Journal of Innovation & Knowledge 10 (2025) 100840

Contents lists available at ScienceDirect

Journal of Innovation & Knowledge

journal homepage: www.elsevier.com/locate/jik

Is the institutional review of institutional and innovative policy instrumental or ceremonial? A multiple case study on the institutional review of policies and procedures in Department of Energy nuclear and nuclear waste facilities

Scott Cunningham [a], Yorgos D. Marinakis [b,*], Steven T. Walsh [c], Reilly White [c]

[a] Government and Public Policy, Politics, University of Strathclyde Glasgow, Glasgow, Scotland
[b] Law Office of Yorgos Marinakis, Santa Fe, NM, 87507 USA
[c] Anderson School of Management, University of New Mexico, Albuquerque, NM 87111 USA

ARTICLE INFO

JEL classifications:
B52
L53
O31
O38
Q48
Q53

Keywords:
Theory of institutional change
Federal government
Multiple case study
Department of energy
Institutional policy
Innovation ecosystem

ABSTRACT

We adopt the theory of institutional change to investigate whether institutional review is instrumental or ceremonial, focusing on the role of institutional policy in horizontally integrating the enterprise. We conduct a qualitative multiple case study, examining a case at a United States Department of Energy (DOE) nuclear facility and another at a DOE nuclear waste facility. We use several DOE documents comprising several hundred pages. Our findings indicate that the review of the formation and revision of institutional policy is instrumental rather than ceremonial. We demonstrate that intra-firm cross-organizational innovation can be facilitated through institution-wide reviews of institutional policies (new policies and revisions) in the institutional policy process. This collaborative management leads to the development of dynamic capabilities, which are hallmarks of high-flex organizations. We find that institutional policy acts as a mediating artifact for knowledge and innovation, enabling cross-organizational collaboration in knowledge creation and innovation. While institutional policy is primarily internal, some aspects may originate from external institutions, particularly when policies restate or implement laws or regulations. We find that the DOE and its "big science" program exhibited dynamic capabilities without the external forcing function of a mishap, suggesting that institutional change or transformation in the big science context can occur endogenously. This study lies at the intersection of dynamic capabilities in strategic management, organizational learning (particularly organizational innovation and knowledge creation), and institutional economics. We contribute to theory by synthesizing a portion of institutional economics—namely institutional change—with the theory of dynamic capabilities, identifying instrumental values as encompassing both ordinary and dynamic capabilities. We apply the dynamic capabilities framework of strategic management to public firms and expand the scope of the mediating artifact. Although the context of this study is public administration, the results are also applicable to private administration.

Introduction

The concept of the ecosystem has been expanded to include innovation ecosystems. The philosophical implications of this expansion are worth examining. (Everdell 2009) argued that the theories and practices comprising Modernism are characterized by a recursive or self-referential logic, are temporally stochastic or spatially heterogeneous, radically subjective, encompass simultaneous multiple perspectives, are discontinuous, and nonlocal. Further, Marinakis (2008) posited that this logic constitutes a topos of complexification, vis-à-vis one of emergence (Zimmermann & Voelcker, 2001), which lacks the iterative finitude of a complex system as illustrated by the fixed point attractor. A topos is a universe for mathematical discourse in which the observer's logic is conceptualized as integral to what is being observed (Trifonov, 1995), such that the physical unfolding of the world is identical to the process of reflecting on it (Zimmermann, 1999, 2000,

* Corresponding author.
E-mail addresses: scott.cunningham@strath.ac.uk (S. Cunningham), ydmarinakis@gmail.com (Y.D. Marinakis), walsh@unm.edu (S.T. Walsh), reillywhite@unm.edu (R. White).

https://doi.org/10.1016/j.jik.2025.100840
Received 8 September 2024; Accepted 30 September 2025
Available online 19 October 2025

2002). In particular, it has been argued that the concept of the ecosystem, applied and in its original natural sense, is a topos of complexification. Essentially, nutrients recursively cycle and energy flows through ecosystems (and plant communities recursively succeed themselves); ecosystem models are temporally stochastic and spatially heterogeneous; observations of ecosystem structures and functions are dependent on the observer (radically subjective); ecosystems demonstrate fractal geometry and hierarchical structure and function; they comprise spatially discrete sections, as in the ecotone; and exhibit nonlocality through weak spatial coupling (Marinakis, 2008). The innovation ecosystem, as conceptualized, should be expected to display similar features. Complex systems theory recursively illustrates and comprises a topos of complexification. The iterated function system (Barnsley, 2014) constructs self-similar (self-referential), hierarchical (simultaneous multiple perspectives) fractals through a mathematical process involving recursion and stochasticity, which is perceptible at various scales (radical subjectivity). If we claim or assume that a system such as an institutional policy system is complex, we can deepen our theoretical and practical understanding thereof by investigating it in terms of the characteristics of the topos of complexification. In this paper, we assume that the institutional policy system is both a complex system and topos of complexification and investigate it as such. We focus on the characteristic of recursion or self-referentiality as it manifests through the institutional review of policies and policy revisions. Institutional review is arguably recursive, depicting a cycle within the enterprise that iteratively continues from the author or policy revision author into the organization proposing changes, which return to the author for disposition and possibly back again into the organization and back again. We are interested in recursion because phenomena such as self-organization and self-regulation are inconceivable without it. From this perspective, we now turn to the research question.

Preliminarily, we ask: how does an enterprise achieve horizontal integration? The classical answer is to use cross-functional teams to breach, in a measured and supervised manner, the vertical barriers of organizational hierarchies, responsibilities, and authorities. Another solution often employed to consolidate acquisitions is to implement an enterprise-wide institutional policy office. However, for many reasons, these solutions are often incomplete, leaving many questions for cross-functional teams and institutional policy offices to grapple with.

One pertinent policy office-related question is whether the recursive activity of institutional review is instrumental or ceremonial. This has practical implications for enterprise management and learning, and theoretical implications for understanding institutional change. According to the theory of institutional economics, a society's institutional structure comprises instrumental and ceremonial values (Bush, 1987). Instrumental values provide "the standards of judgment by which tools and skills are employed in the application of evidentially warranted knowledge to the problem-solving processes of the community" (Bush, 1987). Conversely, ceremonial values serve to maintain invidious distinctions. Institutional review of new policies and procedures, and their proposed revisions, is commonly performed by policy offices across various institutions. (To clarify, organizations are the assemblages of people to which the institutions apply. The term institutional policy might be better stated as organizational or enterprise policy, but is widely used to distinguish it from public policy.) This institutional review process can be complex and long-drawn, prompting institutions to innovate to streamline it, for instance, by limiting reviewers to impacted and affected parties or their representatives. However, should an organization even engage in what is sometimes pejoratively called "policy making by democracy"? Is institutional review merely *pro forma*, or does it add value? Do we engage in institutional review because its recursiveness aligns with our Modernist sensibilities, or because we believe it can practically improve the policy document?

Another pertinent and related question pertains to how an institution provides employees with the means and opportunity to engage in intra-firm cross-organizational knowledge sharing and innovation. While many studies focus on what motivates employees to innovate across organizational lines (e.g., Belloc, 2022; Matinaro & Liu, 2017), we are interested in the potential role of institutional policy and procedure in facilitating cross-organizational knowledge sharing and innovation. Institutional policy serves as a formal vehicle for knowledge creation and sharing (Witherspoon et al., 2013) throughout a firm. Evidently, institutional policy acts as both a mediating artifact through which individuals, organizations, and enterprises engage in collaborative, deliberate knowledge creation (Miettinen & Virkkunen, 2005; Paavola & Hakkarainen, 2005) and a knowledge artifact for sharing and transferring knowledge (Abuhimed et al., 2013). However, the relationship between innovation and knowledge creation (Popadiuk & Choo, 2006) suggests that the mediating artifact can be more than a site for knowledge creation, but also a site for institutional innovation. Thus, institutional policy may serve as a mediating artifact for innovation. However, how does an enterprise innovate in institutional policy that crosses normally inviolate organizational boundaries?

Such questions may be examined more clearly in contexts where organizational boundaries are formidable, the role of institutional policy is central, and the stakes are unusually high. One such context is the Department of Energy (DOE) nuclear and nuclear waste facilities. Institutional policy plays a significant role in DOE nuclear safety (Accident Investigation Board, 2015). We investigate not whether nuclear energy and nuclear weapons are sustainable, but how the nuclear enterprise seeks to operate sustainably. Sustainability broadly entails the triple bottom line of the environment, social, and economic domains (ESG) (Birkel & Müller, 2021). Here, we focus on the environmental aspect.

We conducted a qualitative multiple case study, examining a nuclear facility and nuclear waste facility of the DOE. We used several DOE documents comprising hundreds of pages.

Our primary research question is whether institutional review is instrumental or ceremonial. We address this question vis-a-vis the role of institutional policy in horizontally integrating the enterprise. This connection leads us to our related secondary research questions: what is the role of institutional policy and procedure in cross-organizational knowledge sharing and innovation in the contexts of nuclear and nuclear waste facilities of the DOE? Is institutional policy an internal or external institution, and to what extent can it be innovated? Finally, how does institutional change occur in "big science" contexts?

This study lies at the intersection of dynamic capabilities in strategic management, organizational learning (particularly organizational innovation and knowledge creation), and institutional economics. We contribute to theory by synthesizing a portion of institutional economics—namely institutional change—with the theory of dynamic capabilities by identifying instrumental values as encompassing both ordinary and dynamic capabilities. We apply the dynamic capabilities framework of strategic management to public firms and expand the scope of the mediating artifact. Although public administration is the context of this study, the results are also applicable to private administration.

