The Narragansett Electric Company

d/b/a National Grid

INVESTIGATION AS TO THE PROPRIETY OF PROPOSED TARIFF CHANGES

Rebuttal

Testimony and Schedules of:

Power Sector Transformation Panel
Kayte O'Neill
Robert D. Sheridan
John O. Leana
Timothy R. Roughan
Meghan McGuinness

Book 7 of 7

May 9, 2018

Submitted to:
Rhode Island Public Utilities Commission
RIPUC Docket No. 4770

Submitted by:

nationalgrid

Rebuttal Testimony of
Kayte O'Neill

REBUTTAL TESTIMONY

OF

KAYTE O'NEILL

Dated: May 9, 2018

Table of Contents

I. Introduction and Qualifications 1

II. Purpose of Rebuttal Testimony 1

III. Response to Division's and Acadia Center's Direct Testimony 2

Inclusion of PST Proposals in Base Rates 4

Investing in PST Through a Multi-Year Rate Plan versus an Annual PST Reconciling Mechanism 6

Relationship Between Return on Equity and Performance Incentive Mechanisms 15

IV. Conclusion 22

I. Introduction and Qualifications

Q. Ms. O'Neill, please state your name and business address.

A. My name is Kayte O'Neill. My business address is 40 Sylvan Road, Waltham, Massachusetts 02451.

Q. Have you previously submitted testimony in this proceeding?

A. Yes.

Q. On whose behalf are you submitting rebuttal testimony in this proceeding?

A. I am submitting rebuttal testimony on behalf of The Narragansett Electric Company d/b/a National Grid (Company).

II. Purpose of Rebuttal Testimony

Q. Ms. O'Neill, what is the purpose of your rebuttal testimony?

A. The purpose of my rebuttal testimony is to respond to the pre-filed direct testimony submitted by the Division of Public Utilities and Carriers (Division) and the Acadia Center in this proceeding with regard to: (a) the relationship between the Company's Power Sector Transformation (PST) Plan and cost recovery proposal, and (b) the Company's request for a change in base rates. Specifically, my testimony addresses the Division recommendations that the Company: (1) include certain PST foundational initiatives in base rates; (2) file a multi-year rate plan with forecasts of costs for each year

of the plan, including any forecasted costs relating to a comprehensive grid modernization plan and advanced meter functionality (AMF), rather than recover PST costs through an annually reconciling PST tracker; and (3) accept a return on equity (ROE) below the reasonable range to reflect the revenues that the utility could potentially recover through performance incentive mechanisms.

Q. How is your testimony organized?

A. Section III of my testimony responds to the Division's and Acadia Center's recommendations. Section IV is the conclusion to my testimony.

III. Response to Division's and Acadia Center's Direct Testimony

Q. How would you summarize the Division's recommendations regarding the relationship between the Company's Power Sector Transformation cost recovery proposal and the Company's request for a change in base rates?

A. The Division recommends that the PUC review the Company's proposed PST Plan and investments along with the Company's request for changes in base rates rather than in the separate Docket 4780 the PUC created for the PST proposals. The Division further recommends that the Company undertake certain PST initiatives during the rate year and recover the costs associated with such initiatives through base distribution rates rather than the Company's proposed fully reconciling mechanism – the PST Provision. These initiatives include the Company's proposed advanced metering functionality (AMF)

implementation planning process, GIS Enhancements, the System Data Portal updates and performance incentive mechanisms. The Division also recommends that AMF deployment should commence prior to receiving regulatory approval for cost recovery. Company witness John Leana addresses this recommendation in his rebuttal testimony. The Division also recommends that the Company develop a comprehensive grid modernization plan and implement its PST initiatives pursuant to a multi-year rate plan, rather than through the Company's proposed PST Provision under the incorrect assumption that implementing PST through a multi-year rate plan better aligns the Company's PST spending with PST-related technology changes. Finally, the Division proposes to reduce the Company's allowed ROE by 50 basis points in exchange for the ability to earn through performance incentives.

Q. How would you summarize Acadia Center's recommendations regarding the relationship between the Company's PST cost recovery proposal and the Company's request for a change in base rates?

A. Similar to the Division, Acadia Center recommends that the PUC integrate portions of Docket 4780 that propose to change the Company's business model and consider them in conjunction with the rest of the Company's rate and cost proposals in this docket. (LeBel, p. 13).

Inclusion of PST Proposals in Base Rates

Q. Do you agree with the Division's and Acadia Center's recommendations to integrate portions of the PST Plan into the Company's base rate case?

A. No. As the Company explained in several Data Request responses, separate recovery for the PST initiatives is appropriate because it provides: (1) the necessary flexibility to undertake new types of investments involving emerging technologies and lessons learned across the industry; (2) flexibility to alter recovery levels annually as the significant investments unfold over the years; and (3) the opportunity to allow for substantial stakeholder participation in planning and executing those investments.

To assure stakeholders that the Company is investing customer funds efficiently and effectively, and to avoid rate "shock" from deferred recovery, it will be necessary to continuously review and update proposed PST investments. To achieve this level of transparency, the Company determined that separating the traditional activities necessary to fulfill the Company's principal obligation to provide safe and reliable service (i.e. ISR, Energy Efficiency, and System Reliability Planning) from the proposed PST investments would provide needed clarity and flexibility to respond to changes in future proposed functions and/or technology. Over time, the necessity of separate proceedings may become obsolete, but due to the magnitude of potential costs and the long-term nature of PST investments, starting on the proper path is critical to the long-term success of the investments. The PUC, therefore, should maintain the separate pathway proposed by the

Company to provide an open and transparent process for evaluating and approving potential investments that extend the function of the Company beyond its traditional role.

Q. Why does the Company support a stakeholder process for PST?

A. It is widely acknowledged in Rhode Island (and other jurisdictions) that stakeholder input is critical to the success of new and existing programs in the operation of the electric distribution system. Through the Docket 4600 working group and the year-long external PST stakeholder process, it became evident that, as Rhode Island continues to make progress on its path to transform the electric distribution system and achieve its greenhouse gas reduction targets, the Company will need to be transparent and actively engage its stakeholders. It also was clear that grid modernization investments should, as much as possible, mitigate the risk of "stranded costs" in a period of fast-paced technological change. Stakeholder input will assure that future PST investments best meet the goals of state policy, including customer choice and empowerment, while also providing significant market opportunities to make the on-going process self-sustaining, low cost, and efficient for all participants. If the Company moves forward with these investments without the critical feedback and input of all interested participants, the result may be investments that do not appropriately meet the needs of the state and the Company's customers. Including an annual stakeholder process will support increased alignment and certainty around PST investments before-hand, a more efficient energy delivery system that meets the evolving needs of customers and nurtures a vibrant, clean,

and participatory energy landscape, all of which will result in a more efficient transition to an affordable, sustainable clean energy system for Rhode Island.

Q. Do you agree with the Division's recommendation that the PST initiatives should be treated as "core business" and the costs recovered through base rates (Booth, p. 22)?

A. No. Although the Company anticipates that some or all of the PST initiatives could become part of the core business in the future, until new technology and functionality have become integrated into the Company's normal day-to-day business operations, the PST investments represent new and emerging technologies that are distinct from the Company's current, largely traditional infrastructure and approach to operating the system. It is, therefore, not appropriate to integrate these costs into the revenue requirement in this rate case. The Company has previously articulated the potential to recover the costs through base rates at some future point when the PST investments have been fully integrated into the core business and represent the new "business as usual" approach to operating the system.[1]

Investing in PST Through a Multi-Year Rate Plan versus an Annual PST Reconciling

[1] See Technical Record Session In re: Narragansett Electric Company d/b/a National Grid's Proposed Power Sector Transformation Vision and Implementation Plan, Docket No. 4780, January 26, 2018, Tr. at 94, 122 ("We do anticipate that potentially the ongoing costs of running power sector transformation over the many years that follow . . . that those costs could fit well in base rates on an ongoing basis.") ("We are transitioning to this clean energy future with customer control, choice , information and resiliency in a world of two-way power flow, but we have to make those foundational investments first, and . . . do the ongoing costs of running those systems in the future fit in base rates may absolutely be correct because that is the point at which they transition.").

Mechanism

Q. Do you agree with the Division's and Acadia Center's recommendations to implement a multi-year rate plan as it relates to the proposed PST investments?

A. No. The Company notes that in the Division's response to PUC Data Request 2-1, the Division clarified that it is not proposing a multi-year rate plan in this case; however, Division Witness Woolf, in his testimony, supports a multi-year rate plan as a "balanced and effective solution" to advancing the "utility of the future" (Woolf, p. 37). Not only is a multi-year rate plan not presently before the PUC for consideration in this case, the Company generally disagrees with the concept that a multi-year rate plan is the solution to advancing the "utility of the future" as suggested by the Division. The Company's PST proposal represents a holistic suite of initiatives that will enable the Company to advance new, innovative technologies, with stakeholder input, and to transform the power sector to meet the State's energy goals, which is consistent with the recommendations set forth in the Phase One Report to Governor Gina M. Raimondo, dated November 2017 (Phase One Report).[2] Although the Company acknowledges that a multi-year rate plan is one of the policy goals that the Phase One Report cites for modernizing the utility business model, a multi-year rate plan is not the only framework in which to do so. The Company's PST proposal achieves similar objectives to a multi-year rate plan, as discussed below.

[2] See Phase One Report, at 12.

Q. Can you elaborate on why a multi-year rate plan is not the appropriate framework in which to deliver the PST investments?

A. Yes. Certain PST initiatives, such as AMF deployment, require significant investment. Requiring the Company to bear these costs through a multi-year rate plan, without an opportunity to reconcile costs until its next general rate case, is not only unreasonable, but it also would impair the Company's ability to make appropriate investments and respond to lessons learned in a rapidly changing industry. Similarly, many of the proposed grid modernization investments, while complementing some existing foundational investments, represent significant upgrades and enhancements to the Company's existing informational and other systems that are not yet part of the Company's day-to-day business operations. As the Company indicated in its response to Division Data Response 41-4, the flexibility to leverage multi-jurisdictional synergies with many of these investments, coupled with uncertainty around the deployment schedule, is another reason the Company maintains that the annual review and cost reconciliation mechanism proposed in the PST filing are appropriate.

Requiring the Company to manage PST investments over several years through a static investment plan, at capped annual costs, represents a significant risk to the Company during the investment plan period. To enable the collaborative, iterative process that will be required to balance the interests of all stakeholders, particularly the interests of the Company's customers, it is more reasonable to create a cost recovery mechanism outside

of base distribution rates that can allow a greater level of flexibility and transparency to the program implementation.

Q. The Division also supports a multi-year rate plan based on its conclusion that it addresses "tensions related to cost recovery that often exists between the competing interests of ratepayers and shareholders" (Woolf, p. 33). They further conclude on page 37 of the Woolf Testimony that a multi-year rate plan is fair to all participants because it caps targeting spending at pre-determined reasonable levels, advances initiatives desired by regulators, and is fair to utilities because it provides a reasonable opportunity to recover all of its costs in a timely manner while achieving a reasonable return. How does the Company's PST proposal compare to this structure?

A. The PST proposal also balances the interests of customers and shareholders – there are several ways in which the Company's PST proposal aligns with the goals articulated by the Division for a multi-year rate plan. For example, the Division recommends a multi-year plan, in part, because it requires and facilitates planning over a multi-year horizon on a fully integrated basis (Woolf, p 33). The Division also justifies a multi-year rate plan

on the basis that it would allow all parties to examine the direction in which the utility is planning to move and allow stakeholder and regulator input (Woolf, p. 37).

These also are the features of the Company's proposed PST process. The Company's proposal for annual PST plan filings, with multi-year planning horizons facilitates the very flexibility the Division seeks by allowing annual refinements to the PST Plan, based in part on regular stakeholder input. Under the PST Provision, and the associated annual PST Plan, customers will benefit from a greater level of flexibility and transparency associated with program implementation.

Q. The Division also recommends that an integrated grid modernization plan (GMP) be considered as part of a multi-year rate case (Woolf, p. 45). How do you respond to the Division's recommendation to develop a longer-term GMP?

A. The Company's proposed PST annual process and proposed PST Provision already encompasses a comprehensive grid modernization plan as evidenced by the Company's five-year cash flow projections detailed in its PST filing currently pending in Docket No. 4780. Moreover, the Company already has proposed to continue to update and share its multi-year grid modernization plans through annual PST plan filings, which will include stakeholder involvement. Company witness Robert D. Sheridan discusses the specifics of the Division's proposal for a GMP in his rebuttal testimony.

The Company recognizes why one might suggest that grid modernization investments be included in base rates; however, doing so in this case would fund only one year of a multi-year investment proposal and would not allow for future investments. Conversely,

annual plans with a rolling five-year planning horizon will provide the Company and stakeholders with the opportunity to analyze and implement innovative grid modernization investments with sufficient flexibility to adjust future plans as both technology and public policy continue to advance. For these reasons, the Company maintains that a holistic, annual PST Plan process with annual reconciling cost recovery through the PST Provision continues to be the appropriate pathway to meet customer needs and the State's energy goals.

Q. Why should the PUC approve the PST Provision, rather than a multi-year rate plan with pre-set levels of cost recovery?

A. Through the annual PST plan and stakeholder process, the PST Provision affords the Company, its customers, and the PUC with greater cost transparency than a multi-year rate plan. The activities associated with the PST initiatives represent new types of activities for the Company, and the associated costs have not been reviewed previously by the PUC or the Division. Some of the costs are significant, particularly when layered on other costs to build and maintain the distribution system. Keeping these costs separate will increase transparency and accountability; allowing an annual reconciliation will assure that customers pay no more and no less than the reasonable and prudent costs to implement the PST initiatives. The annual PST Plan process will ensure that the Company does not recover costs that it did not incur prudently, thus posing a risk to the Company if it does not plan and implement PST initiatives efficiently and effectively.

Reconciling recovery also provides the Company with the resources necessary to move forward with its investments designed to serve the various objectives underlying the approved PST activities. In addition, because the PST initiatives, the estimated costs to perform the activities needed to accomplish the objectives of those initiatives, and the rate of progress and spending necessary to complete the PST initiatives are, to some extent, new to the Company, having the flexibility provided through a reconciling mechanism to alter recovery levels in response to changing cost profiles, technologies, and pace of performance will provide a level of added assurance that customers are being charged only to recover costs that the Company anticipates incurring as a result of changing information and learnings during deployment.

Q. Why is the proposed cost recovery cap envisioned through a multi-year rate plan not reasonable to ensure customers are protected from variable bill impacts from year-to-year?

A. As discussed above, reconciling recovery is just as important for customers, as it is for the Company. As technology develops, the PST Provision will allow customers to realize the benefits of decreased costs that arise over multi-year implementations, whereas base rate recovery locks customers into the costs anticipated at the time of the proposal. Recovery through base distribution rates also does not provide flexibility for the Company to be more agile in refining its planning of PST initiatives.

Q. Does the Company agree with the Division's assertions that the PST Provision will shift risks to customers with little or no risk to the Company and result in a spending/cost recovery cycle that would be difficult for the Division and the PUC to evaluate and control (Woolf, p. 24)?

A. No. Risk remains for the Company with the PST Provision because the PUC and the Division will conduct annual spending reviews (like with the ISR) and the Company will not receive cost recovery without PUC approval. Similar to the ISR process, the Company has the burden to demonstrate that costs are reasonable and prudent. Through the annual reconciliation process, the Company is held accountable for any over-spending and must justify those costs to the PUC.

Q. Have other jurisdictions acknowledged cost recovery of new initiatives, similar to power sector transformation, through fully reconciling mechanisms rather than through base rates?

A. Yes. Across National Grid's jurisdictions, many transformative initiatives both past and present, have been recovered through separate factors as a component of reconciling mechanisms. For example, both energy efficiency costs and generation stranded costs are recovered through a separate mechanism.

In particular, Massachusetts recently has indicated its preference for cost recovery of grid modernization investments through a fully reconciling cost recovery mechanism. In

D.P.U. 17-05, Eversource Energy proposed a "performance-based ratemaking mechanism" (PBRM) to implement an annual adjustment to base distribution rates. With the proposed PBRM in place, base distribution rates for Eversource's electric company would be adjusted annually based on the revenue cap formula approved by the Department; Eversource did not propose a separate mechanism that operates outside of base distribution rates. The concept is that base distribution rates are adjusted to provide the utility with a level of revenue support for its ongoing capital investments and operating and maintenance cost increases between rate cases, in lieu of the sales growth that was available historically to offset those cost pressures. Eversource effectively proposed to use a portion of the annual base distribution rate adjustment to pay for $400 million in grid-modernization investments. The Department, however, found that separate cost recovery was more appropriate. The Department affirmed its perspective that the recovery of grid-modernization investments does not belong in base distribution rates in the short term, but rather should be established separately, by finding:

> In the future, as we gain experience with grid modernization, *it may be appropriate to include grid modernization investments together with other capital investments in a PBR*. However, given our expectations that grid modernization will evolve substantially over the next five years, *the Department finds that a more robust review of grid modernization investments than can be afforded by including these investments in the PBR is necessary in the short term*. D.P.U. 17-05, at 442 (emphasis added).

In the context of the Eversource proposal, the Department found that more flexibility was needed to allow for oversight and review of grid-modernization investments as

expectations about those investments evolve. Accordingly, the Department stated expressly that it would establish separate cost recovery through a reconciling mechanism as part of its decision in the grid modernization docket, which is D.P.U. 15-122/15-123 for the Eversource electric companies. D.P.U. 17-05, at 442 (quoted above).

Relationship Between Return on Equity and Performance Incentive Mechanisms

Q. The Division also proposes to reduce the Company's allowed ROE by 50 basis points in exchange for the ability to earn a certain level of performance incentives. Can you explain the Division's proposal?

A. Yes. The Division has suggested an authorized ROE below the reasonable range to reflect the revenues that the Company is expected to recover through performance incentives, which they assert could be "200 basis points or higher" (Woolf & White, pp. 9, 17-18). Specifically, the Division recommends reducing the proposed allowed ROE by 0.5% to "properly and conservatively recognize a reasonable PIM earnings potential and avoid PIM being an unwarranted earnings windfall" (Kahal, p. 46). The Division also proposes that the Company be allowed to retain 100.00 percent of earnings up to 100 basis points above the allowed ROE (i.e., 9.50 percent if the Division's 8.50 percent ROE recommendation is accepted) (Kahal, p. 46). Any excess earnings above 100 basis points would be shared 75/25 in favor of customers under the Division's proposed earnings sharing mechanism (Woolf & Whited, p. 54). The Division rationalizes its recommendations on the assumption that the Company is left with substantial incentive to

achieve performance incentive mechanism metrics, because it will be allowed to keep all performance incentive mechanism earnings up to the 9.5 percent ROE and, potentially, above 9.5 percent based on the earnings sharing formula.

The Division also argues that an adjustment to ROE is justified on the grounds that the performance incentive mechanisms reduce the utility's risk by providing regulatory guidance and some assurance that the costs associated with performance incentive mechanism initiatives will be allowed into rates. Finally, the Division suggests that the Company's history of successfully earning an incentive for its energy efficiency programs means that the substitution of performance incentive mechanisms for some portion of ROE is justified.

Q. Does the Company agree with the Division's proposal to reduce the allowed ROE in exchange for the potential to earn through performance incentive mechanisms?

A. No.

Q. Why not?

A. As discussed in Company Witnesses Meghan McGuiness's and Timothy Roughan's joint rebuttal testimony, the Division's proposal misunderstands the purpose of performance incentive mechanisms. They are not a replacement of return on rate base. Rather, they are a mechanism to drive investment and effort in other areas of utility operation that are

not captured by traditional utility activity.

A properly designed performance incentive mechanism spurs activity in areas that a utility is otherwise not motivated to pursue because it is not necessary to fulfill its core obligations. Docket 4600 and the PST process have made it clear that the investments and activities necessary to achieve the desired transformation of Rhode Island's power sector should be spurred by providing the Company with performance incentives that fairly reward the Company for taking on the risk of applying resources and making investments in areas that are not an ordinary part of its daily business of providing safe and reliable electric service. These are activities that the Company otherwise would not need to entertain at this time. Taking away a portion of the Company's authorized rate of return in exchange for providing these additional incentives is not aligned with the goal of driving additional activity above and beyond what traditionally is expected of a utility and thus defeats the purpose of the performance incentives. Rather, providing the Company with opportunities for earnings that are above and beyond what the Company would be entitled to earn through ROE by providing excellent performance in its traditional roles is the purpose of performance incentives.

In addition, the Division has overstated significantly the value of incentives that the Company realistically can earn. According to Mr. Woolf and Ms. Whited, the Company has the opportunity to earn up to 292 basis points in year three, which includes the

current incentive for energy efficiency.[3] As discussed in Company Witness Robert B. Hevert's testimony, the 192 basis points in shareholder incentive above the 100 basis points the Division asserts the Company can retain is, in actuality, 48 basis points when taking into account the Division's proposed earnings sharing mechanism.[4] This is assuming the Company can achieve the higher targets that the Division has proposed. As discussed in Company Witnesses McGuiness and Roughan joint rebuttal testimony, several of these targets are not attainable.

Accordingly, the PUC should adopt performance incentives that serve the purpose for which they are meant and include them as a complement to the Company's allowed ROE – not a component.

Q. How does the Division view the impact of performance incentive mechanisms on utility risk?

A. The Division suggests that performance incentive mechanisms reduce utility risk by providing regulatory guidance and some assurance that the costs associated with initiatives that support achievement of performance incentive mechanisms will be allowed into rates and that this might support the authorization of a lower ROE (Woolf & Whited, p. 17).

[3] Direct Testimony of Tim Woolf and Melissa Whited, at 18, Table 6, 2021 (high) estimate of PIMs incentive revenue.

[4] *Id.* at 54.

Q. Does the Company agree with the Division's view?

A. No. Company Witness Hevert addresses the issue of utility risk in his rebuttal testimony. Although the approval of performance incentive mechanisms may provide some regulatory guidance, it does not provide assurance of approval of supporting programs, nor does it diminish the Company's burden to demonstrate the value of these programs and the prudence of associated expenditures.

Further, the Division's proposal to reduce the Company's allowed ROE to reflect the existence of performance incentive mechanisms increases risk to the Company, as it replaces the historical regulated opportunity to earn with a potential opportunity to earn. The Division, itself, notes the risk inherent in performance incentive mechanisms in its discussion of whether they should include penalties, noting "the initiatives that we are asking the Company to undertake are somewhat new. This means that there is some uncertainty about the costs, the benefits, and the outcomes of the initiatives." (Woolf & Whited, p. 26). The Division suggests that the prospect of penalties might discourage the Company from pursuing a particular initiative or encourage the Company to propose less aggressive targets (Woolf and Whited, p. 26).

The potential impact of a reduction in allowed ROE due to the availability of performance incentive mechanisms is not unlike the potential impact of penalties. Uncertainty about the Company's ability to earn performance incentives could encourage

the Company to set conservative targets in order to mitigate revenue risk, limiting the potential benefits of performance incentive mechanisms to customers.

Finally, requiring the Company to meet performance incentive mechanism targets simply to earn its required ROE makes the Company a riskier utility than the peer group used to estimate the cost of equity because none of those companies are required to meet such targets to earn their allowed ROE. As such, introducing a framework where the Company needs to meet additional performance hurdles to earn its allowed ROE increases its cost of equity. As Mr. Hevert explains in his rebuttal testimony, "the current framework provides more regulatory stability and certainty than does the process that is pending before the PUC, simply because the PST process is unfolding and there is considerable uncertainty surrounding the outcome."[5]

Q. Do you agree with the Division's view regarding the Company's energy efficiency incentives as a justification for reducing its ROE?

A. No. The Division's view of the Company's energy efficiency incentive is fundamentally flawed. An adjustment to ROE that factors in energy efficiency incentives is at odds with the history and purpose of these incentives. The shareholder incentive mechanism for energy efficiency dates back to 1990, when it was approved by the PUC in Docket No. 1939 for achievement of energy efficiency savings targets. The passage of the Utility

[5] Rebuttal Testimony of Robert B. Hevert, at 82.

Restructuring Act of 1996, as amended, codified the PUC's practice by enacting into law a provision for the funding of demand-side management programs, which provided, for the first time, a statutory basis for energy efficiency, under which the shareholder incentives were approved. Today, there are several places in the Rhode Island General Laws that reference performance based incentives under the current provisions of least cost procurement.[6]

It is against this historical backdrop that the energy efficiency incentive is distinct from the performance incentive mechanisms proposed in this filing, and, as such, should not be included in the overall calculation of performance incentives. As discussed above, the purpose of performance incentive mechanisms is to drive investment and effort in other areas of utility operation that are not captured by traditional utility activity. The purpose of the energy efficiency shareholder incentive mechanisms is to promote superior utility performance in cost-effectively and efficiently securing for customers all efficiency

[6] *See* R.I. Gen. Laws §§39-1-27.7(e), (f). For a discussion of the history of the shareholder incentive mechanism associated with the Company's energy efficiency programs, see the Company's response to PUC Data Request 1-1, Docket No. 4527.

resources lower cost than supply.[7] The Company's success in earning shareholder incentives for its energy efficiency program does not, and should not, justify a reduction in ROE related to performance incentive mechanisms going forward. Past earnings under the incentive are not indicative of future earnings under the incentive. The Division's proposal to include existing energy efficiency incentives in the overall calculation of performance incentives for purposes of the reduced ROE, coupled with their proposed earnings sharing mechanism, significantly reduces the value of revenues that the Company actually can earn, and thus should be rejected.

IV. Conclusion

Q. Does this conclude your testimony?

A. Yes.

[7] *See* State of Rhode Island and Providence Plantations Public Utilities Commission. Least Cost Procurement Standards. at 8-9 (July 28, 2017) (approved by the PUC at an Open Meeting on April 27, 2017 in Docket No. 4684).

