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Thomas Kuhn on Paradigms

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This study provides key arguments and contributions of Kuhn (1970) concerning paradigms, paradigm shifts, and scientific revolutions. We provide interpretations of Kuhn's (1970) key ideas and concepts, especially as they relate to business management research. We conclude by considering the practical implications of paradigms and paradigm shifts for contemporary business management researchers and suggest that ethical rules of conversation are at least as critical for the health of a scientific community as methodological rules (e.g., the rules of logical positivism) derived from the philosophy of science.

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The Structure of Scientific Revolutions

Thomas S. Kuhn's (1962/1970) *The Structure of Scientific Revolutions* (SSR)—with over 100,000 *Google Scholar* citations—is a landmark study devoted to the history of science.[1] Kuhn, as a self-described "practicing historian of science" (1977: 3) emphasizes the critical role of *paradigms*, which are taken to be "universally recognized scientific achievements that for a time provide model problems and solutions to a community of practitioners" (1970: viii). A paradigm consists of the fundamental ideas, methods, language, and theories that are accepted by the members of a scientific community. A paradigm is critical to the potential progress of science as "no natural history can be interpreted in the absence of at least some implicit body of intertwined theoretical and methodological belief that permits selection, evaluation, and criticism" (Kuhn, 1970: 16–17)

SSR emphasized the importance of the evolution of science (Bird 2000, Wray 2011). Thus, SSR brought back historical insights that had been dropped with the eminence of logical positivism and its focus on empirical evidence (Ayer 1959, Carnap 1937). SSR was not an historical account of science, but instead pointed out how the textbook accounts of science highlighting received theory differ substantially from the rich descriptions of the process of advancing this theory. SSR showed that science primarily advances through shifts in theory and not by the accumulation of knowledge, which was commonly held prior to publication of SSR (Oppenheim and Putnam 1958). A key insight from SSR was that contradictory theories cannot be simply reduced to a unified (dialectical) synthesis, but rather that the ideas of a successful competing paradigm must displace ideas of the old paradigm.

In the next section, we describe Kuhn's (1970) notion of paradigms. Then, we consider Kuhn's (1970) thesis of paradigm shifts and scientific revolutions, and provide an evaluation regarding SSR's influence on our understanding of the scientific process. We conclude by considering the practical implications of paradigms and paradigm shifts for modern business management researchers and suggest that ethical rules of conversation are at least as critical for the health of a scientific community as methodological rules (e.g., the rules of logical positivism) derived from the philosophy of science.

Paradigms and Normal Science

Paradigms are a shared constellation of group commitments along the spectrum from preferred analogies and metaphors, to shared exemplars, to heuristics, to ontological models, or accepted hypotheses of laws of nature, which influence what would be accepted as a warranted explanation and as a puzzle solution. Paradigms influence the roster of collectively shared unsolved puzzles and the evaluation of the importance of each puzzle (Kuhn, 1970: 174–191). Scientists addressing these puzzles abide by the rules of their discipline, that is, they follow what Kuhn (1970) called the disciplinary matrix of the paradigm, and the solutions to those puzzles are predetermined, although requiring effort to be discovered or created. Such puzzles typically motivate theoretical and empirical research in determining facts, matching of facts to theory, and articulating theory (1970: 34). The matching of facts to theory encourages a disciplinary search for greater precision of fundamental concepts, more-fine grained measurements of those concepts and their constructs, and replication of empirical results in different contexts. For those working within a paradigmatic tradition, "a scientific community is an immensely efficient instrument for solving the problems or puzzles that its paradigms define" (1970: 166). Members of a scientific community hold a shared set of beliefs that enable this efficiency. Paradigms related to the methodology and received theory afford management scholars the accepted platforms to build their research. These platforms are the assumed facts that scholars do not need to corroborate each time they seek to develop or test a theory. While management research combines theoretical concepts with practical implications, paradigms help by providing frameworks to build on and mechanisms of evolution connecting current research to the accumulated knowledge base.