Materials and methods

Institutional policy: definition

Primarily, we address the definition of institutional policy, beginning by distinguishing policies and procedures, while considering both to comprise institutional policy. Policies contain rules for behavior—*what* is done, *what* workers (employees, contractors, managers, and executives) must do—while procedures contain rules for behavior, namely how something is or must be done. Procedures are rules and policies are meta-rules—rules about rules. Some policies direct *what* workers must do at their jobs, while others direct *how* they must behave as employees of the organization. Procedures are rules for *how* the organization implements external laws and regulations or operates in compliance therewith. Thus, we refer to policy systems as comprising both policies

and procedures. Accordingly, various procedure-type documents exist, including operating instructions, work instructions, and responses to lessons learned. These are also procedures, not policies, because they describe how to do a specific task, in accordance with the definition of a procedure. However, per standard practice, we include such procedures in our definition of institutional policy.

Educational researchers have sought to define education policy, and therefore mainly public policy, but the definitions are broad enough to apply to institutional policy. The "traditional view" defines policy as statements that prescribe action in response to a problem or matter in pursuit of a desired goal or outcome (Nudzor, 2009; Stewart, 2014). This definition implicitly refers to power relations, and much of this research lies at the boundary of education and sociology (Bailey, 2013; Ball, 1993, 2015). This problem-solving view is narrow and occasionally, tautological (e.g., policy is a document indicating policy choices). The more recent process model approach broadens the definition, treating policy as a process rather than an end product. We believe this definition conflates policy with the policy process. In a contemporary policy office, the distinction between policy and the policy process is fundamental, similar to the difference between knowledge and knowledge management. This focus on process is not atypical, and much of the academic research on institutional policy is epistemological. Communication researchers, in particular, have studied how both public and institutional policy knowledge is constructed in organizations (Canary, 2010; Canary & McPhee, 2009; Canary et al., 2013; Tessaro, 2022). Much of this work uses structuration theory as an interpretive heuristic (Canary & Tarin, 2017; Giddens, 2014), which is well-placed. Giddens proposed structuration theory to reconcile what he considered an overemphasis on the role of institutional structure on the one hand and human agency on the other. Structuration theory focuses instead on "how collectives of human actors engage in structured social practices" (Canary & Tarin, 2017, p. 1). The processes associated with institutional policy, such as policymaking and policy communication, occur within such collectives and both involve and create structured social practices.

Institutional policy as a site of organizational learning (Innovation and knowledge creation)

Knowledge management processes, especially knowledge generation, diffusion, and storage, enhance firm innovation (Ode & Ayavoo, 2020); however, the actual mechanisms are less clear. This may be due partly to the endless possibilities for implementing these knowledge processes. However, one mechanism most firms have in common is institutional policy.

The relationship between innovation and knowledge creation (Popadiuk & Choo, 2006) enables us to theorize that mediating artifacts for knowledge creation can also serve as sites of, or mediating artifacts for, invention and innovation. Essentially, institutional policy management systems are innovation and knowledge management systems. Institutional policy management systems comprise policy revision processes (including record retention and institutional review), policy format control, policy version control, policy access control, and policy archiving. The policy process is an innovation and knowledge management system concerning policymaking. In a facilities management context, Puddy et al. (2001) suggested policy (and standards) as a knowledge management system, although this is not entirely accurate. Policies and standards comprise innovation and knowledge, and policies are managed within an innovation and knowledge management system. These systems not only store and manage policies, but also enable effective knowledge-sharing and collaboration throughout the policy-making process. By providing functionalities such as policy revision processes, version control, access control, and archiving, institutional policy management systems facilitate the capture, organization, and dissemination of policy-related knowledge within an institution. Thus, these systems not only support policy management, but also serve as essential tools for knowledge management within organizations.

Institutional policy, organizational routines, and dynamic capabilities

Institutional policy (and procedure) in mature organizations and those operating in highly regulated environments is distinct from organizational routine (Nelson & Winter, 1982). Institutional policy is articulated, while organizational routine is tacit. In other words, institutional policy represents the written portion of internal institutions (Voigt, 2005, 2019; see section 2.5 below), while organizational routines are the parts unwritten. Accordingly, institutional policy is written organizational knowledge, and organizational routines are patterns of interactions representing successful solutions to specific problems (Teece et al., 1997, p. 520). However, in less mature organizations and less regulated environments, institutional policy may be partially or wholly unwritten and undeveloped.

Miettinen and Virkkunen (2005) reject the concept of organizational routine, arguing that it does not enable organizational change. Instead, they conceptualize practices as epistemic objects and mediating artifacts that allow for reflection. Reflection is crucial because it is a precursor to change. However, it is not necessary to abandon the concept of the routine, as the theory of dynamic capabilities (Teece, 2007, 2014; Teece et al., 1997) provides a framework for the intentional change of organizational routines. High-flex firms are characterized by a high willingness to change routines and adopt best practices (i.e., to learn) and to reconfigure asset structures to escape unfavorable or outdated path dependencies and affect internal and external transformation (Teece et al., 1997). Such adoption, reconfiguration, and transformation activities are intentional and result from managerial strategic decisions (Teece, 2014). However, the theory does not focus on the routine, but on what the routines and processes undergird. Organizational routines and processes—the unwritten portions of internal institutions—form the micro-foundations of dynamic capabilities. Whereas ordinary capabilities enable a firm to do things right (and are tactical), dynamic capabilities help a firm do the right thing (and are strategic) (Teece, 2014). Dynamic capabilities "can be disaggregated into the capacity (1) to sense and shape opportunities and threats, (2) to seize opportunities, and (3) to maintain competitiveness through enhancing, combining, protecting, and, when necessary, reconfiguring the business enterprise's intangible and tangible assets" (Teece, 2007). The aforementioned adoption, reconfiguration, and transformation activities support dynamic capabilities. The associated managerial processes, which are coordinative, support interorganizational learning (Teece et al., 1997) as a function and outcome of the institutional policy process (writing and revision). Moreover, although dynamic capabilities were developed for businesses, they can be applied to public firms. In that case, dynamic capabilities are directed toward the mission of the public firm.

Though institutional policy and procedure are ideally distinct from organizational routine, we theorize that they might—along with organizational routine—serve as micro-foundations of dynamic capabilities, as long as they enable and support the relevant activities and managerial processes. Some institutional policies and procedures may have their origins in organizational routines that were subsequently memorialized and formalized, and as pointed out, some organizations rely on unwritten institutional policy for various reasons.

Another reason institutional policy and procedure might serve as micro-foundations of dynamic capabilities is that they act as knowledge artifacts for organizational knowledge and as mediating artifacts for organizational knowledge creation, invention, and innovation. As such, particularly as sites of innovation, they support the adoption, reconfiguration, and transformation activities of strategic management.

Institutional economics and organizations

In institutional economics (Voigt, 2005), institutions are "commonly known rules used to structure recurring interactions and coupled with a sanctioning mechanism whose use will be threatened in case of noncompliance." External institutions are rules enforced by the state,

while internal institutions are rules enforced by non-state means (i.e., they are norms and customs). Institutional policy is an internal institution because it is enforced internally; however, the cases presented here show that its content can comprise external institutions. This is especially true in highly regulated industries such as the nuclear industry, particularly in the segment related to nuclear weapon development for the state by the state and its contractors.

Institutional policy is an internal institution that derives partly from rules enforced by the state and partly from organizational learning, resulting in norms and customs. A federal law or regulation can simultaneously be an internal and external institution. It is an internal institution when enforced as institutional policy and an external institution when enforced as law, since only government-authorized law enforcement can enforce law or regulation as law. A non-governmental institution will not innovate policy (what they do) that derives from an external institution, but will innovate procedures (how they do it) for complying with an external institution and policies that are an internal institution.

The content and enforcement of institutional policy have a direct relationship with institutional (organizational, enterprise) success. For policies that are also external institutions, their content and compliance are mandatory under the law. For policies that are internal institutions—i.e., organizational or enterprise norms and values—their content and compliance are choices that create the overall character and quality of the institution (organization, enterprise) and its work product. An institution's success also depends on the quality of its *procedures*, i.e., *how* it implements internal and external institutions. Innovation in internal institutions and procedures is intended to improve the quality of the organization and its work product or at least economize operations without negatively affecting the quality thereof.

Effective innovation in institutional policy and procedure can only occur through cross-organizational knowledge sharing, as institutional policy *qua* institutional (organizational, enterprise) is a matter of cross-organizational activity. The institutional policy process, as specified in its policy of policies, outlines how (and to what extent) that innovation occurs within that institution.

Institutional economics and organizational change

The concept of instrumental values combines dynamic and ordinary capabilities. Like ordinary capabilities, they enable the organization to "do things right." However, like dynamic capabilities and their underlying routines and processes, instrumental values enable the organization to "do the right thing" (Bush, 1987):

"Instrumental values are not, however, fixed or immutable. The problem-solving processes of the community, being dependent on the processes of inquiry and technological change, are inherently dynamic, requiring changes in habits of thought and behavior. As new patterns of behavior are required to accommodate the absorption and diffusion of new technology, instrumentally warranted patterns of behavior must change accordingly; and this requires changes in the instrumental values that correlate such behavior."

This literature review suggests that institutional review is instrumental rather than ceremonial. Concerning organizational learning and dynamic capabilities, institutional review may provide an institution with an opportunity to reflect and learn, to memorialize and develop its unwritten policy into written institutional policy, and to reconfigure to respond to a changing environment.

Methods

To examine these ideas in context, we use the multiple case study method (Eisenhardt, 1989; Stake, 2003; Yin, 2018). We selected two cases involving institutional policy. We chose the DOE nuclear context as it provides a complex technological operating environment, as evidenced by the documents governing it. To span the breadth of the enterprise, we selected one case related to nuclear facilities and a second one concerning nuclear waste facilities. We used government documents as data sources for the cases.

