



Imperatives of the science of operations and supply-chain management

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ABSTRACT

Although knowledge in operations and supply-chain management (O&SCM) has advanced substantially during the last six decades, our community has not fully utilized the potential for radical innovations. We identify two sets of opportunities for pursuing radical innovations. First, there is an opportunity to pursue all phases of science, including exploratory and qualitative research, developing theories, causation and internal validity, and testing models and theories for external validity (the ability to generalize knowledge to other situations). This would broaden the domain covered by each research effort, minimize the bias resulting from the choice of research paradigm and research domain, to enhance external validity, and to minimize the gap between our research efforts and the real world our community seeks to reshape. Second, there is an opportunity to pursue multiple perspectives because a scientific conclusion valid for a narrow domain may prove to be partially true or even false if one obtains multiple perspectives. Multiple perspectives can be obtained by investigating different parts of the system, by employing different methods of analysis, by using different sources of data, or by using different subsets of the same data. Developing scientific knowledge requires pursuit of all phases of science and of multiple perspectives. In a separate paper, we propose and analyze ways to accomplish it.

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1. Introduction: the need for the science of O&SCM and opportunities for our community

1.1. The need for the science of O&SCM

We know that management, like engineering and medicine, is to some extent an art and that its effectiveness depends on advances in the science of management just as the effectiveness of engineering depends on advances in physical and chemical sciences and the effectiveness of medicine depends on advances in biological sciences. We also know that any scientific knowledge must be based on the right questions and must have internal validity (assignment of causes to effects) as well as external validity (the ability to generalize knowledge to other situations).

The phases for pursuing science include conducting exploratory and qualitative research, developing theories, determining causation and ensuring internal validity, and ensuring external validity by testing models and obtaining multiple perspectives. Langley et al. (1987, p. 5) emphasized that the processes of discovery and the processes of verification are intimately connected and added (p. 3), “What distinguishes science from other works of human

imagination is precisely the insistence on testing, on subjecting hypotheses to the most intense scrutiny with the help of empirical evidence.”

Scientific analysis in the social sciences and the science of management differs from the scientific analysis in natural sciences like physics in two aspects. First, in natural sciences, the underlying laws do not change over time though our understanding of them evolves continuously. In the social sciences and the science of management, the concerned domain itself changes over time. Second, natural sciences deal with homogeneous entities and follow “the law of uniformity of nature,” while many parameters in the science of management differ from firm to firm and from one individual’s mindset to another’s.

1.2. Opportunities for the discipline of operations and supply-chain management

Since World War II, developments in practice and in academic research have substantially advanced knowledge in operations and supply-chain management (O&SCM). However, most of the knowledge we academic researchers have created does not have the scientific validity managers need. Our review of the research published during the last several decades indicates that there is an opportunity to broaden the domain covered by each research effort, to minimize the bias resulting from the choice of research paradigm and research domain, to enhance external validity, and to minimize the gap between our research efforts and the real world our

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community seeks to reshape. We now outline some of these opportunities:

1.2.1. Broaden focus and pursue breakthrough research

Research is almost always incremental and often narrowly focused. However, one research project may advance the knowledge only marginally while another may accomplish a major breakthrough. Similarly, one research project may have a minor impact on a narrow domain while another may have a major impact on a wide domain. In their editorial for the inaugural issue of *Organization Science*, Daft and Lewin (1990) wrote that “a journal-length manuscript is suitable for bite-size, incremental, logical-next-step approach.” Geoffrion (1992, p. 429) commented, “The preoccupation of academia with theory sometimes results in excellent work that strengthens the foundations of MS/OR for decades to come (witness most of the contributions recognized by the Lanchester and von Neumann prizes). But more often, the result is work that is highly incremental or so specialized that eventual application is unlikely.” Daft and Lewin and Geoffrion were essentially referring to research that advances knowledge only marginally and makes a minor impact on a narrow domain. The O&SCM community has an opportunity to broaden focus and pursue breakthrough research.