Rebuttal Testimony of
Robert D. Sheridan

REBUTTAL TESTIMONY

OF

ROBERT D. SHERIDAN

Dated: May 9, 2018

Table of Contents

I. Introduction and Qualifications 1

II. Purpose of Rebuttal Testimony 1

III. Response to Division's Direct Testimony 2

IV. Conclusion 13

I. Introduction and Qualifications

Q. Please state your name and business address.

A. My name is Robert D. Sheridan. My business address is 40 Sylvan Road, Waltham, Massachusetts 02451.

Q. Have you previously submitted testimony in this proceeding?

A. Yes.

Q. On whose behalf are you submitting rebuttal testimony in this proceeding?

A. I am submitting rebuttal testimony on behalf of The Narragansett Electric Company d/b/a National Grid (Company).

II. Purpose of Rebuttal Testimony

Q. Mr. Sheridan, what is the purpose of your rebuttal testimony?

A. The purpose of my rebuttal testimony is to respond to the pre-filed direct testimony submitted by the Division of Public Utilities and Carriers (Division) in this proceeding with regard to the Company's request for a change in base rates and proposed investments in Grid Modernization technology.

Q. How is your testimony organized?

A. Section III of my testimony responds to the Division's recommendations. Section IV is the conclusion to my testimony.

III. Response to Division's Direct Testimony

Q. How would you summarize the Division's recommendations in this docket regarding the Company's proposed Grid Modernization investments?

A. The Company is pleased that the Division appears to generally support the Company's Grid Modernization proposals. However, the Company disagrees with the following aspects of the Division's testimony:

(1) the proposal that the Company, over the next two years, prepare a comprehensive five-year Grid Modernization Plan (GMP) before foundational grid modernization enabling programs are fully implemented, including the requirement for a future business case, based on recommendations accepted by the Rhode Island Public Utilities Commission (PUC);

(2) the Division's rejection of the Company's: (a) proposal for additional Feeder Monitoring Sensors; and (b) recovery of full costs for a System Data Portal;

(3) the Division's position that certain grid modernization investments are "core business" initiatives to be recovered through base rates, namely Geographic

Information System (GIS) Enhancements, Remote Terminal Unit (RTU) separation, and Distribution Supervisory Control and Data Acquisition (DSCADA); and

(4) the Division's position that the Company should perform a benefit/cost analysis (BCA) for all PST grid modernization investments."

Q. What is your reaction to the Division's recommendation that the Company should develop a longer-term Grid Modernization Plan?

A. The Company does not necessarily object to the Division's recommendation for a five-year Grid Modernization Plan (GMP); however, the Company already performs comprehensive planning for grid modernization investments, as evidenced by the five-year cash flow projections detailed in its Power Sector Transformation (PST) Plan currently pending in Docket No. 4780. Moreover, the Company already has proposed to continue to update and share its multi-year grid modernization plans through annual PST plan filings, which will include stakeholder involvement. Annual plans with a rolling five-year planning horizon will provide the Company and stakeholders with the opportunity to analyze and implement innovative grid modernization investments, with sufficient flexibility to adjust its future plans if both the technology, and public policy, advances as rapidly as it has in the recent past.

Although the Division's recommendation for a five-year GMP appears to be consistent

with the Company's philosophy supporting long-term planning for these investments, the Division did not provide sufficient details concerning what information should be included in a five-year GMP that the Company has not already addressed in its PST plan, which includes five-year cash flow projections. Moreover, there are potential limitations of a longer-term (i.e., 15-year) planning horizon versus the five-year planning horizon favored by the Company. For example, a longer-term planning horizon may not be optimal to adapt to the rapid advances in policy and technology. For these reasons, the Company does not believe that the Division's recommendation for a five-year and 15-year GMP should supplant the Company's annual PST Plan process; however, the Company is willing to work with the Division to develop a GMP that is consistent with the Company's PST proposal.

Q. Although the Division supports the Company's pursuit of the majority of its Grid Modernization investments, it opposes investment in additional Feeder Monitoring Sensors, as potentially unnecessary if AMI technology is implemented on a larger scale. Do you agree?

A. While the Company agrees that AMI data will greatly enhance distribution system planning due to increased granularity of information, the Company disagrees that AMI implementation will eliminate the need for Feeder Monitoring Sensors to support real time system operations and the most effective use of the Advanced Distribution Management System (ADMS). The Company's proposed program is limited to installing

feeder monitors only at the feeder head end where substation SCADA is not available. Even after AMI and ADMS are commissioned, there will be important feeder-level data that likely will be missing due to AMI opt-outs, un-metered loads, and limitations on data retrieval rates, all of which sensors at the feeder head end will address. To assess system impacts, AMI meter information must be aggregated using algorithms. The Feeder Monitoring Sensors typically are three-phase systems capable of providing near real-time power measurement quantities at specific nodes on the grid. In contrast, the majority of AMI metering points will be single phase and may not be capable of providing precise aggregated three-phase quantities typically used in SCADA and ADMS applications. Additionally, the data collection rates for the Feeder Monitoring Sensors are much faster than they would be for system wide AMI monitoring, which makes them better suited to support real-time operational needs. AMI metering solutions do not directly integrate to SCADA applications through traditional protocols such as DNP3v2, Modbus, or GOOSE messaging; they integrate to MDMS systems that then need to interface to other Enterprise applications. This creates an inherent delay in data processing for some applications such as a near real-time SCADA system. Further, AMI data generally is read by systems such as an MDMS at much less frequent rates (e.g., every 8 hours), and only system events such as power outages and restorations are reported on demand.

Feeder Monitoring Sensors, on the other hand, are integrated directly to SCADA applications through traditional protocols and are polled, or read, at much more frequent rates (i.e., generally measured in seconds). Finally, beyond basic metrology parameters, Feeder Monitoring Sensors also can provide additional detail about the grid that AMI meters do not (e.g., harmonic quantities, oscillography, fault current measurements, etc.), which may be utilized by more advanced ADMS applications as the technological environment continues to evolve.

Q. Why does the Company disagree with the Division's recommendation to reduce the proposed System Data Portal investments?

A. The Division appears to support the need for the System Data Portal and the majority of the Company's System Data Portal investments, but recommends reducing the overall estimated cost of those investments by 30 percent. The Division has tied that recommendation to a conclusion that the Company's estimated requirements for three additional employees for DER interconnection work is overstated, but otherwise has provided no detailed or quantitative analysis of the Company's revenue requirements supporting that recommendation. Rather, the Division provided an anecdote of interconnection-related staffing decisions made by Duke Energy as the basis for its recommendations for Company interconnection staff.

As the Company detailed in Chapter 3 of the PST Plan, Book 1 of 3 (pp. 45-46), the

System Data Portal is a new program that the Company anticipates will grow and evolve over time as new tools, data, and analysis capabilities develop. Labor to develop and maintain the information posted on the portal is the major cost component. As this is incremental work beyond traditional distribution system planning, additional resources are necessary. The Company based its staffing needs and estimated costs on similar work by its New York affiliate. The Company continues to maintain that two distribution planning engineers and one analyst are required to ensure the successful delivery of the System Data Portal.

Q. With regard to several investments in the Company's PST Plan associated with the Company's control center, the Division recommends that the Company make such investments, but do so through base rates rather than through the proposed PST Provision. Does the Company maintain that its Control Center investments, including DSCADA & ADMS, RTU Separation, and GIS Data Enhancement, are outside of their core business needs and warrant cost recovery treatment separate from base rates?

A. Yes. The driver for these projects is the integration of DER. The Company has provided ample information in this proceeding regarding the scope of its proposed DSCADA, ADMS, RTU Separation, and GIS Data Enhancement investments, explaining why they are PST activities that warrant separate cost recovery treatment.

In Chapter 3 of the Company's PST filing, the Company stated that "Grid Modernization" includes System Data Portal, AMI, Control Center Enhancements, Operational Data Management, and other technologies or capabilities necessary for "integration of DER, and DER utilization for bulk power system and/or distribution operational services or infrastructure deferral." The Control Center Enhancements and other proposed Grid Modernization investments are necessary for the advancement of the PST goals of increasing DER penetration, reducing greenhouse gas emissions and increasing renewable generation, and using DERs for infrastructure deferral.

The Control Center Enhancement investments proposed in the PST are necessary to manage the electric system and accommodate both the growing number of DERs and our ability to leverage them to play a more active role in managing the distribution system and enable DER participation in evolving markets. This new capability requires enhanced operational situational awareness to maintain reliability and safety of the distribution system. These enhancements also help the company to realize the full value added by many grid modernization technologies such as increases in distribution automation. As operating the system becomes more complex, more sophisticated central management systems are needed to monitor, coordinate, and control DER, manage distribution automation, and collect data from grid edge devices.

In particular, with regard to DSCADA, ADMS and the related RTU Separation, the rate at which new monitoring and control points are being added to the Company's present SCADA system is growing by more than 7% per year due to the exponential increase in the number of distribution points being created for distribution automation and larger DER interconnections. Also, combining transmission and distribution data in a common system creates data security challenges with respect to bulk transmission requirements. This combined system increases security expectations for access to distribution system data and also creates challenges from a systems integration perspective. As part of DSCADA deployment, a remote terminal unit (RTU) separation effort will be completed to segregate distribution data from transmission data.

Finally, while the GIS system and data maintained by the Company has been fit-for-purpose to date, the introduction of new use cases, such as for ADMS applications and hosting capacity analysis, requires changes to the data parameters and a higher level of GIS data quality beyond what has been required in the past, which necessitates new investments in GIS. Industry experience deploying ADMS and similar systems has shown that investment in data enhancement is needed to enable the functionalities of these advanced applications.

Q. Why are these investments not necessary for the Company to continue to operate its existing "core business?"

A. The Company's normal operating procedure is to propose investments that are necessary to provide safe and reliable service. Without the proposed grid modernization investments, the Company is able operate the distribution system in a safe and reliable fashion with existing operating practices and current levels of DER integration. As they evolve, the business and operating models envisioned through PST, however, will require additional capabilities to enable the integration of higher levels of DER and reliably operate the system without curtailment. Thus, the proposed investments are forward looking to facilitate changes in the way in which the electric grid functions; they are not strictly necessary, but rather, are desired to achieve a modern grid. For these reasons, these investments are not currently traditional core business suited for recovery in base rates. Instead, these investments are better suited for separate cost recovery treatment, such as the proposed PST Provision.

Q. Lastly, the Division recommends that the Company perform a BCA for all PST grid modernization investments. Do you agree with this recommendation?

A. No. The Company agrees that it can, in most cases, perform a BCA for projects that are not foundational (i.e., not a "core component" of grid modernization). However, the Company believes that BCA is not appropriate for the foundational Grid Modernization investments the Company proposed in Chapter 3 of the PST Plan. These investments are all foundational or "core component" technologies appropriate for least-cost, best fit method. Specifically, the Company disagrees with the Division's statement:

> We note that the DOE Report is clear that it may be appropriate to apply benefit cost analyses to DER-enabling projects. It states that utilities could use best-fit/least-cost methodologies or traditional utility cost-benefit analyses. National Grid has chosen not to use a traditional utility BCA. Further, there is nothing in the DOE Report to suggest that the Company cannot or should not use a different type of BCA, such as the RI Benefit-Cost Framework, if so directed by the Commission. National Grid has chosen not to. (Woolf & Whited, p. 85)

The referenced Department of Energy (DOE) Report[1] does not recommend using a BCA for foundational ("core component") Grid Modernization investments. The DOE Report does indicate that both "least-cost, best-fit for core platform" or "traditional utility cost-customer benefit based on improvement derived from technology" can be used.[2] However, for the Traditional Customer Benefit-Utility Cost method, the DOE report states: "[t]his type of Benefit-Cost Analysis (BCA) is generally applicable to those non-core, modular grid modernization investments related to enhancing reliability and operational efficiency. These technologies include smart meters, advanced meters, Volt-Var management, and optimization analytics . . . ."[3]

For the Least-Cost, Best-Fit Method, the DOE report states: "[t]his traditional method may be the most practical approach to evaluating core platform investments ... This includes investments in the five core categories identified in Chapter 2: Planning tools and models; Physical infrastructure (e.g., wires, transformers, switches, etc.); Advanced

1 U.S. Department of Energy, Office of Electricity Delivery & Energy Reliability, *Modern Distribution Grid, Decision Guide* Vol. III (June 28, 2017) (DOE Report).
2 *See* DOE Report, Table 1.
3 DOE Report at 40.

protection and controls; Sensing and situational awareness; and Operational communications."[4]

Finally, the Rhode Island BCA closely aligns with the DOE's definition for Integrated Power System & Societal Benefit-Cost method. For this method, the DOE report states: "[a]n integrated power system and societal BCA may be useful to evaluate the cost-effectiveness of certain grid investments in relation to the value potential from enabling customer DER integration and/or utilizing DERs … This approach may be applied to non-core, modular investments … (e.g., DERMS, DER portfolio management, and other market enabling technologies…)."[5]

Mr. Booth's testimony appears to agree with the Company's assessment, that is, the BCA is not appropriate for the foundational Grid Modernization projects proposed in the PST plan. On page 34 of Mr. Booth's Testimony, he states that for new business cases, "[t]he Company would use a cost-benefit analysis for each new program that is not foundational," and on page 11, he states that, "[t]he Company correctly characterizes the entire group of its proposed investments as enabling technology, particularly for Distributed Energy Resources (DER) integration, which I consider foundational elements for the continued evolution of the modern grid."

4 *Id*.
5 *Id.*

Therefore, it is clear from the DOE Report, and the above excerpts of Mr. Booth's testimony that the Rhode Island BCA is not appropriate for the foundational Grid Modernization investments the Company proposed in Chapter 3 of the PST Plan, specifically: Feeder Monitoring Sensors (Sensing and Measurement); DSCADA and RTU Separation (SCADA); GIS Data Enhancement (GIS); Enterprise Services, PI Historian, Data Lake, and Advanced Analytics (Operational Data Management); and Telecommunications IT/OT (Operational Communications). These are all Grid Modernization "core component" technologies appropriate for Least-Cost, Best Fit Method.

Note that the System Data Portal investment could be considered to be an "advanced planning tool" that would fall under DOE's "Grid Data Portal" application category, but according to DOE "while a modular type of investment, [advanced planning tool investments] are relatively small and don't warrant a BCA to justify, if the engineering need is determined."[6] The Company has not completed a BCA on this type of project in any of its jurisdictions because the benefits do not lend themselves to monetization, which is required in a full BCA.

IV. Conclusion

Q. Does this conclude your testimony?

6 *Id.*

1 A. Yes.

Rebuttal Testimony of
John O. Leana

REBUTTAL TESTIMONY

OF

JOHN O. LEANA

Dated: May 9, 2018

Table of Contents

I. Introduction and Qualifications 1

II. Purpose of Rebuttal Testimony..... 1

III. Response to Division's Direct Testimony 2

IV. Conclusion…….……..8

I. Introduction and Qualifications

Q. Please state your name and business address.

A. My name is John O. Leana. My business address is 300 Erie Boulevard West, Syracuse, New York 13202.

Q. Have you previously submitted testimony in this proceeding?

A. Yes.

Q. On whose behalf are you submitting rebuttal testimony in this proceeding?

A. I am submitting rebuttal testimony on behalf of The Narragansett Electric Company d/b/a National Grid (the Company).

II. Purpose of Rebuttal Testimony

Q. Mr. Leana, what is the purpose of your rebuttal testimony?

A. The purpose of my rebuttal testimony is to respond to the pre-filed direct testimony submitted by the Rhode Island Division of Public Utilities and Carriers (the Division) in this proceeding regarding the Company's request for a change in base rates and its proposal to invest in Advanced Metering Functionality (AMF) technology. My rebuttal testimony also addresses the Acadia Center's proposal that the Company implement time of use rates as soon as possible.

Q. How is your testimony organized?

A. Section III of my testimony responds to the Division's recommendations. Section IV is the conclusion to my testimony.

III. Response to Division's Direct Testimony

Q. How would you summarize the Division's recommendations in this docket regarding the Company's proposed AMF investments?

A. The Division agrees that it is important that the Company move toward implementation of AMF, and that the Company's proposal for a detailed AMF plan is an important and necessary step to achieve that goal. In fact, the Division's consultant, Gregory L. Booth, bases his recommendations on the Company's grid modernization investments under the assumption that the Company will implement AMF in its service territory. The Division, however, disagrees with the level of funding the Company has requested to perform the work necessary to prepare the detailed AMF plan. Additionally, the Division proposes that:

(1) the Company should not wait for all regulatory cost approvals before advancing a prudent AMF program. (Woolf, p. 46-47)

(2) if the Company implements AMF, alternative technologies such as remote feeder sensors are redundant and not necessary once AMF is deployed (Booth, p. 20);

(3) the PUC should open a separate docket to consider the results of the Company's AMF study, separate and apart from a PST Plan;

(4) the Company's AMF study should consider alternative ownership models for meter infrastructure and shared communication systems (Woolf, p. 47), along with potential access to third-party providers, as well as procurement of AMF as a service rather than a capital investment (Woolf & Whited, p. 77); and

(5) allow less than full recovery of the estimated costs of the AMF study, and such costs should be recovered through base rates.

Q. Does the Company agree with the Division's recommendations?

A. Although the Company is pleased that the Division generally supports the Company's planned implementation of AMF, the Company does not agree with the Division's: (a) proposed reduction in funding to develop the detailed AMF implementation plan; (b) assertion that AMF implementation obviates the need for remote feeder sensors; (c) assertion that there should be a separate docket to consider AMF implementation apart from the Company's other PST proposals; and (d) contention that AMF costs should be recovered through base rates.

Q. Why does the Company disagree with the Division's proposed reduction to the funding for development of the AMF implementation plan?

A. The Company estimated $2 million in cost for a Rhode Island AMF implementation plan. As the Company explained in its responses to Division Data Requests 23-5 and 30-1, the $2 million estimate is the amount necessary to complete all the components of a robust

plan after factoring in synergies from the concurrent planning process being undertaken in New York. Absent these synergies, a standalone study in Rhode Island is estimated to be approximately $3 million. Funding the planning process with less than $2 million will result in a less complete assessment of the optimal manner to implement AMF in Rhode Island.

Notably, the Division asserts that the Company's AMF planning process should include: (1) considering alternative ownership models for meter infrastructure and shared communication systems; (2) studying the potential access to third-party providers; and (3) procuring AMF as a service rather than a capital investment. The scope of work required to analyze these Rhode Island specific options is sizable. Reducing the funding level for the planning process would substantially inhibit the Company's ability to appropriately analyze these alternatives when preparing its AMF implementation plan. Providing the Company with its requested level of funding will ensure that the necessary resources are available to successfully plan for the implementation of this foundational investment in the future of the Company's operations to provide the enhanced capabilities expected of the electric grid of the future.

Q. Why does the Company disagree with the Division's assertion that alternative technologies such as remote feeder sensors are redundant and not necessary once AMF is deployed?

A. As a threshold matter, the Division's recommendation is broad and lacks any evidentiary

support. Mr. Sheridan addresses this issue in detail in his rebuttal testimony. Further, the Company's response to Division Data Request 32-21 explains the critical role that remote feeder sensors will play, irrespective of the implementation of AMF.

Q. Why does the Company disagree with the Division's proposal that the Company and the PUC open a separate docket to consider the implementation of AMF after the Company completes is AMF implementation plan?

A. The Company does not support PUC review of AMF implementation outside of the Company's proposed annual PST Plan. AMF implementation is part of the holistic PST Plan because, as recognized by the Division's consultant Mr. Booth, AMF is a foundation for many PST-related investments. In addition, certainty of full cost recovery is a necessary condition to advance AMF given the level of investment and the Division's recommendation to engage the vendor community to work with the Company to respond to new and innovative models that do not currently exist. Moreover, separating PUC evaluation of AMF implementation from other PST investments will make it more difficult to fully consider the interrelationship between AMF and those investments, including the consideration of the common or shared Operational Data Management investments. To successfully transform the power sector, it is critical that the PUC review and approve interrelated investments in a cohesive fashion to ensure that there are no unnecessary delays or excess costs that result from misaligned approvals of AMF investments and PST investments.

Q. How does the Company respond to both the Division's recommendation that implementation of time-varying rates (TVR) be a part of the development of the AMF implementation plan and the Acadia Center's recommendation to implement opt-in time of use rates as soon as possible?

A. As the Division aptly pointed out in their testimony (Booth, p. 15-17), AMF is one of the critical enabling activities or technologies and is foundational to many grid modernization activities. TVR is one such activity for which AMF technology will enable. The development and implementation of TVR will be a key component of the Company's planning process for the implementation of AMF in Rhode Island.

Acadia Center, however, asserts that the Company's proposal to rollout opt-out TVR beginning in 2023 will miss significant opportunities to allow customers to load shift, create a market for energy management technology, and learn lessons for the larger roll-out of such rates (LeBel, p. 5). Acadia Center recommends that the PUC order the Company to make opt-in time of use rates available for residential and small business rate classes as soon as possible, with significant outreach, education, and customer tools to achieve a reasonable adoption rate. (LeBel, p. 5) The Company disagrees. Acadia Center's recommendation for opt-in time of use rates as soon as possible would require changes to the existing rate structure and would require the Company to install, on a widespread basis, different metering technology. Additionally, the Company would need to make billing system changes for an activity that will become obsolete after AMF

implementation. Such investments are unwarranted if the Company is going to pursue a pathway to a full AMF deployment, which will include, among other things, TVR. In addition, customers have had options for alternative pricing structures from the competitive energy supplier community since restructuring of the electric industry twenty years ago. These suppliers continue to market their services to the Company's customers. Their offerings are not limited by the Company's metering plant because, under the Company's Enhanced Meter Options program, any customer can request an interval meter, and their supplier can then offer a TVR option.

Q. Why does the Company disagree with the Division's recommendation that the Company commence its AMF investments without PUC approval?

A. The Division's consultant Mr. Woolf, recommended the following regarding this issue:

> The Commission should direct the Company to complete the AMI study and file it with the Commission for review prior to implementation. . . . If deployment is ultimately approved by the Commission, the costs of deployment should be included in base rates as a part of the multi-year rate plan filing made during the first half of 2020. But implementation should not be delayed in order for the means of cost recovery to be engraved in regulatory stone before the Company advances prudent programs.
>
> (Woolf, p. 46).

The Company disagrees with Mr. Woolf's conclusion. Company witness Kayte O'Neill addresses the Division's recommendations for a multi-year rate plan. Additionally, the scope and scale of the proposed AMF investments are significantly greater than the investments that the Company historically undertakes in the manner suggested by the

Division. Given the level of investment the Company would be unable to proceed with AMF absent cost recovery; therefore, it would be impractical for the Company to undertake these investments and advance implementation of AMF prior to a decision from the PUC on the means for cost recovery.

IV. Conclusion

Q. Do you have any general concluding remarks?

A. The funding of the AMF implementation planning process is critical to continue the momentum that the Docket 4600 and the PST process have stimulated so the State can move forward on foundational investments for the utility of the future and for the benefit of customers.

Q. Does this conclude your testimony?

A. Yes.

REBUTTAL TESTIMONY

OF

TIMOTHY R. ROUGHAN

AND

MEGHAN MCGUINNESS

Dated: May 9, 2018

Table of Contents

I. Introduction and Qualifications 1

II. Purpose of Rebuttal Testimony 3

III. Summary of Company Performance Incentive Mechanisms Proposals 5

IV. Response to Division's Direct Testimony 8

Overall Performance Incentive Mechanisms Framework 8

Capital Efficiency Performance Incentive Mechanisms 11

System Efficiency Performance Incentive Mechanisms 12

Distributed Energy Resources Performance Incentive Mechanisms 19

Network Services Performance Incentive Mechanisms 26

Division's Performance Incentive Mechanism Proposals 28

Division's Benefit Cost Analysis 34

V. Conclusion 40

I. Introduction and Qualifications

Timothy R. Roughan

Q. Mr. Roughan, please state your name and business address.

A. My name is Timothy R. Roughan. My business address is 40 Sylvan Road, Waltham, Massachusetts 02451.

Q. By whom are you employed and in what capacity?

A. I am employed by National Grid USA Service Company, Inc. as the Director of Retail Regulatory Strategy. My responsibilities include providing regulatory and policy direction on issues relative to grid modernization activities. I have worked on policies regarding all aspects of distributed generation (DG) including interconnection, net metering and Renewable Energy Growth programs, non-wires alternatives (NWA), and associated tariffs.

Q. Please describe your educational background and professional experience.

A. I am a 1982 graduate of Worcester Polytechnic Institute with a Bachelor of Science in Mechanical Engineering and have worked for the Service Company or its predecessors for 35 years in multiple roles.

Q. Have you previously testified before the Rhode Island Public Utilities Commission

(PUC) or any other regulatory commissions?

A. Yes, I have testified before the PUC in many dockets; most recently, I testified in the Company's revenue neutral rate design docket in 2015, Docket No. 4568, and the Company's 2018 System Reliability Procurement Report filing in Docket No. 4756. I also have participated in the stakeholder process before the PUC in connection with the Changing Distribution System, Docket No. 4600 and in the Power Sector Transformation (PST) Initiative that the Rhode Island Division of Public Utilities and Carriers (Division) led. I also am co-sponsoring the Joint Power Sector Transformation testimony currently under review by the Rhode Island Public Utilities Commission (PUC) in Docket No. 4780.

Meghan McGuinness

Q. Ms. McGuinness, please state your name and business address.

A. My name is Meghan McGuinness. My business address is 40 Sylvan Road, Waltham, Massachusetts 02451.

Q. By whom are you employed and in what position?

A. I am employed by National Grid USA. My current position is Principal Analyst, Regulatory Strategy. In this position, I support the development of regulatory strategy on matters related to grid modernization and utility business model reform.

Q. Please describe your educational background and professional experience.

A. I received a Bachelor of Arts in Economics and Environmental Studies from Middlebury College in 2000, and a Master of Science in Technology and Policy from Massachusetts Institute of Technology in 2008. Prior to joining National Grid in 2016, I worked on energy and environmental policy and regulatory issues affecting utilities for a number of organizations, including the Bipartisan Policy Center, NERA Economic Consulting, MIT's Center for Energy and Environmental Policy Research, and the United States Environmental Protection Agency.

