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A Comparison of Government Regulation of Risk in the Financial Services and Nuclear Power Industries

by John B. Taylor and Frank A. Wolak

Stanford Institute for Economic Policy Research
Stanford University
Stanford, CA 94305
(650) 725-1874

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In this paper we examine and compare the problem of safety and soundness regulation in two industries that have dominated the headlines in recent years—nuclear power and financial services. In both industries, a major purpose of regulation and supervision is the prevention of excessive risk taking which can result in extraordinary harm to society. While clearly important industries in their own right, we hope a side-by-side comparison sheds light on the broader policy problem. One of the most striking differences in our comparison is that the recent safety record in the nuclear power industry in the United States appears to be better than the safety record in the financial sector, as evidenced most recently by the failure and bailout of several large financial firms and the resulting global financial crisis.

An important issue in addressing the adequacy of regulation and supervision is the problem of regulatory capture, or the tendency for regulated firms and their government regulators to develop mutually beneficial relationships that are harmful to the economy, public safety and people's lives more generally. The benefits to the regulated firms may include lax supervision, protection from competition, or even government bailouts. The benefits to the regulators may be lucrative post government employment, political contributions, or favors to

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family and friends, which may be implicit or explicit. Of course, the underlying problem of regulatory capture goes beyond heavily regulated industries. Sometimes called the problem of crony capitalism, it can exist in any industry in which government policy has a large role, which is the vast and growing majority of industries today.

This across-industry comparison of the regulation of risk yields insights about which mechanisms from one industry can be usefully transferred to the other industry and which cannot or should not. Moreover, understanding why certain mechanisms cannot be readily transferred suggests directions for future research into the design of mechanisms for regulating risk for both sectors. Although there are a number of reasons for the relative success of the nuclear power sector in managing risk, we focus on those which may have lessons for regulation of risk in the financial sector, including the success of a non-profit industry sponsored organization—the Institute for Nuclear Power Operation (INPO)—which provides comprehensive monitoring and strong incentives to reduce risk.

Changes in the structure of the electricity utility industry over the past 20 years has created challenges for the regulation of risk that are similar to those that exist in the financial sector. For this reason, modifications of the current regime of safety regulation in the nuclear power sector may be necessary to address these new sources of conflict between maintaining public safety and the firm's financial conditions.

1. Regulating and Supervising Financial Services

The financial sector in the United States is regulated and supervised by a large number of federal and state government agencies with overlapping jurisdictions. Commercial banks are regulated by the Federal Reserve, the Office of the Comptroller of the Currency, and the Federal

Deposit Insurance Corporation, along with state regulatory agencies. Securities firms and markets are regulated by the Securities and Exchange Commission and the Commodity Futures Trading Commission. Insurance companies are regulated at state level. The government sponsored enterprises Fannie Mae and Freddie Mac are regulated by the Federal Housing Finance Agency (FHFA), which combined the previous Office of Federal Housing Enterprise Oversight (OHFEO) with the Federal Housing Finance Board.

The Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010 expanded the Federal Reserve's responsibility beyond bank holding companies to all systemically important financial institutions. It also created a new Bureau of Consumer Financial Protection financed by the Federal Reserve and a Financial Stability Oversight Council to coordinate across the federal government regulatory agencies with the help of a new Office of Financial Research. The Dodd-Frank financial reform bill also created an "orderly liquidation authority" in which large (too big to fail) financial firms could be resolved by the Federal Deposit Insurance Corporation rather than go through bankruptcy proceedings. There is disagreement about whether Dodd-Frank bill increases or decreases the chance of government bailouts of such firms. An alternative, or supplement, to the "orderly liquidation authority" would be to create a special bankruptcy process for financial firms called Chapter 14.[1]

Rulemaking is an important part of financial market supervision and regulation. For example, the Dodd-Frank Bill alone requires 235 different rulemakings in which broad requirements in the legislation are translated into specific regulations. Most of the regulatory agencies listed above are involved in the rulemaking process.

[1] See *Ending Government Bailouts As We Know Them*, Kenneth Scott, George Shultz and John B. Taylor (Eds.), Hoover Press, 2010

Rulemaking proceeds in accordance with the Administrative Procedure Act, in which agencies draft rules which are then put out for public comment and revised. The final rule is then published in the Federal Register. The financial industry, including trade groups like the Securities Industry and Financial Markets Association (SIFMA). is of course deeply involved in rule making. While it is essential to draw on their expertise, this raises another route for lobbing for special treatment.