Cases

We present two cases where policy, innovation, and safety are central. In case 1, the National Nuclear Safety Administration (NNSA) innovatively revised the Occurrence Reporting and Processing System (ORPS) policy to improve both efficiency and institutional learning, while the Defense Nuclear Facilities Safety Board objected and invoked the Atomic Energy Act against the Secretary of Energy. In case 2, a flawed DOE contractor policy (procedure) revision process led to packing nuclear waste with a bag of organic kitty litter, resulting in a US $2 billion accident. Case 2 further involved the DOE policy regarding how the NNSA should manage its contractors. In summary, case 1 involved safety in nuclear facilities, and case 2 safety in nuclear waste facilities. Others have previously discussed case 2 (Ialenti, 2021; Klaus, 2019); however, these studies did not and could not exhaust the issues in this complex set of facts. This is evidenced by the voluminous government documents we used as sources: the DOE Inspector General Management Alert (Department of Energy Inspector General, 2014) comprises 14 pages, DOE Phase 1 Accident Investigation Report (DOE OEM Accident Investigation Board, 2015) 302 pages, DOE Phase 2 Accident Investigation Report (Accident Investigation Board, 2015) 394 pages, and the Technical Assessment Team report (Technical Assessment Team, 2015) comprises 277 pages.

Results

Case 1: department of energy occurrence reporting [Safety in nuclear facilities]

Department of Energy Orders (DOE O) are documents that are subsets of DOE Directives. Directives include policies, orders, notices, manuals (currently being phased out), and guides. They comprise a policy-based order applicable to DOE entities and a Contractor Requirements Document, which can be made applicable to DOE contractors by contract. Directives are documents in which the DOE sets, communicates, and institutionalizes policies, requirements, responsibilities, and procedures for departmental elements and contractors.

The DOE Order in this case governs occurrence reporting, or colloquially, accident reporting. The purpose of occurrence reporting is "[t]o notify Department of Energy (DOE) personnel, including National Nuclear Security Administration (NNSA) personnel, about events that could adversely affect the health and safety of the public or the workers, the environment, DOE missions, or the credibility of the Department" (DOE O 232.2A, *sec*. 1). From its issuance in 1990 through August 1, 2018, DOE received 72,000 occurrence reports (Ruocco, 2018a).

DOE engaged in continuous quality improvement over the occurrence reporting Order, as evidenced by numerous revisions from 1990 to 2016. DOE-wide occurrence reporting first emerged in DOE O 5000.3A, *Occurrence Reporting and Processing of Operations Information*, issued in May 1990. DOE O 5000.3A was superseded in 1993 (DOE O 5000.3B Chg 1, *Occurrence Reporting and Processing of Operations Information*), 1995 (DOE O 232.1, *Occurrence Reporting*), 1997 (DOE O 232.1A, *Occurrence Reporting and Processing of Operations Information*), 2003 (DOE O 231.1A, *Environment, Safety, and Health Reporting*), 2011 (DOE O 232.2, *Occurrence Reporting and Processing of Operations Information*), and 2017 (DOE O 232.2A, *Occurrence Reporting and Processing of Operations Information*). Only two of these preceding versions were considered significant revisions, namely DOE O 5000.3B issued in 2003 and DOE O 232.2A in 2017.

In 2016, DOE introduced a pilot process "to revise DOE orders using diverse team members (Federal and contractors) that hold leadership

positions in the communities that they represent" (Ruocco, 2018b). This team structure and process were formalized to some extent the following year in DOE O 251.1D, *Departmental Directives Program*, as an Integrated Project Team (IPT). DOE tasked the 2016 IPT with evaluating DOE Manual 232.1–2, *Occurrence Reporting and Processing of Operations Information*. Under Appendix B of DOE O 251.1D, membership of an IPT must comprise all affected groups including the Offices of Primary Interest, DOE headquarters program and staff organizations, DOE field/-site offices, and laboratories. In this pilot, IPT members were Federal and contractors comprising senior-level management, subject matter experts, and occurrence reporting practitioners from across the DOE. The 2016 pilot IPT for 232.2 was instructed to (Perry, 2017, Enclosure 1, page 1):

- "Develop and present the 'Commander's Intent' for DOE O 232.2 by clarifying the purpose of DOE's event reporting in terms of significance and the value of lessons learned based on a risk-informed strategy.
- Examine how the DOE Lessons Learned program and site-level Contractor Assurance Systems could be leveraged to support DOE corporate learning and improvement. In addition, the IPT was asked to determine the need and value in reporting/learning of occurrences of lower significance that may be a precursor or near-miss to a more significant event and how this data can include corporate learning and lessons learned for DOE.
- Identify how tailoring of the Order requirements at the Program Secretarial Office (PSO) level could be used to balance critical reporting needs specific to Mission Areas while providing flexibility to other missions of the Department."

The IPT's innovations occur within supervised, measured limits. DOE O 251.1D AdminChg 1 Appendix B sets out the IPT Directives Process, which states, in part (page B-3):

- "IPT members must engage stakeholders throughout the IPT process and provide IPT documents to stakeholders, when appropriate. IPT members must document these communications, and provide the tracking sheet to the DRB, the IPT Co-Chairs, and/or the Departmental Directives Program when requested. These stakeholders must include, but are not limited to: (1) affected program and site offices; (2) Field Management Council representatives, as requested; (3) National Laboratory Directors Council representatives, upon DRB request; (4) the appropriate DOE or NNSA counsel; (5) the Office of Primary Interest responsible for any DOE Technical Standard being invoked in the directive; (6) the Office of Policy, Office of Acquisition Management (MA-61); (7) Field Contracting Officers; (8) CTAs, when appropriate; and (9) the DOE Departmental Representative to the DNFSB [Defense Nuclear Facilities Safety Board] for all directives of interest to the DNFSB."

Based on two in-person workshops and conference calls to solicit comments, the 2016 IPT recommended comprehensive changes to the DOE occurrence reporting Order (Secretary of Energy, 2017, Enclosure 1, page 1):

- "Redefinition of significance categorization levels for reporting to enhance efficiency of reporting.
- Modification of the time to report events commensurate with risk.
- Reduction in the overall complexity of event reporting [reducing a six-tier system for categorizing occurrence reporting criteria (Operational Emergency, Significance Categories 1–4, and R [recurring]) to a three-tier system (High Level, Low Level, and Informational Level Reports)].
- Better alignment with other required events reporting.
- Clarification of the roles and responsibilities of the Order in accordance with Departmental policy as stated in the Secretary of Energy's memorandum entitled, *Department of Energy Roles/Responsibilities -National Laboratories,* issued on October 20, 2016."

The "[m]ajor focus of the revision" was reportedly "to return the ORPS order to its original role of event notification" and to recognize "the important oversight and follow-up role of DOE Field Offices, as well as the organizational learning value of the information contained in the ORPS database" (Ruocco, 2018b). DOE O 232.2A underwent the standard DOE O review and comment cycle and was approved and issued.

However, the Defense Nuclear Facilities Safety Board (DNFSB), who were members of the IPT, disagreed with the innovations in the proposed revision (Perry, 2017). The DNFSB was created by section 311 of the Atomic Energy Act, 42 U.S.C. § 2286(a). Its members comprise five citizens of the United States who are respected experts in nuclear safety. According to 42 U.S.C. § 2286a(a), "The mission of the Board shall be to provide independent analysis, advice, and recommendations to the Secretary of Energy to inform the Secretary, in the role of the Secretary as operator and regulator of the defense nuclear facilities of the Department of Energy, in providing adequate protection of public health and safety at such defense nuclear facilities, including with respect to the health and safety of employees and contractors at such facilities."

The technical staff of the DNFSB communicated some concerns to the IPT during the review and comment cycle of draft DOE O 232.2A. IPT and DOE senior management accepted all but seven of DNFSB's comments on the draft Order.

DNFSB's letter dated May 10, 2017, invoking 42 USC § 2286b(d), *Powers of [DNFSB] Board*, states that "the information which the Board may require the Secretary of Energy to report under this subsection may include any information … designated as safeguards information…" The letter was concerned with the deletion in DOE O 232.2A of the requirement to report a Potentially Inadequate Safety Analysis (PISA). A background thereof is furnished below.

Every DOE nuclear facility has a safety basis. According to 10 CFR § 830.3(a) (10 CFR § 830, *Nuclear Safety Management* governs the safety of DOE nuclear facilities—reactors and nonreactor nuclear facilities where an activity is conducted for or on behalf of DOE—to the exclusion of nuclear waste facilities, which are governed by the Nuclear Waste Policy Act of 1982, 42 U.S.C. §10,101 et seq.), a safety basis is the documented safety analysis and hazard controls that provide reasonable assurance that a DOE nuclear facility can be operated safely in a manner that adequately protects workers, the public, and the environment. The Unreviewed Safety Question (USQ) process is the mechanism for keeping a safety basis current. This process comprises reviewing potential USQs, reporting them to the DOE, and obtaining its approval before taking any action that involves a USQ. Again, according to the CFR, a USQ means a situation where:

(1) The probability of the occurrence or consequences of an accident or the malfunction of equipment important to safety previously evaluated in the documented safety analysis could be increased.
(2) The possibility of an accident or malfunction of a type different from any evaluated previously in the documented safety analysis could be created; or
(3) The documented safety analysis may not be bounding or may be otherwise inadequate.

The third criterion above is the PISA, i.e., the identification of a PISA triggers a USQ determination, as described in DOE G 424.1–1C, Implementation Guide for Use in Addressing Unreviewed Safety Question Requirements.

In DOE O 232.2A, the DOE deleted the requirement to report PISAs in the ORPS. In their May 10, 2017 letter, the DNFSB objected and stated that the DOE would need to establish another mechanism to meet the notification requirement contained in 10 CFR § 830.