Paradigms are not merely acquired, codified rules that limit both the nature of acceptable solutions and the steps by which they are obtained, but also shared intuitions by a community of scholars, which are often tacitly communicated within the practice of science (Kuhn, 1970: 191–198; Polanyi 1962). A paradigm creates clear boundaries for what makes up a given field or defines which theory is relevant. These boundaries enable scientists to harmonize the choice of research questions, methods, and ultimately, the direction of inquiry in their fields. A cogent shared schema leads to *normal science*, which can be defined as "research firmly based upon one or more past scientific achievements, achievements that some particular scientific community acknowledges for a time as supplying the foundation for its further practice" (1970: 10). Normal science serves to corroborate the existing paradigms, which are accepted by the scientific community and the ideas that typically appear in textbooks. It enables scientists to pursue a level of detail, otherwise not possible, by narrowly concentrating the efforts of the community on a small set of problems. Conversely, paradigms may also constrain management scholars by limiting creativity, especially in cases where the creative idea conflicts with existing paradigms.

Scientific achievements are typically recounted, though seldom in their original form, by both elementary and advanced textbooks of the discipline. Management journals serve as the historical record of paradigms. *Progress* in management research depends on correctly interpreting and citing the articles that together make up those paradigms.[2] Since scientists are confined to the disciplinary matrix, it is difficult for them to take a broad, abstract view of the accumulated knowledge. Instead, most knowledge is gained by incremental advances exemplified by testing discrete hypotheses. Scientists can, and often do, build a career based on the incremental advances of normal science. While a scientific discipline ostensibly champions independent critical thinking, a scientist pursuing innovative theory or methodologies at a level of scientific revolution may be met with sharp (and often personal) criticism rather than praise. Instead, scientists are trained to learn the same fundamental models of their mentors and to embrace a shared commitment to a paradigm (Kuhn, 1970).[3]

There are observable patterns to a successful paradigm. Specifically, the success of a paradigm in normal science, which is a highly cumulative enterprise, typically requires: (i) an enduring group of adherents; and (ii) maintaining a sufficiently open mind to leave all sorts of problems within the discipline to be resolved (Kuhn, 1970: 10).

Kuhn states that: "examples which include law, theory, application, and instrumentation together—provide models from which spring particular coherent traditions of scientific research" (1970: 13). It is characteristic to normal science to ask those questions that the paradigm is equipped to solve. Consequently, "it is no criterion of goodness in a puzzle that its outcome be intrinsically interesting or important" (Kuhn, 1970: 36). Instead, a contribution within normal science is typically evaluated by a scientific community in terms of its adherence to its legitimate problems and standards within the accepted paradigm. Thus, a benefit of a paradigm is not in welcoming criticism or in openly promoting a scientific revolution, but rather in providing efficient communication among members of a scientific community.

Pre-paradigmatic time-periods, in contrast, typically involve struggles in communication among scientists unable to take for granted a body of beliefs. Kuhn notes that: "History suggests that the road to a firm research consensus is extraordinarily arduous... In the absence of a paradigm or some candidate for paradigm, all of the facts that could possibly pertain to the development of a given science are likely to seem equally relevant. As a result, early fact-gathering is a far more random activity than the one that subsequent scientific development makes familiar" (1970: 15). Work to establish a paradigm occurs through fits and starts, often without an attribution to those scientists pushing to understand the boundaries of the existing paradigm. While textbooks of different disciplines may summarize the accepted content of a paradigm, those textbooks do not necessarily address the messy process of argumentation and negotiation that occurs before a paradigm gains acceptance.

Overall, Kuhn's views regarding paradigms depart substantially from the widely held logical positivist view prevalent before SSR. Kuhn maintains that received theory typically seeks to make an established discipline immune from attack and suggests that progress of science requires the rejection of the old paradigm rather than the simple assimilation of new knowledge. The fact that the promotion of a new paradigm requires "a redefinition of the corresponding science" (Kuhn, 1970: 103) is the basis for Kuhn's (1970) thesis describing scientific progress as episodic *revolutionary* events that conflict with the accepted ideas of the discipline.