Q. Have you previously testified before the PUC or any other regulatory agencies?

A. Yes, I am co-sponsoring the Joint Power Sector Transformation testimony currently under review by the PUC in Docket No. 4780.

II. <u>Purpose of Rebuttal Testimony</u>

Q. Mr. Roughan and Ms. McGuinness, what is the purpose of your joint rebuttal testimony?

A. The purpose of our rebuttal testimony is to respond to the pre-filed direct testimony submitted by the Division in this proceeding regarding the Company's proposed Power Sector Transformation performance incentive mechanisms.

Q. How is your testimony organized?

A. Section III summarizes the Company's performance incentive mechanisms proposals. Section IV responds to the Division's recommendations. Section V is the conclusion.

Q. Are you attaching any schedules to your testimony?

A. Yes, we are attaching the following schedule:

- Schedule MM-1 – Article entitled, *Assessing the Averch-Johnson-Wellisz Effect for Regulated Utilities.*

Q. Please summarize the Company's rebuttal points associated with the Division's[1] performance incentive mechanism recommendation?

A. The Company's and the Division's general philosophy toward the value of performance incentive mechanisms differ on one key point. While the Division alleges without support that the purpose of performance incentives is in large to part to correct a bias toward capital investment, the Company's purpose in proposing performance incentives

[1] Due to the scope of the Division's recommendations associated with the Company's performance incentive mechanisms, the Company has focused its rebuttal on the Division's testimony rather than the testimony of other intervenors that may have raised points similar to the Division.

is to promote innovation and incentivize the Company to undertake activities that it otherwise would not within the traditional regulatory framework, to advance state policy objectives, and to move toward a new utility business model.

Beyond these key points, although the Company is willing to refine some of its metrics to address points raised by the Division, the Company disagrees with various Division recommendations to eliminate or substantially redesign its proposed suite of performance metrics. Lastly, the Company disagrees with the Division's recommendation to use a societal discount rate for the Company's benefit-cost analyses (BCAs), rather than the Company's weighted average cost of capital (WACC), and also disagrees with the Division's assumptions about avoided distribution capacity costs. The Division's assumptions, combined with proposed targets for key metrics that are practically unachievable, result in the Division significantly overstating the potential benefits (and thus revenue opportunity) from performance incentive mechanisms.

III. Summary of Company Performance Incentive Mechanisms Proposals

Q. Please summarize the Company's proposed PST performance incentive mechanisms.

A. The Company has developed its performance incentive mechanisms to support the policy priorities identified by stakeholders through Docket No. 4600 and emphasized during the Power Sector Transformation (PST) Initiative, which progressed in parallel with the

Company's development of its proposal. The Company proposes to develop performance incentive mechanisms in three categories: (1) System Efficiency, (2) Distributed Energy Resources, and (3) Network Support Services. These three categories align with the recommended categories for performance incentive mechanisms in the PST Phase One Report to Governor Gina M. Raimondo, November 2017 (Phase One Report or Report). The Report describes each category as follows: (1) System Efficiency incentives are intended "to achieve savings for ratepayers from the utility controlling long-term utility costs"[2]; (2) Distributed Energy Resources "includes targeted incentives for a range of distributed energy resources that require utility action to implement"[3]; and (3) Network Support Services "includes actions that the utility will need to accomplish to demonstrate capabilities essential for the future utility."[4] Incentives in these three categories will advance the objectives identified in the PST Initiative, Docket 4600, and Rhode Island energy policy goals, while also providing new benefits and opportunities to customers. Incentives also will encourage prudent investments in system efficiency, increasing distributed energy resources, and network support services. The Company understands that incentives around these three categories should spur outcomes as set forth below.

(1) System Efficiency – Incentives around system efficiency are intended to drive the Company to deliver both near and long-term savings to customers by encouraging more efficient use of the system. Reductions in system coincident peak demand,

[2] PST Phase One Report, page 24.
[3] *Id.*
[4] *Id.*

for example, can reduce forward capacity market costs to customers and also can reduce transmission costs billed to Rhode Island customers. Further, integration of new load in a manner that does not increase peak demand can avoid or minimize the infrastructure investments needed to support additional load and create downward pressure on rates by spreading the fixed system costs over increased load.

(2) Distributed Energy Resources – Incentives to encourage the Company's active efforts to integrate distributed energy resources support the state's goals of encouraging customer engagement and investment, promoting emissions reductions, and supporting economic development within the state. The Company developed new performance incentive mechanisms in this category to complement existing incentives for distributed energy resources, such as energy efficiency and distributed generation contracts.

(3) Network Support Services – Incentives in this category reward the Company for actions it would not otherwise undertake that support the development of a more digitized and decentralized system for the benefit of customers. These activities lay the groundwork for the longer-term transformation of the power sector.

Within each of these three categories, the Company has proposed a set of performance incentive mechanisms intended to encourage successful delivery of new programs and broader Company activities aligned with Rhode Island state goals to transform the operation of the State's energy grid.

Q. What is the purpose of the Company's Capital Efficiency Performance Incentive Mechanisms?

A. The Company's ability to identify efficiencies in the delivery of capital investments has the potential to generate meaningful savings for customers over time. However, the current regulatory framework does not reward the utility for identifying and delivering such efficiencies. An important element of performance-based regulation is the movement toward a regulatory framework that provides a more equal incentive for the delivery of operating and capital cost savings. To that end, the Company has proposed two new incentives related to the efficient delivery of capital.

The first proposal targets complex capital projects and provides incentives for the Company to find ways to deliver agreed-upon outputs at a lower-than-forecast cost. The second proposal is designed to encourage increased productivity in the delivery of overhead distribution-line projects, providing incentives for Company innovation to more efficiently deliver roughly $45 million in "routine" capital expenditures per year.

IV. Response to Division's Direct Testimony

Overall Performance Incentive Mechanisms Framework

Q. Please summarize the Division's recommendations for the role of performance incentive mechanisms in the regulatory framework.

A. The Division asserts that performance incentive mechanisms can help a utility prioritize certain outcomes or goals that warrant attention from a policy perspective. The Division also asserts, without support or justification, that utilities have a financial incentive to maximize profits by expanding capital investments and increasing rate base, which can lead to undue bias toward capital investments and result in projects that are not least-cost for customers. The Division recommends that performance incentive mechanisms offset these financial incentives and serve as a first step toward a new utility business model (Woolf and Whited, p. 11-12). Additionally, the Division sees performance incentive mechanisms as an element of the utility's return on equity (ROE), such that the allowed ROE should be reduced to account for the performance incentives the utility could obtain.

Q. Does the Company agree with the Division's perspective regarding the role of performance incentive mechanisms?

A. The Company does not agree with the Division's characterization of bias toward capital investments. The Division provides no evidence to support its assertion of capital bias by the Company. This assertion ignores the significant efforts the Company already has undertaken, and is continuing to develop, to interconnect large amounts of customer-driven distributed generation, as well as the Company's efforts to engage customers in demand response and reduce peak demand. Further, the Company has a long history of making investment and operational decisions for the benefit of customers under the current regulatory framework. Regulatory oversight of capital and operating

expenditures ensures their prudency and requires the Company to demonstrate alignment with customer interests and regulatory standards. Review of the Company's proposed capital investments through the Infrastructure, Safety, and Reliability (ISR) proceedings, for example, ensures that the Company's capital investments are least cost and in the best interest of customers.

More broadly, the theory that rate of return regulation leads to a bias toward capital investment, termed the Averch-Johnson (or sometimes the Averch-Johnson-Wellisz) effect in industrial and regulatory economics, is not well-supported by empirical evidence, as explained in the article attached as Schedule MM-1.[5]

The value in performance incentives is not in correcting this alleged capital bias; it is in promoting innovation and incentivizing the utility to undertake activities that it otherwise would not within the traditional regulatory framework, but that serve to advance state policy objectives and move toward a new utility business model. As such, performance incentive mechanisms should not replace portions of the Company's allowed ROE, which is a return that shareholders have a constitutional right to earn in return for their

[5] Most recently, author, Stephen M. Law (2014) reviewed 192 studies on this issue and found that studies claiming to find strong evidence of the effect suffer from identifiable flaws in methods or assumptions. He suggests that the absence of evidence of the effect in well-designed studies is likely because regulators, by virtue of their awareness of the theoretical effect, take steps to mitigate it. *See* Stephen M. Law, *Assessing the Averch-Johnson-Wellisz Effect for Regulated Utilities, in* 6 INTERNATIONAL JOURNAL OF ECONOMICS AND FINANCE No. 8 (2014); *See also* Paul Joskow, *Regulation and Deregulation after 25 Years: Lessons Learned for Research in Industrial Organization, in* 26 REVIEW OF INDUSTRIAL ORGANIZATION No. 2 169-19 (2005) (noting, "[i]n my view, students of regulation of legal monopolies have wasted at least 15 years extending the Averch-Johnson model of regulatory behavior, and trying to test it empirically without much success."); Paul Joskow & L.R. Nancy, *The Effects of Economic Regulation, in* II HANDBOOK OF INDUSTRIAL ORGANIZATION (R. Schmalensee & R.D. Willig eds., 1989).

investment to provide safe and reliable service. Rather, performance incentive mechanisms are an opportunity for the utility to obtain additional earnings if it undertakes tasks in furtherance of goals distinct from its obligation to provide safe and reliable service and achieves certain targeted outcomes as a result of those incremental efforts. Company Witnesses Kayte O'Neill and Robert Hevert discuss the flaws with integrating performance incentive mechanisms with ROE in their respective rebuttal testimony.

Capital Efficiency Performance Incentive Mechanisms

Q. How would you summarize the Division's recommendations in this docket regarding the Company's proposed Capital Efficiency performance incentive mechanisms?

A. The Division asserts that the Company's Capital Efficiency performance incentive mechanism is not necessary because its proposed three-year rate plan would provide a financial incentive to reduce capital costs and improve productivity between rate cases. The Division concludes that the performance incentive mechanisms proposed by National Grid could place too much risk on customers because the Company would determine the initial capital costs used to set the targets and would have an incentive to overstate cost projections (Woolf & Whited, p. 63).

Q. How do you respond?

A. Company Witness Kayte O'Neill responds more fully to the Division's recommendation for a multi-year rate plan. With respect to the Capital Efficiency performance incentive

mechanisms, the Company does not agree with the Division's assertion that its proposal would provide an incentive for the Company to overstate project costs and place risk on customers. This assertion does not reflect how the Company conducts estimates in practice. National Grid's Electric Project Estimating (EPE) group performs estimates according to national standards set forth by the AACE International[6] and American Society of Professional Estimators, respectively. In addition, EPE uses risk registers to assess risk on a project to apply appropriate contingencies based on project scope. Over-estimating costs for the purpose of this incentive would have a negative impact on National Grid's ability to meet annual budget and portfolio delivery goals. Rather, an incentive that rewards the Company for identifying efficiencies in the delivery of capital projects has the potential to generate meaningful savings for customers over time.

System Efficiency Performance Incentive Mechanisms

Q. How would you summarize the Division's recommendations regarding the Company's proposed System Efficiency performance incentive mechanisms?

A. The Division recommends the PUC conceptually adopt System Efficiency performance incentive mechanisms (Woolf & Whited, p. 27-28). More specifically, the Division appears to support a Forward Capacity Market (FCM) Peak Demand Reduction performance incentive mechanism (Woolf & Whited, p. 28) and a Transmission Peak Reduction performance incentive mechanism. With respect to FCM Peak Demand

6 This is the formal corporate name for this entity.

Reduction, the Division suggests that demand reduction should be calculated as the difference between a forecasted baseline weather-normalized FCM peak and the actual weather-normalized FCM peak for that year, rather than year-over-year reductions relative to the 2018 peak. The Division suggests that the baseline "should include the impacts of DERs that the Company would earn an incentive for, so that there is no double counting of savings" (Woolf & Whited, p. 28-29). Further, the Division recommends that the Company's FCM Peak Demand Reduction performance incentive mechanism be modified to change the Company's proposed baseline to account for all DER impacts, and it proposes to convert that baseline forecast into annual targets by applying a deadband equal to 0.5 standard errors of the Company's peak demand forecast for each year in setting the minimum targets to help ensure that the utility is not provided incentives for outcomes for which it is not responsible (Woolf & Whited, p. 64-65). The Division's proposed medium target for 2019 would require the Company to reduce the annual weather-normalized peak by an additional 43.5 MW beyond the impacts of all existing and proposed Company programs (Woolf & Whited, p. 30). The Division proposes that incentives would be equal to 50 percent of the quantified net benefits of the FCM reductions achieved (Woolf & Whited, p. 28-30).

With respect to Transmission Peak Demand Reduction, the Division recommends that the performance incentive mechanism should use a metric of the sum of monthly peak demand per year, excluding the highest peak month. The Division opposes measuring

the Company's performance in terms of year-over-year reductions and suggests that the baseline would be the 11-month sum of forecasted weather-normalized peak demand for the year in question (Woolf & Whited, p. 31), and the Division developed its own forecast using Company data for the baseline. The Division notes that the Company does not have a monthly peak demand forecast and suggests that, based on its forecast, the Company's proposed targets could reward the utility for peak reductions that would have occurred in the absence of the performance incentive mechanism or utility actions and risks rewarding the Company for actions such as energy efficiency activities that already are subject to incentives (Woolf & Whited, p. 66-67). In addition, the Division recommends that the Transmission Peak Reduction performance incentive should be equal to 50 percent of the quantified net benefits of the transmission peak reductions achieved (Woolf & Whited, p. 34).

Finally, the Division does not support the Company's proposed Off-Peak Charging Rebate performance incentive mechanism, suggesting that "customer participation in the rebate program does not necessarily mean that customers will change their charging behavior" (Woolf & Whited, p. 67).

Q. How do you respond to the Division's recommendations regarding the Company's FCM Peak Demand Reduction performance incentive mechanism?

A. The Company disagrees with the suggestion that it has the means to artificially increase

peak demand in the first year in order to make it easier to achieve the maximum targets in the following two years (Woolf & Whited, p. 64, footnote 34). Peak demands are fully customer driven. The Division's claim that the Company both can and would artificially increase peak demand is ludicrous and without any support.

The Company also does not agree with the Division's assertion that the estimated impacts of the Company's PST programs should be part of the Company's forecast used to set peak targets. It is not appropriate to include proposed PST program peak impact estimates as part of the forecast – all PST programs remain subject to approval. Further, estimates of their peak impacts are preliminary and were developed for purposes of the individual program BCAs. While VVO expansion differs from the other programs that might contribute peak demand reductions in that it is an ongoing program under the ISR, it should also remain outside of the Company's forecast because maintaining the estimated level of peak savings over time requires significant Company effort.

Q. Do you agree with the Division's suggestion that Company programs should be included in the baseline because "the Company proposes to earn incentives for these activities through other performance incentive mechanisms" (Woolf & Whited p. 29, footnote 8)?

A. The Company agrees with the Division that it should not earn an incentive for MW reductions from energy efficiency under the FCM Peak Reduction performance incentive

mechanism. The Company has not proposed new performance incentive mechanisms for VVO expansion or solar photovoltaic (PV) installation. Although the Company receives certain financial incentives for some renewable energy projects installed through the Renewable Energy Growth Program, and for long-term contracts under the Long-Term Contracting Standard and the Distributed Generation Standard Contracts program,[7] these installations are unlikely to contribute to achievement of the FCM peak reduction target because their capacity will be bid into the FCM and the incentives paid are not related to peak impacts. The Company did propose performance incentive mechanisms for storage; however, these performance incentives are not tied to peak impacts, but rather they support the deployment of cost-effective storage as a resource in support of potential system benefits and the state's greenhouse gas and renewable energy goals. As Division Witnesses Woolf and Whited noted in their testimony on behalf of the Advanced Energy Economy Institute in New York Public Service Case 17-E-0238, regarding Niagara Mohawk Power Corporation's rates for electric service, "[t]here may be benefits from allowing the Company to earn multiple rewards for the same initiative. This is especially true if the initiative provides multiple benefits to customers."[8] The Company agrees with this view, provided each stream of benefits is counted and rewarded only under one single incentive.

[7] *See* R.I. Gen. Laws §§ 39-26, 39-26.1, 39-26.2.

[8] Direct Testimony of Tim Woolf and Melissa Whited, at 11.

Q. Do you agree with the Division's recommendation to apply a deadband to set the Company's targets and the Division's proposed targets?

A. No. The Division's recommendation to use a standard error-based deadband would increase the risk that the Company will achieve target peak reductions and still not earn an incentive if the forecast error is such that the Company's forecast weather-normalized peak is lower than actual peak. The Company also does not agree with the targets proposed by the Division. Achievement of these targets would require resources far in excess of the Company's proposed program budgets. The Division's BCA assumes that these targets can be achieved at no incremental cost in reflection of the fact that the Company did not propose new programs to support this metric. Tthis assumption is baseless and completely unrealistic. Incremental peak reductions cannot be achieved without incremental costs to the Company. Achievement of the Division's 2019 medium target would, according to the Division's assumptions, provide the Company with a reward of approximately $527,000 in that year. For context, under the Company's 2018 Energy Efficiency Annual Plan, the Company will spend about $94.57 million, with an expected peak impact of 24.8 MW. Achievement of the incremental 43.5 MW proposed by the Division likely would cost the Company far more than the value of the incentive, suggesting that the Division's proposed targets and incentive structure are unworkable.

Q. How do you respond to the Division's recommendations regarding the Company's Transmission Peak Reduction performance incentive mechanism?

A. The Company recognizes that its proposed targets for Transmission Peak Reduction did not adequately account for energy efficiency impacts outside of peak month and, thus, would risk rewarding the Company for peak reductions that would be eligible under the existing efficiency incentives and/or would occur absent additional Company efforts. The Company is in the process of developing a monthly forecast to support revised Transmission Peak Reduction targets.

Nonetheless, there are numerous flaws in the Division's model to develop a weather normalized forecast, and this model and its resulting standard error should not be the basis upon which targets for this performance incentive mechanism are set. In particular, the Division's model does not adequately capture historical monthly profiles, is not tied in any way to the Company's summer peak forecast, and suffers from poor goodness-of-fit, as evidenced by its adjusted R-squared of only 0.67. In other words, the Division's model explains only 67% of historical actuals versus what their model is predicting, resulting in an overly inflated standard error, which is far too unreliable to set Company targets. As with the FCM Peak Reduction targets, Monthly Transmission Peak Reduction targets set using this method will not be achievable under proposed program budgets.

The Company is preparing a more robust monthly forecast approach, which ties the future monthly transmission peaks directly to the month-by-month historical peaks over the last five years of data to create a true monthly peak profile and ties that profile

directly to the summer peak forecast, as provided in Attachment DIV 5-32-2 to the Company's response to data request Division 5-32, to ensure internal consistency.

Q. How do you respond to the Division's recommendations regarding the Company's Off-Peak Rebate Participation performance incentive mechanism?

A. The Company disagrees with the Division's suggestion that participation is not a robust metric. The Company's intent with this metric is to encourage customer engagement in a program featuring time-varying price signals to inform a broader transition to time-varying rates. It is similar to the Time Varying Rates – Electric Vehicles performance incentive mechanism included in the PST Phase One Report, which would measure the percent of customers with electric vehicles (EV), or percent of EV load, enrolled in a time-varying rate. Finally, the proposed performance incentive mechanisms provide support to Rhode Island's zero emission vehicle (ZEV) and greenhouse gas (GHG) goals by improving the economics of EV ownership, and it encourages efficient integration of new load to avoid incremental system costs.

Distributed Energy Resources Performance Incentive Mechanisms

Q. How would you summarize the Division's recommendations in this docket regarding the Company's proposed Distributed Energy Resource performance incentive mechanisms?

A. The Division recommends that the Company's Distributed Energy Resource (DER)

performance incentive mechanisms be modified and proposes alternatives. The Division suggests that it is appropriate to establish at least one performance incentive mechanism for each type of DER and suggests its own performance incentive mechanisms (Woolf & Whited, p. 34). The Division also criticizes several aspects of the Company's DER performance incentive mechanisms. The Division argues that the metrics and targets for the DER performance incentive mechanisms are inadequate.

Distributed Generation-Friendly Substation Transformer Performance Incentive Mechanism

The Division argues that the Company's Distributed Generation (DG)-Friendly Substation Transformer does not require a performance incentive mechanism because the Company should be installing ground fault detection (3VO) at its substations without a performance incentive mechanism.

Residential Demand Response Performance Incentive Mechanism

The Division argues that the number of customers participating in the residential demand response program is not a sufficient metric and recommends instead using a metric equal to the amount of peak demand in MW that customers have signed up to reduce through participating in the Residential DR program. The Division suggests setting targets based on enrolled capacity.

C&I Demand Response Performance Incentive Mechanism

The Division also suggests that the C&I Demand Response performance incentive mechanism should have an incentive based on shared savings. The Division's proposed metric would be equal to the amount of peak demand in MW that customers have signed up to reduce through participation. Targets would be based on a moderate scaling up of the existing program (Woolf & Whited, p. 37).

Electric Heat Performance Incentive Mechanism

The Division also recommends that an Electric Heat performance incentive mechanism should be based on avoided CO_2 emission estimates contained in the Company's benefit-cost analysis for the Initiative, which are higher than what the Company proposes. The Division proposes a shared savings approach based on 50/50 sharing of net savings (Woolf & Whited, p. 38-39).

Electric Vehicle Performance Incentive Mechanism

The Division proposes that the Electric Vehicle performance incentive mechanism should be based on a goal of reducing greenhouse gases, rather than simply rewarding higher adoption levels of any type of electric vehicle (Woolf & Whited, p. 39).

Storage Performance Incentive Mechanisms

The Division suggests that the Behind-the-meter Storage performance incentive

mechanism should be awarded on a shared savings basis to encourage the Company to promote cost-effective behind-the-meter storage and to protect customers if cost-effective solutions are not available. The Division proposes targets that are slightly lower than those proposed by the Company (Woolf & Whited, p. 40-41). The Division also alleges that that Behind-the-Meter Storage performance incentive mechanism is not sufficiently defined and may not be cost effective.

The Division concludes that the Company Owned Storage mechanism is not justified on economic grounds as the BCA is only 0.45 (Woolf & Whited, p. 67-68) and that this mechanism should be expanded to include any form of utility scale storage because the Company indicates that utility scale storage owned by the Company may not be cost-effective over the next three years. According to the Division, these incentives also should be on a shared-savings basis to encourage the utility to promote cost-effective options (Woolf & Whited, p. 43).

Non-wires Alternative Analysis (NWA) Performance Incentive Mechanism

Finally, the Division argues that the NWA Performance Incentive mechanism should continue for the next three years, as presented in the 2018 SRP (Woolf & Whited, p. 44).

Q. How do you respond?

A. The Company disagrees with several aspects of the Division's recommendations relating to its DER performance incentive mechanisms, as discussed below.

DG-Friendly Substation Transformer Performance Incentive Mechanism

The Company disagrees with the Division's position that the DG-Friendly Substation Transformer performance incentive mechanism is not needed. Implementation of this program will play an important role in accelerating the benefits from DG in support of the state's renewable energy and GHG goals, including:

- Reductions in CO2 and criteria pollutant emissions
- Avoided energy and capacity costs
- Avoided renewable energy credit costs

The incentive will reward the Company for successfully implementing a fundamental design shift in proactively installing these system upgrades in order to advance interconnection of large quantities of distributed generation in support of Rhode Island's clean energy and climate goals.

In addition, a reward for fundamentally innovative programs such as the Company's 3V0 program is an important element of a regulatory framework that includes performance incentives. Such incentives can produce dynamic effects that benefit customers and support state policy goals beyond the immediate proceeding. The existence of incentives that reward the Company for successfully delivering innovative programs that support

state policy goals and deliver new benefits for customers will encourage the Company to develop innovative programs going forward, due to the Company's knowledge that there is potential to be rewarded for such innovation. The Company could simply have not suggested this design change and used the ISR for other system needs, but elected to pursue this program in lieu of other potential investments. The dynamic effect of incenting this type of behavior will accelerate the development and deployment of other new programs, to the benefit of customers and the system as a whole.

Residential and C&I Demand Response Participation Performance Incentive Mechanisms

With respect to the Company's proposed Residential and C&I Demand Response Participation Performance Incentive Mechanisms, although the Company is open to alternative specifications for these metrics, the Company believes that it is most appropriate to finalize metric definitions, targets, and potential earnings, through the proceedings for the annual Energy Efficiency Program Plan.

Electric Heat Performance Incentive Mechanism

Although the Company agrees with the Division's approach for setting targets for the Electric Heat performance incentive mechanism, as it is the same as the Company's approach, the Division appears to have miscalculated the impacts of the Electric Heat Initiative in its production of Attachment 4 to Division Witness Woolf and Whited's

testimony. Mr. Woolf's and Ms. Whited's testimony incorrectly states that the benefit/cost ratio for the Electric Heat initiative is 1.4 (Woolf & Whited, p. 38). The Company filed a Societal Cost Test of 1.12 and Ratepayer Impact Metric of 2.42. Further, the Division's proposed targets do not align with the Company's benefit-cost analysis for the program and overstate program impacts. The appropriate targets for this performance incentive mechanism are the revised targets that the Company filed in response to Division Data Request 25-18, reproduced below.

Electric Heat Initiative Targets – Avoided metric tons of CO_2 per year

	2019	**2020**	**2021**
Min	137	202	179
Mid	171	253	224
Max	206	303	269

Electric Vehicle Performance Incentive Mechanism

The Company conceptually supports the Division's proposal to convert the Company's proposed Electric Vehicles performance incentive mechanism targets into avoided CO_2 emissions, and use avoided CO2 emissions as the metric for performance.