1.2.2. Build on innovations by companies, and encourage practice-driven academic research

Many developments in managing organizations during the last six decades have come from O&SCM, including Toyota-like manufacturing and service systems (a combination of quality management and just-in-time operations), distributed production and integrated supply networks, process reengineering, industrialization of services and the dichotomy of high-contact and low-contact service operations, and sustainability (green products and reverse supply chains). In most cases, the organizations either pursued the innovations on their own without help from academia or relied on practice-driven academic research, and in a few cases, they applied theoretical work reported in the literature. Academic researchers had only marginal roles in innovations in organizations because management innovators need the cooperation of companies to pursue innovations and while many companies are fairly receptive to such work, academic researchers in O&SCM tend to avoid the additional efforts required in these endeavors. Such avoidance is one of the major reasons for leading journals to publish many articles that are armchair extensions of what has been reported in the literature. It also explains why such extensions may not necessarily be connected to the real world and why we are not fully utilizing one of the major sources of radical innovations in academic research in O&SCM.

1.2.3. Pursue all phases of science

The O&SCM community generally does not pursue all phases of science, including exploratory and qualitative research, developing theories, causation and internal validity, and testing models and theories for external validity. Currently, mathematical models and hypothesis testing dominate academic research in O&SCM.

1.2.4. Tune research for ill-defined systems and multiple objectives

In 2004, Hopp, editor-in-chief of *Management Science*, wrote, “Military applications and those that followed in the private sector (inventory control, scheduling, resource allocation, and so forth) had clear objectives and a narrow scope. In contrast, general management decisions involve ill-defined systems and multiple objectives, as well as human behavior and values” (2004, p. 5). A substantial part of academic research in O&SCM deals with well-defined problems and with one or two objectives. In many cases,

the findings from such research may have little internal or external validity for facilitating management decisions.

1.2.5. Incorporate multiple perspectives and cross disciplinary boundaries

For managers to consider academic research valid and useful, it must include multiple perspectives which can be obtained by investigating different parts of the system, by employing different methods of analysis, by using different sources of data, or by using different subsets of the same data. Academic researchers in O&SCM, however, do not consider multiple perspectives on most problems. When they do pursue multiple perspectives, they usually take decades to obtain a subset of the desired multiple perspectives, too few to develop a valid and reliable theory. Furthermore, while real-world problems rarely fall under the purview of a single discipline, academic research in O&SCM, with the exception of the marketing-operations interface and the current trend in behavioral operations, rarely crosses its boundaries.

1.3. Scientific research paradigms

Kuhn (1970, 1996) defined a scientific paradigm as what is to be observed and examined, what questions are to be asked, how questions are to be structured, and how results of the investigations are to be interpreted. He observed that peaceful periods in science are interrupted by crisis-driven revolutions, that internal or external events trigger the crises, and that each revolution leads to the rise of a new research paradigm which handles the same bundle of data as the earlier paradigm but places the data in different systems of relations. He observed that the existing paradigm and a competing emerging paradigm often battle for years before one or the other paradigm becomes dominant. Several paradigms often co-exist for some time, usually until after their originators pass away. The emergence of the new dominant paradigm may not be clear for decades.

Eldredge and Gould (1972) developed the concept of *punctuated equilibrium*. They said that new species arose through sudden punctuations of rapid change, but environmental selection determined the fates of the new species. In the case of sciences, a punctuated equilibrium is analogous to the rise of a new paradigm, which will survive only if the environment, that is, the community consensus, supports it. Thus, paradigm revolutions or punctuated changes can take place in the sciences and in the systems being investigated.

In both Kuhn’s analysis of paradigms and in Eldredge and Gould’s punctuated equilibria, periods of evolution are punctuated by revolutionary changes. Although Kuhn essentially discussed theoretical paradigms, the term paradigm has often been used in social and management sciences to include methodological paradigms. We address both types of paradigms.

In this paper, we discuss what constitutes scientific knowledge and radical innovation, analyze the shortcomings of the discipline of O&SCM from a historical perspective, and argue that we can mitigate these shortcomings by pursuing all phases of science and by pursuing multiple perspectives. The paper is organized as follows: in Section 2, we describe the current state of O&SCM and its history since 1880 in the context of its scientific paradigms. In Section 3, we explain the need for pursuing multiple perspectives in O&SCM research. In Section 4, we describe examples of the bullwhip effect and the product diffusion process in which organizations obtained multiple perspectives over several decades, we identify the factors that trigger the need for and development of multiple perspectives, and we suggest four propositions on obtaining new insights from multiple research perspectives. In Section 5, we highlight some points covered in the paper and offer concluding remarks.

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