Global financial firms are also regulated by government agencies in other countries. Some international coordination is provided by groups like the Financial Stability Board which has recently designated 29 large banking firms as "systemically important" including 12 headquartered in the United States, 13 in Europe, and 4 in Asia. The designated firms are Bank of America, Bank of New York Mellon, Citigroup, Goldman Sachs, J.P. Morgan, Morgan Stanley, State Street, Wells Fargo, Royal Bank of Scotland, Lloyds Banking Group, Barclays, HSBC, Credit Agricole, BNP Paribas, Banque Populaire, Societe Generale, Deutsche Bank, Commerzbank, Unicredit, UBS, Credit Suisse, Dexia, ING, Banco Santander, Nordea, Mitsubishi UFJ, Mizuho, Sumitomo Mitsui, and Bank of China.

1.1 Excessive Risk Taking and the Financial Crisis

The financial crisis and panic of 2008 revealed serious deficiencies in the regulatory and supervision process. Although there is disagreement about whether the scope of regulation was too narrow, there is little disagreement that the rules and regulations already in place were not adequately enforced by the regulators and supervisors in a number of important cases.

The most documented cases are Fannie Mae and Freddie Mac, the two giant private, government-sponsored enterprises that support the U.S. housing market by buying mortgages

and packaging them into marketable securities which they then guarantee and sell to investors or add to their own portfolios. Both organizations have been regulated by government agencies with the purpose of preventing excessive risk taking by the institutions.

However, by any reasonable measure both agencies undertook excessive risk starting in the late 1990s by guaranteeing home mortgages which had a high probability of default. For this reason they share a significant blame for the financial crisis and the global recession. By encouraging people to take on such loans they accentuated the housing boom which led to the financial bust. Obviously their regulators failed in their most fundamental responsibility and the result was catastrophic.

But Fannie Mae and Freddie Mae were not the only regulated financial institutions that took on excessive risk. Large financial firms from Citibank to AIG to Bank of America to Bear Stearns to Lehman Brothers—all regulated by government agencies with the stated purpose to prevent excessive risk—were heavily invested in risky securities based on questionable home mortgages or other debt. The regulatory system apparently failed as well.

1.2 Regulatory Capture: The Case of Fannie Mae

What role did regulatory capture have in causing this failure? In the case of Fannie Mae and Freddie Mac the evidence of regulatory capture is substantial. Gretchen Morgenson and Joshua Rosner[2] document a massive support system between well-connected individuals in these organizations and government officials which encouraged excessive risk taking. By providing favorable regulatory treatment and protection from competition the government enabled Fannie

[2] Morgenson, Gretchen and Joshua Rosner, *Reckless Endangerment*, Times Books, New York, 2011

Mae to bring in $2 billion in excess profits, according to a 1996 study by the Congressional Budget Office.[3]

Morgenson and Rosner provide considerable information about how the regulatory capture took place. Fannie Mae officials got jobs for friends and relatives of elected officials. They set up partnership offices around the country which provided more such jobs. They financed publications in which writers argued that Fannie's role in promoting homeownership justified federal support. They commissioned work by famous economists, which argued that Fannie was not a serious risk to taxpayers. In this way they countered critics who argued that both Fannie and Freddie posed significant risks.

They made campaign contributions and charitable donations to co-opt groups like ACORN, which had been asking for tighter regulations. They persuaded executive branch officials to ask their staffs to rewrite reports critical of Fannie. The mortgage firm Countrywide partnered with Fannie in originating many of the mortgages Fannie packaged (26 percent in 2004) and gave "sweetheart" loans to politicians with power to affect Fannie.

Fannie's lobbying efforts were resisted by some government officials. CBO Director June O'Neill, for example, refused to stop the release of the 1995 CBO study showing that federal support increased Fannie's profits by $2 billion. John W. Snow, the Treasury Secretary proposed in 2003 the creation of a new federal agency to regulate and supervise Fannie.

While this problem was most severe in the case of Fannie Mae and Freddie Mac, the same problem also apparently existed between some of the large Wall Street financial firms and their regulators at the Federal Reserve Bank of New York. It is very hard to imagine that heavily regulated banks could have engaged in such extreme risk-taking without at least the implicit support of regulators, and when Citigroup built up its hidden off-balance sheet risks in 2006, the

[3] Congressional Budget Office (1996), “Assessing the Costs and Benefits of Fannie Mae and Freddie Mac,” May.

New York Fed did not object, though it had the power to do so. However, the same type of hard evidence that Morgenson and Rosner found in the case of Fannie Mae and Freddie Mac has yet to surface in the case of the other firms.

Firms in other industries undoubtedly take actions to increase their influence and receive favorable regulatory treatment, but what is different in the case of Fannie Mae, Freddie Mac, and the other financial firms is that the government responded with such lax regulatory oversight and favorable treatment that the entire economy suffered severely.

Regulatory failure in the nuclear sector has economy-wide impacts similar to the financial sector, particularly for the regions near a nuclear disaster. However, as we discuss below, a single safety disaster in one firm threatens the financial viability of all firms in the nuclear sector. This provides incentives for firms to take actions to discourage excessive risk-taking at other firms in the nuclear sector, an incentive which has apparently been absent in the financial sector. In addition, the potential profitability upside to excessive risk-taking in the nuclear power sector is limited because the revenues received by plant owners are regulated by government agencies.