Paradigm Shifts and Scientific Revolutions

Kuhn examines anomalies, or violations of expectations, and "the emergence of crises that might be induced by repeated failure to make an anomaly conform" (1970: ix). Anomalies are typically not highlighted within normal science, and it is not random that disciplines tend to focus on structural dimensions of the paradigm[4] , rather than on the processes of paradigm shifts. Indeed, textbooks of each discipline describe development of their scientific inquiry as linear, which hides processes that reside at the heart of scientific development (1970: 140). The historical account of science generally places the current paradigm on a pedestal and may obfuscate the back-and-forth that occurs in the process of determining better explanations or solutions. The *process* of a paradigm shift may in fact be masked from the scholars in the field. Kuhn notes that: "a concept of science drawn from [textbooks] is no more likely to fit the enterprise that produced them than an image of national culture drawn from a tourist brochure ..." (1970: 1). Paradigm shifts are the transitions that taken together constitute the "usual development pattern of mature science" (Kuhn, 1970: 12)

Kuhn remarks further that: "the member of a mature scientific community is like the typical character of Orwell's *1984*, the victim of a history rewritten by the powers that be" (1970: 167). Challenging the portrayal of scientific inquiry as evidence-based, Kuhn suggests that often "believing is seeing," in which research is "a strenuous and devoted attempt to force nature into the conceptual boxes supplied by professional education" (1970: 5). If the data are tortured long enough, nature will confess. Despite the normative value of science as consisting of open-minded evaluators of evidence, scientists often have a tendency toward intolerance and resistance to new ideas (Barber, 1961; Beveridge, 1959; Kuhn, 1970: 24). Thus, the normal science process often actively suppresses novelty, and the project whose outcome does not lead to the anticipated result is presumed to reflect "not on nature but on the scientist" (Kuhn, 1970: 35). There is clearly an incentive for scholars to follow the paradigms accepted in their field because challenging the accepted norms is risky, takes time, and may be evaluated as deficient. The fact that the historical account of science is typically rewritten (by the powers that be) after a paradigm shift and emphasizes the currently received paradigm means that students who simply read the textbooks are unaware of the occurrence of the shift. Paradigm shifts therefore may be an invisible process to all but the scholars involved firsthand.

It should be noted that some contend that Kuhn's idea of "normal science" is misguided. Kuhn suggests that normal science is the most frequently occurring type of scientific work and that it is distinct from "revolutionary science." For Kuhn (1970), normal science concerns day-to-day systematic hypothesis testing performed by scientists within an established paradigmatic framework and using accepted methods. However, critics of normal science suggest that Kuhn's (1970) ideas are a revolt against the philosophy of logical positivism (Ayer, 1959), and a rejection of the scientific criterion that all theoretical ideas might be effectively tested (e.g., Shapere, 1964). Watkin's (1970) critique of Kuhn's (1970) normal science suggests that normal science is more a test of the scientist than a test of theory. It also might be that the advent of a new paradigm corresponds to a well-elaborated theoretical explanation rather than growing empirical evidence to counter the existing paradigm (Watkins, 1970). While admitting the existence of what Kuhn (1970) calls normal science, Popper (1970: 53) is quite disparaging of the endeavor, saying that normal scientists are "badly taught,' "victim(s) of indoctrination," and simply wish to be told what the facts are to know. Although Kuhn (1970) clearly made a careful distinction in describing normal and revolutionary science, Kuhn seems to capitulate to his many critics in this area and admits that "if a demarcation criterion exists" it is not fruitful to "seek a sharp or decisive one"

(1970a: 6). The reality is that the scientific endeavor benefits from testing of different contingencies, defining the boundary conditions of a given paradigm, and the replication of tests of existing paradigms.