In his October 11, 2017 response (Secretary of Energy, 2017), the Secretary of Energy stated that the PISA reporting requirement in 10

CFR § 830 does not specify that the ORPS be used as a notification conduit. Moreover, a PISA was not yet determined to be an "event" under the ORPS framework. The procedure under 10 CFR § 830 was as follows (Secretary of Energy, 2017, Enclosure 1, page 1):

"[o]nce a PISA has been declared, 10 CFR Part 830 also requires that the facility personnel perform the unreviewed safety question determination (USQD) process. If the USQD is positive, then the PISA and the USQD results are reported into ORPS to notify DOE of the safety analysis inadequacy."

The DNFSB also objected to the alleged downgrade by DOE O 232.2A of positive USQ reporting in the ORPS. DOE O 232.2A effectively reduced the threat level of positive USQs from Significance Category 2 (i.e., High) to Informational.

However, in his October 11, 2017 response (Secretary of Energy, 2017), the Secretary of Energy also stated that PISAs and USQs were governed by 10 CFR § 830 and that the outcome of the PISA and USQ process would not be downgraded by DOE O 232.2A. Rather, the recategorization of a positive USQ determination report as informational more accurately reflects the information that a USQ ORPS report would contain, "while allowing [i.e., without interfering with] the established USQ processes and procedures at a particular site to work as intended."

Other changes proposed by the IPT were similarly met with objections from the DNFSB. For example, the IPT changed the reporting requirement for Low-Level events. Instead of a Written Notification Report in 2 days and Final Report in 45, the IPT recommended a single report ("Written Notification/Final Report") be issued within 10 business days. The DNFSB objected with the "parade of horribles" that "10 business days could be more than 2 weeks at some defense nuclear facilities" and that "the allowance of only 10 days for the single report greatly restricts the time allowed for developing and reporting on any investigative information for these occurrences, including causal analysis, corrective actions, and lessons learned." To this, the Secretary of Energy responded that "this time allotment will allow for event response" (vis-à-vis spending those first two days writing a report) and that "Informational and Low Level Reports may be updated at any time."

Case 2: drum 68660 [Safety in nuclear waste facilities]

On February 14, 2014, Drum 68660 burst open. Packed with nitrate salt residues from plutonium processing in the 1970s and 1980s at Los Alamos National Laboratory (LANL), it had been placed half a mile deep in a salt cavern that was part of the DOE's Waste Isolation Pilot Plant (WIPP) operated by Nuclear Waste Partnership LLC (NWS). Located in southern New Mexico near Carlsbad, WIPP was designed to provide permanent underground storage for defense-related transuranic (TRU) waste and transuranic mixed waste. WIPP comprised panels of rooms with rows and columns. This drum was located in Panel 7, Room 7, Row 16, Column 4, meaning it was surrounded by numerous other drums. Drum 68660 had been packaged at the LANL Waste Characterization, Reduction, and Repackaging (WCRR) Facility by the LANL contractor, Los Alamos National Security LLC (LANS) and LANS contractor Energy Solutions (Technical Assessment Team, 2015). The DOE Technical Assessment Team investigating the incident assessed the WCRR waste (re)packaging procedures as providing limited and conflicting documentation, noting that the goal of the operation was to produce drums suitable for shipment to the salt caverns (Technical Assessment Team, 2015). At the time of the breach, no personnel were present in the storage area, and while no personnel received external contamination, 21 individuals received low-level internal contamination and trace amounts of radioactive material were detected off-site (Technical Assessment Team, 2015).

Initial indications of the drum breach came from an alarm triggered by a Continuous Air Monitor. Isotopic ratios of the air samples were compared with those calculated from records of the waste drum contents, leading to the identification of candidate drums. Photographic evidence subsequently confirmed the identity of the breached waste drum. On May 1, 2014, both the Carlsbad Field Office and LANL declared a PISA regarding the potential for untreated nitrate salt-bearing waste being emplaced. The PISAs were not specifically declared for WIPP, but for the general concern regarding the dangers of storing untreated nitrate salts. This is because PISAs are governed by 10 CFR § 830, which does not apply to nuclear waste repositories.

The incident triggered a DOE Inspector General Management Alert (Department of Energy Inspector General, 2014) in which the DOE identified deficiencies in the LANL procedure revision process. The DOE had instructed LANL to use a May 2012 technical paper by the LANL - Carlsbad Operations Difficult Waste Team (DWT). This paper stated that "Kitty Litter/Zeolite clay" was an acceptable absorbent for packing nitrate salts for disposal at WIPP. Nitrate salts can ignite if not stabilized before drying out, and the silicate minerals in inorganic kitty litter effectively stabilize urea and ammonia as well as nitrates (Conca, 2014). The writer of the LANL procedure claimed that he was not provided with either the May 2012 technical paper or LANL decision letter adopting it; instead, he relied on handwritten notes calling for using an organic absorbent. Energy Solutions later claimed that in a meeting between LANL and Energy Solutions, LANL had verbally approved the use of "organic" kitty litter.

According to the Inspector General's Management Alert (Department of Energy Inspector General, 2014: 4), "LANL's procedure revision process did not ensure that all of the appropriate organizations reviewed changes to the Procedure. According to LANL's directive for Environmental Programs Procedure Preparation, Revision, Review, Approval, and Use, responsible line managers and document owners are to assign SMEs and designate the required review authorities. However, LANL did not require that an SME review the Procedure change for chemical reactivity. Further, LANL's Environmental organization was not included in the procedure revision process to review documents that described the handling and processing of hazardous chemicals and waste."

The Inspector General also noted deficiencies in the institutional review process (Department of Energy Inspector General, 2014: 4): "Under the CCP [DOE's Central Characterization Project]/LANL Interface Document, LANL has primary responsibility to notify CCP when there are changes to policies, processes or procedures that may affect CCP characterization activities or operations. However, the Interface Document does not require a response from CCP. According to LANL officials, while the CCP was made aware of the changes to the Procedure, including the use of the 'organic' kitty litter to process nitrate salt drums, no concerns were identified by the CCP."

A member of the DOE Technical Assessment Team investigating the incident later stated that nearly 700 drums at WIPP had similar contents repackaged with organic kitty litter (these were subsequently isolated and monitored). Until recently, it was unclear why only Drum 68660 failed (Morrisson, 2017). The thermal runaway of Drum 68660 has now been modeled, and the hypothesis is that the only unique attribute of Drum 68660 was that its vent may have been restricted (Hobbs et al., 2022).

The Los Angeles Times reported that the drum breach contaminated 35 % of the underground area of WIPP (Vartabedian, 2016). The DOE Phase 2 Accident Investigation Report (Accident Investigation Board, 2015) presented a more measured assessment, stating that only alpha contamination was detected (general surface alpha contamination levels in Room 7 of 8000–40,000 dpm [disintegrations per minute], Room 6 of 10,000–20,000 dpm, and Room 1 of 6000–28,000 dpm).

The Los Angeles Times also reported that the direct cost of the cleanup totaled US$640 million (Vartabedian, 2016). The DOE disputed this figure, reporting a total cost of US$244 million, plus US$270–398 million for ventilation system upgrades that were only partly due to the event (Mosher, 2016). *The Times* further asserted that WIPP would need an additional 7 years to recover from the backlog, which at an estimated US$200 million per year, totals US$1.4 billion. In fact, WIPP resumed operations on June 2, 2018 after an estimated direct cost of US$242

million (WNN, 2018).

The DOE Phase 1 Accident Investigation Report (Accident Investigation Board, 2014: ES-6) identified the root cause (causal factors that if corrected, would prevent the recurrence of the same or similar accidents) as "NWP's and CBFO's [Carlsbad DOE Field Office] management failure to fully understand, characterize, and control the radiological hazard. The cumulative effect of inadequacies in ventilation system design and operability compounded by the degradation of key safety management programs and safety culture resulted in the release of radioactive material from the underground to the environment, and the delayed/ineffective recognition and response to the release." The Report further identified eight contributing causes (events or conditions that collectively, with other causes, increased the likelihood or severity of an accident but that individually did not cause the accident):

- Implementation of the NWP Conduct of Operations Program was not fully compliant with DOE O 422.1, *Conduct of Operations*.
- NWP did not have an effective Radiation Protection Program per the 10 Code of Federal Regulations (CFR) 835, Occupational Radiation Protection.
- NWP did not have an effective maintenance program.
- NWP did not have an effective Nuclear Safety Program per 10 CFR 830 Subpart B, Safety Basis Requirements. The conservatism in the Documented Safety Analysis (DSA) hazard/accident analysis and corresponding Technical Safety Requirement (TSR) controls had decreased over time.
- NWP's implementation of DOE O 151.1C, *Comprehensive Emergency Management System*, was ineffective.
- The site safety culture did not fully embrace and implement the principles of DOE Guide (G) 450.4–1C, *Integrated Safety Management Guide.* There was a lack of a questioning attitude, reluctance to raise and document issues, and an acceptance and normalization of degraded equipment and conditions. The execution of the NWP Contractor Assurance System (CAS) per DOE O 226.1B, *Implementation of Department of Energy Oversight Policy,* was ineffective. The execution of the CAS did not identify precursors to this event or the unacceptable conditions and behaviors documented in this Phase 1 report.
- CBFO oversight per DOE O 226.1B was ineffectively executed. CBFO failed to establish and implement adequate line management oversight programs and processes and hold personnel accountable.
- Oversight of DOE Headquarters (HQ) line management was ineffective. DOE HQ failed to ensure that CBFO was held accountable for correcting repeatedly identified issues involving radiological protection, nuclear safety, Integrated Safety Management (ISM), maintenance, emergency management, work planning, and control and oversight.