2. Regulating Nuclear Power

Nuclear power in the United States is subject to federal regulatory oversight for safety and output price by two separate government agencies, the Nuclear Regulatory Commission (NRC) and the Federal Energy Regulatory Commission (FERC). The safety oversight function of the NRC—which has an overall annual budget of $1 billion and employees about 4,000 people—includes nuclear power plant commissioning licensing for the use of radioactive material and waste repositories, and monitoring of operations. Both the NRC and FERC employ

administrative procedures established under the Administrative Procedure Act (APA) of 1946 for regulatory decision-making. The power of these Independent Regulatory Agencies (IRAs) was established through enabling legislation that allows them significant scope for the interpretation of legislative intent in carrying out their regulatory mission.

The framework set out by the APA establishes a quasi-legal process managed by an Administrative Law Judge (ALJ) to conduct public hearings and make decisions with respect to power plant commissioning for the case of the NRC and output pricing for the case of the FERC. Interested parties with standing on an issue are allowed to submit evidence to the public proceeding and can cross-examine witnesses offered by other parties. The ALJ's decision following the conclusion of the evidentiary hearings, along with all of the accompanying evidence and testimony presented, are forwarded to the members of the regulatory commission and the commission is free to adopt the ALJ's decision or write its own. However, any decision the regulatory commission reaches must follow from the evidence presented in the ALJ process only, so that it is most common for the ALJ's decision to be adopted with only minor modifications.

In making its final decision on an issue, the commission is not allowed to rely on other information, such as private communication with one of the parties, in formulating its decisions. In fact, private contact between commission members and parties on a pending issue before the commission, what is typically called *ex parte communication*, is prohibited. Violation of this rule is grounds for legal review the commission's decision. The other basis for legal review of a commission decision is a failure to make the decision in a manner that is consistent with intent of the enabling legislation. Because of the technical nature of many of the decisions that come

before these two commissions, the courts give significant deference to them in interpreting the intent of the law.

2.1. Potential for Regulatory Capture in Nuclear Power Sector

In many ways, the APA process is designed to limit the scope for regulatory capture. All information relevant to the decision made on a nuclear power plant licensing decision (by the NRC) or a pricing decision (by the FERC), must be presented in a public hearing and be subject to cross-examination. Any decision ultimately made by the regulatory commission is also subject to judicial review for consistency with the intent of the underlying legislation and consistency with due process, i.e., the decision follows directly from the evidence presented.

However, there are a number of details of the regulatory processes at these two commissions that may allow scope for regulatory capture. First, the ALJ process can be extremely costly and time consuming, relative to a more informal process. The somewhat open-ended nature of the evidentiary process can allow a participant with deep pockets, such as a nuclear power plant owner, to impose significant costs on other participants in the regulatory proceedings. Therefore, well-financed participants may be able to exert a greater influence on the outcome of the regulatory process.

A number of regulatory agencies have attempted to address this issue by allowing certain classes of interested parties to recover their costs of participation. For example, environmental groups participating in a nuclear power plant licensing process may be able to file with the commission to recover the costs of their participation from the owner of the actual or proposed power plant.

A second issue concerns the selection and monitoring administration law judges. Few of the regulatory agencies collect and disclose systematic information on the decisions of their administrative law judges. These judges are also employees of the agencies and may therefore have career concerns both in and outside the agency that can impact their decisions. Although there is a rigorous and relatively independent process for selecting lawyers to become ALJs that is designed to reduce the opportunities for regulatory capture, for a variety of reasons, most agencies typically do not use this process for selecting ALJs. A procedure called, "selective certification" allows a regulatory agency to bypass this formal process and choose its own candidate from the set of candidates for an ALJ position that the independent process has determined to be "qualified." The upside of the "selective certification" approach is that the regulatory agency can appoint someone with the necessary technical expertise for that specific regulatory agency to serve as an ALJ. The downside is that the "selective certification" process opens up the opportunities for regulatory capture.

A crucial issue that limits the scope for regulatory capture is the recognition following the Three Mile Island (TMI) accident in 1979 that the current and future financial viability of entire nuclear power industry depends on there being no nuclear accidents. As Detroit Edison CEO Walter J. McCarthy, Jr. stated in a speech to other nuclear utility CEOs at the time, "Each licensee is a hostage of every other licensee," and "that we truly are all in this together."[4] This perspective led to the industry to form INPO as an industry-run regulatory bureaucracy to ensure the safe and reliable operation of nuclear facilities in the United States. As we discuss below, INPO has been a major factor in achieving the significant safety and reliability improvements of the nuclear power sector since TMI.