While conventional wisdom stresses the pressures toward conformity found in Kuhn (1970)—for example Daft and Lewin (1990) refer to a "normal science straightjacket"—we emphasize that the strenuous efforts to achieve such paradigmatic conformity sow the seeds of their own demise. Kuhn reminds us that "normal science ... often suppresses fundamental novelties because they are necessarily subversive of its basic commitments. Nevertheless, so long as those commitments retain an element of the arbitrary, the very nature of normal research ensures that novelty shall not be suppressed for very long" (1970: 5). Kuhn provides a narrative of science where there are long intervals of continuity, but the cumulative force of anomalies builds up to the point where there is discontinuity and a gestalt switch, that is, a paradigm shift (1970: 85). We can observe then a path-dependent process that "leads the profession at last to a new set of commitments, a new basis for the practice of science" (1970: 6). Such a paradigm shift typically requires a reconstruction of prior theory and the reevaluation of prior fact within the discipline. Scholars must wrangle with evidence that conflicts with widely accepted theory or requires new methods of explanation. Kuhn states: "The extraordinary episodes in which [a] shift of professional commitments occurs are the ones known as *scientific revolutions*. They are the tradition-shattering complements to the tradition-bound activity of normal science" (1970: 6). In such cases, an older paradigm is replaced in whole or in part by an incompatible new paradigm (1970: 92). Scientific revolutions require the scholarly community to forgo its own commitments to paradigms when anomalies defy those paradigms. The accumulation of anomalies causes a crisis or disequilibrium, which forces scholars to abandon what they assumed to be true and even what is sometimes foundational to their discipline.

The evaluation of a new paradigm within a discipline vis-à-vis the conventional paradigm requires a comparative assessment of imperfect alternatives. Kuhn notes: "The decision to reject one paradigm is always simultaneously the decision to accept another, and the judgment leading to that decision involves the comparison of both paradigms with nature *and* with each other" (1970: 77). Kuhn suggests that such a comparative assessment is not fully made on logical grounds. Indeed, "when paradigms enter, as they must, into a debate about paradigm choice, their role is necessarily circular. Each group uses its own paradigm to argue in that paradigm's defense" (1970: 94). The basis of evaluating a given scientific contribution is not always clear as each perspective builds its own case from its unique foundation. Therefore, "the competition between paradigms is not the sort of battle that can be resolved by proofs" (1970: 148), and "the proponents of competing paradigms practice their trades in different worlds" (1970: 150). Though the idea is to determine which of the competing paradigms is better than the other, the scholarly combatants are not likely to agree on what the criteria are for making such an assessment. Moreover, proponents of a paradigm tend to favor evaluation criteria that favor their preferred paradigm (McAllister, 1999: 41).

Kuhn observes that a new paradigm gains its scientific status because it is more successful than the existing paradigm in solving agreed-upon problems that the discipline finds acute. Kuhn cautions: "To be more successful, is not, however, to be either completely successful with a single problem or notably successful with any large number" (1970: 23), and "there are losses as well as gains in scientific revolutions and scientists tend to be peculiarly blind to the former" (1970: 167). The tradeoffs inherent in the process mean that the new paradigm may seem to provide a better explanation, but even the better solution may require compromise, failing to provide a full explanation of the observed phenomena.

A natural paradox exists between sticking to a paradigm and shifting the paradigm. Researchers can get so bogged down in the conditions of the paradigm that they see any anomalies as undesirable. They may attribute any anomalies to limitations in their own empirical observations and analysis methods rather than a *refutation* of the existing paradigm.[5]

Evaluation of success can also change with the advent of a new paradigm. Kuhn states: "The normal-scientific tradition that emerges from a scientific revolution is not only incompatible but often actually *incommensurable* with that which has gone before" (1970: 103). The new paradigm cannot be judged by the same standards held by adherents of the conventional paradigm because there is no common standard of measurement.[6] Theory choice involves historical, personal, subjective, and tacit dimensions (Polanyi, 1962). Therefore, Kuhn maintains that there is neither a neutral algorithm nor a systematic decision procedure for theory choice (1970: 200). Kuhn suggests that when a paradigm shift occurs, there are "usually significant shifts in the criteria determining the legitimacy both of problems and of proposed solutions" (1970: 109). Moreover, there is a new gestalt in which the scientist's perception of the environment must be revised (Hanson, 1958; Kuhn, 1970: 112).