Behind-the-meter Storage Performance Incentive Mechanism

With respect to the proposed Company-owned Storage performance incentive mechanism, the Company does not agree with the Division's suggestion that a Company-owned Storage performance incentive mechanism is not warranted due to the benefit cost

(BCA) ratio of 0.45 for the Company's proposed Energy Storage Initiative. Given the rapidly changing cost landscape for energy storage, the Company's BCA ratio should not be seen as indicative of the potential cost-effectiveness for any Company-owned storage initiative over the next three years, and the Company expects to continually evaluate the business case for storage to meet different system needs going forward. The Company is open to a shared-savings approach for this performance incentive mechanism.

NWA Performance Incentive Mechanism

Finally, the Company is open to an NWA performance incentive mechanism. The approved sharing mechanism incentive in the 2018 System Reliability Procurement (SRP) plan is the appropriate starting point for NWA performance incentive mechanisms.

Network Services Performance Incentive Mechanisms

Q. How would you summarize the Division's recommendations in the docket regarding the Company's proposed Network Support Services performance incentive mechanisms?

A. The Division concluded that the Company's Network Support Services performance incentive mechanisms are not justified given that the Company should be undertaking such activities as part of its core business. Specifically, the Division asserts that Advanced Meter Functionality (AMF) Customer Engagement and Deployment is premature because system-wide AMF is not yet approved. The Division also asserts that VVO is within the Company's core performance obligations and does not warrant a

performance incentive mechanism. Finally, the Division states that, because the Company is already under a legislative requirement and performance standards for interconnection support and interconnection already is a core obligation, a performance incentive mechanism is not warranted for interconnection support (Woolf & Whited, p. 70).

Q. How do you respond?

A. The Company maintains that the Network Support Services performance incentive mechanisms are appropriate to drive the outcomes desired under both the PST Initiative and Docket No. 4600. The Company disagrees with the Division's statement that its performance incentive mechanism for AMF Customer Engagement and Deployment is premature and believes that such an incentive rewards the Company for actions that will help to maximize and expedite the benefits of AMF to customers upon full deployment.

Regarding the AMF/VVO performance incentive, this incentive was linked to a pilot that was not approved in the ISR; therefore, the Company is no longer pursuing this performance incentive mechanism.

Finally, the Company disagrees with the Division's assertion that the Company's proposed interconnection performance incentive mechanisms are not relevant given legislative and tariff requirements. These incentives would require Company

performance above and beyond tariff requirements, which would serve to expedite achievement of the State's clean energy goals and the associated benefits. Increasing the efficiency and certainty of timing of project interconnection greatly assists in getting projects built and on-line quickly, accelerating progress toward the State's 1,000 MW renewable energy goal by 2020. The recent law governing interconnection timeliness aligns with those baseline requirements. Failure to comply with those requirements carries potential penalties, which does not constitute an "incentive" in the context of Docket 4600 and the PST stakeholder processes.

Division's Performance Incentive Mechanism Proposals

Q. Is the Division recommending any performance incentive mechanisms that the Company is not proposing?

A. Yes. The Division recommends two performance incentive mechanisms to help low-income customers, and two performance incentive mechanisms to encourage the Company to provide customer information and improve distribution demand forecasting practices:

- A Low-Income PST Participation performance incentive mechanism would apply a metric of the percent of low-income customers enrolled in any one of the Company's DER programs, including demand response, electric heat, electric vehicles and electric storage. (Woolf & Whited p. 46). The target would be to

increase participation by 5%-10% higher than the baseline percentage of low-income customers (Woolf & Whited, p. 47).

- A Low-Income Discount performance incentive mechanism should encourage National Grid to increase the number of low-income customers that are on the low-income A-60 rate. The metric will be the percent of customers on the rate, with a baseline of the average participation over the last five years (Woolf & Whited, p. 48).
- A Data Access performance incentive mechanism will encourage National Grid to develop customer and third-party data access plans. The target would be to submit a Third-Party Data Access Plan by July 2019 (Woolf & Whited, p. 49).
- A Peak Demand Forecasting performance incentive mechanism will encourage National Grid to improve and expand its current forecasting practices. The target would be to submit a Peak Demand Forecasting Report by July 2019 (Woolf & Whited, p. 50).

Q. How do you respond?

A. The Company agrees that PST programs should engage and provide opportunities to low-income customers. However, a low-income performance incentive mechanism does not clearly link to a quantifiable value or benefit for low-income customers. The Data Access performance incentive mechanism is a more appropriate subject for discussion and implementation as part of a future AMF filing, which will provide the basis for

decision making about customer and third-party data access. A Peak Demand Forecasting metric also is premature. Achieving the needed granularity to substantially increase forecasting accuracy requires the types of grid sensors, data back haul, and other systems proposed as part of the Chapter 3 – Grid Modernization proposals in the PST filing. Until the Company installs these systems, highly accurate distribution-level peak forecasts are not possible. For these reasons, the Company does not agree with the Division's recommendations to add these additional performance incentive mechanisms.

Q. The Division also makes certain recommendations regarding the filing of a Performance Incentive Plan. Please summarize those recommendations.

A. With regard to seeking PUC approval for performance incentive mechanisms going forward, the Division recommends the Company submit annual Performance Mechanism Plans by October 31 of each year to establish performance incentive mechanisms for the following year. Under the Division's proposal, the first Performance Mechanism Plan would be submitted by November 31, 2018 to allow time to prepare after the order in this docket is issued. The Division recommends that the PUC open a docket to review and make findings on the first Performance Mechanisms Plan (Woolf & Whited, p. 51). The Division recommends the PUC allow for full stakeholder input to its review over the course of several months. The Division acknowledges that the performance incentive mechanisms might not be approved by the PUC until March of 2019, but suggests that the Company should still begin work to achieve the performance incentive mechanism

targets in January of 2019, based on direction provided by the PUC in the order in this docket (Woolf & Whited, p. 51-52).

Q. How does the Company respond?

A. The Company does not agree with the Division's proposal to submit an annual Performance Mechanism Plan. First, the Company has proposed performance incentive mechanisms as part of a holistic suite of PST initiatives to support the state's energy policy priorities that the state and other stakeholders identified through Docket 4600 and the PST Initiative. In addition, the Company proposed an annual PST filing and PST Provision that would include the performance incentive mechanisms, which the Company proposes to file on December 1, 2018 and then each January 1 thereafter. It would be impractical, not to mention administratively burdensome, for the Company and the PUC to have a separate Performance Mechanism Plan filing on a different schedule and in a different docket from the overall PST Plan process. Finally, the Division's recommendation for the Company to start work on achieving performance incentive mechanism targets prior to receiving approval from the PUC is not reasonable. The Company continues to maintain that its proposed annual PST Plan process, together with stakeholder input, provides for the most comprehensive and holistic planning and review process, and that a separate process for performance incentive mechanisms is not warranted or necessary.

Q. The Division also makes recommendations regarding annual reporting relating to performance incentive mechanisms. Please summarize those recommendations.

A. The Division recommends that the Company file an annual Performance Report in the third quarter of the year following the relevant performance year. The Division also suggests that rates should be adjusted following approval of the report. The Division states that annual performance reports should include information on every performance incentive mechanism that applies to National Grid, including service quality performance incentive mechanisms, Energy Efficiency performance incentive mechanisms, and all performance incentive mechanisms created in this case (Woolf & Whited, p. 52). The reports should include information about metrics and indicate performance trends (Woolf & Whited, p. 52). The Division suggests that streamlined versions of the report also should be filed every quarter, similar to quarterly energy efficiency reports (Woolf & Whited, p. 52-53). The Division recommends that rates be adjusted once per year following review and approval of annual performance reports.

Q. How do you respond?

A. The Company is not opposed to submitting annual reports on performance incentive mechanisms; however, the Company proposes that reporting for performance incentive mechanisms should follow the proposed annual PST Plan process – not a separate process. Additionally, the Company maintains that it should continue its existing reporting practices for current incentive mechanisms that are not part of the PST Plan, rather than consolidating all incentive mechanisms into a single report, as suggested by

the Division. The Company already reports on incentives, such as service quality and energy efficiency, through annual reporting requirements tied to those specific programs. Consolidation of these incentives into a report on PST-related performance incentive mechanisms is redundant and would provide no additional value over current reporting.

Also, the Company does not agree with the Division's proposal to require quarterly reports and submits that an annual report is appropriate. In addition to being overly burdensome, quarterly reports will not provide much additional value beyond annual reporting. Annual reporting also is consistent with the way in which the Company reports other metrics such as electric service quality and energy efficiency.[9]

Q. The Division also proposes to reduce the Company's allowed ROE by the number of basis points the Company could earn if it achieves all the performance incentives in the Division's proposals. Do you agree with this proposal??

A. No. Company Witness Kayte O'Neill addresses this proposal in her rebuttal testimony.

Q. Do you agree with the Division's proposed Earnings Sharing Mechanism?

A. No. Under the Division's proposal, the Company's earnings from the efficiency incentive would fall under the earnings sharing mechanism. Counting the efficiency incentive under the earnings sharing mechanism runs counter to current practice and the

[9] Although the Company submits quarterly program reports for energy efficiency, the Company reports its performance relative to savings goals and shareholder incentive as part of its annual report.

purpose of the energy efficiency incentives, as more fully described in Company Witness O'Neill's rebuttal testimony. Further, assuming that the Company is on track to earn its target ROE and earnings on efficiency incentives in line with historical performance truncates the value of the new performance incentive mechanisms being proposed to 25% of the value proposed by the Division.

Division's Benefit Cost Analysis

Q. Please summarize the Division's recommendations regarding the Company's Benefit-Cost Analysis (BCA).

A. The Division agrees with the Company's use of the Rhode Island Benefit-Cost Framework, but recommends that the Company's BCA be revised to include avoided distribution costs, updated FCM assumptions, and a societal discount rate, and to not use the weighted average cost of capital (WACC). The Division also incorporates new assumptions about avoided transmission costs.

Q. How do you respond to the Division's suggestion to use system average avoided distribution capacity costs in the BCA?

A. The Company does not agree with the Division's suggestion for several reasons. The system average values applied to energy efficiency cost-effectiveness become less relevant as efficiency programs drive load growth to negative levels, as negative load growth increases the likelihood that avoided transmission and distribution system costs

will be zero. Further, unlike energy efficiency, which simply removes load from the system, resources such as solar PV and storage will inject load on the system and may actually increase distribution system costs depending on the timing of these injections. For example, recent empirical economic research from California indicates significant uncertainty in the economic benefits of distributed solar, and in many cases increased distribution costs. Specifically, Cohen, Kauzmann, and Callay (2016) find highly heterogenous value of distributed PV, and on average very small distribution capacity value.[10] More recently, Wolak (2018), analyzing empirical data from California, finds negative distribution value.[11] Wolak suggests that larger amounts of distributed solar capacity and more geographically concentrated solar capacity predict higher distribution network prices and average distribution network costs. For these reasons, it is reasonable to assume zero distribution value in its benefit cost analysis, absent the availability of project-specific, engineering-based estimates of avoided or increased distribution costs. The Division's assumptions for avoided distribution capacity will overstate the potential net benefits from performance incentive mechanisms.

Q. Does the Company agree with the Division's avoided transmission cost assumptions?

[10] M.A. Cohen, P.A. Kauzmann & D.S. Callaway, *Effects of Distributed PV Generation on California's Distribution System, Part 2: Economic analysis*, *in* SOLAR ENERGY 128, 139-152 (2016).

[11] F.A. WOLAK, EVIDENCE FROM CALIFORNIA ON THE ECONOMIC IMPACT OF INEFFICIENT DISTRIBUTION NETWORKPRICING AND A FRAMEWORK FOR A PROPOSED SOLUTION (2018).

A. The Company was not able to review the proprietary Daymark study upon which the Division based its avoided transmission cost assumptions, making it impossible to evaluate these assumptions. It is important to note that, similar to distribution, the Company does not believe that the application of system average values for avoided transmission capacity are justified in an environment of declining load growth. The avoided transmission cost assumptions used by the Company in its evaluation of potential savings to customers under the Transmission Peak Reduction performance incentive mechanism were intended to reflect an upper bound for Rhode Island customer savings on billed transmission for already incurred costs due to lower capacity share; these were not intended to represent avoided capacity investments.

Q. Does the Company agree with the Division's avoided FCM cost assumptions, and, specifically, that the Company used outdated values?

A. No. The Company used the most up-to-date avoided FCM capacity costs available at the time of the November 2017 filing. The costs the Company used came from the AESC 2015 Update results and assumptions document. The values in the Company's Inputs-general tab in the BCA are copied directly from the Avoided Unit Cost of Electric Capacity section of this updated report at page 45. The values in the Company's BCA are then taken and applied a two percent inflation rate (the two percent matches the updated amount in the AESC 2015 Update). For example, the value for year 2022 is $137.44 $/kW-yr (this number is shown on both the updated report and in the Company's

BCA file, cell F92 on Inputs-General tab). When applying the two percent inflation rate to the value stream beginning in 2018, the Company arrives at an avoided capacity cost of $151.75/kW-yr. That said, it would be appropriate to update these values to reflect the values in the final version of the AESC 2018.

Q. Please summarize the Division's arguments in support of using a societal discount rate.

A. The Division makes three arguments in support of a societal discount rate. First, the Division suggests that the use of the phrase "long-term" in the Docket 4600 Guidance Document, as well as the inclusion of goals related to climate change and jobs and economic development all suggest the use of a societal discount rate that places greater emphasis on long-term impacts. Second, the Division suggests that the purpose of the BCA is to "identify the optimal mix of resources that will lead to 'reliable, safe, clean, and affordable energy to Rhode Island customers over the long-term'" (Woolf &Whited, p. 91-92), and that the use of a utility WACC cannot be consistent with this purpose. Finally, the Division suggests that a societal discount rate is consistent with the Company's approach in cost-effectiveness analysis for energy efficiency.

Q. How do you respond?

A. The utility WACC, and not a societal discount rate, is the appropriate discount rate for the BCA for all PST programs and proposed performance incentive mechanisms for

several reasons. The use of the Company's after-tax WACC is the appropriate discount rate for estimating the net present value of these initiatives, which represent utility investment and the associated costs to deploy capital and other expenses ultimately borne directly by utility customers. Second, the utility WACC is the appropriate discount rate for evaluating the potential savings to customers when evaluating DERs that might defer or replace capital investment, as it will capture the true value of avoided costs to customers.

Finally, use of the utility WACC is established precedent for BCAs in other jurisdictions. The New York Public Service Commission affirmed the utility WACC as the appropriate discount rate, noting that "[t]o use a rate other than the WACC would distort evaluation of the value of measures that are alternatives to utility service."[12] Similarly, the Massachusetts Department of Public Utilities ordered that the utility-specific WACC was the appropriate discount rate to use in the business case for grid modernization investments.[13]

Q. Are there any other reasons not to use the societal discount rate in the BCA?

A. Yes. The use of a discount rate that is lower than the Company's WACC may

[12] State of New York Public Service Commission. Order Establishing the Benefit Cost Analysis Framework. Case 14 M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision, at 26 (January 21, 2016).

[13] Massachusetts Department of Public Utilities. D.P.U. 12-76-C. Investigation by the Department of Public Utilities into its own Motion into Modernization of the Electric Grid (November 5, 2014).

inappropriately under-value near term costs and benefits relative to more speculative benefits accrued at the end of the forecast period, potentially resulting in over-estimation of the cost-effectiveness of the proposed investments and possibly unjustified costs to customers in the near term. In that sense, the Division's added emphasis on the "long term" in the Docket 4600 objective to provide "reliable, safe, clean, and affordable energy to Rhode Island customers over the long-term" risks being at the expense of "affordable" to today's customers.

Further, it is important to recognize that the assumed value of CO2 reductions, used in the Rhode Island test and based on the AESC 2015, already reflects the long-term impacts of CO2 emissions because it was derived from the marginal cost of emissions reductions necessary to achieve 2050 targets equal to 80% below 1990 emissions. There is no need for additional emphasis on the long term through the discount rate, as the initiatives and projects being evaluated, and their non-CO2 quantified impacts are shorter term in nature.

Finally, although the Company uses a lower discount rate for its energy efficiency cost effectiveness analysis, the Least Cost Procurement Standards that guide evaluation of cost-effectiveness call for use of "a discount rate that indicates that energy efficiency is a low-risk resource in terms of cost of capital risk, project risk, and portfolio risk."[14]

[14] State of Rhode Island and Providence Plantations Public Utilities Commission Least Cost Procurement Standards.

The uniqueness of energy efficiency may justify a discount rate that is lower than should be used for analysis of performance incentive mechanisms and PST investments.

V. Conclusion

Q. Does this conclude your testimony?

A. Yes.

July 28, 2017, at 3 (approved by the PUC at an Open Meeting on April 27, 2017 in Docket No. 4684).

Rebuttal Schedule of
Roughan and McGuinness

Index of Schedules

Schedule MM-1	Article entitled, *Assessing the Averch-Johnson-Wellisz Effect for Regulated Utilities*

Schedule MM-1

Schedule __ MM-1

Article entitled, *Assessing the Averch-Johnson-Wellisz Effect for Regulated Utilities*

International Journal of Economics and Finance; Vol. 6, No. 8; 2014
ISSN 1916-971X E-ISSN 1916-9728
Published by Canadian Center of Science and Education

Assessing the Averch-Johnson-Wellisz Effect for Regulated Utilities

Stephen M. Law[1]

[1] Economics Department, Mount Allison University, Sackville, New Brunswick, Canada

Correspondence: Stephen Law, Economics, Mount Allison University, Sackville, NB, E4L 1A7, Canada. Tel: 1-506-364-2355. E-mail: slaw@mta.ca

Received: April 14, 2014 Accepted: May 5, 2014 Online Published: July 25, 2014

doi:10.5539/ijef.v6n8p41 URL: http://dx.doi.org/10.5539/ijef.v6n8p41

Abstract

This paper expands upon the observation of Paul Joskow (2005) that exploration of the Averch-Johnson-Wellisz (AJW) effect over the previous fifteen years had been a waste of time and effort. In a non-random selection of 192 articles published since 1962, 39% fail to specify or provide results of tests for necessary pre-conditions for the effect and in almost all remaining articles a strong conclusion should not be reached due to problems with single-period estimation, capital price calculations, definitions of output, or input complementarities. In general, there is little evidence to suggest that there was ever an AJW effect.

Keywords: industrial organization, inefficiency, regulation

1. Introduction

The purpose of this paper is to present the theoretical and empirical support for the Averch-Johnson-Wellisz (AJW) effect in network utilities under rate-of-return (ROR) regulation or, more accurately, to document the lack of evidence supporting the common claim that the AJW effect has had widespread and important impact on utilities. The primary AJW proposition states that if a regulated firm is required to choose an output price to earn no more than an allowed rate of return, based on the level of installed capital, this policy will create an incentive for the firm to choose a capital-labour ratio which is higher for the given output level than would be chosen without the regulation, that is, that ROR regulation causes distortions in input levels. This paper expands upon the notorious observation of Paul Joskow (2005) that exploration of the AJW effect over the previous fifteen years had been a waste of time and effort.

The propositions underlying the AJW effect have received considerable attention in the fifty years since the hypotheses were first published. Entering the title of the paper by Averch and Johnson into the search engine for JSTOR yields almost 9000 items. Using an idiosyncratic, non-random sample of 192 peer-reviewed journal articles published since Averch and Johnson (1962) and Wellisz (1963) proposed the effect, we find that almost 40% fail to specify or provide the results of tests for necessary pre-conditions before making assertions about the AJW effect or closely-related economic results of regulation. Further, close examination of the empirical results provided in remaining articles which claim to provide evidence of the AJW effect indicates that a strong conclusion as to the presence of the effect should not be reached due to (1) single- rather than multi-period estimation, (2) incorrect capital price calculations, (3) problematic definitions of output, or (4) the reason that for the firms in these regulated industries, *installed* capital assets are complementary to other inputs.

A necessary condition for the AJW effect is that capital and labour are to some significant extent substitutable in the production process. If they are complements the impact of the AJW effect is reduced or eliminated. If the two inputs are perfect complements then there is no scope for the AJW effect whatsoever. Another necessary condition is that the regulatory constraint is binding on the operations of the firm, which may not be the case if in the wider set of regulatory interactions that occur before and after the setting of the allowable rate of return there is some channel through which the firm can influence the outcome (Note 1). In addition, for the AJW effect to matter, the regulator must not have taken steps, by adjusting the time lag between regulatory hearings for example, to mitigate the effect (Note 2). Many theorists and empirical researchers believe that the AJW effect, even where it exists, is likely to be of very small impact (Note 3). An examination of the results of tests of complementarity and separation in the literature which reports empirical examinations of the production functions of regulated firms suggests that any network utility, which would have very high capital to labour ratios under any regulatory regime due to the nature of the associated production technology, might be generally

characterised by complementarity (or a very low degree of substitution) of capital and labour. As a result, the kind of industry which is most often regulated is also the kind of industry in which we are least likely to see the AJW effect. Thus, while there may be other reasons to "not prefer" rate-of-return regulation, the AJW effect is not one of them.

Although the theoretical structure developed by Averch and Johnson (1962) and Wellisz (1963) has been carefully disseminated in courses in Industrial Organization and Regulatory Economics ever since its publication, the necessary empirical conditions for the AJW effect have often been ignored and typically remain untested in articles that nonetheless claim its pertinence (Note 4).

In 1973, almost eleven years–and many published studies–after the publication of the original 1962 article, Leland Johnson observed that: the question remains about the importance of overcapitalization and cross-subsidization in reality. Are the Averch-Johnson effects merely an intellectual curiosity, or do they describe serious distortions in the behavior of regulated firms? Unfortunately the answer is not clear. It is not enough to compare the behavior of regulated and unregulated firms (Note 5).

By 2005, Joskow's answer to Johnson's question appears to be that the AJW effects are an intellectual curiosity and this response is confirmed here.

One purpose of this paper is to document the prevalence of this failure to provide evidence to support an assertion of the importance of the AJW effect. Another is to connect observations about regulatory theory to this discussion. And, finally, this paper may provide the basis for a later assessment of Joskow's claim that wasted were the efforts over the past fifteen years to come to terms with the work of Averch, Johnson, and Wellisz. It is worthwhile to begin with the original statement of Averch and Johnson and follow its evolution over the subsequent decades.

2. The Averch-Johnson-Wellisz Model and Interpretations

2.1 The AJ Model: Averch and Johnson (1962)

In 1962, Harvey Averch and Leland Johnson published a paper in the *American Economic Review* which set out a model for a regulated monopolist producing an output, $z = z(x_1, x_2)$, inverse demand function given by $p = p(z)$, and two inputs, physical capital, $x_1 \geq 0$, and labour, $x_2 \geq 0$, such that $z(x_1, 0) = z(0, x_2) = 0$, $\frac{\partial z}{\partial x_1} > 0$ and $\frac{\partial z}{\partial x_2} > 0$. With factor prices, r_1 and r_2, profit is given by $\pi = pz - r_1x_1 - r_2x_2$. Given an acquisition cost for capital of c_1, current depreciation, u_1, and cumulative depreciation, U_1, the constraint for rate-of-return regulation can be written as

$$s_1 \geq \frac{pz - r_2x_2 - u_1}{c_1x_1 - U_1} \tag{1}$$

where s_1 is the maximum allowable rate of return. Averch and Johnson set $U_1 = u_1 = 0$ and $c_1 = 1$ for convenience and note that if $r_1 > s_1$ the firm exits. Assuming $r_1 \leq s_1$ they define

$$L(x_1, x_2, \lambda) = pz - r_1x_1 - r_2x_2 - \lambda[pz - s_1x_1 - r_2] \tag{2}$$

and note that if $\lambda = 0$, the firm is not constrained by the regulation, if $\lambda = 1$, $r_1 = s_1$, the firm is so constrained that any combination of x_1 and x_2 satisfying constraint (1) is a solution and, finally, if $0 < \lambda < 1$, then the firm is constrained by the regulation and "the input of x_1 is such that...its use is expanded beyond the point at which its marginal cost would be equal to its marginal value product" (Note 6).

Averch and Johnson note that "the extent to which the regulation affects output depends on the nature of the production function (and) if it involves fixed proportions, i.e., $\min\left(\frac{x_1}{a}, \frac{x_2}{b}\right)$, the regulated firm is constrained to the efficient expansion path" (Note 7).

2.2 Geometric Interpretation: Zajac (1970)

In 1970, Zajac published an article in the *American Economic Review* presenting a geometric interpretation of the AJW model. The motivation for the article, according to Zajac, was that "unfortunately, Averch and Johnson carried out their analysis using the rather abstract tools of nonlinear programming and the Kuhn-Tucker theorem (and hence) its detailed understanding has thereby been denied a large number of persons concerned with regulation for whom these tools are foreign and uncomfortable" (Note 8). Zajac recasts the regulatory constraint for a firm producing output, q, as:

$$\frac{pq - wL}{K} \leq f \tag{3}$$

where $x_1 = K$ is capital with average factor cost of $r_1 = i$, $x_2 = L$ is labour with average factor cost of $r_2 = w$ and f is the "fair rate of return" imposed as a maximum by the regulator. Since profit is thus $\pi = pq - iK - wL$ the regulatory constraint is $\pi \leq (f - i)\ K$. Zajac then demonstrates that a profit-maximizing firm will choose the largest level of capital, K_{MAX}, that satisfies the regulatory constraint. Over the following four decades, instructors of courses in Industrial Organization have laboured to reproduce the Zajac diagrams on blackboards, photocopied the figures for class hand-outs for their students, or required students to seek out Zajac's article on their own.

Zajac notes that a key assumption is that the rate of return set by the regulator exceeds the cost of capital (i.e., $f > i$) but does not make any comment about the underlying technology of production. Zajac demonstrates that the firm does not have an incentive to acquire useless capital. An implication of this result is that if the underlying technology involves fixed proportions, the constraint curve depicted in Figures 2 and 3 will lie over the set of efficient points and the K_{MAX} point will be on the expansion path of efficient points, that is, there will be no Averch-Johnson effect. This result was noted by Averch and Johnson in their original article but, importantly, was omitted from Zajac's more accessible treatment of the AJW model. Importantly, because it was generally to Zajac (1970) that scholars and students of regulation turned when seeking "a detailed understanding" of the analysis of Averch and Johnson.