[4] Rees, Joseph V. (1994) Hostages of Each Other: The Transformation of Nuclear Safety since Three Mile Island, The University of Chicago Press, p. 2.

Because there are ready alternatives for producing electricity besides nuclear power, the entire nuclear industry faces the risk that all nuclear power plants will be shut down and no further power plants built if there is an accident. The recent discussions in Japan and many other countries about the future of nuclear power and the decision of several European countries to abandon nuclear power in response to the Fukushima disaster justify Walter J. McCarthy's statements. In this sense, the nuclear power sector may have a built-in incentive for strong self-regulation of catastrophic risk which does not currently exist in the financial sector. While there has been a political backlash to the recent actions of Wall Street financial firms and their regulators, the view that the financial sector is essential to the economy limits the adverse effects on the entire industry.

3. Performance of United States Nuclear Power Sector

The performance of the United States nuclear power industry has been increasingly impressive on both safety and economic grounds since the 1970s. The annual capacity factor of a generation unit is a useful summary measure of the operating efficiency of a nuclear power plant because the low variable cost of operating nuclear facilities implies that, except in extremely rare circumstances, if a generation unit is available to operate, it will operate. The annual capacity factor of a generation unit is defined as the total amount of output produced by the generation unit annually divided by the nameplate capacity of the generation unit times the total number of hours in the year. For example, if a 50 mega-watt (MW) generation unit produced 328,500 MW-hours (MWh) annually, it would have an annual capacity factor of 0.75 = 328,500 MWh/(50 MW x 8760 hours).

Note that for other power plants, a capacity factor may not be the most useful measure of its operating efficiency. For example, a natural gas-fired power plant may be too expensive to operate during certain hours of the year simply because demand is not sufficiently high to require the unit to operate. Consequently, a lower capacity factor for a natural gas-fired unit does not imply it is unable to operate in fewer hours of the year than a nuclear generation unit.

The fleet-level average capacity factor is a summary measure of the operating efficiency of the United States nuclear power plant fleet. A higher value of this capacity factor implies that more electricity is being produced from the same amount of installed nuclear generation capacity. To compute the fleet-level average annual capacity factor, simply repeat the calculation described above with the numerator equal to the annual output of all nuclear generation units in the United States and denominator equal to the sum of total nuclear generation capacity in the United States times the number of hours in the year.

Figure 1 plots the fleet-level average annual capacity factor for nuclear generation units in the United States from the early 1970s until the present time. The figure starts at less than 50 percent in the early 1970s and steadily rises to almost 91 percent in 2010. It is important to note that although no new nuclear power plants were completed after 1996, total nuclear capacity has increased by a few percentage points per year since then because of capacity additions at existing facilities. Nevertheless, fleet-level capacity factors continued to rise steadily after that date. A number of explanations have been offered for this tremendous improvement in operating efficiency in the past thirty years.