According to DOE O 225.1B, *Accident Investigations*, members of an Accident Investigation Board must include a DOE Accident Investigator. Furthermore, all members of the Accident Investigation Board must be DOE Federal employees with subject matter expertise in areas related to the accident, including knowledge of the Department's ISM directives. In addition, both the Chairperson and DOE Accident Investigator must be selected from a duty station different from the accident location. The Phase 1 Accident Investigation Board included members from the DOE Office of Environmental Management (DOE-EM), DOE-EM Office of Environmental Management Consolidated Business Center, DOE-Idaho, Mine Safety and Health Administration, staff of the Chief of Nuclear Safety, Oak Ridge Laboratory Office of Environmental Management, Idaho Field Office, Carlsbad Field Office, and Richland Operations Office.

The DOE Phase 2 Accident Investigation Report (Accident Investigation Board, 2015: ES-2) attributed the event to the procedure itself rather than to the procedure development process, stating, "[i]f LANL had adequately developed and implemented repackaging and treatment procedures that incorporated suitable hazard controls and included a rigorous review and approval process, the release would have been preventable."

The DOE Phase 2 Accident Investigation Board included members from the DOE-Idaho, NNSA, DOE OEM, and Oak Ridge Laboratory Office of Environmental Management.

The Phase 2 Report stated that the NNSA Los Alamos Field Office (NALA) failed to provide the required oversight over LANL (Accident Investigation Board, 2015):

"DOE O 226.1B requires that each DOE field element establish an effective contractor oversight program. The Board identified that NALA relies substantially on the DOE Facility Representatives to provide contractor operational oversight. While it is the primary job of the DOE Facility Representatives to provide contractor oversight, there was no identification of a DOE SME in the area of waste remediation or CCP also performing contractor operational oversight. During interviews with the Facility Representatives and review of the NA-LA organizational chart, there was no identification of a DOE expert in this area for the Facility Representatives to reach out to for support."

The Phase 2 Report also stated that the LANL CAS was not in compliance with DOE O 226.1B, as it did not identify error precursors (unfavorable conditions that increase the probability of error during a specific action and create error-likely situations) to the event.

Discussion

We now consider each case separately before identifying and discussing cross-case themes.

DOE O 232.2A

In the 2016 pilot process, the DOE used the policy revision process as a means and the institutional policy as a venue for encouraging institutional innovation. Specifically, the policy process was formal and included institutional review by the IPT, including its member, the DNFSB. The formation and deployment of the IPT represented an instance of organizational learning and innovation by the DOE, evidencing an instrumental goal of engaging diverse stakeholders. The DOE directed the IPT to engage in several outcome-oriented revisions to DOE 232.2, driven partly by the DOE's commitment to continuous quality improvement (Table 1). The DNFSB objected to numerous revisions, either due to their prioritization of traditional practices or as a matter of precaution. Reportedly, the DOE considered many of the then-current reporting practices as formalities (Table 1).

The pilot process did not require the IPT to engage in radical innovation. The IPT charter specified neither radical nor incremental

Table 1
Case Study 1: DOE Occurrence Reporting (Safety in Nuclear Facilities).

Category	Instrumental Evidence
Formation of the Integrated Project Team (IPT)	Establishment of the IPT to engage diverse stakeholders for policy revision
Outcome-Oriented Revisions	Redefinition of significance of categorization levels and streamlining of reporting processes; modification of the time to report events commensurate with risk; reduction in the overall complexity of event reporting; better alignment with other required event reporting; clarification of the roles and responsibilities of the Order per Departmental policy
Continuous Quality Improvement	Ongoing revisions driven by feedback and lessons learned from past incidents
Category	**Ceremonial Evidence**
Defense Nuclear Facilities Safety Board (DNFSB) Objections	The DNFSB objected to changes, prioritizing traditional practices.
Prior Practices as Formalities	Previous occurrence reporting practices served mainly to meet compliance requirements.

innovation (e.g., Norman & Verganti, 2014). Rather, it was to engage in organizational learning, effectively extending that of the DOE that resulted in the formation of the IPT. Since their work product was an update to the Directive DOE O 232.2A, it served as a mediating artifact for knowledge and innovation. As the IPT was constrained by the pilot process and later by the Directive DOE O 251.1D, its activities were supervised and measured.

We view the 2016 IPT-recommended changes to the DOE occurrence reporting Order (Secretary of Energy, 2017, Enclosure 1, page 1) as representing a rejection of ceremonial values by the IPT and DOE from an institutional change theory perspective (Bush, 1987). The DNFSB objected that PISAs were no longer to be reported in the ORPS and that USQs were now reported in the ORPS in the Informational significance category. However, there was never any requirement to report PISAs in the ORPS or USQs at significance categories higher than informational, indicating that the previous practices were ceremonial. These previous practices exemplified ceremonial "encapsulation" of instrumental reports. The explanation or interpretation of this dispute may be that the DNFSB did not understand 10 CFR § 830 or that it reasonably differed in its interpretation of the requirements. However, equally, the members of the DNFSB may have felt their power was being undermined and that they were being sidelined by the DOE: they, the DNFSB, were a statutory authority, whereas the IPT was merely a discretionary pilot project. The IPT was being consulted, but not the DNFSB. The DNFSB responded to the IPT by reasserting the existing ceremonial encapsulations. In short, the IPT innovated, and the DNFSB responded as a potential check on the IPT's innovations. To add insult to injury, the DNFSB's conservative recommendations to the DOE were rejected, prompting them to seek to maintain the distinction of their privileged status through an appeal. However, the positions adopted by the DNFSB regarding the proposed changes to DOE O 232.2A lacked support in 10 CFR § 830 and in practice.

The DOE demonstrated dynamic capabilities when it innovated, developed, and used the IPT. The DOE decision memorandum to revise the Order stated, "Revisions to this Order will help the Department better accomplish its mission by improving consistency in implementation, reducing duplicative reporting, increasing quality of reporting, and clarifying roles and responsibilities." Here, the DOE sought to "maintain competitiveness through enhancing, combining, protecting, and, when necessary, reconfiguring the business enterprise's intangible and tangible assets" (Teece, 2007) through the adoption, reconfiguration, and transformation of new routines and processes, i.e., the pilot of the IPT and adoption of its specific recommendations.

Drum 68660

The procedure revision that resulted in the use of organic versus inorganic kitty litter did not undergo a formal policy process. Notably, it did not undergo institutional review, and the procedure writer's work was unchecked by subject matter experts as required. Where institutional review was necessary, it was one-sided, as in the instance of the CCP/LANL interface, where the CCP was not required to comment on LANL's proposed procedure changes. Though not explicitly stated, the analyses possibly resulted in corrective actions—organizational learning—to prevent similar events. This is suggested by the vital role of institutional review in the subsequent Phases 1 and 2 Accident Investigation Boards. DOE O 225.1B, *Accident Investigations*, ensures broad and expert review. Some of these subject matter experts were required to come from outside the affected and impacted organization. This evidences a change in perspective regarding the value of institutional review, viewing it as instrumental rather than ceremonial. The subsequent comprehensive investigation and root cause analysis, culminating in a recommendation for enhanced oversight, demonstrated DOE's instrumental values (Table 2). Conversely, the contractor engaged in what turned out to be an inadequate review with informal processes (Table 2).

Table 2
Case Study 2: Drum 68660 (Safety in Nuclear Waste Facilities).

Category	Instrumental Evidence
Comprehensive Investigation	Detailed investigation following the breach identified procedural failures and led to actionable insights.
Recommendation for Enhanced Oversight	Recommendations for improved oversight and review processes emerged from the investigation.
Root Cause Analysis	The accident investigation identified root causes and contributing factors.
Category	**Ceremonial Evidence**
Inadequate Review Process	Effective engagement of subject matter experts was lacking in the procedure revision process.
Prior Compliance as Ceremonial	Previous procedural review processes were merely formalities designed to meet regulatory requirements.

Cross-Case themes

In both cases, institutional policy and procedure played a significant role in cross-organizational knowledge sharing and innovation. They provided employees with a site for supervised, measured collaboration for knowledge sharing, organizational knowledge construction, and organizational innovation, all of which are instrumental rather than ceremonial.

More than motive, innovation in institutional policy requires means and opportunity. Institutional review played a vital role in both cases, providing the means and opportunity for knowledge sharing and communal innovation. In the DOE O 232.2A case, the then-pilot IPT Directives Process, later formalized in DOE O 251.1D, enabled institutional review during the revision drafting process. In contrast, in the Drum 68660 case, the accident was attributed to the lack of institutional review, while the subsequent accident investigation boards were cross- and extra-organizational. These observations highlight the crucial role of institutional review in enterprise-wide knowledge and innovation. This is significant because a firm's organizational structures can discourage or prevent cross-organizational knowledge sharing and innovation. Within a firm, chains of command; lines of managerial authority and responsibility; and statutory, regulatory, and contractual requirements can stifle intra-firm cross-organizational knowledge sharing and innovation. The presence of a mediating artifact, along with the license to contribute to it, provides the means and opportunity to share knowledge and innovate communally.

Institutional review of institutional policy also provided a shared plan for the organizations. This shared plan allowed for supervised, measured, and coordinated efforts across boundaries of authority and responsibility. Here, institutional review provided a supervised, measured way to horizontally integrate the organizations.

In the DOE O 232.2A case, the DOE showed no deference to ceremonial values. It innovated with the appointment of a non-statutory committee of stakeholders (the IPT), bypassing a statutory body (the DNFSB). It implemented IPT's recommendations such as reducing duplicative reporting against the wishes of the DNFSB. In the Drum 68660 case, LANL similarly showed no deference to ceremonial values, but rather an excess thereof. LANL, under the leadership of LANS, according to the Inspector General, did not have an effective or sufficient institutional review process for changes to policy and procedure. While some reviews may be arguably excessive or pro forma, the cost of an ineffective and insufficient institutional review process in this case was hundreds of millions of US dollars.

Avoiding decontextualization

Jackson et al. (2019) argued that reductionism decontextualizes by focusing on individual behavior, that grand theory decontextualizes by focusing on ahistorical abstraction, and that both approaches decontextualize by neglecting the linkages between the micro level (actors)

and macro level (time, space, and numbers). In these cases, we presented the micro-level view. We now provide the macro-level view and investigate potential micro-macro linkages.