2.3 Restatement and Correction: Baumol and Klevorick (1970)

Another article which is essential for understanding the literature related to the AJW effect was also published in 1970. Baumol and Klevorick's article in the *Bell Journal of Economics and Management Science* begins by noting that the model in Averch and Johnson (1962) is similar to one published at almost the same time by Wellisz in the *Journal of Political Economy* (Note 9). Baumol and Klevorick suggest that "the phenomenon that emerges from the A-J theorem may not be of very great significance in practice" and "it is at least plausible that other potential sources of difficulty in the regulatory process dwarf the consequences of the distortion in the capital-labour ratio that the model predicts." Baumol and Klevorick restate the regulatory constraint as:

$$s = r_1 + v \geq \frac{pz - r_2 x_2}{x_1} \tag{4}$$

with $v \geq 0$, assuming with Averch and Johnson, $U_1 = u_1 = 0$ and $c_1 = 1$, and also making the standard assumption that "$r_1 + v$ is taken to be less than the (*unregulated*) profit-maximizing rate of return" (Note 10). Baumol and Klevorick extend the logical structure created by Averch and Johnson and conclude that the original authors and those who took it up over the subsequent years (between 1962 and 1970) either implied or assumed the following propositions (Note 11):

Proposition 1: *The profit-maximizing firm under regulatory constraint will tend to use a capital-labor ratio different than that which minimizes cost for its output level.*

(Alleged) Proposition 2: *The capital-labor ratio of the regulated firm will be larger than that of the unconstrained profit-maximizing monopolist.*

Proposition 3: *The capital-labor ratio of the regulated firm will be larger than the one that minimizes costs for the output level that it elects to produce.*

(Alleged) Proposition 4: *The regulated firm will produce an output larger than that which maximizes profits.*

Proposition 5: *For the firm that seeks to maximize total profit subject to the regulatory constraint, we have* $\frac{\partial x_1}{\partial s} < 0$ *for* $r_1 < s < r_m$ (where r_m is the rate of return obtained at the (unconstrained) profit-maximizing input-output combination). In other words, the greater the difference between (s) the regulatory fair rate of return and (r_1) the cost of capital (since we are increasing s holding r_1 constant), the smaller will be the value of x_1, the firm's use of capital.

Proposition 6: *The sales-maximizing firm under rate-of-return regulation is motivated to use a labor-capital ratio greater than that which minimizes cost for the output level it chooses to produce.*

Baumol and Klevorick provide restatements of the proofs of Propositions 1 and 3. As might be supposed by the use of "alleged", they show that Propositions 2 and 4 are false. These points (1, "true"; 2, "false; 3, "true"; 4, "false") have been incorporated into standard regulatory theory and doubtless have provided the basis for a large number of exam questions in undergraduate courses in Industrial Organization or the Economics of Regulation.

In demonstrating Proposition 3, although it might appear at first that Baumol and Klevorick failed to consider the case of perfect complementarity between inputs, noting only that for the regulated firm "z_1 / z_2, the marginal rate of substitution of capital for labor, is now below the ratio of input prices, r_1 / r_2, (and) with diminishing marginal

rate of substitution of capital for labor for a fixed output level, this can occur only as the result of relative increase in the use of capital" (Note 12).

Later in the paper, we find their statement that depending on the marginal rate of substitution between x_1 and x_2, the employment of labor may either increase or decrease as s gets closer to r_1. If labor and capital are complementary in the gross revenue function, then as the quantity of capital used by the firm increases its use of labor will also rise. But if capital is a substitute for labor in producing revenue, then x_1 and x_2 will move in opposite directions in the A-J model (Note 13).

and that "since capital and labor can either be complements or substitutes in producing output....we simply cannot conclude that the A-J proposition 4 is always valid." (Note 14).

In their discussion of an article by Bailey and Coleman which develops a model of regulatory lag, Baumol and Klevorick connect the timing of regulatory reviews to the regulated firm's choice of capital level: "in practice, the rate-of-return constraint is not enforced continually" and "one might surmise that ... (regulatory lag) serves to weaken the A-J input-proportion effect, at least to some extent." (Note 15) This observation can be made more powerfully after considering the later contributions of Joskow, Spulber, Laffont, Tirole, and others who have sought to embed the regulatory constraint within a more general model of regulator-firm interactions (Note 16). We will return to this topic below. Nonetheless, in 1970, Baumol and Klevorick concluded that the conventional treatment of the effect of the regulatory constraint–without considering the regulatory lags or specifying more carefully the incentives of the firm–led to an overemphasis on the AJW effect as a source of inefficiency. They note that "the A-J overcapitalization is an example of the inefficiencies emphasized in the more conventional analyses. But even if it occurs in practice it does not seem likely to produce effects that are very serious." (Note 17). "The point is simply that while regulation may well be suspected of being the source of some non-negligible inefficiencies in the economy, it is not clear that the phenomenon encompassed by A-J analysis is the most disquieting of these." (Note 18). And further research has supported this point.

2.4 Modern Restatements: Examples Church and Ware (2000), Caputo and Partovi (2002) and (2008)

Caputo and Partovi (2002) provide a concise derivation of what Baumol and Klevorick labelled "Proposition 5" and show the equivalence of a number of different conditions, with economic content, that may be imposed to achieve this proposition. In so doing, they closed the debate between Akira Takayama and Mohamed El-Hodiri on the one hand (Note 19) and Israel Pressman and Arthur Carol on the other (Note 20) regarding the (theoretical) existence of the effect presented in Proposition 5. This effect, though, is not what is commonly taken to be the AJW effect. Researchers seeking an exhaustive and excellent derivation of the comparative statics of rate-of-return regulation should turn to the work of Caputo and Partovi (2008). This derivation includes consideration of most of the technical issues raised here, with the exception that risk aversion is not explicitly discussed.

For a fine summary of central issues related to the AJW model, interested readers are encouraged to turn to Church and Ware (2000) for their discussion of cost-of-service regulation (Note 21). Church and Ware present the AJW model and then go on to consider three mitigating factors: regulatory lag, prudence and facilities reviews, and regulatory risk. Under this last topic, they note that: the A-J model assumes that capital expenditures are not sunk. In fact utilities are regulated typically because they are natural monopolies due to large sunk capital investments (Note 22).

This point forms the basis for some of the observations provided below, drawn from empirical studies of regulated utilities.

2.5 Theoretical Problems with the AJW Propositions

The first problems with the Averch-Johnson-Wellisz model were in its construction. Many of these problems were corrected in subsequent reformulations such as Zajac (1970), Stonebender (1972) and Baumol and Klevorick (1970), who more carefully constructed the analysis, and even more recent papers such as Borrmann and Finsinger (2006) who calculate the range for the multiplier in the AJW model assuming that the profit function is single-peaked. Some authors maintained that the AJW proposition is fundamentally flawed, for example: it has been shown by L. Courville that a proof of overcapitalization requires the additional assumption of strictly convex isoquants....Thus, Courville has strengthened our contention "that the very assumptions used to prove the A-J effect. require an assumption that the A-J effect exists in the first place" (Note 23).

However, the requirement of strictly convex isoquants has not been found to be overly restrictive and, indeed, most researchers make this assumption, implicitly or explicitly.

A second problem with the AJW model was identified by Meyer (1979) who notes the importance of risk in

investment decisions and observes that: even *without* the influence of rate of return regulation, a risk averse firm would not utilize least cost input/technology configurations ...implying a relative emphasis on variable inputs, not fixed inputs, as a way to buffer risk. Capital brings with it higher fixed costs which the risk averse firm shies away from. In an unconstrained setting...risk aversion biases input choice toward too little (capital) for least expected cost production, but under regulation the A-J term produces a countervailing balance toward least expected cost production rather than further away from it (Note 24).

To further underscore the importance of accounting for risk in understanding a regulated firm's valuation of capital, Meyer further observes that: "Since empirical data is drawn from actual situations involving uncertainty and varying degrees of risk aversion across regulated firms, the results may suggest at least one of the reasons definitive empirical results isolating an A-J effect have proved elusive when couched in an econometric methodology derived from a riskless framework." (Note 25).

A third set of problems to arise with the AJW model is even more serious and less amenable to correction by a more careful treatment of the risk-adjusted price of capital. The fundamental prediction of the model is that in the presence of rate-of-return regulation "given Q, K/L is too high", that is, the capital-labour ratio, K/L, chosen by the firm will exceed the ratio that would be chosen by an unregulated firm, were that firm to be producing the same level of output, Q (which it likely would not). But what if there is rate-of-return regulation and the most appropriate model of firm-regulator interaction predicts something else? Besanko and Spulber (1992) construct a model in which the firm chooses a level of capital and the regulator subsequently sets the price cap or allowed rate-of-return. Besanko and Spulber (B&S) predict that in the face of regulation, the firm chooses a lower than optimal level of cost-reducing capital because the regulator, acting second, would appropriate the returns from the capital (Note 26). We are left with the following problem: the AJW proposition states that if there is rate-of-return regulation, given Q, K/L will be "too high"; while in contrast, the B&S model suggests that if there is binding regulation, K/L will be "too low", given Q. The primary distinction is whether the firm moves first or the regulator moves first. This distinction is easy to make in a theoretical model but much more difficult to test empirically. In practice, both the regulator and the firm continually emit signals about their intentions and their assessments of market and cost conditions. Regulatory hearings provide a formal forum for the dissemination of these signals and there are additional dissemination channels such as press releases, announcements, and interviews. Typically, firms can anticipate regulatory changes before they are passed by formal procedures and regulators follow developments in the industry at trade shows and through business reports and reports to shareholders.

Burness, Montgomery and Quirk (1980a and 1980b), BMQ hereafter, identify a competing hypothesis to the AJW model in Joskow (1974) based on the observation that rate reviews are typically initiated by the regulated firm rather than by the regulatory authority. They conclude that the Averch-Johnson model is not consistent with the observed facts that: "(1) regulatory agencies set prices as well as allowed rates of return; (2) regulated firms often operate in the inelastic portion of their demand curves; and (3) the impetus for regulatory review almost always comes from the regulated firm rather than the regulatory agency" (Note 27).

Nowell and Shogren (1991) extend this approach to analyze the timing of the request for a rate review, asserting that the evidence indicates that the regulatory agency does not blindly enforce the regulatory constraint. The timing of requests is a choice variable for the regulated firm and not the (regulatory) commission (Note 28).

The B&S model and other similar models which set the regulator and the firm or firms inside a regulation game form a more general framework for the evaluation of regulation and, more importantly for this paper, for the construction of empirically-testable predictions about the behavior of firms. This wider set of possibilities does not rule out the AJW effect entirely since a richer model may deliver the AJW effect as a sub-case, one of many possible outcomes, but it reduces its general applicability (Note 29). For this wider model to be useful, we need a way of identifying the essential timing characteristic which would yield the AJW result versus the B&S or other results. Assuming one can distinguish the temporal sequence of interactions one could test the following predictions, in the presence of ROR, if the regulator "moves first", for a given Q, there is a higher K/L; if the regulator "moves second", there is a lower K/L, given Q. More importantly, regardless of whether this temporal distinction can be made operational, while there may be reasons to suggest that regulators might want to steer clear of rate-of-return regulation, the automatic presumption that we get sub-optimal capital-labour ratios should be discarded.

In evaluating the AJW model as a theory of regulation, Laffont and Tirole (1993) state that: an oddity of the model is that the regulator, while actively enforcing the rate-of-return constraint, has no explicit objective function Furthermore, taking for granted that limiting the regulated firm's rent is a primary objective of the

regulator it must be the that some unexplicit constraint prevents the regulator from extracting the firm's full rent. Could (the A-J model's regulatory) constraint emerge as the "reduced form" of a more complex model? If so, wouldn't the reduced form be sensitive to changes in the structural form, which would make comparative statics exercises perilous? (Note 30).

And subsequently, Joskow (2005) observes that: the Averch-Johnson model and its progeny have been replaced with a richer set of models of regulation, both normative and positive, that consider asymmetric information, political economy considerations, legal constraints on agency behavior and their effects on the incentive properties of regulatory mechanisms and ultimately on the behavior and performance of regulated firms. I have in mind here in particular work by Laffont and Tirole (1986, 1993) Baron and Besanko (1984), Lewis and Sappington (1988) and many others (Note 31).

Further, a final complication raised by theoretical analysis and most pertinent to empirical studies is that even if in a particular study of a regulated firm or firms there is some evidence of some distorted input choice resembling the AJW effect its source is not necessarily as posited by the AJW model (Note 32). We turn now to additional problems that arise when attempting to provide evidence of the AJW effect in empirical studies of regulated network utilities.

3. The Averch-Johnson-Wellisz Model: Empirical Issues

There is a fundamental problem in estimating parameters of cost or production functions of regulated firms. In the presence of regulation, a researcher may take published regulatory practices or posted rules and construct a regulatory constraint. The presence of the AJW effect is then assumed and the AJW model is used to obtain estimates of characteristics (such as input complementarity) of the regulated firm's technology. This method is used fairly commonly in the literature. An example of a theoretical presentation of this approach can be found in Färe and Logan (1983). Färe and Logan observe that if we can write down the regulatory constraint that gives rise to the AJW model we can use the specific prediction of the AJW model to back out the regulated firm's technology. They assume a particular response to the regulation and assume that the AJW effect is as predicted. Subsequent empirical use of this approach is based on the following binary test: either the regulation is binding and yields the AJW effect or it is not binding and there is no distortionary effect (Note 33). If the regulation is not binding then results assuming that it is and results ignoring the regulation should not be statistically different. If the results are statistically different, then most researchers conclude that the regulation is binding and has an impact as predicted by Averch, Johnson, and Wellisz. Among other problems, if the input distortion arises from some other source (e.g., cost pass-through rules) then the researcher may be left unable to perform the calculation required to back out the unregulated firm's technology. Further, as Färe and Logan themselves note, "to reconstruct the rate-of-return regulated production function, it is necessary to have knowledge about the rate-of-return constraint as well as to know the rate-of-return regulated cost function." (Note 34) So, unless the assumed regulatory constraint captures exactly the interaction between the firm and the regulator, when we use this approach, all conclusions are conditional on the accuracy of the formulation of the regulatory constraint. Given a sufficiently rich data set, we are able to examine past behaviour of regulated firms with the goal of determining the impact of regulation or uncovering features of the underlying technology. But there is a danger within these projects of assuming that which we have come to test (e.g., with a naïve application of the Färe and Logan methodology).

Beyond explanation, we may wish to forecast even if this exercise is complicated by the fact that our observations are coloured by the regulatory framework that is part of the specific data-generating process that a particular study might be investigating. If we wish to predict, we must have accounted for the effect of the regulatory game. Does the firm move first? Or does the regulator? Do their responses change over decades as economists publish papers suggesting that their responses are driven by expectations of changes to rates-of-return, capital-labour ratios, or other important economic variables? We must be sure our predictions are robust to the choice of game.

Previous papers have attempted identification through the use of (1) time-series (before-and-after comparison); (2) cross-section (comparison of regulated-and-not) plus combinations (panel data) and (3) less extreme versions of each of these, involving variation in the intensity of regulation. Examples of these approaches (from Joskow & Rose, 1989) include Spann (1974) and Nelson and Wohar (1983).

But if identification is not so simple, if the data set employed does not deliver clean counter-factual scenarios for testing, then there is a problem with the assertion that rate-of return regulation has caused input distortion since the AJW model may not be responsible for the apparent result. There are many other possible explanations for "overcapitalization", some of them more readily identifiable, econometrically, than others (expectations held by

the firm of rising demand, for example). The testing of the AJW effect occurred during a specific period of history, during which many large corporations in the private sector that were unregulated also operated with high capital-labor ratios or used excess labor. Part of the reason for these features of economic organization in this time included: the rising power of labor so that these measures would be adopted to avoid strikes or to avoid unionization; management practices of the time; measures to reduce labor turnover where workers had (unmeasured) human capital; and some part of an apparent excess use of capital inputs may be the implicit creation of an efficiency wage by reducing the effort-level of employees.

Joskow and Rose, commenting on the importance of identification when studying the impact of regulation, note that interactions of regulation with changing economic conditions may, when properly modeled, provide an additional way of identifying regulatory effects (Joskow, 1974; Carron & MacAvoy, 1981; Hendricks, 1975; Burness, Montgomery, & Quirk, 1980; Greene & Smiley, 1984). In particular, certain regulatory constraints may be binding under one set of economic conditions, but not under another. Implementing this approach requires particular attention to the nature of the regulatory process under study and how it works when economic conditions change. Joskow's (1974) model of state public utility commission behavior provides an example of this approach (Note 35).

Note that "paying attention to the nature of the regulatory process" differs materially from "assuming the nature of the regulatory model" which is a less careful but more common approach. Joskow and Rose also claim that "estimates of firms' production functions, combined with information on input prices, can be used to test whether regulated firms make cost-minimizing output choices".

But from where are the production functions obtained? Typically–and problematically–from estimates based on the data drawn from the actual experience of the regulated firm or firms. Joskow and Rose go on to note that although: estimating demand functions for regulated firms should present no particular difficulties. We are not as sanguine about cost or production function estimation. Estimates of production or cost functions from observed combinations of outputs, inputs, input prices, and costs tend to rely on a number of implicit assumptions, including equilibrium conditions and exogenous factor prices. These may be implausible for many regulated markets (Note 36).

and, further to the extent that one treats factor prices as exogenous (when they are endogenous), or fails to model explicitly direct regulatory constraints on production decisions, the resulting cost estimates can be quite misleading (Note 37).

And what if the regulatory constraints are endogenous, the result of the game played by the firm and the regulator? Explicitly modelling regulatory constraints based on the publicly-released statements of the regulatory authority will not solve the empirical problem if the firms made input choices based on different constraints determined in a wider game. Further, assuming that the AJW constraints are necessarily binding, when estimating features of the underlying technology, is not a very viable approach if the underlying technology does not support the AJW model, if capital and labour are complements for example. We turn now to some of the empirical studies which grappled more or less carefully with these problems.

4. Representations and Assessments of the Averch-Johnson-Wellisz Model

"In my view, students of regulation of legal monopolies wasted at least 15 years extending the Averch-Johnson model of regulatory behaviour and trying to test it empirically without much success." (Note 38).

Entering the title of the paper by Averch and Johnson (1962) into the search engine for JSTOR yields 8922 items (as of December 2013). Once items which have no direct connection to the AJW model are removed by searching within those items for those with the authors' names, this number drops to 550. Finally, selecting from the remainder those articles which seem to pertain more-or-less directly to the issues raised here (and adding some relevant studies found through other searches) yields a non-random sample of 192 journal articles, book chapters, or working papers. This sample forms the basis for the analysis and comments of this section of the discussion (Note 39). It is intended to be at least somewhat representative of the response of economists to the AJW model. The sample itself is reproduced in the Appendix.

4.1 The Problematic Studies: Inconclusive or Incomplete

Following in the tradition of McKay (1976) who assesses three empirical investigations of the AJW effect–and extending evaluative principles to theoretical papers–the items in the sample are examined to determine what they contribute to the debate on the existence and importance of the AJW effect (Note 40). We consider four possible determinations of problem in decreasing order of importance: Type D ("problematic"), Type C ("not sufficiently careful"), Type B ("not sufficiently thorough") and Type A ("thorough"). (Note 41) Using the

non-random sample of peer-reviewed articles, we calculate a number of evocative statistics.

The least serious category is the "not sufficiently thorough" grouping, which contains all papers which do not explicitly present all of the cases and required conditions for the AJW effect. A study is thorough if there is testing for necessary conditions of input substitution or separability or the papers presents explicit assumptions in model to address substitution and separability. Of the 192 items considered here, 163 or 84.9% fall into Group B or C or D.

An unfortunately large number of studies–well over one third–are placed into the "not sufficiently careful" category. 74 items or 38.5% are articles of Type C or D. These papers are a subset of the "not thorough" set. Theoretical papers were placed into this category primarily for being misleading or incomplete, especially in regard to implicit assumptions (Note 42). The most common reason for a theoretical work to be considered "not careful" is if the substitutability of inputs was assumed without explicit mention of its importance. Empirical studies were placed in this category if the AJW effect is discussed (but not always asserted as "found") without a presentation of any tests for necessary pre-conditions, especially tests on the complementarity of inputs.

If we consider as "problematic" items which are flawed or incorrectly conclusive, 12 of the 192 or 6.25% fall into this category. These are the Type D articles, a subset of the "not careful" group. The primary reason for a paper to be placed in this category is for the AJW effect to be reported as "found" or "proven" either on the basis of an empirical study which is subsequently shown to suffer from methodological or data problems or for the AJW effect to be reported without any test for the presence of one or more of the economic conditions necessary for its existence (Note 43). These papers, then, go further than the "not careful" papers in that their authors claim to have provided evidence of the existence of the AJW effect, rather than simply discussing the AJW effect in passing. Given the apparent widespread acceptance of the AJW effect, the test for inclusion in this category is biased: no empirical paper which fails to find the AJW effect is labelled problematic. Readers should adjust their own posterior beliefs accordingly.

Another way for a paper to be considered "problematic" is if it presents one of the common misconceived versions of the AJW effect, that is, that the AJW propositions imply that the regulated firm will choose a capital stock that is too large, the regulated firm will pay a price for its capital that is too high, or that the regulated firm will acquire unproductive capital. None of these is correct.

Examples of problematic papers include Courville (1974), Spann (1974) and Petersen (1975) all of which are dealt with in McKay (1976) whose "single most important objection to these studies is that they neglect to take into account one of the basic assumptions which is made when production or cost functions are used to represent technological possibilities." Since regulatory authorities require utilities to satisfy demand, "the use of annual energy as the output and either total plant cost or capacity as the measure of capital contradicts....the assumption that engineering suboptimizations have taken place so that the function gives the maximum output attainable with the given inputs." (Note 44) Gollop and Karlson (1980) also provide evidence to refute the finding of the AJW effect in these three papers. They develop and apply a multiperiod econometric model....The resulting empirical description of the industry's technology and the estimated residential demand elasticity are consistent with the findings of other applied research. The important empirical conclusion, however, is that we find no evidence of input distortion (Note 45).

When Gollop and Karlson restrict their model to a single period, the result confirms the Averch-Johnson hypothesis and supports the earlier research by Spann (1974), Courville (1974), and Petersen (1975). The results of the more general inter- temporal model, however, suggest that the above inference is the result of specification bias and not regulatory bias. This contrasts with the single-period model inference that inefficient producer behavior can be attributed to rate-of- return regulation. This "inefficiency," however, most likely is due to specification bias, not regulatory bias. Three of the four estimating equations in the single period and multiperiod models are identical. Only the optimizing condition with respect to capital is specified differently. Of course, it is precisely this first-order condition that is central to the evaluation of the Averch-Johnson hypothesis (Note 46).

Another, more recent example of a Type D paper, is found in Saal and Parker (2001) who report finding an AJW effect in regulated water utilities in England and Wales. Capital for labor substitution has been occurring during the 1990s, something consistent with the argument that, where economic regulation allows for a rate of return on investment at or above the cost of capital, incentives exist to overinvest (Averch and Johnson 1962). Regulation of the water industry in the 1990s seems to have failed to counteract this tendency (Note 47).

But the study does not present any tests for necessary conditions; in particular, the substitutability of labour for capital in the operations of water and sewer services is simply assumed in the analysis (Note 48).

We may conclude from this sample that economists in general have not been as careful as they might have been in discussing the hypotheses of the AJW model. Further, if we restrict our attention to empirical studies of regulated industries undertaken on unique data sets, 92 of the 192 papers in the sample, then they can be grouped as follows: 70.7% are not sufficiently thorough, 31.5% are not sufficiently careful and 4.4% are problematic.

4.2 Evidence for the AJW Effect

Some papers provide a careful counter-factual and do not assume the AJW effect before attempting to find it or discover its effect on the production or cost functions. Of the many papers that claim to have found evidence of the AJW effect, only a few use methodologies that are sufficiently thorough or careful. Even these studies, taken together, are not conclusive. For example, although Hayashi and Trapani (1976) find evidence of the AJW effect for US electric utilities during 1965–1969, Nelson and Wohar (1983) find no evidence of the AJW effect in US electric utilities for 1950–1973, but find evidence of the effect over the period 1974–1978.

Granderson and Lovell (1998) find the AJW effect in US Natural Gas Pipelines for 1977–1987 and, using much the same data set, Granderson and Linvil (1996) find evidence of the AJW effect for US Natural Gas Pipelines for 1981–1987 but not 1977–1980. The finding of the AJW effect is for the period just prior to the deregulation of this industry. It is possible that, at least toward the end of the sample period, as firms anticipated deregulation, more complex firm-regulator interactions were occurring than those contemplated by the AJW model.

Nemoto, Nakanishi and Madono (1993) find overcapitalization consistent with the AJW effect in nine Japanese electric utilities over the period 1981 to 1985. The authors note that during this period "the government frequently encouraged investment of electric utilities as a complement to fiscal policy" and therefore "government intervention in the decision process of investment makes it unlikely that investment series in this period reflect rational behavior described by dynamic factor demand models." (Note 49) The results in the paper could also arise from a regulator's perceived need for security of supply in the event of a sudden large increase in demand.

A very persuasive finding of input bias in a regulated industry is provided by Atkinson, Färe and Primont (2002) for US Railroads, over the 1951–1975 period, but no claim that this input bias is the result of the AJW effect is advanced by the authors of this paper.