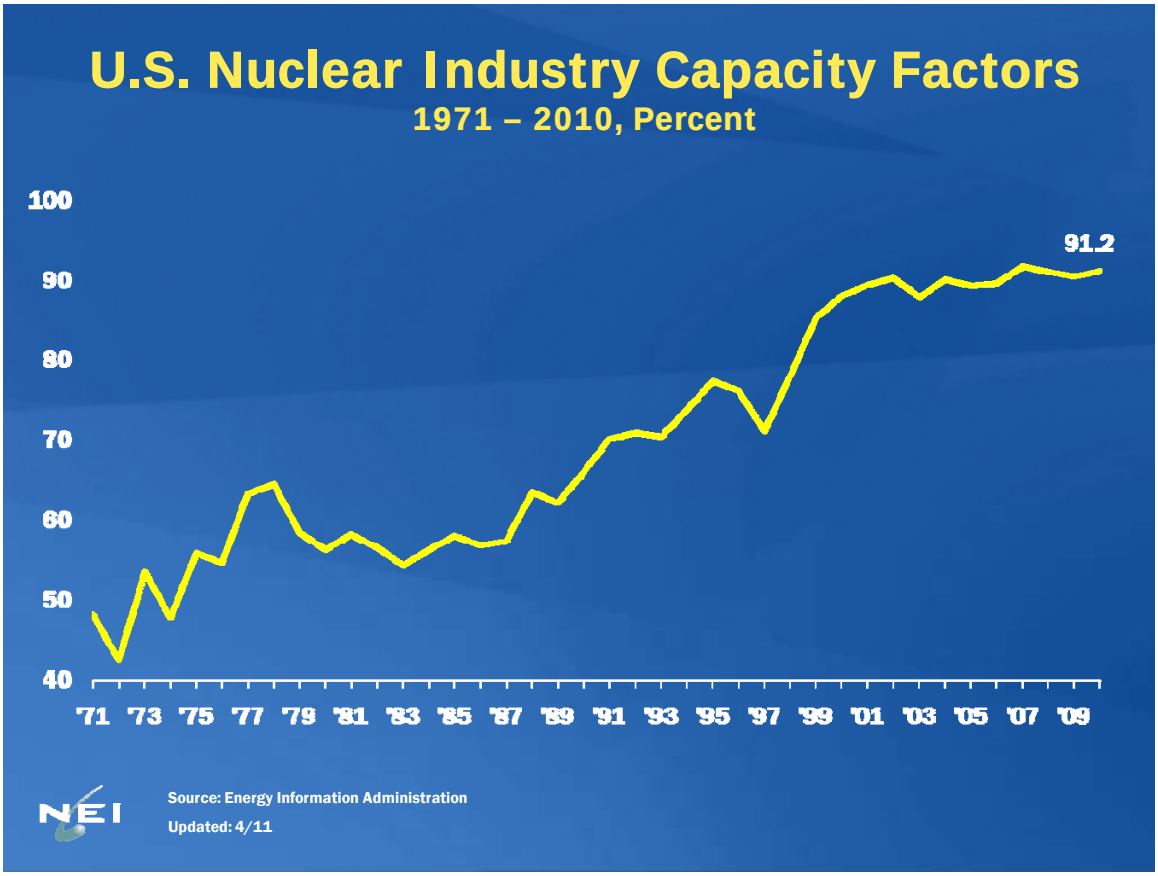

Figure 1: United States Fleet-Level Nuclear Capacity Factors

On the nuclear safety side, there have been no major nuclear power plant incidents in the United States since the Three Mile Island (TMI) event in 1978. The hazard of an unplanned outage, the instantaneous conditional probability of outage given that the plant has not had an unplanned outage up to that point in time, has declined since TMI.[5] This result implies a lower rate of unplanned outage events per plant-year during the post-TMI time period. The reduction in the risk of an unplanned outage in the post TMI period is largest for plants with the highest risk of an unplanned outage during the pre-TMI time period.[6] In addition, although there has been a continuous the reduction the hazard of an unplanned outage at all nuclear power plants

[5] David, P.A., Maude-Griffin, R. and Rothwell, G. (1996) "Learning by Accident? Reductions in the Risk of Unplanned Outages in U.S. Nuclear Plants After Three Mile Island," *Journal of Risk and Uncertainly*, 13, 175-198 estimate proportional hazards model for the length of spells of operating hours for all U.S. nuclear power plants and find the hazard rate for an unplanned outage fell significantly after TMI.
[6] Ibid, p. 193.

since the time each plant began operating, the rate at which the unplanned outage hazard rate declined, accelerated during the post-TMI period.[7]

A broad measure of overall plant safety and performance compiled by INPO for the entire U.S. nuclear power plant fleet has steadily improved over the post-TMI time period.[8] This index is based on measures of power plant performance such as the generation unit capacity factor and safety measures such as the forced loss rate (the percentage of energy generation during non-outage periods that a plant is not capable of supplying because of unplanned energy losses) and scrams (automatic shutdowns) per 7,000 hours of operation. Over the 10-year period, 1995 to 2004, these average performance index measures almost doubled from their values at the start of the time period.[9]

3.1 Explaining Nuclear Reliability and Safety Improvements

There are a number of factors driving these increases in reliability and safety. The first is the increasing standardization of operating procedures in the nuclear industry driven primarily by the formation of INPO and the changes in regulatory oversight at NRC in the aftermath of the TMI. This standardization was facilitated by the Electric Power Research Institute (EPRI) which had been earlier set up voluntarily by the utilities to sponsor research, including research on ways to improve safety; with all U.S. nuclear utilities participating, EPRI worked with engineers from the utilities to develop standardized safety guidelines and do research on inspection technologies to detect potential failures and identify aging deterioration. A second is the consolidation of plant ownership in the nuclear power industry, with a smaller number of

[7] Ibid, p. 193.
[8] Kadak, A.C. and Matsuo, T. (2007) "The Nuclear Industry's Transition to Risk-Informed Regulation and Operation in the United States, Reliability Engineering and System Safety, 92, 609-618, compute the average of the INPO performance index for various types of U.S. nuclear power plants for the period 1995 to 2004.
[9] Ibid, p. 613.

firms owning and operating nuclear power plants according to a common set of operating procedures. A third factor is the increasing use of performance-based regulatory schemes that reward the generation unit owner with a higher rate of return for higher capacity factors and punish them with a lower rate-of-return for lower capacity factor. The fourth factor is the introduction of formal wholesale electricity markets where plant owners sell the output they produce at a market-clearing price, rather than under a regulatory process that only allows the plant owner the opportunity to recover all prudently incurred costs associated with constructing and operating the nuclear power plant.