Macro-Level context

A relevant macro-level phenomenon involves differing institutional logic, in case 1 possessed by the DOE and in contrast, the DNFSB, and in case 2 by the DOE and in contrast, LANS. The institutional logics approach theorizes that "organizations may be permeated by multiple competing or contradictory institutional logics given by wider societal context" (Jackson et al., 2019). We return to the phenomenon of differing institutional logic in the micro-macro linkages section 4.4.2.

Accountability is another macro-level phenomenon. In the abstract, we refer to the accountability of an agent to its principal, or of a principal to whomever it reports. The NNSA is accountable to the DOE, and both the NNSA and DOE are accountable to Congress. The LANL Director must hold a physics Ph.D. because every year, he must testify to Congress on the readiness of the nation's nuclear stockpile. Under DOE Order 226.1B, *Implementation of Department of Energy Oversight Policy*, the NNSA is accountable to its parent organization, the DOE, for the supervision of its management and operations (M&O) contractors. In addition, the Objective of DOE Order 232.2A refers explicitly to the credibility of the DOE. One strand of principal-agent theory (Laffont & Martimort, 2009) relates to the credibility of the principal, which does not arise from the performance of the agent, but r from the principal's "credible commitment" (to the mission, to democracy, etc.) as evidenced by its delegation to an (independent) agent (Knott & Miller, 2006; Mueller & Pereira, 2020).

The United States federal government contracts with industrial entities that manage and operate federally funded research and development centers (FFRDCs) such as the United States National Laboratories. In these cases, the national laboratories are the FFRDCs, and the federal government is represented by the DOE/NNSA. In its most abstract form, in these cases, the DOE or its subagency NNSA is the owner, the industrial entity the principal, and the laboratory staff collectively serve as the agent. This owner-principal-agent approach to national laboratory management emerged not out of ideology or theory, but because of the exigencies of war: the first three national laboratories, at Los Alamos (New Mexico), Hanford (Washington), and Oak Ridge (Tennessee), were established for war-related nuclear research and development. The concept was so successful that 17 national laboratories now operate under the DOE.

However, long-standing opinions hold that there is a "broken trust" between the DOE and national laboratories, to the extent that new governance models and new missions for these laboratories have been suggested (Commission to Review the Effectiveness of the National Energy Laboratories, 2015: iv, 12; Curtis et al., 1997). In fact, concern over the management of the weapons mission led Congress to establish the NNSA within the DOE in the 1990s (Commission to Review the Effectiveness of the National Energy Laboratories, 2015). These new suggested governance models included managing the laboratories through a government-owned corporation (SEAB, 1995). The new missions included industrial competitiveness and industrial ecology (Curtis et al., 1997). However, these opinions and suggestions resulted in a mountain of incompatible recommendations and expectations for action (Curtis et al., 1997), leading to scope creep. Even the NNSA broadened the mission of the laboratories from nuclear weapons to national security, prompting a recommendation from the Commission that "Congress recognize that maintenance of the stockpile remains the core mission of the Labs" (Commission to Review the Effectiveness of the National Energy Laboratories, 2015).

DOE began competing for the national laboratory M&O contracts in 1995. In 1997, the DOE changed its procurement regulations to conform to the Competition in Contracting Act of 1984 (CICA). The DOE competes for a national laboratory contracts if the current contractor's performance is considered unsatisfactory, if the potential for improved cost or technical performance through competition is identified, if viable competitive alternatives are determined to exist in the marketplace, and/or if the changing focus of the laboratory mission has stimulated interest in considering competitive procurements. We return to this feature in the macro context when discussing the micro-macro linkages in the next section.

Micro-Macro linkages

We first apply the macro theme of differing institutional logic to the cases. In case 1, the DOE imposed an innovation agenda or ecosystem through the IPT, resulting in a change or recursive cultural evolution in institutional logic from the safety and security of redundancy to the efficiency of innovation. This exemplifies the historically contingent, non-deterministic nature of the context. The DNFSB did not approve of the innovation and its institutional logic differed from that of the DOE. Either the DNFSB wanted to retain its ceremonial power—it had objected to several provisions in the draft DOE O 232.2A, seven of which were rejected, which must have been perceived as more than an insult—or it genuinely valued the security of the older, more precautionary reporting requirements such as using the ORPS as the notification conduit for PISAs or predetermining events as PISAs or USQs as high-level safety concerns. In case 2, the DOE maintained the institutional logic that institutional review is instrumental, whereas LANS operated under the institutional logic that it is ceremonial. Both cases establish the principle that an owner must align its principal's institutional logic (e.g., its values) with its own, or that a principal must align its agent's institutional logic with its own. This principle does not change with context.

We now apply the macro theme of organizational accountability to the cases. For both cases 1 and 2, we observe that the DOE most recently competed for the LANL M&O contract in 2007, the SNL M&O contract in 2017, and the LANL contract in 2018. Regarding LANL, the 2014 kitty litter event was cited by the NNSA as a reason for competing for the LANL M&O contract (General Accounting Office, 2020). This explicitly establishes the micro-macro level linkage for case 2. However, the NNSA also cited the 2015 Electrical Arc Flash Event (Williams, 2016) and suspension of operations at the PF-4 facility from June 2013 to September 2016 for safety and operational issues (General Accounting Office, 2020). These events followed the 2011 nuclear criticality violation (Malone, 2017). Regarding SNL, the DOE's Office of Inspector General concluded that the then-contractor Lockheed Martin wrongfully used federal funds provided to Sandia for lab operations to lobby for a no-bid contract extension it received (Friedman, 2014). Regarding LANL, reportedly, "UC had operated both Los Alamos and Lawrence Livermore labs since their inception, but pressure to open the contracts to competitive bidding began a few years ago due to congressional displeasure over security breaches and operational problems at the labs" (Chemical & Engineering News, 2007). These facts are also relevant to case 1, with its themes of continuous quality improvement and elimination of redundancy and inefficiency. The incidents stated in the preceding paragraph are detrimental to credibility and mission readiness. The purposes of the abovementioned revisions to DOE 232.2A are consistent with the goal of operational improvement.

We now interpret these linkages through the metatheory of critical realism (Bhaskar, 2014) and its progeny methodology of retroduction (Belfrage & Hauf, 2017). Critical realism is characterized by ontological realism (there exists a reality independent of our minds), epistemological relativism (our knowledge of reality is fallible), and judgmental realism (but we have the capacity to assess which explanations are more credible; Danermark et al., 2019; Rybczynska-Bunt et al., 2021). Along these lines, "retroduction is the mode of inference in which events are explained by postulating mechanisms which are capable of producing them" (Sayer, 1992). Retroduction proceeds by asking what must be true for events to be possible. What must be true for a principal to feel they could eliminate precautionary redundancies in their policy process? They must have believed that these redundancies were ceremonial.

What must be true for a policy writer to feel he could rely on handwritten notes? Or what must be true for a contractor to give verbal approval to its subcontractor for a momentous procedural change? They must have believed that formal or institutional review was ceremonial. Both these findings illuminate an underlying culture that exhibits disdain for organizational learning. We summarize this in Table 3.

Conclusion

Before returning to our research question, it is worthwhile to discuss the differing orientations of instrumental and ceremonial institutional review vis-a-vis key characteristics (Table 3). Rather than repeating the content of Table 3, we observe that instrumental institutional review focuses on achieving meaningful outcomes and improvements. It involves applying oneself to the task and engaging others. It requires a commitment to the success of the enterprise. Instrumental institutional review is a topos, in which the observer's logic is integral to what he is observing, such that the physical unfolding of the enterprise is identical to the process of reflecting thereon. Instrumental institutional review does more than govern the enterprise. It how the enterprise learns about and creates itself.

Long-Term implications

Recursion within an innovation ecosystem played a theme in these cases in a myriad of ways, from the recursive nature of institutional review to cultural evolution in the change of institutional logic that occurred with the DOE's imposition of an innovation agenda or ecosystem, to the self-referential nature of the value judgments of labeling something as instrumental or ceremonial. Knowledge construction occurs through reflection. An organization constructs organizational knowledge through self-reflection. Institutional review horizontally integrates the enterprise by enabling the organization to construct organizational knowledge itself and of its context. Institutional review is a micro-foundation of dynamic capabilities because it enables an institution to change rapidly. Institutional policy is organizational knowledge and innovation, but a chasm lies between knowledge and wisdom. The best institutional policy aspires to be organizational wisdom, and the recursion of institutional review enables the organization to distill that knowledge into wisdom. The prescription is that an organization should professionalize its policy system with policy specialists and a structured policy process.

Table 3
Key Characteristics of Instrumental and Ceremonial Institutional Reviews.

Feature	Instrumental Institutional Reviews	Ceremonial Institutional Reviews
Purpose	Focus on achieving meaningful outcomes and improvements	Primarily for compliance and fulfilling formalities; maintaining power imbalances
Stakeholder Engagement	Involves diverse stakeholders including subject matter experts	Limited involvement, often excluding key stakeholders
Decision-Making Basis	Data-driven and evidence-based evaluations	Based solely on tradition or superficial compliance
Focus	Emphasis on process effectiveness and operational improvements	Emphasis on following established procedures disregarding opportunities for innovation
Adaptability	Encourages questioning and revising existing practices	Reinforces the status quo and resists necessary changes
Impact on Policy	Leads to meaningful changes in policies and procedures	Results in cosmetic or no substantive changes
Accountability	Clearly defined roles and responsibilities for implementation	Undefined responsibilities, leading to lack of ownership
Monitoring Mechanisms	Establishes systems to track effectiveness and compliance	Lacks mechanisms for evaluating impact or compliance
Communication	Effective dissemination of findings and recommendations	Poor communication, limiting stakeholder understanding
Feedback Mechanisms	Facilitates ongoing feedback and iterative improvements	Limited opportunities for feedback, leading to disengagement

Research questions

Reverting to our main research question, we find that institutional review of institutional policy formation and revision is instrumental rather than ceremonial. As the DOE noted, institutional policy is not self-executing (Accident Investigation Board, 2014). More fundamentally, it is not self-updating or self-reviewing. The DOE Directives provide opportunities for organizational learning, knowledge construction, and innovation. While the existence of an enterprise-wide institutional policy office is essential for horizontally integrating the enterprise, it is not a sufficient condition. It is also necessary to adopt institutional review in the policy process, at least by impacted and affected organizations—generously determined—for both new policies and policy revisions.