Consider the following example. Concerning the economic foundations of strategy and the canonical problem of vertical integration, the neoclassical theory of the firm (Marshall, 1920) described the construct of the firm as a production function that transformed inputs into outputs based on available technology. Similar to Kuhn's (1970)'s notions of a paradigm shift, it became apparent over time that too much was being asked of the neoclassical theory of the firm. As Kuhn (1970) predicted, for a time the process of normal science attempted to handle the puzzle of vertical integration within the existing paradigm and thus efforts to use neoclassical theory in an all-purpose way persisted. However, over time it became widely recognized that the conventional neoclassical paradigm led to fundamental confusion for explaining contractual innovations. The growing dissatisfaction with the existing paradigm and the development of an alternative theory in transaction cost economics (Williamson, 1975) led to a competing paradigm and over time an observable paradigm shift.[7] Consistent with Kuhn's (1970) predictions, convoluted interpretations of relational vertical contracting and full financial ownership via vertical integration persisted until a competitive alternative, the transaction cost theory, emerged to explain and predict vertical integration (Ketokivi & Mahoney, 2016; Mahoney, 2005; Williamson, 1985, Williamson, 1996). Since its inception, this theory has been widely used by researchers to explain efficiency of transactions and relationships in outsourcing of operations (Ketokivi & Mahoney, 2020) and information systems (Poppo & Zenger, 1998).

Some supporters maintain that paradigm shifts provide an explanation for how science in practice changes over time, which elevates revolutionary breakthroughs as distinctive from normal science. Others, however, suggest that change in science is more nuanced than that, entailing a process filled with contention, requiring dialogue among competing theorists, often better described as incremental rather than revolutionary in nature, depending largely on the subjective judgment of competing factions, and often taking place in a politically charged environment that requires savvy and courage, beyond intellect, to achieve change (see, e.g., Hull, 2010).

Conclusion

Kuhn describes scientists as "addicts" devoting their "professional attention to demanding puzzles" (1970: 38). Incremental work based on both the old and new regime must be undertaken simultaneously to enable competition between old and new paradigms either to reject incumbent theory or to adopt its alternative. Kuhn notes that: "Competition between segments of the scientific community is the only historical process that ever actually results in the rejection of one previously accepted theory or in the adoption of another" (1970: 8). However, winning such a competition is typically transitory. Kuhn states that: "To be accepted as a paradigm, a theory must seem better than its competitors, but it need not, and in fact never does, explain all the facts with which it can be confronted" (1970: 17–18). Not only is the favored paradigm unable to solve any given problem completely, it might be quite limited in the number of problems it can solve (Kuhn, 1970: 23).

A major critique of Kuhn (1970) concerns the idea of incommensurable schema.[8] Popper (1970), Putnam (1981), and Davidson (1985) submit that Kuhn's incommensurability position, in which different conceptual schemes are untranslatable or imperfectly translatable, is incoherent. Unreflective acceptance of Kuhn's (1970) incommensurability position might also prematurely suppress useful conversations within a field. Mahoney submits: "Kuhn's incommensurability thesis has been used, in large measure, to legitimize intellectual vested interests. It is very easy to claim incommensurability. It is an academic way of saying 'shut-up; I do not want to have a conversation with you; I am an expert in my field.' As President Harry Truman said: 'An expert is someone who doesn't want to learn anything new, because then he wouldn't be an expert' (McCloskey, 1990: 111). Conversational bridges can and should be built between contested terrains" (Mahoney, 1993: 186). It is a "dangerous dogma" to assume that groups of scientists are unable to converse and critique the other group's contributions because of the incommensurability of their work (Popper, 1970: 56). The progress of science depends on bridges of communication across competing scholars and paradigms to enable paradigm shifts and the wave of new knowledge that results from crossing those contested terrains of change. While the unique and different perspectives representing incumbent and aspirant paradigms present an element of challenge, competing scholars must work to understand the vocabulary, methods, and explanations of others to determine what paradigm(s) may better fit the puzzle at hand.

A new paradigm presents additional opportunities for researchers to use innovative methods for examining important phenomena. However, existing methods and common language that researchers share are critical, used extensively, and do not disappear completely even as a result of a paradigm shift (Kuhn, 1970). Having an established set of methods and observations remains imperative for inquiry. Researchers must seek to understand and appreciate their own adopted methodologies and those of others in their field. Otherwise, researchers will each build their own foundation, but not be able to agree on a common base (Kuhn, 1970). Researchers, in effect, should choose old, new, or hybrid methods to investigate the problems of their field.