3.1.1 Institute for Nuclear Power Operations

INPO was founded in December of 1979 as a not-for-profit organization by the nuclear power industry in response to the TMI accident. INPO's mission is: "To promote the highest levels of safety and reliability—to promote excellence—in the operation of commercial nuclear power plants."[10] This is accomplished through nuclear power plant evaluations that assess: (1) the knowledge and performance of plant personnel, (2) condition of systems and equipment, (3) quality of programs and procedures, and (4) effectiveness of plant management. [11] INPO also runs the National Academy of Nuclear Training to provide training for nuclear power professionals and evaluate the quality of individual plant and utility training programs. INPO also provides reviews of significant events in the nuclear power industry and shares the lessons learned and best practices throughout the industry. Finally, INPO provides assistance with specific technical or management issues at the request of an individual plant owner.

[10] "Our History" section of INPO web-site (http://www.inpo.info
[11] "What We Do" section of INPO web-site, http://www.inpo.info.

James Ellis, the CEO of INPO, attributes five factors to INPO's success as a self-regulating industry group: (1) CEO engagement, (2) nuclear power safety focus, (3) support from the nuclear industry, (4) accountability and (5) independence. There is general agreement that the CEO engagement is the primary driver of the success of INPO.

From the beginning the INPO's board of directors has been composed of CEO's of companies that own nuclear power plants. INPO provides briefings personally to the CEO of the operating company in the presence of their management on its performance evaluations (also called on-site peer reviews) conducted at their nuclear power plants. INPO also holds annual meetings with all of its members where power plants are graded on their performance and these grades are shared with all of the CEOs in an executive session. A CEO of a nuclear power company provides the following description of the process:

> All the CEOs are gathered in a big room with Zack Pate [INPO's president], and he flashes up the most recent evaluation numbers for each of the utilities by name. That's the only time we learn how our peers are ranked, and it kind of hits you right between the eyeballs. The first slide has all the number ones, the best-rated utilities. Lots of praise from Zack, and all those CEOs kind of puff up and get a big smile on their face. [They also receive a plaque.] Then come the number twos, and those guys also feel pretty good about it. And then come the number threes, and they just kind of sit there passive. Then you get down to the fours and the fives. And after some pretty frank discussion of their problems, those guys are feeling rather uneasy to say the least. I guess you could say it's a sense of pride or ego. All CEOs are pretty egotistical. I mean these are people who have worked their way up to managing a major utility, and our societal cultural aim is to strive to be the best and get to the top of the pyramid. I think that's really the driver here. We all want to be a one, and none of us want to be viewed as a poor performer among our peers.[12]

[12] Joseph V. Rees. Hostages of Each Other: The Transformation of Nuclear Safety since Three Mile Island (pp. 104-105).

This "management by embarrassment" as this CEO referred to it has been very effective at causing the owners of the laggard power plants to improve their performance.

Nuclear safety focus means that safety has been the exclusive focus of INPO's activities in spite of calls for in INPO to become involved in other issues that relate to the nuclear power industry. *Support from industry* means that the industry understands and accepts that it must subject its plants to on-site peers reviews. Since 1980, INPO has conducted more than 1,200 such reviews, an average of more than 16 at every nuclear power plant.[13] *Accountability* implies that INPO can be confident that its recommendations are implemented in a timely fashion. Over time, INPO has increased its ability to make nuclear power plant owners accountable in an unconventional manner. Originally, INPO's plant evaluations were distributed industry-wide in an effort to publicly shame poor performance. However, this led to the following unintended outcome described by Joseph Rees:

> After reading dozens of these reports, one can't help noticing their carefully restrained wording and their tactfully diplomatic tone. Nor can one avoid the sense that, for some reason, INPO officials were extremely reluctant to use bluntly candid language in their written assessment of a nuclear plant's performance. They were pulling their punches, and the reason why is not hard to uncover. As an industry organization, INPO was responding to the concerns of its most powerful constituency-the nuclear utility CEOs-who were understandably nervous about the risks associated with such reports.[14]

As a consequence, INPO changed to distributing the evaluation reports only to the plant's owner, including the company CEO. James Ellis, CEO of INPO states that this change "provided more open and candid interactions and discussions of problems or areas for improvement. The

[13]Ellis, James, O. "Testimony to National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling" August 25, 2010.
[14] Joseph V. Rees. Hostages of Each Other: The Transformation of Nuclear Safety since Three Mile Island (p. 94).

confidentiality of reports has proven to be an important aspect of performance improvement and nuclear safety."[15]

INPO also has the ability to impose sanctions on power plants owners, even though it does not have the statutory authority to shut down an operating plant. That power resides with the NRC. However, on several occasions INPO has exerted pressure on power plant owners to shutdown plants, delay starting up a plant or even change the company's management, if a safety issue was not properly addressed. Joseph Rees describes the example of Philadelphia Electric's Peach Bottom plant as an example of INPO's ability enforce its recommendations in the face of significant resistance from the plant owner.[16]

An initial INPO evaluation of the Peach Bottom plant found that the management of was unwilling to take the "appropriate actions to stress and enforce standards of expected performance." INPO also perceived a "lack of corporate support in implementing needed changes." Finally, INPO found that "long-standing company practices" were an impediment to implementing the necessary changes. A follow-up evaluation twelve months later again found serious problems at Peach Bottom. Ongoing interactions between INPO staff and the Peach Bottom operators finally resulted in INPO's president writing a stern letter to Philadelphia Electric's CEO and having a private meeting with the CEO and company executives. A follow-up evaluation still found a large number of problems at the plant.