Regarding the role of institutional policy and procedure in cross-organizational knowledge sharing and innovation, in the DOE nuclear and nuclear waste facilities context, the case studies show that intra-firm cross-organizational innovation can be facilitated through institution-wide review of institutional policies (new policies, revisions) within the institutional policy process, such that institutional policies serve as collaborative mediating artifacts that facilitate and foster cross-organizational innovation. This collaborative management leads to the development of dynamic capabilities (Teece et al., 1997), which are hallmarks of high-flex organizations.

We find that institutional policy is a mediating artifact for knowledge and innovation, and institutional review enables cross-organizational collaboration in knowledge creation and innovation. However, institutional review enables not only institutional policy to function as a mediating artifact for knowledge and innovation, but also as institutional controls, supervision, or limits on those activities. Institutional review acts as a quality assurance/quality control mechanism over institutional policy. It also enables the organization to explicitly address the degree of the proposed innovation, for example, whether the innovation shall be incremental or radical.

We find that institutional policy is an internal institution, but parts thereof can have their origins in external institutions, as in the cases where the policy restates or implements law or regulation. Only authorized governmental institutions can change or innovate the law, while a non-governmental institution can change or innovate how they comply with the law.

Regarding how institutional change occurs in "big science" contexts, we find that the DOE and its "big science" program demonstrated dynamic capabilities without the external forcing function of a mishap; thus, institutional change or transformation, in a big science context, can occur endogenously.

Limitations and future research

This research is limited by the scope and context of its cases, namely DOE Directives in nuclear and nuclear waste facilities. Specifically, it is limited to the highly regulated and complex environment of DOE's nuclear operations and facilities, which may restrict the generalizability of the findings to other sectors or organization types. However, as discussed in section 4.4, we address this perceived limitation as an example of decontextualization and consider the study in micro-macro terms.

History is written by the victors, which in this case, the DNFSB was not; however, from the records we have, we cannot determine whether the DNFSB was acting per ceremonial values or in accordance with a

specific type of instrumental value known as the precautionary principle (Marinakis et al., 2016). The precautionary principle holds that the lack of scientific evidence does not preclude action if the damage would otherwise be serious and irreversible; for instance, the lack of evidence that an event is not yet a PISA does not preclude acting as if it were one or the lack of evidence that a USQ is not yet a high-level safety concern does not preclude acting as if it were. In effect, the DOE was rejecting the precautionary principle in these situations in favor of innovation. Meanwhile, he DNFSB might have been reasserting its support for the precautionary principle. Determining the DNFSB's motivation will not change the conclusions of this case study. Institutional review is not intended to resolve all disagreements; rather, it provides a forum in which to air, discuss, and resolve them. The draft Directive was a site for organizational knowledge construction and innovation. If it indeed represented a rejection of the precautionary principle, then that rejection was still an innovation that emerged from the IPT's innovation ecosystem.

In general, the instrumental-ceremonial values dichotomy represents a logic or discourse of colonization. For example, from within a religion or culture, rituals are essential to believers; however, those outside that religion may label the same rituals as ceremonial. This is illustrated by the seminal case of the ceremonial-instrumental dichotomy, the Trobriand Islander canoe construction (Bush, 1987, citing Malinowski, 2013 [1922/1994]). The Trobrianders believed in magic, and to them, the interruption of building to perform magical rites is instrumental. To a non-believer, the rites are ceremonial. Here, a decolonization of the instrumental-ceremonial values dichotomy might provide a more contemporary perspective on how organizations construct knowledge and innovation.

We had preconceived notions about the instrumental nature of institutional reviews, which may have influenced our interpretation of the findings and data. To mitigate this bias, we adopted an understanding-driven rather than proof-driven approach (Poulis et al., 2013), selecting cases based on relevance and focus rather than attempting to prove a point. Our emphasis is on institutional review in the nuclear operations of the DOE. Besides this check for contextual appropriateness, no other pre-selection steps were taken. When we began the multiple case study, we were uncertain about where the cases would lead us or how they would conclude.

The lack of a clear understanding regarding the specific trigger for the failure of Drum 68660, especially given the presence of many similar drums, could be viewed as a shortcoming in the depth of our case analysis. Nonetheless, the case illustrates how inadequate institutional review resulted in a non-compliant substitution.

Finally, policy revisions are projects, not operations; thus, they have schedules rather than cycle times. A policy revision, during the process of discovering institutional review, may turn out to be extraordinary rather than routine, potentially causing significant delays in the schedule. Such delays could be misinterpreted as evidence against institutional review, unnecessarily impacting "revision cycle time," if stakeholders do not recognize that the nature of policy revision is project-based with a project schedule, not operational with a cycle time. We did not address how such misunderstandings might affect stakeholders' perceptions of the value of institutional review.

CRediT authorship contribution statement

Scott Cunningham: Writing – review & editing, Methodology, Conceptualization. **Yorgos D. Marinakis:** Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Steven T. Walsh:** Writing – review & editing, Supervision, Conceptualization. **Reilly White:** Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization.

References

Abuhimed, D., Beheshti, J., Cole, C., AlGhamdi, M. J., & Lamoureux, I. (2013). Knowledge artefacts: Lessons learned and stories as a means to transfer knowledge amongst cohorts of high school students working on an inquiry-based project. *Proceedings of the American Society for Information Science and Technology, 50*(1), 1–4.

Accident Investigation Board. (2014). *Department of energy office of environmental management accident investigation report. phase 1 radiological release event at the waste isolation pilot plant, February 14, 2014. April 2014*. U.S. DOE Office of Environmenta Management.

Accident Investigation Board. (2015). *Department of energy office of environmental management accident investigation report. phase 2 radiological release event at the waste isolation pilot plant, February 14, 2014. April 2015*. U.S. DOE Office of Environmental Management.

Bailey, P. L. (2013). The policy dispositif: Historical formation and method. *Journal of Education Policy, 28*(6), 807–827.

Ball, S. J. (1993). What is policy? Texts, trajectories and toolboxes. *The Australian Journal of Education Studies, 13*(2), 10–17.

Ball, S. J. (2015). What is policy? 21 years later: Reflections on the possibilities of policy research. *Discourse: Studies in the Cultural Politics of Education, 36*(3), 306–313.

Barnsley, M. F. (2014). *Fractals everywhere*. Academic Press.

Belfrage, C., & Hauf, F. (2017). The gentle art of retroduction: Critical realism, cultural political economy and critical grounded theory. *Organization Studies, 38*(2), 251–271.

Belloc, F. (2022). Profit sharing and innovation across organizational layers. *Journal of Economic Behavior & Organization, 197*, 598–623.

Bhaskar, R. (2014). *The possibility of naturalism: A philosophical critique of the contemporary human sciences*. Routledge.

Birkel, H., & Müller, J. M. (2021). Potentials of industry 4.0 for supply chain management within the triple bottom line of sustainability–A systematic literature review. *Journal of Cleaner Production, 289*. Article 125612.

Bush, P. D. (1987). The theory of institutional change. *Journal of Economic Issues, 21*(3), 1075–1116.

Canary, H. (2010). Constructing policy knowledge: Contradictions, communication, and knowledge frames. *Communication Monographs, 77*(2), 181–206.

Canary, H. E., & McPhee, R. D. (2009). The mediation of policy knowledge: An interpretive analysis of intersecting activity systems. *Management Communication Quarterly, 23*(2), 147–187.

Canary, H. E., Riforgiate, S. E., & Montoya, Y. J. (2013). The policy communication index: A theoretically based measure of organizational policy communication practices. *Management Communication Quarterly, 27*(4), 471–502.

Canary, H. E., & Tarin, C. A. (2017). Structuration theory. In C. Scott, & L. Lewis (Eds.), *The international encyclopedia of organizational communication* (pp. 1–15). John Wiley & Sons.

Chemical & Engineering News. (2007). DOE names contractor for Livermore lab. Retrieved April 20, 2023, from https://cen.acs.org/articles/85/i20/DOE-names-Contractor-Livermore-lab.html.

Commission to Review the Effectiveness of the National Energy Laboratories. (2015). *Interim report of the commission to review the effectiveness of the national energy laboratories*. U.S. Department of Energy. Retrieved June 11, 2025, from https://www.energy.gov/labcommission/commission-review-effectiveness-national-energy-laboratories.

Conca, J. (2014). *Nuclear waste leak raced to — kitty litter*. Forbes. Retrieved October 22, 2023, from https://www.forbes.com/sites/jamesconca/2014/05/10/nuclear-waste-leak-traced-to-kitty-litter.

Curtis, C. B., McTague, J. P., & Cheney, D. W. (1997). Fixing the national laboratory system. *Issues in Science and Technology, 13*(3), 49–56.

Danermark, B., Ekström, M., & Karlsson, J. C. (2019). *Explaining society: Critical realism in the social sciences*. Routledge.

Department of Energy Inspector General. (2014). *Management alert: Remediation of selected transuranic waste drums at Los Alamos national laboratory – potential impact on the shutdown of the department's waste isolation plant, September 2014*. Department of Energy.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review, 14*(4), 532–550.