Paradigm shifts occur as either discoveries (e.g., novelties of fact) or inventions (e.g., novelties of theory), with the two cases being difficult to separate as all facts are theory-laden (Kuhn, 1970; Van De Ven, 2007). One of the challenges during paradigm shifts is that it is not clear how the editorial teams at academic journals will evaluate the quality of research. There are usually substantial shifts in the criteria determining the legitimacy both of canonical problems and of proposed solutions when a paradigm shift occurs (Kuhn, 1970: 109).

Kuhn (1970), however, neglects acknowledging the importance of argumentation in the process of transitioning from one paradigm to another (Fuller, 1992). Kuhn (1970) described the typical transition from one paradigm to another in terms of the epistemological and ontological criteria favored by (and typically favoring) those holding the incumbent theory. Toulmin (1970) provides insights concerning the *process* by which a paradigm shift occurs as a negotiation among scientists holding competing explanations for their observations. Scientists of opposing paradigms might have to acknowledge limitations of their own theories or accept that new observations require adjustments to their own beliefs. Transitioning from one paradigm to another requires scientists to use the lens of alternative theory to evaluate the weaknesses of the incumbent theory (Feyerabend, 1970). Closely related, Fuller (1992: 258) claims that Kuhn's (1970) vision of science is simply devoid of political concerns, in fact stating that Kuhn (1970) sought to "minimize the presence of disagreement" by revering homogeneous communities of scientists who all agree with a given paradigm. In business management research, the process of determining what theory will receive prominence depends on the scientist's ability to argue the case for the paradigm and to communicate the suitability of the paradigm for explaining the phenomena in question (Green, 2004). The determination of what paradigm prevails cannot be a purely machine-like, objective assessment of the science.

Kuhn's (1970) book has, through the discourse surrounding it for multiple decades now, catalyzed substantial discussion about *science as process* and the scientific endeavor that we pursue. In one sense, Kuhn provided assurance to academics that we all benefit from solving our "paradigmatic puzzles" (Fuller, 1992: 274), and a sense of optimism regarding the sometimes modest phenomena that we examine. At the same time, Kuhn's (1970) arguments challenge the collaborative ideal of critical rationalism (Fuller, 1992: 274), in which scientists humbly submit their own work to the objective testing and critique of others, perhaps even those outside of their specific paradigm.

As a final note, the health of a scientific field does not depend solely on methodological sophistication. The promise that though our sins be as scarlet, methodology will make us pure is a false one. Ultimately the health of our scientific communities also relies on *communicative action* (Habermas, 1987) and the ethical rules of conversation, such as: don't lie, give attention; do not shout; let other people talk, explain yourself when asked, and do not resort to violence or conspiracy in the aid of our ideas (Habermas, 1987; Mahoney, 1993; McCloskey, 1985). Fruitful inquiry thrives in an environment of open and honest debate regarding the validity and usefulness of a given paradigm and consequent paradigm shifts.[9] Doctoral student programs, professional conferences, and research journals have critical roles in highlighting the importance of civility in discourse and in encouraging diversity in methodologies and paradigmatic views (Drnevich et al. 2020).

Rigidity about a paradigm or sophistication in methodology should not keep research from addressing real and practical problems. Researchers should avoid becoming prisoners of their own paradigms. Although it is instrumental for researchers to embrace one or two paradigms in their career, it remains important that a researcher avoid condemning other paradigms just for the sake of criticism. Researchers should be open to the possibility that they are not fully informed or that they do not fully understand the other paradigm. Researchers equipped with sufficient understanding or capabilities in alternative paradigms drive scientific progress. Paradigms should propel scientific progress by providing common understanding of a discipline; they are not to be used as motives for entrenchment that prevent shifts toward better theories.