This plant owner management versus INPO stalemate was finally resolved when INPO formed an industry panel to respond to the Peach Bottom problem. This panel was harshly critical of Philadelphia Electric's senior management and ultimately led to its board of directors causing the "early retirement" of the top managers at the company. The new management at

[15] Ellis, James, O. "Testimony to National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling" August 25, 2010.
[16] Joseph V. Rees. Hostages of Each Other: The Transformation of Nuclear Safety since Three Mile Island (p. 110).

Philadelphia Electric subsequently implemented INPO's reforms at the Peach Bottom plant and safety and reliability improved. This sequence of events is often cited by industry observers as the first example of INPO's ability to make the industry accountable for its recommendations.

The final factor, *independence*, has been somewhat of a challenge for INPO. Initially, the founders of INPO had the idea that members of the board of directors should be from outside of the nuclear power industry to ensure its independence. However, the argument that such a board would lack legitimacy from the industry and therefore reduce the effectiveness of INPO as a regulator ultimately led to a board composed of industry executives. INPO is also independent of the NRC, although a number of commentators have argued that the NRC defers much of its industry regulation and oversight functions to INPO and often adopts INPO standards as its own standards.

3.1.2 Industry Consolidation

According to the World Nuclear Association, as of the end of 1991, 101 utilities had some ownership interest in nuclear power plants.[17] At the end of 1999, that number had dropped to 87, and the largest twelve utilities owned 54% of industry capacity. Today, ten utilities own more than 70% of industry capacity in the United States. This consolidation has come about through mergers and well as sales of individual facilities. There has also been consolidation in the number of operators of nuclear power plants, with 45 operators in 1995 to 25 today.

Most the of nuclear generation capacity consolidation was the result of mergers. The merger of Unicom and PECO in 2000 formed Exelon, which created the largest nuclear energy supplier in the USA. Exelon has 10 nuclear plants that produce roughly 20% of US nuclear electricity output. In 2000, Carolina Power & Light merged with Florida Progress Corporation

[17] http://www.world-nuclear.org/info/inf41.html

to become Progress Energy, which owns five plants in North Carolina, South Carolina and Florida. In 2001, FirstEnergy Corporation merged with GPU Inc.

Management contracts have also been used to consolidate plant operations. Companies that own multiple generation units typically form management companies that contract to provide operating and maintenance services to companies that own single generation units. For example, Exelon currently has management contracts with PSEG of New Jersey to operate nuclear units that it owns. Exelon markets the "Exelon way" of nuclear power plant operation and maintenance as leading to lower variable operating costs and higher plant-level capacity factors than other plants in the industry.

The motivation for both types of consolidations is to capture cost savings and operating efficiencies. A number of studies have found evidence of "learning by doing" in nuclear power plant operations, both at the industry-level and utility-level.[18] In fact, one study comparing learning by doing in France versus the U.S. finds that a sizable operating efficiency penalty was paid by the U.S. nuclear power industry as a result of the many different technologies used by different regional utilities and the lack of multi-plant ownership of nuclear generation facilities during the early stages of the nuclear industry.[19] In contrast, France with standardized plant designs and multi-plant ownership experienced significantly high operating efficiencies significantly earlier.

3.1.3 Incentive Regulation Schemes

[18] Lester, Richard K. and McCabe, Mark J. (1993) "The Industrial Structure on Learning by Doing in Nuclear Power Plant Operations," *RAND Journal of Economics*, 24(3), 418-438 and Zimmerman, Martin B. (1982) "Learning Effects and the Commercialization of New Energy Technologies: The Case of Nuclear Power," *The Bell Journal of Economics*, 13(2), 297-310.
[19] Lester and McCabe (1993).