4.3 Lack of Evidence of the AJW Effect

One the reasons that researchers have not found much empirical support for the AJW effect may be that regulators who were aware of the effect would have taken action to prevent it through a mix of incentives and penalties applied to the regulated firms. Managers of regulated firms might be aware that regulators would respond to evidence for the AJW effect by imposing new regulations and seek to prevent the establishment of new rules. In this light, the study of Boyes (1976) is particularly interesting. Boyes examines a system of input demand functions for steam-electric generating plants in the Unites States (except Texas, South Dakota, Minnesota and Iowa) over the period 1957 to 1964 and finds no support for the AJW effect. The data set covers a period prior to publication of Averch-Johnson (1962) or Wellisz (1963) and so regulators are unlikely to have been influenced by the hypotheses of the AJW model.

Close examination of the empirical results provided in many empirical studies suggests that in many sectors the AJW effect could not be present since for the firms in these regulated industries, *installed* capital assets are complements to other inputs. While it is possible that there may be some substitution possibilities between capital and labour prior to the acquisition of the capital, after installation the two inputs are likely to be complements. Sankar (1977) observes that Dhrymes and Kurz (1964) found that, at the plant level, the partial elasticity of substitution between capital and labor is zero and that between capital and fuel is very small. Further, using time series data for the U.S. electric utility industry for the period 1949–1968, Sankar (1972) found that an investment function based on a Leontief-type production model performed better than the functions based on a neoclassical model. Perhaps, a more realistic model would be the one which permits greater substitution possibilities before the investment is undertaken and less substitution possibilities after the investment is made (Note 50).

And in Pescatrice and Trapani (1980) we find that an analysis of the objectives of the private firms in the sample reveals some evidence consistent with internal cost minimization as predicted by the (AJW) regulatory model. However, not all of the perverse (distortionary) behavior predicted by the static rate-of-return model can be confirmed. In particular, the positive relation between nonbase input prices and their quantities demanded was not observed in most cases. The fact that these input demand distortions do not manifest themselves in the data is most likely due to the fact that the comparison was performed for the generation of power only and that

substitution possibilities among inputs is somewhat limited by technology in this facet of the operation (Note 51).

Finally, Nelson and Wohar (1987) in their study of US electric utilities note that It is...possible to obtain three different estimates of the elasticities of scale and substitution for the unregulated technology. The traditional estimates are appropriate for the assumption that regulation is not binding, while the Fare-Logan estimates are consistent with the assumptions of binding regulation and cost minimization with respect to capital (and, presumably, the assumption that the regulatory constraint is correctly specified). The estimates...from the variable cost function are appropriate in both of these cases and in the case when the firm is not in equilibrium with respect to its use of capital (Note 52).

It is worth observing that the estimate of the elasticity of substitution between capital and labour in this third specification–the variable cost function which is appropriate in all three cases–suggests that these two inputs are complements (Note 53).

The three examples presented here are all drawn from electric utilities but most regulated network industries share fundamental technological characteristics with electricity–especially the high sunk cost of capital that is required for the network itself–and that is why they are typically regulated. Thus the kind of industry which is most often regulated may also be the kind of industry in which we are least likely to see any significant AJW effect.

Consider telephone service, as another example. In commenting on the telecommunications industry Greenwald and Sharkey play down the need for concern over the AJW effect: Another potential distortion due to rate of return regulation is the distortion in investment decisions which may lead to overly capital intensive technologies. However, the size of the incentives involved is not clear, and the general empirical evidence supporting the existence of substantial economic inefficiencies of this sort is weak to non-existent (Note 54).

In a 1999 study of local telephone service in the United States, Resende finds that, although ROR is supposed to cause input bias in the regulated firm according to the AJW model, the removal of ROR does not cause any productivity gain from an end to the hypothesized input bias: The evidence indicates that alternative regulatory regimes (price-cap and incentive regulation) do not seem to play any role in improving productive efficiency, in comparison to traditional rate-of-return regulation. This result displays robustness with respect to the choice of the technical change variable (Note 55).

4.4 Treatment of AJW Effect in Teaching Materials

Given the wealth of evidence against the AJW hypothesis, how is this subject treated in the materials developed for teaching? To examine how past and current students might have been exposed to the AJW hypothesis, we can consider a sample of recent and current textbooks in Microeconomics and Industrial Organization.

Many textbooks for intermediate- or upper-level Microeconomic theory have kept this subject out of the content. Examples include: Besanko and Braeutigam (2005), Cowell (2005), Gravelle and Rees (2004), Jehle and Reny (2011), Perloff (2012), and Varian (2010). Pindyck and Rubinfeld (2013) discuss rate-of-return regulation as a topic but there is no mention of the AJW effect (Note 56). In contrast, Eaton, Eaton and Allen (2012) and Frank and Parker (2010) provide uncritical presentations of the Averch-Johnson effects which make no reference to the empirical literature which, in general, fails to support the hypothesis (Note 57). Instructors using these textbooks might consider providing some additional material to their students, such as a reading from one of the textbooks from the field of Industrial Organization where the topic is typically considered more systematically.

As expected, many textbooks, or collections of readings for courses, from the fields of Industrial Organization and Regulation Economics have more extensive treatments of rate-of-return regulation. At the graduate level, while the classic theory text In Industrial Organization, Tirole (1988), does not discuss the AJW effect, the classic Regulation text, Laffont and Tirole (1993) present the AJW model in the introductory chapter (Note 58). Brushing the results and extensions of the AJW model aside, along with “its much-discussed empirical relevance”, Laffont and Tirole provide a concise critique of its structure, asking whether the regulatory constraint (similar to Equations (1), (3) or (4) above) could “emerge as the ‘reduced form’ of a more complex model. (and, if so), wouldn’t the reduced form be sensitive to changes in the structural form, which would make comparative statics exercise perilous?” (Note 59) And more perilous would be an empirical estimation strategy that assumed the reduced form was binding over periods during which the structure of regulation was changing.

Also at the graduate level, Spulber (1989) provides an extensive development of the AJW model (Note 60). Spulber asserts that the static AJW model has serious limitations and “an empirical test for regulatory bias must involve specification of a dynamic model”. (Note 61) As noted above, in their textbook for graduate and

advanced undergraduate instruction, Church and Ware (2000) present the AJW hypothesis and discuss some of the important mitigating factors: regulatory lag, prudence and facilities reviews, and regulatory risk (Note 62).

In contrast, Viscusi, Harrington, Jr. and Vernon (2005), in a textbook for a similar level of instruction, present the Averch-Johnson effect with few qualifiers. They state that "Using what some today would regard as very strong assumptions about how regulation constrains the firm, it was shown that firms would choose too much capital relative to other inputs." (Note 63) They also note that although one might argue that the Averch-Johnson effect may provide an incentive for capital-intensive technological change, the net effect of rate-of-return regulation on innovation is not so clear.

At the undergraduate level, the treatment of the AJW effect is also mixed. Some texts dispense with the model altogether, such as the one from Pepall, Richards and Norman (2011) which does not contain any discussion of rate-of-return regulation. Some texts provide the necessary evidence or caveats. For example, Burgess (1995) states that "the question of whether or not the operations of regulated enterprise is subject to A-J effects is a matter of empirical testing (and on) this question the indications are mixed." (Note 64) Burgess also provides references to empirical tests of the AJW hypothesis: "Spann's (1974) study seemed to confirm it; Boyes' (1976) study did not." (Note 65) Another undergraduate-level textbook, from Waldman and Jensen, (2013) explains the AJW effect and provides a useful discussion of some of the related empirical literature, both supportive and not (Note 66).

Carlton and Perloff (2005) explain the AJ Effect and unfold a simple numerical example to show how the regulated firm responds to the regulation by overcapitalizing (Note 67). They include a note that "rate-of-return *may* lead to undercapitalization...because of dynamic considerations" (Note 68). The textbook also has a brief section dealing with some of the empirical evidence, citing the work of Courville (1974), Petersen (1975) and Spann (1974) in support, the technical criticism of McKay (1977), and the studies of Smithson (1978) and Baron and Taggart (1977) which do not support the hypothesis. Following this promising beginning, Carlton and Perloff nonetheless assert that "there is a general consensus that production under ROR is likely to be inefficient" despite their conclusion that "the empirical evidence on overcapitalization is mixed." (Note 69).

Some textbooks that present the model provide insufficient discussion of the empirical literature. Lipczynski and Wilson (2001) offer up the AJ effect as one of three problems with rate-of-return regulation, focussing only on the importance of the regulator's choice of constraint, noting that "if the rate of return is set at a wrong level it can encourage firms to either over- or underinvest in assets". (Note 70) In marked contrast to the assertions in this article, Sherman (2008) claims that "empirical tests ... have indicated a bias toward capital inputs and the finding of a bias is strong evidence that rate-of-return regulation reduces input efficiency." (Note 71).

In general, advanced-undergraduate / graduate level texts–such as Laffont and Tirole (1993), Church and Ware (2000), Spulber (1989)–deal with the AJW effect with considerable skepticism and with the caveats and discussion of empirical results required for readers to come to draw reasonably well-informed conclusions about the hypotheses of Averch and Johnson (1962) and Wellisz (1963). Of the remaining textbooks which present the AJW hypotheses, mostly textbooks at the undergraduate level, the majority do not successfully discuss the model along with the weakness of empirical support for the predictions of the model, with the result that students might have some difficulty in properly assessing the extent to which the effect has been found in outcomes of real ROR situations.

5. Conclusions

In most of the articles claiming to provide evidence of the AJW effect a strong conclusion should not have been reached due to (1) single- rather than multi-period estimation, (2) incorrectly specified capital prices, (3) problematic definitions of output, or (4) the reason that for the firms in these regulated industries, installed capital assets are complements to other inputs. Network industries, which typically have very high capital to labour ratios under any regulatory regime, are frequently characterised by complementarity of capital and labour. The kind of industry which is most often regulated under ROR may also be the kind of industry in which we are least likely to see the AJW effect.

A few studies have carefully found evidence suggestive of the AJW effect. Studies from the same period in different industries found no evidence and more recent papers have found no evidence of the AJW effect. Either there never was a very significant AJW effect and/or regulators read the economics literature, too, and took steps to mitigate the AJW effect.

Certainly, there is no justification for assuming the AJW effect in trying to reconstruct or estimate the unregulated cost or production function. Most currently-regulated industries have been regulated for some time

and technological change occurred in the regulated context. On the one hand, some regulatory constraints that appear to be binding are not; on the other, effects of regulation can persist even after the regulatory constraint has been relaxed (Note 72). If we assume that we can specify the regulatory constraint, assume it binds, and then proceed with estimation then we must accept that our estimation results are conditional on the accuracy of our specification of the regulatory constraint. There are two prescriptions that arise from this paper:

(1) For empirical research: Consider the AJW effect, if at all, as one only possible outcome among many in the context of a set of regulatory interactions. Do not assume that the AJW effect is binding without careful testing.

(2) For pedagogy: Reduce the emphasis of the AJW effect in the teaching of Industrial Organization and present it, if at all, as one only possible outcome among many in the context of a set of regulatory interactions, along with possible mitigating factors.

It is not that the search for the AJW effect has not produced some interesting papers, just that this search could be abandoned in favour of more productive enterprises. Explorers who set out to find the Northwest Passage made other interesting discoveries. "Research" into the nature of philogiston, the ether, and the philosopher's stone yielded insights into chemistry, so too the exploration of the AJW effect has produced some important results for regulation economists (although not the secret of the transformation of lead into gold and perhaps not immortality). We can agree with Joskow (2005) that it is time to set aside further exploration which takes as its primary objective the identification of the size of the AJW effect but not that the research was "a waste of time and effort".

Acknowledgments

Law acknowledges support for this project from the Mount Allison University Research Fund. Research assistance for this project was provided by Adam Arsenault, David Byrne, Pippa Gherson, Nathan Hall, Marc Lalonde, Nelson Paterson, Jeff Spencer, and Advait Vij.

References

Atkinson, S. E., Rolf, F., & Daniel, P. (2003). Stochastic Estimation of Firm Inefficiency Using Distance Functions. *Southern Economic Journal, 69*(3), 596–611. http://dx.doi.org/10.2307/1061696

Averch, H., & Leland, L. J. (1962). Behavior of the Firm under Regulatory Constraint. *American Economic Review, 52*(5), 1052–1069.

Baron, D. P., & David, B. (1984). Regulation, Asymmetric Information, and Auditing. *RAND Journal of Economics, 15*(4), 447–470. http://dx.doi.org/10.2307/2555518

Baumol, W. J., & Alvin, K. K. (1970). Input Choices and Rate-of-Return Regulation: An Overview of the Discussion. *Bell Journal of Economics and Management Science, 1*(2), 162–190. http://dx.doi.org/10.2307/3003179

Berg, S. V., & John, T. (1995). Contributions of Neoclassical Economics to Public Utility Analysis. *Land Economics, 71*(3), 310–330. http://dx.doi.org/10.2307/3146349

Besanko, D., & Ronald, R. B. (2005) *Microeconomics* (2nd ed.). Danvers, Massachusetts: John Wiley & Sons, Inc.

Besanko, D., & Daniel, S. (1992). Sequential-Equilibrium Investment by Regulated Firms. *RAND Journal of Economics, 23*(2), 153–170. http://dx.doi.org/10.2307/2555981

Borrmann, J., & Jörg, F. (2006). An Alternative Way of Determining the Range of Averch and Johnson's Lagrange Multiplier: A Note. *Applied Economics Letters, 13*(5), 269–271. http://dx.doi.org/10.1080/13504850500393907

Boyes, W. J. (1976). An Empirical Investigation of the Averch-Johnson Effect. *Economic Inquiry, 14*(1), 25–35. http://dx.doi.org/10.1111/j.1465-7295.1976.tb00374.x

Burgess, G. H. Jr. (1995). *The Economics of Regulation and Antitrust*. New York, NY: Harper Collins College Publishers.

Burness, H., Stuart, W., David, M., & James, P. Q. (1980a). Capital Contracting and the Regulated Firm. *American Economic Review, 70*(3), 342–354.

Burness, H., Stuart, W., David, M., & James, P. Q. (1980b). The Turnkey Era in Nuclear Power. *Land Economics, 56*(2), 188–202.

Caillaud, B. J. M., Roger, G., Patrick, R., & Jean, T. (1988). Government Intervention in Production and

Incentives Theory: A Review of Recent Contributions. *RAND Journal of Economics, 19*(1), 1–26. http://dx.doi.org/10.2307/2555394

Callen, J. L. (1978). Production, Efficiency, and Welfare in the Natural Gas Transmission Industry. *American Economic Review, 68*(3), 311–323.

Caputo, M. R., & Hossein, P. M. (2002). Reexamination of the A-J Effect. *Economics Bulletin, 12*(8), 1–9.

Caputo, M. R., & Hossein, P. M. (2008). Intrinsic Comparative Statics of a General Class of Profit-Maximizing Rate-of-Return Regulated Firms. *Oxford Economic Papers, 60*(2), 369–382. http://dx.doi.org/10.1093/oep/gpm037

Carlton, D. W., & Jeffrey, M. P. (2005). *Modern Industrial Organization* (4th ed.). New York, NY: Pearson Addison Wesley.

Church, J., & Roger, W. (2000). *Industrial Organization: A Strategic Approach.* Toronto: The McGraw-Hill Companies, Inc. Retrieved from http://homepages.ucalgary.ca/~jrchurch/page4/page4.html

Corey, G. R. (1971). The Averch and Johnson Proposition: A Critical Analysis. *Bell Journal of Economics and Management Science, 2*(1), 358–373. http://dx.doi.org/10.2307/3003173

Courville, L. (1974). Regulation and Efficiency in the Electric Utility Industry. *Bell Journal of Economics and Management Science, 5*(1), 53–74. http://dx.doi.org/10.2307/3003092

Cowell, F. A. (2005). *Microeconomics: Principles and Analysis*. Oxford, UK: Oxford University Press.

Crew, M. A. (1982). Efficiency and Regulation: A Basis for Reform. *Managerial and Decision Economics, 3*(4), 177–187. http://dx.doi.org/10.1002/mde.4090030403

Dhrymes, P. J., & Mordecai, K. (1964). Technology and Scale in Electricity Generation. *Econometrica, 32*(3), 287–315. http://dx.doi.org/10.2307/1913038

Eaton, B., Curtis, D., Eaton, F., & Douglas, W. A. (2012). *Microeconomics: Theory with Applications* (8th ed.). Toronto: Pearson Prentice Hall.

El-Hodiri, M., & Akira, T. (1973). Behavior of the Firm under Regulatory Constraint: Clarifications. *American Economic Review, 63*(1), 235–237.

Evans, L., & Steven, G. (1988). Public-Utility Regulators Are Only Human: A Positive Theory of Rational Constraints. *American Economic Review, 78*(3), 444–462.

Färe, R., & James, L. (1983). The Rate-of-Return Regulated Firm: Cost and Production Duality. *Bell Journal of Economics, 14*(2), 405–414. http://dx.doi.org/10.2307/3003642

Färe, R., & James, L. (1986). Regulation, Scale and Productivity: A Comment. *International Economic Review, 27*(3), 777–781. http://dx.doi.org/10.2307/2526694

Filer, J. E., & Daniel, R. H. (1983). Empirical Tests for the Effect of Regulation on Firm and Interruptible Gas Service. *Southern Economic Journal, 50*(1), 195–205. http://dx.doi.org/10.2307/1058050

Frank, R. H., & Ian, C. P. (2010). *Microeconomics and Behaviour* (4th ed.). Toronto: McGraw-Hill Ryerson.

Gal-Or, E., & Michael, H. S. (1992). Regulatory Regimes in the Electric Power Industry: Implications for Capacity. *Journal of Regulatory Economics, 4*(3), 263–278. http://dx.doi.org/10.1007/BF00133623

Gollop, F. M., & Stephen, R. K. (1980). The Electric Power Industry: An Econometric Model of Intertemporal Behavior. *Land Economics, 56*(3), 299–314. http://dx.doi.org/10.2307/3146033

Granderson, G., & Carl, L. (1996). The Impact of Regulation on Productivity Growth: An Application to the Transmission Sector of the Interstate Natural Gas Industry. *Journal of Regulatory Economics, 10*(3), 291–306. http://dx.doi.org/10.1007/BF00157674

Granderson, G., & Knox, L. C. A. (1998). The Impact of Regulation on Input Substitution and Operating Cost. *Southern Economic Journal, 65*(1), 83–97. http://dx.doi.org/10.2307/1061353

Gravelle, H., & Ray, R. (2004). *Microeconomics* (3rd ed.). Harlow, Essex, UK: Pearson Education Limited.

Greenwald, B. C., & William, W. S. (1989). The Economics of Deregulation of Local Exchange Telecommunications. *Journal of Regulatory Economics, 1*(4), 319–339. http://dx.doi.org/10.1007/BF00139900

Hayashi, P. M., & John, M. T. (1976). Rate of Return Regulation and the Regulated Firm's Choice of

Capital-Labor Ratio: Further Empirical Evidence on the Averch-Johnson Model. *Southern Economic Journal, 42*(3), 384–398. http://dx.doi.org/10.2307/1056617

Jehle, G., & Philip, J. R. (2011). *Advanced Microeconomic Theory* (3rd ed.). Harlow, UK: Pearson Education Limited.

Johnson, L. L. (1973). Behavior of the Firm under Regulatory Constraint: A Reassessment. *American Economic Review, 63*(2), 90–97.

Joskow, P. L. (1974). Inflation and Environmental Concern: Structural Change in the Process of Public utility Price Regulation. *Journal of Law and Economics, 17*(2), 291–327. http://dx.doi.org/10.1086/466794

Joskow, P. L. (2005). Regulation and Deregulation after 25 Years: Lessons Learned for Research in Industrial Organization. *Review of Industrial Organization, 26*(2), 169–193. http://dx.doi.org/10.1007/s11151-004-7295-6

Joskow, P. L., & Nancy, L. R. (1989). The Effects of Economic Regulation. In R. Schmalensee & R. D. Willig (Eds.), *Handbook of Industrial Organization* (Vol. II). Amsterdam, The Netherlands: Elsevier Science Publishers B.V.

Kolpin, V. (2001). Regulation and Cost Inefficiency. *Review of Industrial Organization, 18*(2), 175–182. http://dx.doi.org/10.1023/a:1007823231402

Laffont, J. J., & Jean, T. (1986). Using Cost Observations to Regulate Firms. *Journal of Political Economy, 94*(3), 614–641. http://dx.doi.org/10.1086/261392

Laffont, J. J., & Jean, T. (1993). *A Theory of Incentives in Procurement and Regulation*. Cambridge, Massachusetts: MIT Press.

Law, S. M. (1999). Holding the Line: The CRTC and the Pricing of Basic Canadian Cable Television Services. *Canadian Journal of Economics, 32*(2), 294–317. http://dx.doi.org/10.2307/136441

Law, S. M., & James, F. N. (2003). Unintended and Persistent Consequences of Regulation: The Case of Cable Television in Canada. *Journal of Network Industries, Competition and Regulation, 4*(4), 389–408.

Lewis, T. R., & David, E. M. S. (1988). Regulating a Monopolist with Unknown Demand. *American Economic Review, 78*(5), 986–998.

Lipczynski, J., & John, W. (2001). *Industrial Organization: An Analysis of Competitive Markets*. Harlow, UK: Pearson Education, Ltd.

Liston, C. (1993). Price-Cap Versus Rate of Return Regulation. *Journal of Regulatory Economics, 5*(1), 25–48. http://dx.doi.org/10.1007/BF01066312

McKay, D. J. (1976). *Has the Averch-Johnson Effect Been Empirically Verified?* Social Sciences Working Paper 132, Division of the Humanities and Social Sciences, California Institute of Technology, October 1976.

Meyer, R. A. (1979). Regulated Monopoly under Uncertainty. *Southern Economic Journal, 45*(4), 1121–1129. http://dx.doi.org/10.2307/1056958

Needy, C. W. (1976). Social Cost of the A-J-W Output Distortion. *Southern Economic Journal, 42*(3), 486–489. http://dx.doi.org/10.2307/1056629

Nelson, R. A., & Mark, E. W. (1983). Regulation, Scale Economies, and Productivity in Steam-Electric Generation. *International Economic Review, 24*(1), 57–79. http://dx.doi.org/10.2307/2526115

Nelson, R. A., & Mark, E. W. (1987). A Reply to Regulation, Scale and Productivity: A Comment. *International Economic Review, 28*(2), 535–539. http://dx.doi.org/10.2307/2526742

Nemoto, J., Yasuo, N., & Seishi, M. (1993). Scale Economies and Over-Capitalization in Japanese Electric Utilities. *International Economic Review, 34*(2), 431–440. http://dx.doi.org/10.2307/2526923

Nowell, C., & Jason, F. S. (1991). The Timing of a Rate Request by a Regulated Firm. *Southern Economic Journal, 57*(4), 1054–1060. http://dx.doi.org/10.2307/1060333

Pepall, L., Daniel, J. R., & George, N. (2011). *Contemporary Industrial Organization, A Quantitative Approach*. Danvers, Massachusetts: John Wiley & Sons, Inc.

Perloff, J. M. (2012). *Microeconomics* (6th ed.). Boston, Massachusetts: Pearson Education, Inc.

Pescatrice, D. R., & John, M. T. III (1980). The Performance and Objectives of Public and Private Utilities Operating in the United States. *Journal of Public Economics, 13*(2), 259–276.

http://dx.doi.org/10.1016/0047-2727(80)90016-X

Petersen, H. C. (1975). An Empirical Test of Regulatory Effects. *Bell Journal of Economics, 6*(1), 111–126. http://dx.doi.org/10.2307/3003217

Pindyck, R. S., & Daniel, L. R. (2013). *Microeconomics* (8th ed.). New York: Pearson Education, Inc.

Pressman, I., & Arthur, C. (1971). Behavior of the Firm under Regulatory Constraint: Note. *American Economic Review, 61*(1), 210–212.

Pressman, I., & Arthur, C. (1973). Behavior of the Firm under Regulatory Constraint: Reply. *American Economic Review, 63*(1), 238.

Resende, M. (1999). Productivity Growth and Regulation in US Local Telephony. *Information Economics and Policy, 11*(1), 23–44. http://dx.doi.org/10.1016/S0167-6245(98)00020-1

Rothwell, G. S., & Kelly, A. E. (1987). A Note on Allowed and Realized Rates of Return of the US Electric Utility Industry. *Journal of Industrial Economics, 36*(1), 105–110. http://dx.doi.org/10.2307/2098600

Saal, D. S., & David, P. (2001). Productivity and Price Performance in the Privatized Water and Sewerage Companies of England and Wales. *Journal of Regulatory Economics, 20*(1), 61–90. http://dx.doi.org/10.1023/A:1011162214995

Sankar, U. (1972). Investment Behavior in the US Electric Utility Industry 1948–1968. *Bell Journal of Economics and Management Science, 3*(2), 645–664. http://dx.doi.org/10.2307/3003043

Sankar, U. (1977). Depreciation, Tax Policy and Firm Behavior under Regulatory Constraint. *Southern Economic Journal, 44*(1), 1–12. http://dx.doi.org/10.2307/1057294

Shepherd, W. G. (1966). Regulatory Constraints and Public Utility Investment. *Land Economics, 42*(3), 348–354. http://dx.doi.org/10.2307/3145351

Sherman, R. (2008). *Market Regulation.* New York, NY: Pearson Addison Wesley.

Smithson, C. W. (1978). The Degree of Regulation and the Monopoly Firm: Further Empirical Evidence. *Southern Economic Journal, 44*(3), 568–580. http://dx.doi.org/10.2307/1057211

Spann, R. M. (1974). Rate of Return Regulation and Efficiency in Production: An Empirical Test of the Averch-Johnson Thesis. *Bell Journal of Economics and Management Science, 5*(1), 38–52. http://dx.doi.org/10.2307/3003091

Spiegel, Y., & Daniel, F. S. (1994). The Capital Structure of a Regulated Firm. *RAND Journal of Economics, 25*(3), 424–440. http://dx.doi.org/10.2307/2555770

Spulber, D. F. (1989). *Regulation and Markets*. Cambridge, Massachusetts: MIT Press.