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Notes

[1]Kuhn (1970: xi) notes that James B. Conant, then president of Harvard University, introduced Kuhn to the *history of science*—see, for example, Conant (1947). Subsequently, Kuhn (1970) was particularly influenced by: Jean Piaget's (1930) insights in psychology on (children's) causal beliefs; Pierre Duhem (1904), Émile Meyerson (1930), Arthur O. Lovejoy (1936), Alexandre Koyré (1939), and Herbert Butterfield (1949) on the history of scientific knowledge; Hans Reichenbach (1938), Carl Gustav Hempel (1952), and R. B. Braithwaite (1953) on concept formation, the distinction between observational and theoretical terms, scientific explanation, and prediction; Nelson

Goodman (1951) on methodological principles; Willard Quine (1953) on logic and the analytic tradition; Benjamin Whorf (1956) on the effect of language on worldview; Norwood Hanson (1958) on patterns of scientific discovery and the process of abduction; Michael Polanyi's (1962) concept of tacitness; and Karl Popper (1959) on prediction and the criterion of falsifiability, albeit Kuhn is careful to distinguish Popper's (1959) normative science criterion of falsification from the historical view of science and the concept of anomalies (1970: 146–147).

[2]It should be noted that in Kuhn's view, "science is a cognitive empirical investigation of nature that exhibits a unique sort of progress [that] takes the form of ever-improving technical puzzle-solving ability, operating under strict—though always tradition-bound—standards of success or failure" (Kuhn 2000: 2).

[3]The inculcation of values toward scientific commitment coexists with the dark side of conformity. Weintraub noted within the economics discipline that, "an insidious and subtle thought control pattern is asserted through recommendations and promotions, and in publications. And so, we reap a sad harvest in homogeneous half-truths" (1985: 512). Long ago, William Stanley Jevons wrote about the "noxious influence of authority," stating that: "In matters of philosophy and science, authority has ever been the great opponent of truth. A despotic calm is usually the triumph of error. In the republic of the sciences, sedition and even anarchy are beneficial in the long run to the greatest happiness of the greatest number" (1879: 298).

[4]Early criticisms of Kuhn's thesis concerned the vagueness in the concept of "paradigm" (Masterman, 1970; Shapere, 1964). Shapere submits that Kuhn's paradigm "covers a range of factors in scientific development including or somehow involving laws and theories, models, standards, and methods (both theoretical and instrumental), vague intuitions, [and] explicit or implicit metaphysical beliefs (or prejudices). In short, anything that allows science to accomplish anything can be a part of (or somehow involved in) a paradigm" (1964: 385). Kuhn responded to these critiques, noting: "in much of the book, the term 'paradigm' is used in two different senses. On the one hand, it stands for the entire constellation of beliefs, values, and techniques, shared by the members of a given community. On the other, it denotes one sort of element in that constellation, the concrete puzzle solutions which, employed as models or examples, can replace explicit rules as a basis for the solution of the remaining puzzles of normal science" (1970: 175). The first sense of the construct of a paradigm concerns the bigger picture of the sociology of science. The second sense of the construct of a paradigm concerns exemplar past achievements.

[5]Concerning the very idea of refutation of theories, Popper notes that: "In point of fact, no conclusive disproof of a theory can ever be produced; for it is always possible to say that the experimental results are not reliable, or that the discrepancies which are asserted to exist between the experimental results and the theory are only apparent and that they will disappear with the advance of our understanding" (1959: 28).

[6]Kuhn (1970) was challenging a dominant view in the 1950s that contradictory theories could be reduced to one another (e.g., Oppenheim & Putnam, 1958). We thank an anonymous reviewer for bringing this idea to our attention. Kuhn maintained that it was impossible to define all terms of one theory in the vocabulary of another theory, in which its original meaning in mathematics of "no common measure" becomes "no common language" (2000: 36). Furthermore, Kuhn considered incommensurability in terms of "methods, problem-field, and standards of solution" (1970: 103).

[7]Singhal and Singhal (2012) provide a history and paradigm shifts in operations and supply-chain management, and Kumar et al. (2018) describe paradigm shifts at the interface of operations and information systems management.

[8]Sankey (1993) notes that Kuhn's treatment of incommensurability divides into early and late positions. Originally, Kuhn's incommensurability construct involved semantical, observational, and methodological differences between paradigms in which proponents of incommensurable theories are unable to communicate, and that there is no recourse to neutral experience or objective standards to adjudicate between theories. In subsequent efforts, Kuhn restricted the construct of incommensurability to semantic differences and to the indeterminacy of translation.

[9]Bauer (2004) offers suggestions to mitigate dogmatism and fraud in modern science. We thank an anonymous reviewer for this suggestion.

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