Everdell, W. R. (2009). *The first moderns: Profiles in the origins of twentieth-century thought*. University of Chicago Press.

Friedman, G. H. (2014). *Special inquiry. alleged attempts by sandia national laboratories to influence congress and federal officials on a contract extension*. Department of Energy, Office of the Inspector General, Office of Audits and Inspections. Retrieved April 20, 2023, from https://www.energy.gov/ig/articles/special-inquiry-doeig-0927.

Government Accountability Office. (2020). *National nuclear security administration contracting: Review of the NNSA report on the Los Alamos national laboratory contract competition. gao-20-292r NNSA contracting*. Government Accountability Office.

Giddens, A. (2014). *Giddens' theory of structuration*. Routledge.

Hobbs, M. L., Britt, P. F., Hobbs, D. T., Kaneshige, M. J., Minette, M., Mintz, J., Pennebaker, F. M., Parker, G. R., Jr., Pierce, R., Rosenberg, D. M., & Schwantes, J. (2022). Thermal runaway of nitric acid-soaked kitty litter in transuranic waste. *Process Safety and Environmental Protection, 167*, 543–549.

Ialenti, V. (2021). Drum breach: Operational temporalities, error politics and WIPP's kitty litter nuclear waste accident. *Social Studies of Science, 51*(3), 364–391.

Jackson, G., Helfen, M., Kaplan, R., Kirsch, A., & Lohmeyer, N. (2019). The problem of de-contextualization in organization and management research. In T. B. Zilber, J. M. Amis, & J. Mair (Eds.), *The production of managerial knowledge and organizational theory: New approaches to writing, producing and consuming theory* (pp. 21–42). Emerald Publishing Limited.

Klaus, D. M. (2019). What really went wrong at WIPP: An insider's view of two accidents at the only US underground nuclear waste repository. *Bulletin of the Atomic Scientists, 75*(4), 197–204.
Knott, J. H., & Miller, G. J. (2006). Social welfare, corruption, and credibility: Public management's role in economic development. *Public Management Review, 8*(2), 227–252.
Laffont, J. J., & Martimort, D. (2009). *The theory of incentives: The principal-agent model.* Princeton University Press.
Malinowski, B. (2013). *Argonauts of the Western Pacific: An account of native enterprise and adventure in the archipelagoes of Melanesian New Guinea [1922/1994]*. Routledge.
Malone, P. (2017). *A near-disaster at a federal nuclear weapons laboratory takes a hidden toll on America's arsenal. repeated safety lapses hobble Los Alamos national laboratory's work on the cores of U.S. nuclear warheads*. Science. Retrieved April 16, 2023, from https://www.science.org/content/article/near-disaster-federal-nuclear-weapons-laboratory-takes-hidden-toll-america-s-arsenal.
Marinakis, Y. D. (2008). Ecosystem as a topos of complexification. *Ecological Complexity, 5*(4), 303–312.
Marinakis, Y., Harms, R., & Walsh, S. T. (2016). The precautionary principle: What is it, where did it come from, how should we use it? *Journal of International & Interdisciplinary Business Research (2014-2019), 3*(1), 1–13.
Matinaro, V., & Liu, Y. (2017). Towards increased innovativeness and sustainability through organizational culture: A case study of a Finnish construction business. *Journal of Cleaner Production, 142*, 3184–3193.
Miettinen, R., & Virkkunen, J. (2005). Epistemic objects, artefacts and organizational change. *Organization, 12*(3), 437–456.
Morrisson, J. (2017). How the wrong cat litter took down a nuclear waste repository. *Chemical & Engineering News, 95*(20). Retrieved October 22, 2023, from https://cen.acs.org/articles/95/i20/wrong-cat-litter-took-down.html.
Mosher, D. (2016). *A typo and a bag of kitty litter might cost US taxpayers billions in nuclear waste cleanup*. Business Insider. Retrieved October 28, 2023, from https://www.businessinsider.com/kitty-litter-nuclear-waste-accident-2016-8.
Mueller, B., & Pereira, C. (2020). Credibility and the design of regulatory agencies in Brazil. *Brazilian Journal of Political Economy, 22*, 449–472.
Nelson, R. R., & Winter, S. G. (1982). *An evolutionary theory of economic change*. Harvard University Press.
Norman, D. A., & Verganti, R. (2014). Incremental and radical innovation: Design research vs. technology and meaning change. *Design Issues, 30*(1), 78–96.
Nudzor, H. (2009). What is "policy", a problem: Solving definition or a process conceptualisation. *Educational Futures, 2*(1), 85–96.
Ode, E., & Ayavoo, R. (2020). The mediating role of knowledge application in the relationship between knowledge management practices and firm innovation. *Journal of Innovation & Knowledge, 5*(3), 210–218.
Paavola, S., & Hakkarainen, K. (2005). The knowledge creation metaphor: An emergent epistemological approach to learning. *Science & Education, 14*, 535–557.
Perry, R. (2017). *Letter to defense nuclear facilities safety board chairman Sullivan.* Department of Energy.
Popadiuk, S., & Choo, C. W. (2006). Innovation and knowledge creation: How are these concepts related? *International Journal of Information Management, 26*(4), 302–312.
Poulis, K., Poulis, E., & Plakoyiannaki, E. (2013). The role of context in case study selection: An international business perspective. *International Business Review, 22*(1), 304–314.
Puddy, J. R., Price, I., & Smith, L. (2001). FM policies and standards as a knowledge management system. *Facilities, 19*(13/14), 504–515.
Ruocco, A. (2018a). *General occurrence reporting training: Doe O 232.2A, occurrence reporting and processing of operations information module 1*. Department of Energy, Office of Environment, Health, Safety and Security. Retrieved June 11, 2025, from https://www.energy.gov/sites/default/files/2018/12/f58/O-232-2A-ORPS-Training-Module-1.pdf.
Ruocco, A. (2018b). *Occurrence reporting and processing system (ORPS) overview*. Department of Energy, Office of Environment, Health, Safety and Security. Retrieved June 11, 2025, from https://www.energy.gov/ehss/articles/module-1-general-occurrence-reporting-training-doe-o-2322a-occurrence-reporting-and.
Rybczynska-Bunt, S., Weston, L., Byng, R., Stirzaker, A., Lennox, C., Pearson, M., Brand, S., Maguire, M., Durcan, G., Graham, J., Leonard, S., Shaw, J., Kirkpatrick, T., Owens, C., & Quinn, C. (2021). Clarifying realist analytic and interdisciplinary consensus processes in a complex health intervention: A worked example of Judgemental rationality in action. *Evaluation, 27*(4), 473–491.
Sayer, R. A. (1992). *Method in social science: A realist approach*. Psychology Press.
SEAB. (1995). *Alternative futures for the department of energy national laboratories.* Secretary of Energy Advisory Board.
Stake, R. E. (2003). Case studies. In N. K. Denzin, & Y. S. Lincoln (Eds.), *Strategies of qualitative inquiry* (pp. 134–164). Sage.
Stewart, D. W. (2014). What is policy? And why it matters. *Journal of Public Policy & Marketing, 33*(1), 1–3.
Teece, D. J. (2007). Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal, 28*(13), 1319–1350.
Teece, D. J. (2014). A dynamic capabilities-based entrepreneurial theory of the multinational enterprise. *Journal of International Business Studies, 45*, 8–37.
Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18*(7), 509–533.
Tessaro, D. (2022). Transitions in environmental policy discourse, from ecologically and socially guided to profit-driven: What is the effect of the institutional policy-making process? *Journal of Environmental Policy & Planning, 24*(1), 68–80.
Trifonov, V. (1995). A linear solution of the four-dimensionality problem. *Europhysics Letters, 32*(8), 621.
Vartabedian. (2016). *Nuclear accident in New Mexico ranks among the costliest in U.S. history*. Los Angeles Times. Retrieved October 22, 2023, from https://www.latimes.com/nation/la-na-new-mexico-nuclear-dump-20160819-snap-story.html.
Voigt, S. (2005). Islam and the institutions of a free society. *The Independent Review, 10*(1), 59–82.
Voigt, S. (2019). *Institutional economics: An introduction.* Cambridge University Press.
Williams, J. (2016). *Lessons learned from the 2015 LanL electrical arc flash event*. Los Alamos National Laboratory. Retrieved April 16, 2023, from https://www.energy.gov/ehss/articles/lessons-learned-2015-lanl-electrical-arc-flash.
Technical Assessment Team. (2015). *Waste isolation pilot plant technical assessment team report, SRNL-RP-2014-01198, revision 0*. Department of Energy.
Witherspoon, C. L., Bergner, J., Cockrell, C., & Stone, D. N. (2013). Antecedents of organizational knowledge sharing: A meta-analysis and critique. *Journal of Knowledge Management, 17*(2), 250–277.
WNN. (2018). *WIPP returns to normal operations*. World Nuclear News. Retrieved October 28, 2023, from https://www.world-nuclear-news.org/Articles/WIPP-returns-to-routine-operations.
Yin, R. K. (2018). *Case study research and applications: Design and methods*. SAGE Publications Inc.
Zimmermann, R. E. (1999). *The klymene principle: A unified approach to emergent consciousness*. Univ., Interdisziplinäre Arbeitsgrupe für Philosophische Grundlagenprobleme der Wiss. und der Gesellschaftlichen Praxis.
Zimmermann, R.E. (.2000). Loops and knots as topoi of substance: Spinoza revisited (gr-qc/0004077). *ArXiv*.
Zimmermann, R. E. (2002). Spinoza in context: A holistic approach in modern terms. In E. Martikainen (Ed.), *Infinity, causality, and determinism. cosmological enterprises and their preconditions* (pp. 165–186). Peter Lang.
Zimmermann, R.E. &. Voelcker, W. (2001). Topoi of emergence: Foundations and applications (nlin/0105064). *ArXiv*.