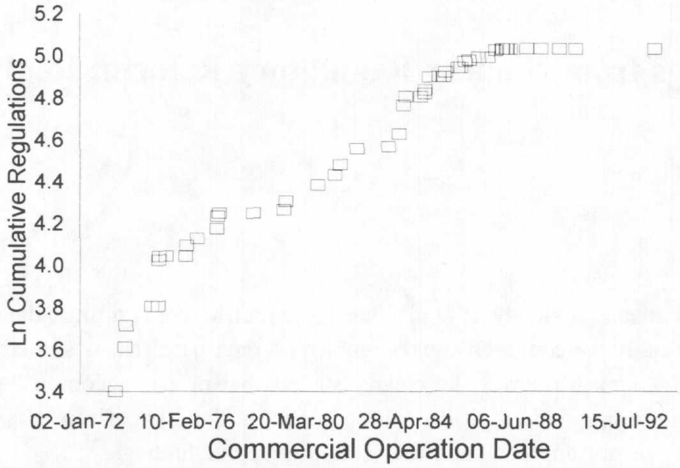

Figure 1.

first unit level. Management, site location, design, transmission lines, and substations tend to be common to the entire project. The utilities incur architectural, land acquisition, and planning costs for the entire project even before they begin the first unit. Moreover, as Dismukes suggests, ". . . current ratemaking practices do not allow utilities to recover capital expenditures until a plant has been placed into service." Management thus has incentive to "front-load" costs onto the first unit to achieve faster cost recovery. Dismukes' approach fails to distinguish between differences in the actual cost of first units and differences in accounting practices regarding first units (relative to subsequent units). More importantly, the division of a collection of overall project attributes into two or three individual "plants" arbitrarily diminishes the site's overall scale of output by 50 to 67 percent (for multi-unit projects with equal-sized units). We continue to favor the per-project approach to estimating costs and economies of scale.

Similarities, including massiveness and wall thickness, exist between modern nuclear power plant construction and the building of the great cathedrals and castles of the Middle Ages. For example, William of Sens, a brilliant French architect, was brought in to direct the extensive reconstruction of the Canterbury Cathedral in 1174. In 1179 William laid the foundation for the enlargement of the church to build a chapel (a second unit) for St. Thomas à Becket. The new foundation extended into the monks' cemetery, requiring careful exhumations and reburials (environmental reparations). In 1180 William directed the construction of the wall that encloses the choir and presbytery (third unit). He was forced to narrow the far end of the choir because of the placement of the existing towers (design error), whose massiveness precluded moving them (retrofitting).[1]

The reconstruction at Canterbury required about seven years (the average project duration in our nuclear sample was about ten years). In an accounting of the costs of construction, it would make little economic sense to use a dummy variable for the central nave costs (first unit) and then exclude the choir and the chapel in evaluating the overall scale of the project, since all areas were and are used for the production of religious services. Similarly, we would not doubt that

1. The details regarding the reconstruction of Canterbury Cathedral are taken from an observer's account, Gervase of Canterbury, in *The Medieval Reader* [2, 171–76].

duration contributed to the costs of construction (clerics meddled with the plans while William, the architect, continued to collect his handsome stipend).

Our duration variable captures the legitimate role of time (the intervals between project construction start dates and commercial operation dates). Duration adds to resources cost because it increases with inefficient project management and more complex (and changing) designs, plus safety and environmental retrofits. However, our study demonstrates that duration, as important as it is, does not explain as much as do cumulative regulations, once we have adjusted for regional differences. Our estimated cost elasticity of regulation is greater than unitary. When Zimmerman [4] earlier found construction costs rising in a one-to-one relation to duration, in part he was capturing the cumulative effect of regulation (which he did not consider separately).

All of which brings us back to Dismukes and time. In Dismukes' model, the most important independent variable is plant completion date. But unless nuclear plants have distinctive horoscopes, why should birth dates be so important—particularly since costs over time have already been normalized into overnight dollars? True, as Dismukes suggests, the final costs of plants completed in 1993 were 2.5 times those completed in 1968. Even so, knowing that units would have been cheaper if each had been completed in 1968 is less useful than knowing the causes of cost escalation. At the risk of being unfair to astrology, we submit that the greater part of those ascending costs can be laid to rising regulatory standards and increasing duration (associated with managerial inefficiency, design error, and required retrofitting). Although NRC regulations continue to accumulate, the pace has slowed considerably (as reflected in Figure 1). Assuming NRC regulations remain relatively stable over the next several decades, we would not expect a nuclear plant begun in 2010 and completed in 2018 to be 2.5 times as costly (in constant dollars) as a similar plant completed in 1993. Yet, that is the implication of Dismukes' approach, with its emphasis on the passage of time as the primary explanation of nuclear plant costs.

III. Conclusions

For a researcher or policy-maker interested only in quantifying the accounting practice of front-loading utility construction costs, Dismukes' model may be the proper tool. However, the modeling of construction costs with time as an "explanatory" variable seems to be a step backward econometrically. The passage of time does not cause anything; even rusting or aging is caused by oxidization or free radicals.

With Dismukes' model, nuclear construction costs per plant seem destined to rise through infinity regardless of how the industry, or regulators, respond. Our model suggests that perhaps costs can be controlled—if experience is enhanced, construction duration shortened, regulation stabilized, and optimal scale achieved. As our policy simulation matrix shows, regulatory reform to encourage pre-approved, standardized, and smaller designs could move the industry more rapidly down the learning curve. As we said, the "reasonably optimal" size is not necessarily the largest possible; utilities can reduce duration and augment experience by the selection of a standard "right-sized" project for regional needs. As we also said, the net benefits of future nuclear projects should be compared with alternative energy sources, including environmental costs and benefits.

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References

1. Canterbery, E. Ray, Ben Johnson, and Don Reading. "Cost Savings from Nuclear Regulatory Reform: An Econometric Model." *Southern Economic Journal,* January 1996, 554–66.

2. Cantor, Norman F., editor. *The Medieval Reader.* New York: HarperCollins, 1994.

3. Joskow, Paul L. and Nancy L. Rose, "The Effects of Technological Change, Experience, and Environmental Regulation on the Construction Cost of Coal-Burning Generating Units." *Rand Journal of Economics,* Spring 1985, 1–27.

4. Zimmerman, Martin B., "Learning Effects and the Commercialization of New Energy Technologies: The Case of Nuclear Power." *Bell Journal of Economics,* Autumn 1982, 297–310.