Stonebraker, R. J. (1972). A Geometric Treatment of Averch-Johnson's Behavior of the Firm Model: Comment. *American Economic Review, 62*(1/2), 140–141.

Takayama, A. (1969). Behavior of the Firm under Regulatory Constraint. *American Economic Review, 59*(3), 255–260.

Tirole, J. (1988). *The Theory of Industrial Organization*. Cambridge, Massachusetts: MIT Press.

Varian, H. R. (2010). *Intermediate Microeconomics, A Modern Approach* (8th ed.). New York, NY: W.W. Norton & Company.

Viscusi, W. K., Joseph, E., Harrington, Jr., & John, M. V. (2005). *Economics of Regulation and Antitrust* (4th ed). Cambridge, Massachusetts: MIT Press.

Waldman, D. E., & Elizabeth, J. J. (2013). *Industrial Organization: Theory and Practice* (4th ed). New York, NY: Pearson Addison Wesley.

Wellisz, S. H. (1963). Regulation of Natural Gas Pipeline Companies: An Economic Analysis. *Journal of Political Economy, 71*(1), 30–43. http://dx.doi.org/10.1086/258732

Westfield, F. M. (1965). Regulation and Conspiracy. *American Economic Review, 55*(3), 424–443.

Winston, C. (1993). Economic Deregulation: Days of Reckoning for Microeconomists. *Journal of Economic Literature, 31*(3), 1263–1289.

Zajac, E. E. (1970). A Geometric Treatment of Averch-Johnson's Behavior of the Firm Model. *American Economic Review, 60*(1), 117–125.

Notes

Note 1. These necessary conditions have also been noted by other commentators, for example by Kolpin (2001) in the *Review of Industrial Organization*:

If the monopolist perceives there is even an implicit policy in which past behaviour may influence future allowed returns, the AJ effect does not apply and one need not expect cost inefficiency to be observed. Another class of examples emerges when production and/or profits fail differentiability. For instance, it is easy to construct examples in which a firm endowed with Leontief production technology will continue to employ labor and capital in efficient proportions when exposed to rate-of-return regulation. More generally, any scenario in which the marginal productivity of .capital. varies discontinuously with the availability of those inputs necessary for their operation is subject to the failure of the AJ effect. Kolpin (2001), page 181.

Note 2. See Church & Ware (2000), page 849.

Note 3. See, *inter alia*, Baumol & Klevorick (1970).

Note 4. I am not immune to this accusation *(mea culpa*). Fifteen years ago, I published an article studying a particular regulated industry in which I referred to the article by Averch & Johnson and noted that the regulator's rules were biased toward capital investment (the structure of the price cap reduced the possibility that cost-savings from new equipment would be eroded by corresponding rate decreases; the capital expenditures price mechanism directly rewarded investment with rate increases; and the rate increases permitted when the rate-of-return was below a benchmark provided an additional incentive for these regulated firms to hold a larger stock of assets). Despite presenting results from estimation over data that might have provided some indication of whether capital and labour were substitutes, the article is regrettably silent on this matter.

Note 5. Johnson (1973), page 91.

Note 6. Averch & Johnson (1962), page 1056.

Note 7. Averch & Johnson (1962), page 1057. Also Corey (1971), at page 364, contains a diagram and a discussion of the absence of the AJW effect when inputs are complements.

Note 8. Zajac (1970), page 117.

Note 9. Unlike the addition of .Boiteux. to .Ramsey-Boiteux.–in Caillaud, Guesnerie, Rey & Tirole (1988) and in *A Theory of Incentives and Procurement* by Jean-Jacques Laffont and Jean Tirole (1993)–which has been largely successful, as measured by increased citations of the work of Boiteux, the observation of William Baumol and Alvin Klevorick does not seem to have convinced many subsequent authors to adopt as the name of the regulatory model they discuss the Averch-Johnson-Wellisz model or its main result the AJW effect. In the years immediately following the publication of the AJW papers, some scholars were careful to mention both–examples include Westfield (1965) and Shepherd (1966)–some authors were careful to cite both, even if the contribution of Wellisz was not noted explicitly in the text–examples include Takayama (1969) and Corey (1971)–but despite a few rare exceptions–such as Needy (1976), Filer & Hollas (1983) and Evans & Garber (1988)–references to Wellisz drop off sharply after 1971 even while research into the AJ effect continues. In notable contrast to this observation are only a few articles–such as one in the *American Economic Review* by Callen (1978) and another in *Land Economics* by Berg & Tschirhart (1995)–which refer to the AJW model.

Note 10. Baumol & Klevorick (1970), page 164, emphasis added.

Note 11. Baumol & Klevorick (1970), pages 162, 165, 166, 168, 175, and 180.

Note 12. Baumol & Klevorick (1970), pages 167–168.

Note 13. Baumol & Klevorick (1970), page 177.

Note 14. Baumol & Klevorick (1970), page 178.

Note 15. Baumol & Klevorick (1970), page 182.

Note 16. See, e.g., Laffont & Tirole (1993), page 34.

Note 17. Baumol and Klevorick (1970), page 188.

Note 18. Baumol and Klevorick (1970), page 189.

Note 19. Takayama (1969), El-Hodiri & Takayama (1973).

Note 20. Pressman & Carol (1971), Pressman & Carol (1973).

Note 21. Church & Ware (2000), pages 841–852.

Note 22. Church & Ware (2000), page 850.

Note 23. Quotation drawn by Pressman & Carol from page 210 of Courville's Carnegie-Mellon PhD Dissertation. Pressman & Carol (1973), page 238.

Note 24. Meyer (1979), pages 1125–1126.

Note 25. Meyer (1979), page 1124.

Note 26. See also Spiegel & Spulber (1994).

Note 27. Burness, Montgomery & Quirk (1980b), page 198.

Note 28. Nowell & Shogren (1991), page 1059.

Note 29. Liston (1993) discusses some examples of regulatory games that yield the AJW effect as a subcase:

Besanko (1984) argues that in a symmetric information environment the A-J model is unsatisfactory because it implicitly assumes that the regulator acts myopically. However, if the firm has private information about its productivity parameter, he suggests that the input bias could arise endogenously as part of the optimal regulatory regime. He constructs an adverse selection model in which the regulator uses a .graduated ROR. that decreases with the capital employed, as well as its power to monitor capital investments. Because less productive firms benefit more from increases in capital than more productive ones, the graduated ROR induces them to self-select. The resulting over-capitalization (i.e., the input bias) is viewed as an unavoidable, although welfare improving, consequence of lower information rents. (See also Baron's (1990, 1380–1381) presentation of Besanko's model.) Liston (1993), Note 13, page 41.

Note 30. Laffont & Tirole (1993), page 34.

Note 31. Joskow (2005), page 188.

Note 32. One example is provided by Gal-Or and Spiro. .A conclusion of the study is that the existing regulatory regime, which has as its primary instrument the determination of allowed rate of return on invested capital, provides utilities with incentives to invest in base-load capacity at levels that exceed the socially optimal level. Although this conclusion is similar to that derived in the seminal paper by Averch and Johnson (1962)..., it is derived from a model which is substantially different from theirs. Furthermore, our conclusions are stronger.. Gal-Or & Spiro (1992), page 264.

Note 33. This procedure sometimes involves estimating the Lagrangian multiplier (from Equation 2 above) and testing whether it is significantly different from zero or from one.

Note 34. Färe and Logan (1983), page 406.

Note 35. Joskow & Rose (1989), page 1461.

Note 36. Joskow & Rose (1989), page 1463.

Note 37. Joskow & Rose (1989), page 1463.

Note 38. Joskow (2005), page 188.

Note 39. Some articles are excluded from our sample although they contain a reference to the AJW effect. These papers mention AJW in order to indicate that they are not studying ROR or AJW but instead studying, for example, debt-service regulations or accounting rules or other issues.

Note 40. Earlier reviews of the evidence for the AJW effect that have been published, such as MacKay (1976), Crew (1982) and Winston (1993), draw conclusions on the basis of smaller samples of published studies. For example, Crew (1982) suggests the following papers find support for the AJW effect–Courville (1974), Hayashi & Trapani (1976), Peterson (1975) and Spann (1974)–and the following works do not find support–Boyes (1976), Crew & Kleindorfer (1980 and 1982), and Smithson (1978).

Note 41. The categorization of papers was performed by individuals with no personal ties to any of the authors, primarily student research assistants who were instructed to separate the papers without remorse or mercy. Nothing in the categories should be taken as a commentary on the competence of the authors since later developments can often render work problematic in hindsight.

Note 42. Caputo & Partovi (2002) provide a precise, and convenient, set of statements for the economic conditions which may be assumed in order to establish the AJW model.

Note 43. Rothwell & Eastman (1987) emphasize the importance of measuring the cost of capital carefully before drawing any conclusion about the AJW effect, noting that:

Different measures of the cost of capital yield different conclusions about the appropriateness of using models assuming the same financial and regulatory constraints as in Averch and Johnson (1962). The realized rate of return was greater than the AFUDC rate for all years except 1981. However, when we use a market price of the cost of capital, the realized rate of return was less than the cost of capital from 1979 to 1982. This finding violates the financial constraint of the single-period Averch-Johnson model, suggesting that the model is an inappropriate description of electric utility behavior in the late 1970s and early 1980s. (This does not imply that the model is necessarily appropriate before the late 1970s.) Also, we found that the allowed rate of return was greater than the realized rate after 1976. Using the realized rate as a proxy for the allowed rate in single-period models will bias estimates of overcapitalization toward accepting the Averch-Johnson thesis. Rothwell & Eastman (1987) page 108.

Note 44. McKay (1976), page 2.

Note 45. Gollop & Karlson (1980), page 313.

Note 46. Gollop & Karlson (1980), page 313.

Note 47. Saal & Parker (2001), page 87.

Note 48. Although many of the utilities in their sample reduce labor input and increase capital input while increasing output, the authors provide no elasticities or statistics to support a conclusion of substitution.

Note 49. Nemoto, Nakanishi & Madono (1993), page 432.

Note 50. Sankar (1977) note 2, page 2.

Note 51. Pescatrice & Trapani (1980), pages 274–275.

Note 52. Nelson & Wohar (1987), page 538.

Note 53. Nelson & Wohar (1987), Table 1, page 538.

Note 54. Greenwald & Sharkey (1989), page 325.

Note 55. Resende (1999), page 41.

Note 56. Pindyck & Rubinfeld (2013), pages 381–382.

Note 57. Eaton. Eaton & Allen (2012), pages 357–361; Frank & Parker (2010), pages 381–383.

Note 58. Laffont & Tirole (1993), pages 33–34. In a section of the subsequent chapter, on pages 93–99, Laffont and Tirole further present a more thorough discussion of Private Information on the Desirability of Investment: Rate of Return on Investment, Incentives and the Averch-Johnson Model in which they ask (page 95): Is an Averch-Johnson overinvestment a concern in an optimal regulatory scheme? They contrast the behavior of the regulator and regulated firm under uncertainty about the cost of investment with the behavior of the firm in the AJW model, noting the inconsistency of the results of the AJW model and their more general theoretical model.

Note 59. Laffont & Tirole (1993), page 34.

Note 60. Spulber (1989), pages 287–293.

Note 61. Spulber (1989), page 292.

Note 62. Church & Ware (2000), pages 847–851.

Note 63. Viscusi, Harrington, Jr. & Vernon (2005), page 433.

Note 64. Burgess (1995), page 71.

Note 65. Burgess (1995), Note 6, page 93.

Note 66. Waldman & Jensen (2013), pages 633–635.

Note 67. Carlton & Perloff (2005), pages 707–712.

Note 68. Carlton & Perloff (2005), Note 30, page 709, emphasis added.

Note 69. Carlton & Perloff (2005), page 712.

Note 70. Lipczynski & Wilson (2001), page 392.

Note 71. Sherman (2008), page 422.

Note 72. See, e.g., Law & Nolan (2003).

Appendix A

Citations for Articles in Dataset

Papers published after 1989 (.in the last fifteen years. before Paul Joskow's 2005 paper in the *Review of Industrial Organization*) have a **bold** date of publication.

1) Adrangi, B., Garland, C., & Kambiz, R. (**1995**). Analysis of the Deregulation of the US Trucking Industry: A Profit Function Approach. *Journal of Transport Economics and Policy, 29*(3), 233–246.

2) Alesina, A., Silvia, A., Giuseppe, N., & Fabio, S. (**2005**). Regulation and Investment. *Journal of the European Economic Association, 3*(4), 791–825. http://dx.doi.org/10.1162/1542476054430834

3) Atikinson, A. B., & Waverman, L. (1973). Resource Allocation and the Regulated Firm: Comment. *Bell Journal of Economics and Management Science, 4*(1), 283–287. http://dx.doi.org/10.2307/3003149

4) Atkinson, S. E., & Christopher, C. (**1994**). Parametric Estimation of Technical and Allocative Inefficiency with Panel Data. *International Economic Review, 35*(1), 231–243. http://dx.doi.org/10.2307/2527099

5) Atkinson, S. E., & Robert, H. (1976). Interfuel Substitution in Steam Electric Power Generation. *Journal of Political Economy, 84*(5), 959–978. http://dx.doi.org/10.1086/260492

6) Atkinson, S. E., & Robert, H. (1980). A Test of Relative and Absolute Price Efficiency in Regulated Utilities. *Review of Economics and Statistics, 62*(1), 81–88. http://dx.doi.org/10.2307/1924275

7) Atkinson, S. E., & Robert, H. (1984). Parametric Efficiency Tests, Economies of Scale, and Input Demand in U.S. Electric Power Generation. *International Economic Review, 25*(3), 647–662. http://dx.doi.org/10.2307/2526224

8) Atkinson, S. E., Rolf, F., & Daniel, P. (**2003**). Stochastic Estimation of Firm Inefficiency Using Distance Functions. *Southern Economic Journal, 69*(3), 596–611. http://dx.doi.org/10.2307/1061696

9) Averch, H., & Leland, L. J. (1962). Behavior of the Firm under Regulatory Constraint. *American Economic Review, 52*(5), 115–121.

10) Azariadis, C., Kalman, J. C., & Alfredo, P. (1972). A Partial Utility Approach to the Theory of the Firm. *Southern Economic Journal, 38*(4), 485–494. http://dx.doi.org/10.2307/1056504

11) Bailey, E. E. (1972). Peak-Load Pricing under Regulatory Constraint. *Journal of Political Economy, 80*(4), 662–679. http://dx.doi.org/10.1086/259918

12) Bailey, E. E. (1973). Resource Allocation and the Regulated Firm: Comment on the Comments. *Bell Journal of Economics and Management Science, 4*(1), 288–292. http://dx.doi.org/10.2307/3003150

13) Bailey, E. E., & Roger, D. C. (1971). The Effect of Lagged Regulation in an Averch-Johnson Model. *Bell Journal of Economics and Management Science, 2*(1), 278–292. http://dx.doi.org/10.2307/3003168

14) Bailey, E. E., & Malone, J. C. (1970). Resource Allocation and the Regulated Firm. *Bell Journal of Economics and Management Science, 1*(1), 129–142. http://dx.doi.org/10.2307/3003026

15) Baron, D. P., & Robert, A. T. Jr. (1977). A Model of Regulation under Uncertainty and a Test of Regulatory Bias. *Bell Journal of Economics, 8*(1), 151–167. http://dx.doi.org/10.2307/3003491

16) Barzel, Y. (1963). Productivity in the Electric Power Industry. *Review of Economics and Statistics, 45*(1), 395–408. http://dx.doi.org/10.2307/1927924

17) Barzel, Y. (1964). The Production Function and Technical Change in the Steam Power Industry. *Journal of Political Economy, 72*(2), 133–150. http://dx.doi.org/10.1086/258883

18) Baumol, W. J., & Burton, G. M. (1967). The Firm's Optimal Debt-Equity Combination and The Cost of Capital. *Quarterly Journal of Economics, 81*(4), 547–578. http://dx.doi.org/10.2307/1885578

19) Baumol, W. J., Dietrich, F., & Thijs, T. R. (1979). The Price-Iso Return Locus and Rational Rate Regulation. *Bell Journal of Economics, 10*(2), 648–658. http://dx.doi.org/10.2307/3003356

20) Baumol, W. J., & Alvin, K. K. (1970). Input choices and Rate-of-Return Regulation: An Overview of the Discussion. *Bell Journal of Economics and Management Science, 1*(2), 162–190. http://dx.doi.org/10.2307/3003179

21) Bawa, V. S., & David, S. S. (1980). Dynamic Behavior of a Firm Subject to Stochastic Regulatory Review. *International Economic Review, 21*(3), 627–642. http://dx.doi.org/10.2307/2526358

22) Bhattacharyya, A., Elliott, P., & Kambiz, R. (**1994**). An Examination of the Effect of Ownership on the Relative Efficiency of Public and Private Water Utilities. *Land Economics, 70*(2), 197–209. http://dx.doi.org/10.2307/3146322

23) Biglaiser, G., & Michael, R. (**2000**). Dynamics of Price Regulation. *RAND Journal of Economics, 31*(4), 744–767. http://dx.doi.org/10.2307/2696357

24) Blair, R. D., David, L. K., & Patricia, L. P. (1985). A Note on Purchased Power Adjustment Clauses. *Journal of Business, 58*(4), 409–417. http://dx.doi.org/10.1086/296306

25) Blitz, R. C., & Millard, F. L. (1965). The Economics of Usury Regulation. *Journal of Political Economy, 73*(6), 608–619. http://dx.doi.org/10.1086/259087

26) Boyes, W. J. (1976). An Empirical Examination of the Averch-Johnson Effect. *Economic Inquiry, 14*(1), 25–35. http://dx.doi.org/10.1111/j.1465-7295.1976.tb00374.x

27) Braeutigam, R. R., & John, C. P. (1989). Diversification Incentives under Price-Based and Cost-Based Regulation. *RAND Journal of Economics, 20*(3), 373–391.

28) Braeutigam, R. R., & John, C. P. (**1993**). Effects of the Change from Rate-of-Return to Price-Cap Regulation. *American Economic Review, 83*(2), 191–198.

29) Brandon, P. S. (1971). The Electric Side of Combination Gas-Electric Utilities. *Bell Journal of Economics and Management Science, 2*(2), 688–703. http://dx.doi.org/10.2307/3003014

30) Brennan, M. J., & Eduardo, S. S. (1982). Consistent Regulatory Policy under Uncertainty. *Bell Journal of Economics, 13*(2), 506–521. http://dx.doi.org/10.2307/3003470

31) Breslaw, J., & Smith, J. B. (1982). The Restrictiveness of Flexible Functional Forms and the Measurement of Regulatory Constraint. *Land Economics, 58*(4), 553–558. http://dx.doi.org/10.2307/3145701

32) Brocas, I., Kitty, C., & Isabelle, P. (**2006**). Regulation under Asymmetric Information in Water Utilities. *American Economic Review, 96*(2), 62–66.

33) Callen, J. L. (1978). Production, Efficiency, and Welfare in the Natural Gas Transmission Industry. *American Economic Review, 68*(3), 311–323.

34) Callen, J. L., Frank, M. G., & Herbert, M. (1976). The Benefits and Costs of Rate of Return Regulation. *American Economic Review, 66*(3), 290–297.

35) Caputo, M. R., & Hossein, P. M. (**2002**). Reexamination of the A-J Effect. *Economics Bulletin, 12*(8), 1–9.

36) Caputo, M. R., & Hossein, P. M. (**2008**). Intrinsic Comparative Statics of a General Class of Profit-Maximizing Rate-of-Return Regulated Firms. *Oxford Economic Papers, 60*(2), 369–382. http://dx.doi.org/10.1093/oep/gpm037

37) Christensen, L. R., & William, H. G. (1976). Economies of Scale in U.S. Electric Power Generation. *Journal of Political Economy, 84*(4), 655–676. http://dx.doi.org/10.1086/260470

38) Courville, L. (1974). Regulation and Efficiency in the Electric Utility Industry. *Bell Journal of Economics and Management Science, 5*(1), 53–74. http://dx.doi.org/10.2307/3003092

39) Cowing, T. G., & Kerry, V. S. (1977). A Note on the Variability of the Replacement Investment Capital Stock Ratio. The *Review of Economics and Statistics, 59*(2), 238–243. http://dx.doi.org/10.2307/1928823

40) Crew, M. A., & Paul, R. K. (1978). Reliability and Public Utility Pricing. *American Economic Review, 68*(1), 31–40.

41) Crew, M. A., & Paul, R. K. (1979). Managerial Discretion and Public Utility Regulation. *Southern Economic Journal, 45*(3), 696–709. http://dx.doi.org/10.2307/1057470

42) Crew, M. A., & Paul, R. K. (1983). Regulatory Influences on Managerial Incentives: Comment. *Southern Economic Journal, 50*(1), 265–266. http://dx.doi.org/10.2307/1058062

43) Das, S. P. (1980). On the Effect of Rate of Return Regulation under Uncertainty. *American Economic Review, 70*(3), 456–460.

44) Datta, A. (**2003**). Divestiture and Its Implications for Innovation and Productivity Growth in US Telecommunications. *Southern Economic Journal, 69*(3), 644–658. http://dx.doi.org/10.2307/1061699

45) Daughety, A. F. (1984). Regulation and Industrial Organization. *Journal of Political Economy, 92*(5), 932–953. http://dx.doi.org/10.1086/261265

46) Davis, E. G. (1973). A Dynamic Model of the Regulated Firm with a Price Adjustment Mechanism. *Bell Journal of Economics and Management Science, 4*(1), 270–282. http://dx.doi.org/10.2307/3003148

47) De Borger, B. L. (1984). Cost and Productivity in Regional Bus Transportation: The Belgian Case. *Journal of Industrial Economics, 33*(1), 37–54. http://dx.doi.org/10.2307/2098423

48) Dhrymes, P. J. (1964). On the Theory of the Monopolistic Multiproduct Firm under Uncertainty. *International Economic Review, 5*(3), 239–257. http://dx.doi.org/10.2307/2525510

49) Dhrymes, P. J., & Mordecai, K. (1964). Technology and Scale in Electricity Generation. *Econometrica, 32*(3), 287–315. http://dx.doi.org/10.2307/1913038

50) Dodds, D. E., & Jonathan, A. L. (**1994**). Can Utility Commissions Improve on Environmental Regulations? *Land Economics, 70*(1), 63–76. http://dx.doi.org/10.2307/3146441

51) Edelson, N. M. (1971). Resource Allocation and the Regulated Firm: A Reply to Bailey and Malone. *Bell Journal of Economics and Management Science, 2*(1), 374–378. http://dx.doi.org/10.2307/3003174

52) El-Hodiri, M., & Akira, T. (1973). Behavior of the Firm under Regulatory Constraint: Clarifications. *American Economic Review, 63*(1), 235–237.

53) Elton, E. J., & Martin, J. G. (1977). Optimal Investment and Financing Patterns for a Firm Subject to Regulation with a Lag. *Journal of Finance, 32*(5), 1485–1500. http://dx.doi.org/10.1111/j.1540-6261.1977.tb03349.x

54) Emmons, W. M. (**1997**). Implications of Ownership, Regulation, and Market Structure for Performance: Evidence from the US Electric Utility Industry before and after the New Deal. *Review of Economics and Statistics, 79*(2), 279–289. http://dx.doi.org/10.1162/003465397556638

55) Evans, L., & Steven, G. (1988). Public-Utility Regulators Are Only Human: A Positive Theory of Rational Constraints. *American Economic Review, 78*(3), 444–462.

56) Farber, S. C. (1989). The Dependence of Parametric Efficiency Tests on Measures of the Price of Capital and Capital Stock for Electric Utilities. *Journal of Industrial Economics, 38*(2), 199–213. http://dx.doi.org/10.2307/2098530

57) Färe, R., & James, L. (1983). The Rate-of-Return Regulated Firm: Cost and Production Duality. *Bell Journal of Economics, 14*(2), 405–414. http://dx.doi.org/10.2307/3003642

58) Färe, R., & James, L. (1986). Regulation, Scale and Productivity: A Comment. *International Economic Review, 27*(3), 777–781. http://dx.doi.org/10.2307/2526694

59) Gagnepain, P., & Marc, I. (**2002**). Incentive Regulatory Policies: The Case of Public Transit Systems in France. *RAND Journal of Economics, 33*(4), 605–629. http://dx.doi.org/10.2307/3087477

60) Gal-Or, E., & Michael, H. S. (**1992**). Regulatory Regimes in the Electric Power Industry: Implications for Capacity. *Journal of Regulatory Economics, 4*(3), 263–278. http://dx.doi.org/10.1007/BF00133623

61) Gilbert, R. J., & David, M. N. (**1994**). The Dynamic Efficiency of Regulatory Constitutions. *RAND Journal of Economics, 25*(4), 538–554. http://dx.doi.org/10.2307/2555974

62) Goddard, F. O. (1971). On the Effectiveness of Regulation of Electric Utility Prices: Comment. *Southern Economic Journal, 38*(1), 125–126. http://dx.doi.org/10.2307/1056084

63) Gollop, F. M., & Stephen, R. K. (1980). The Electric Power Industry: An Econometric Model of Intertemporal Behavior. *Land Economics, 56*(3), 299–314. http://dx.doi.org/10.2307/3146033

64) Gort, M., & Richard, A. W. (1988). Foresight and Public Utility Regulation. *Journal of Political Economy, 96*(1), 177–188.