The goal of incentive regulation schemes is to make it profitable for price-regulated nuclear power plant owners to reduce costs by achieving high capacity factors. A popular example of this sort of scheme was the Diablo Canyon Performance-Based Pricing (PRP) plan adopted in 1988 between Pacific Gas and Electricity (the plant owner) and the California Public Utilities Commission (the regulator), which fixed the price at which energy produced by Diablo Canyon was sold. This price was set significantly above the variable operating cost of a Diablo Canyon unit, so Pacific Gas and Electric had a strong financial incentive to produce as much output as possible from this power plant. Other state regulators enacted similar incentive regulation schemes for the nuclear power plants under their jurisdictions, and have achieved similar results. These incentive regulation schemes also provided strong incentives for the plant owners to reduce the operating and maintenance costs associated with their facilities. A number of researchers have documented significant operating cost savings for nuclear power plants over this time period.[20]

3.1.4 Electricity Industry Re-structuring

Electricity industry re-structuring, where nuclear generation unit owners face the default option of selling their output into a formal bid-based wholesale market, provide strong incentives for owners to maximize their capacity factor of their generation units. Typically, the market-clearing price in wholesale market is set by generation units with significantly higher variable operating costs, particularly during the high demand periods of the day. Consequently, a nuclear power plant owner can earn significant revenues in excess of its variable costs by operating hours of the day when the market price is above the variable operating costs of their generation

[20] Zhang, F. (2007) "Does Electricity Restructuring Work? Evidence from the Nuclear Energy Industry," The Journal of Industrial Economics, LV(3), 397-418, is a recent example.

unit. A number of studies have documented incremental increases in annual average capacity factors associated with nuclear generation units selling into a restructured market relative to selling into a vertically-integrated regulated market structure.[21]

3.2 The Potential for Future Regulatory Failure in the Case of Nuclear Power

The recent outstanding safety and performance record of United States nuclear power sector is no reason for complacency. There have been no plant retirements since 1998 and most of the existing fleet has either received or expects to receive a 20-year extension on their licenses from the NRC. These extensions would bring the projected operating life of most plants to almost 60 years, which is significantly longer than was envisioned at the time these plants were built.

The potential risk of future regulatory failure is the result of the combination of an aging nuclear fleet and the fact that an increasing number of facilities sell into formal wholesale electricity markets. This circumstance can potentially increase risks due to the potential for large profits if the generation unit owner is willing to engage in privately risky behavior (continuing to operate in spite of potential safety concerns at the nuclear facility unit because of high wholesale prices) that can have publicly harmful consequences (creating a catastrophic failure). For example, the average wholesale prices in most United States wholesale electricity markets currently average in the range of $50/MWh to $60/MWh. However, during periods of stressed system conditions, prices can hit as high as $3,000/MWh, which was the case during the summer of 2011 in the Electricity Reliability Council of Texas (ERCOT) wholesale electricity market.

[21] Zhang, F. (2007) "Does Electricity Restructuring Work? Evidence from the Nuclear Energy Industry," The Journal of Industrial Economics, LV(3), 397-418, is a recent example.

With variable operating costs for the nuclear power plants in the range of $15/MWh, a nuclear power plant owner can earn massive variable profits by producing as much output as possible during these high-priced periods. This creates an incentive for the unit owner to produce as much output as possible during these time periods, which may lead the owner to produce energy from a facility that would be shut down for safety reasons during a period with lower wholesale prices. Consequently, the combination of high-powered incentives to keep operating costs down, aging nuclear facilities, and the potential for sustained periods of high wholesale electricity prices could increase risks of a catastrophic nuclear power plant failure.

It is important to note that the incentive for a catastrophic failure is lower in the case of a vertically-integrated monopoly regime where plant owners face cost-of-service price regulation. In that case generation units would only be able to recover their prudentially incurred costs regardless of operating condition, including times of stressed system conditions. This lack of a financial upside, and the significant financial downside associated with a catastrophic plant failure, makes it unlikely that a price-regulated expected profit-maximizing plant owner would push a plant beyond its safe operating limits, or economize on operating expenses, as long as these operating expenses were deemed to be prudently incurred by the regulator.

In sum, the possibility of an industry-wide catastrophe is remote because the price of wholesale electricity typically differs by location and hour of the day. Therefore, it would be extremely rare for all nuclear power plants in the U.S. to experience a sustained period of extremely high wholesale prices.

4. Conclusion

In this paper we compared risk regulation in the financial sector and in the nuclear power sector in the United States. Both sectors are heavily regulated and both are susceptible in principle to regulatory capture. However, the safety record in the nuclear power sector is much better than the record in financial services in United States, as evidenced by the recent severe financial crisis and the lack of a major nuclear incident since Three Mile Island. In effect, regulatory failure—including through regulatory capture—has been much more of a problem in the financial industry.

There are many differences between these two industries—including the competitive structure, the availability of substitutes, the importance of proprietary information, the ability to monitor risks, and the degree of price regulation as distinct from risk regulation which can account for these some of these differences. Nevertheless, there are a number of useful lessons from the successful regulation of catastrophic risk in the nuclear power sector that could improve the regulation of risk in the financial sector. In particular, study of the feasibility of a financial industry analog to the Institute for Nuclear Power Operations would be a worthwhile topic for future research.