65) Granderson, G. (**1999**). The Impact of Regulation on Technical Change. *Southern Economic Journal, 65*(4), 807–822. http://dx.doi.org/10.2307/1061277

66) Granderson, G., & Carl, L. (1996). The Impact of Regulation on Productivity Growth: An Application to the Transmission Sector of the Interstate Natural Gas Industry. *Journal of Regulatory Economics, 10*(3), 291–306. http://dx.doi.org/10.1007/BF00157674

67) Granderson, G., & Knox, L. C. A. (1998). The Impact of Regulation on Input Substitution and Operating Cost. *Southern Economic Journal, 65*(1), 83–97. http://dx.doi.org/10.2307/1061353

68) Greenwald, B. C., & William, W. S. (1989). The Economics of Deregulation of Local Exchange Telecommunications. *Journal of Regulatory Economics, 1*(4), 319–339. http://dx.doi.org/10.1007/BF00139900

69) Guthrie, G. (**2006**). Regulating Infrastructure: The Impact on Risk and Investment. *Journal of Economic Literature, 44*(4), 925–972. http://dx.doi.org/10.1257/jel.44.4.925

70) Hayashi, P. M., & John, M. T. (1976). Rate of Return Regulation and the Regulated Firm's Choice of Capital-Labor Ratio: Further Empirical Evidence on the Averch-Johnson Model. *Southern Economic Journal, 42*(3), 384–398. http://dx.doi.org/10.2307/1056617

71) Hayashi, P. M., Melanie, S., & John, M. T. (1985). Pricing Efficiency under Rate-of-Return Regulation: Some Empirical Evidence for the Electric Utility Industry. *Southern Economic Journal, 51*(3), 776–792. http://dx.doi.org/10.2307/1057879

72) Herendeen, J. B. (1975). A Financial Model of the Regulated Firm and Implications of the Model for Determination of the Fair Rate of Return. *Southern Economic Journal, 42*(2), 279–284. http://dx.doi.org/10.2307/1056777

73) Hiebert, L. D. (**2002**). The Determinants of the Cost Efficiency of Electric Generating Plants: A Stochastic Frontier Approach. *Southern Economic Journal, 68*(4), 935–946. http://dx.doi.org/10.2307/1061501

74) Hirschey, M., & James, L. P. (1983). Regulatory Influences on Managerial Incentives: Reply. *Southern Economic Journal, 50*(1), 267–269. http://dx.doi.org/10.2307/1058063

75) Hollas, D. R. (1989). Firm/Interruptible Gas Pricing Patterns in a Regulated Environment. *Journal of Regulatory Economics, 1*(1), 47–67. http://dx.doi.org/10.1007/BF00150297

76) Hollas, D. R., & Stanley, R. S. (1988). An Examination of the Effect of Ownership Form on Price Efficiency: Proprietary, Cooperative and Municipal Electric Utilities. *Southern Economic Journal, 55*(2), 336–350. http://dx.doi.org/10.2307/1059107

77) Isaac, R. M. (1982). Fuel Cost Adjustment Mechanisms and the Regulated Utility Facing Uncertain Fuel Prices. *Bell Journal of Economics, 13*(1), 158–169. http://dx.doi.org/10.2307/3003437

78) Israilevich, P., & Kim, J. K. (1987). *A Test of Two Views of the Regulatory Mechanism: Averch-Johnson and Joskow.* Library of the Federal Reserve Bank of Cleveland, Working Paper 8713. Retrieved from http://www.clevelandfed.org/research/workpaper/1987/wp8713.pdf

79) Joskow, P. L. (1972). The Determination of the Allowed Rate of Return in a Formal Regulatory Hearing. *Bell Journal of Economics and Management Science, 3*(2), 632–644. http://dx.doi.org/10.2307/3003042

80) Joskow, P. L. (1973). Cartels, Competition and Regulation in the Property-Liability Insurance Industry. *Bell Journal of Economics and Management Science, 4*(2), 375–427. http://dx.doi.org/10.2307/3003047

81) Joskow, P. L. (1973). Pricing Decisions of Regulated Firms: A Behavioral Approach. *Bell Journal of Economics and Management Science, 4*(1), 118–140. http://dx.doi.org/10.2307/3003142

82) Joskow, P. J. (1974). Inflation and Environmental Concern: Structural Change in the Process of Public Utility Price Regulation. *Journal of Law and Economics, 17*(2), 291–327. http://dx.doi.org/10.1086/466794

83) Kaestner, R., & Brenda, K. (**1990**). The Effects of Regulation and Competition on the Price of AT&T Intrastate Telephone Service. *Journal of Regulatory Economics, 2*(4), 363–377. http://dx.doi.org/10.1007/BF00134477

84) Milton, Z. K. (1969). Output of the Restrained Firm. *American Economic Review, 59*(4), 583–589.

85) Kahn, A. E. (1968). The Graduated Fair Return: Comment. *American Economic Review, 58*(1), 170–174.

86) Kennedy, T. E. (1977). The Regulated Firm with a Fixed Proportion Production Function. *American Economic Review, 67*(5), 968–971.

87) Klevorick, A. K. (1966). The Graduated Fair Return: A Regulatory Proposal. *American Economic Review, 56*(3), 477–484.

88) Klevorick, A. K. (1971). The Graduated Fair Return: A Further Comment. *American Economic Review, 61*(4), 727–729.

89) Klevorick, A. K. (1971). The 'Optimal' Fair Rate of Return. *Bell Journal of Economics and Management Science, 2*(1), 122–153. http://dx.doi.org/10.2307/3003164

90) Klevorick, A. K. (1973). The Behavior of a Firm Subject to Stochastic Regulatory Review. *Bell Journal of Economics and Management Science, 4*(1), 57–88. http://dx.doi.org/10.2307/3003139

91) Knittel, C. R. (**2002**). Alternative Regulatory Methods and Firm Efficiency: Stochastic Frontier Evidence from the US Electric Industry. The *Review of Economics and Statistics, 84*(3), 530–540. http://dx.doi.org/10.1162/003465302320259529

92) Knittel, C. R. (**2004**). Regulatory Restructuring and Incumbent Price Dynamics: The Case of US Local Telephone Markets. *Review of Economics and Statistics, 86*(2), 614–625. http://dx.doi.org/10.1162/003465304323031157

93) Kolbe, L. A., & Lynda, S. B. (**1998**). The Impact of Stranded-Cost Risk on Required Rates of Return for Electric Utilities: Theory and an Example. *Journal of Regulatory Economics, 13*(3), 255–275. http://dx.doi.org/10.1023/A:1008081104532

94) Kolpin, V. (**2001**). Regulation and Cost Inefficiency. *Review of Industrial Organization, 18*(2), 175–182. http://dx.doi.org/10.1023/A:1007823231402

95) Krouse, C. G., Kenneth, L. D., Christos, C., Tanja, D., Carter, J. M. R., & Daniel, J. R. (1999). The Bell System Divestiture/Deregulation and the Efficiency of the Operating Companies. *Journal of Law and Economics, 42*(1), 61–97. http://dx.doi.org/10.1086/467418

96) Kwoka, J. E. Jr. (1993). Implementing Price Caps in Telecommunications. *Journal of Policy Analysis and Management, 12*(4), 726–752. http://dx.doi.org/10.2307/3325348

97) Laffont, J. J. (**1994**). The New Economics of Regulation Ten Years After. *Econometrica, 62*(3), 507–537. http://dx.doi.org/10.2307/2951658

98) Laffont, J. J., & Jean, T. (1986). Using Cost Observation to Regulate Firms. *Journal of Political Economy, 94*(3), 614–641. http://dx.doi.org/10.1086/261392

99) Lasserre, P., & Pierre, O. (**1994**). Factor Demands, Cost Functions, and Technology Measurements for Regulated Firms. *Canadian Journal of Economics, 27*(1), 218–242. http://dx.doi.org/10.2307/135812

100) Law, S. M. (**1999**). Holding the Line: The CRTC and the Pricing of Basic Canadian Cable Television Services. *Canadian Journal of Economics, 32*(2), 294–317.

101) Leland, H. E. (1974). Regulation of Natural Monopolies and the Fair Rate of Return. *Bell Journal of Economics and Management Science, 5*(1), 3–15. http://dx.doi.org/10.2307/3003089

102) Levy, B., & Pablo, T. S. (**1994**). The Institutional Foundations of Regulatory Commitment: A Comparative Analysis of Telecommunications Regulation. *Journal of Law, Economics, & Organization, 10*(2), 201–246.

103) Link, A. N. (1977). A Comment on the .Efficient Allocation of Resources in a Regulated and Unionized Monopoly. *Southern Economic Journal, 44*(2), 383–384. http://dx.doi.org/10.2307/1057595

104) Liston, C. (**1993**). Price-Cap versus Rate of Return Regulation. *Journal of Regulatory Economics, 5*(1), 25–48. http://dx.doi.org/10.1007/BF01066312

105) Lyon, T. P. (**1995**). Regulatory Hindsight Review and Innovation by Electric Utilities.. *Journal of Regulatory Economics, 7*(3), 233–254. http://dx.doi.org/10.1007/BF01067096

106) Lyon, T. P., & John, W. M. (**2005**). Regulatory Opportunism and Investment Behavior: Evidence from the ILS. Electric Utility. *RAND Journal of Economics, 36*(3), 628–644.

107) MacAvoy, P. W., & Roger, N. (1973). Relative Prices on Regulated Transactions of the Natural Gas Pipelines. *Bell Journal of Economics and Management Science, 4*(1), 212–234. http://dx.doi.org/10.2307/3003145

108) Majumdar, S. K. (1997). Incentive Regulation and Productive Efficiency in the U.S. Telecommunications Industry. *Journal of Business, 70*(4), 547–576. http://dx.doi.org/10.1086/209731

109) Marino, A. M. (1978). Peak Load Pricing under Regulatory Constraint: Two Remarks. *Southern Economic Journal, 44*(3), 606–615. http://dx.doi.org/10.2307/1057214

110) Marino, A. M. (1981). Optimal Departures from Marginal Cost Pricing: The Case of a Rate of Return Constraint. *Southern Economic Journal, 48*(1), 37–49. http://dx.doi.org/10.2307/1058594

111) Mathios, A. D., & Robert, P. R. (1989). The Impact of Alternative Forms of State Regulation of AT&T on Direct-Dial, Long-Distance Telephone Rates. *RAND Journal of Economics, 20*(3), 437–453. http://dx.doi.org/10.2307/2555581

112) Mayo, J. W., & Joseph, E. F. (1988). The Effects of Regulation on Research and Development: Theory and Evidence. *Journal of Business, 61*(3), 321–336. http://dx.doi.org/10.1086/296435

113) McNicol, D. L. (1973). The Comparative Statics Properties of the Theory of the Regulated Firm. *Bell Journal of Economics and Management Science, 4*(2), 428–453. http://dx.doi.org/10.2307/3003048

114) Meyer, R. A. (1975). Publicly Owned versus Privately Owned Utilities: A Policy Choice. *Review of Economics and Statistics, 57*(4), 391–399. http://dx.doi.org/10.2307/1935898

115) Meyer, R. A. (1976). Capital Structure and the Behavior of the Regulated Firm under Uncertainty. *Southern Economic Journal, 42*(4), 600–609. http://dx.doi.org/10.2307/1056252

116) Meyer, R. A. (1979). Regulated Monopoly under Uncertainty. *Southern Economic Journal, 45*(4), 1121–1129. http://dx.doi.org/10.2307/1056958

117) Miller, M. H., & Franco, M. (1966). Some Estimates of the Cost of Capital to the Electric Utility Industry, 1954–1957. *American Economic Review, 56*(3), 333–391.

118) Miller, M. H., & Franco, M. (1967). Some Estimates of the Cost of Capital to the Electric Utility Industry, 1954–1957: Reply. *American Economic Review, 57*(5), 1288–1300.

119) Mirakhor, A. (1976). Efficient Allocation of Resources in a Regulated and Unionized Monopoly. *Southern Economic Journal, 42*(4), 725–729. http://dx.doi.org/10.2307/1056267

120) Moore, T. (1970). The Effectiveness of Regulation of Electric Utility Prices.. *Southern Economic Journal, 36*(4), 365–375. http://dx.doi.org/10.2307/1056848

121) Moszer, I. M., & Max, M. (1978). An Approach toward Unifying the Efficient and Fair Rates of Return. *Southern Economic Journal, 45*(2), 394–409. http://dx.doi.org/10.2307/1057670

122) Myers, S. C. (1972). The Application of Finance Theory to Public Utility Rate Cases. *Bell Journal of Economics and Management Science, 3*(1), 58–97. http://dx.doi.org/10.2307/3003071

123) Myers, S. C. (1973). A Simple Model of Firm Behavior under Regulation and Uncertainty. *Bell Journal of Economics and Management Science, 4*(1), 304–315. http://dx.doi.org/10.2307/3003152

124) Needy, C. W. (1976). Social Cost of the A-J-W Output Distortion. *Southern Economic Journal, 42*(3), 486–489. http://dx.doi.org/10.2307/1056629

125) Needy, C. W. (1978). The Gold-Plating Controversy: A Reconciliation. *Southern Economic Journal, 45*(2), 576–582. http://dx.doi.org/10.2307/1057685

126) Nelson, R. A. (1983). Estimated Elasticities from Regulated and Unregulated Cost Functions. *Economic Letters, 11*(4), 311–318. http://dx.doi.org/10.1016/0165-1765(83)90022-8

127) Nelson, R. A. (1984). Regulation, Capital Vintage, and Technical Change in the Electric Utility Industry. *Review of Economics and Statistics, 66*(1), 59–69. http://dx.doi.org/10.2307/1924696

128) Nelson, R. A., & Mark, E. W. (1983). Regulation, Scale Economies and Productivity in Steam-Electric Generation. *International Economic Review, 24*(1), 57–79. http://dx.doi.org/10.2307/2526115

129) Nelson, R. A., & Mark, E. W. (1987). A Reply to Regulation, Scale and Productivity: A Comment. *International Economic Review, 28*(2), 535–539. http://dx.doi.org/10.2307/2526742

130) Nemoto, J., Yasuo, N., & Seishi, M. (**1993**). Scale Economies and Over-Capitalization in Japanese Electric Utilities. *International Economic Review, 34*(2), 431–440. http://dx.doi.org/10.2307/2526923

131) Neuberg, L. G. (1977). Two Issues in the Municipal Ownership of Electric Power Distribution Systems. *Bell Journal of Economics, 8*(1), 303–323. http://dx.doi.org/10.2307/3003501

132) Niho, Y., & Robert, A. M. (1983). Effects of Regulation and Capital Market Imperfections on the Dynamic Behavior of a Firm. *Southern Economic Journal, 49*(3), 625–636. http://dx.doi.org/10.2307/1058705

133) Nolan, J., Pamela, R., & John, R. (**2005**). Small Market Air Service and Regional Policy. *Journal of Transport Economics, 39*(3), 363–378.

134) Nwaeze, E. T. (**2000**). Deregulation of the Electric Power Industry: The Earnings, Risk and Return Effects. *Journal of Regulatory Economics, 17*(1), 49–67. http://dx.doi.org/10.1023/A:1008101304713

135) Okuguchi, K. (1975). The Implications of Regulation Induced Technical Change: Comment. *Bell Journal of Economics, 6*(2), 703–705. http://dx.doi.org/10.2307/3003253

136) Oum, T. H., & Yimin, Z. (**1995**). Competition and Allocative Efficiency: The Case of the US Telephone Industry. *Review of Economics and Statistics, 77*(1), 82–96. http://dx.doi.org/10.2307/2109994

137) Oum, T. H., & Anming, Z. (**2004**). Alternative Forms of Economic Regulation and Their Efficiency Implications for Airports. *Journal of Transport Economics and Policy, 38*(2), 217–246.

138) Pavia, T. M. (**1995**). Profit Maximizing Cost Allocation for Firms Using Cost-Based Pricing. *Management Science, 41*(6), 1060–1072. http://dx.doi.org/10.1287/mnsc.41.6.1060

139) Peles, Y. C., & Jerome, L. S. (1976). The Effect of Rate of Return Regulation is Highly Sensitive to the Nature of the Uncertainty. *American Economic Review, 66*(3), 278–289.

140) Peles, Y. C., & Jerome, L. S. (1979). On Regulation and Uncertainty: Reply. *American Economic Review, 69*(1), 195–199.

141) Peles, Y. C., & Greg, W. (**1996**). Incentive Effects of Rate-of-Return Regulation: The Case of Hong Kong Electric Utilities. *Journal of Regulatory Economics, 10*(1), 99–112. http://dx.doi.org/10.1007/BF00133360

142) Perrakis, S. (1976). On the Regulated Price-Setting Monopoly Firm with a Random Demand Curve. *American Economic Review, 66*(3), 410–416.

143) Perrakis, S. (1976). Rate of Return Regulation of a Monopoly Firm with Random Demand. *International Economic Review, 17*(1), 149–162. http://dx.doi.org/10.2307/2526071

144) Perrakis, S., & Izzet, S. (1972). Resource Allocation and Scale of Operations in a Monopoly Firm: A Dynamic Analysis. *International Economic Review, 13*(2), 399–407. http://dx.doi.org/10.2307/2526033

145) Pescatrice, D. R., & John, M. T. III (1980). The Performance and Objective of Public and Private Utilities operating in the United States. *Journal of Public Economics, 13*(2), 259–276. http://dx.doi.org/10.1016/0047-2727(80)90016-X

146) Petersen, H. C. (1975). An Empirical Test of Regulatory Effects. *Bell Journal of Economics, 6*(1), 111–126. http://dx.doi.org/10.2307/3003217

147) Pint, E. M. (**1992**). Price-Cap versus Rate-of-Return Regulation in a Stochastic-Cost Model. The *RAND Journal of Economics, 23*(4), 564–578. http://dx.doi.org/10.2307/2555906

148) Pressman, I., & Arthur, C. (1971). Behavior of the Firm under Regulatory Constraint: Note. *American Economic Review, 61*(1), 210–212.

149) Pressman, I., & Arthur, C. (1973). Behavior of the Firm under Regulatory Constraint: Reply. *American Economic Review, 63*(1), 238.

150) Ranganathan, V. (**2004**). Electricity Act 2003: Moving to a Competitive Environment. *Economic and Political Weekly, 39*(20), 2001–2005.

151) Resende, M. (**1999**). Productivity Growth and Regulation in US Local Telephony. *Information Economics and Policy, 11*(1), 23–44. http://dx.doi.org/10.1016/S0167-6245(98)00020-1

152) Rothwell, G. S., & Kelly, A. E. (1987). A Note on Allowed and Realized Rates of Return of the US Electric Utility Industry. *Journal of Industrial Economics, 36*(1), 105–110. http://dx.doi.org/10.2307/2098600

153) Saal, D. S., & David, P. (**2001**). Productivity and Price Performance in the Privatized Water and Sewerage Companies of England and Wales. *Journal of Regulatory Economics, 20*(1), 61–90. http://dx.doi.org/10.1023/A:1011162214995

154) Sankar, U. (1972). Investment behavior in the U.S. Electric Utility Industry 1948–1968. *Bell Journal of Economics and Management Science, 3*(2), 645–664. http://dx.doi.org/10.2307/3003043

155) Sankar, U. (1977). Depreciation, Tax Policy and Firm Behavior under Regulatory Constraint. *Southern Economic Journal, 44*(1), 1–12. http://dx.doi.org/10.2307/1057294

156) Sappington, D. (1980). Strategic Firm Behavior under a Dynamic Regulatory Adjustment Process. *Bell Journal of Economics, 11*(1), 360–372. http://dx.doi.org/10.2307/3003421

157) Scheidell, J. M. (1976). The Relevance of Demand Elasticity for Rate-of-Return Regulation. *Southern Economic Journal, 43*(2), 1088–1095. http://dx.doi.org/10.2307/1057333

158) Schmalensee, R. (1977). Valuing Changes in Regulated Firms' Input Prices. *Southern Economic Journal, 43*(3), 1346–1351. http://dx.doi.org/10.2307/1057792

159) Scott, F. A. (1983). A Note on Uncertain Input Prices, Profit Risk, and the Rate-of-Return Regulated Firm. *Land Economics, 59*(3), 337–341. http://dx.doi.org/10.2307/3145736

160) Shepherd, W. G. (1966). Regulatory Constraints and Public Utility Investment. *Land Economics, 42*(3), 348–354. http://dx.doi.org/10.2307/3145351

161) Sherman, R. (1977). Ex Ante Rates of Return for Regulated Utilities. *Land Economics, 53*(2), 172–184. http://dx.doi.org/10.2307/3145922

162) Sherman, R. (1977). Financial Aspects of Rate-of-Return Regulation. *Southern Economic Journal, 44*(2), 240–248. http://dx.doi.org/10.2307/1057577

163) Sherman, R. (1981). Pricing Inefficiency under Profit Regulation. *Southern Economic Journal, 48*(2), 475–489. http://dx.doi.org/10.2307/1057946

164) Sherman, R. (**2001**). The Future of Market Regulation. *Southern Economic Journal, 67*(4), 782–800. http://dx.doi.org/10.2307/1061571

165) Sherman, R., & Michael, V. (1982). Rate-Of-Return Regulation and Two-Part Tariffs. *Quarterly Journal of Economics, 97*(1), 27–42. http://dx.doi.org/10.2307/1882625

166) Sheshinksi, E. (1971). Welfare Aspects of a Regulatory Constraint: Note. *American Economic Review, 61*(1), 175–178.

167) Silva-Echenique, J. (1989). Quasi-Vertical Integration and Rate-Of-Return Regulation. *Canadian Journal of Economics, 22*(4), 852–866. http://dx.doi.org/10.2307/135502

168) Smith, V. K. (1974). The Implications of Regulation for Induced Technical Change. *Bell Journal of Economics and Management Science, 5*(2), 623–632. http://dx.doi.org/10.2307/3003124

169) Smith, V. K. (1975). The Implications of Regulation for Induced Technical Change: Reply. *Bell Journal of Economics and Management Science, 6*(2), 706–707. http://dx.doi.org/10.2307/3003254

170) Smith, V. K. (1981). Elasticities of Substitution for a Regulated Cost Function,. *Economic Letters, 7*(3), 215–219. http://dx.doi.org/10.1016/0165-1765(81)90054-9

171) Smithson, C. W. (1978). The Degree of Regulation and the Monopoly Firm: Further Empirical Evidence. *Southern Economic Journal, 44*(3), 568–580. http://dx.doi.org/10.2307/1057211

172) Smithson, C. W. & Veendorp, E. C. H. (1982). The Optimum. Degree of Rate-of-Return Regulation: A Two Sector Analysis. *Southern Economic Journal, 48*(3), 733–744. http://dx.doi.org/10.2307/1058664

173) Spann, R. M. (1974). Rate of Return Regulation and Efficiency in Production: An Empirical Test of the Averch-Johnson Thesis. The *Bell Journal of Economics and Management Science, 5*(1), 38–52. http://dx.doi.org/10.2307/3003091

174) Spann, R. M., & Edward, W. E. (1970). The Economics of Railroading: The Beginning of Cartelization and Regulation. *Bell Journal of Economics and Management Science, 1*(2), 227–244. http://dx.doi.org/10.2307/3003182

175) Spiegel, Y., & Daniel, F. S. (**1994**). The Capital Structure of a Regulated Firm. *RAND Journal of Economics, 25*(3), 424–440. http://dx.doi.org/10.2307/2555770

176) Stein, J. L., & George, H. B. (1972). Behavior of the Firm under Regulatory Constraint. *American Economic Review, 62*(5), 964–970.

177) Stonebraker, R. J. (1972). A Geometric Treatment of Averch-Johnson's Behavior of the Firm Model: Comment. *American Economic Review, 62*(1/2), 140–141.

178) Strimling, D. V., & Abbas, M. (1974). A Note on the Averch-Johnson Effect Controversy. *Southern Economic Journal, 41*(1), 149–151. http://dx.doi.org/10.2307/1056108

179) Taggart, R. A. Jr. (1981). Rate-of-Return Regulation and Utility Capital Structure Decision. *Journal of Finance, 36*(2), 383–393.

180) Takayama, A. (1969). Behavior of the Firm under Regulatory Constraint. *American Economic Review, 59*(3), 255–260.

181) Thomadakis, S. B. (1982). Price Regulation under Uncertainty in an Asymmetric Decision Environment. *Quarterly Journal of Economics, 97*(4), 689–698. http://dx.doi.org/10.2307/1885106

182) Turnbull, G. K. (1984). Uncertain Input Prices, Profit Risk, and the Rate-of-Return Regulated Firm: Comment. *Land Economics, 60*(4), 408–410. http://dx.doi.org/10.2307/3145718

183) Turnbull, G. K. (1986). Theory of the Firm under the Threat of Input Supply Interruption. *Southern Economic Journal, 52*(3), 807–817. http://dx.doi.org/10.2307/1059276

184) Vogelsang, I., & Jorg, F. (1979). A Regulatory Adjustment Process for Optimal Pricing by Multiproduct Monopoly Firms. *Bell Journal of Economics, 10*(1), 157–171. http://dx.doi.org/10.2307/3003324

185) Waverman, L. (1975). Peak-Load Pricing under Regulatory Constraint: A Proof of Inefficiency. *Journal of Political Economy, 83*(3), 645–654. http://dx.doi.org/10.1086/260345

186) Wellisz, S. H. (1963). Regulation of Natural Gas Pipeline Companies: An Economic Analysis. *Journal of Political Economy, 71*(1), 30–43. http://dx.doi.org/10.1086/258732

187) Wenders, J. T. (1976). Peak Load Pricing in the Electric Utility Industry. *Bell Journal of Economics, 7*(1), 232–241. http://dx.doi.org/10.2307/3003198

188) Westfield, F. (1965). Regulation and Conspiracy. *American Economic Review, 55*(3), 424–443.

189) Westfield, F. (1971). Methodology of Evaluation of Economic Regulation. *American Economic Review, 61*(2), 211–217.

190) Wills, H. R. (1982). The Simple Economics of Bank Regulation. *Economica New Series, 49*(195), 249–259. http://dx.doi.org/10.2307/2553625

191) Zajac, E. E. (1970). A Geometric Treatment of Averch-Johnson's Behavior of the Firm Model. *American Economic Review, 60*(1), 117–125.

192) Zhang, F. (**2007**). Does Electricity Restructuring Work? Evidence from the US Nuclear Energy Industry. *Journal of Industrial Economics, 55*(3), 397–418. http://dx.doi.org/10.1111/j.1467-6451.2007.00317.x