Mechanisms of Innovation in the Space and Defense Sector: A Review

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ABSTRACT

Despite a rich legacy of space sector technological achievements, agencies are increasingly being criticized for their inability to deliver on their innovative promises. Although the phenomenon of innovation has received substantial attention across multiple disciplines, it has largely focused on relatively simple products in nearly competitive markets, making its applicability to the space system context suspect. This paper reviews the economic, political science/strategic, business and operational literatures most relevant to complex product innovation in government markets. It categorizes their insights in terms of the sources of innovation as – external political-level leadership, internal bureaucratic politics, structure of the system, new technologies and user innovations – to illustrate the overlap and gaps among the disciplinary insights. It argues that past studies have over emphasized innovations that were generated by idiosyncratic events and have not adequately addressed the architectural dimension of complex product innovation. If useful prescriptions are to be developed, the process of normal complex product innovation in monopsony markets must be examined as a whole. To this end, the paper suggests several priorities for future work.

Keywords: *Complex Products, Defense Sector, Government Monopsony, Innovation Mechanisms, User Innovations*

INTRODUCTION

Innovation is widely recognized as an important driver of economic growth and efficiency across multiple disciplines (Utterback, 1974) and a necessity for sustained technological competitiveness. However, despite significant scholarly attention by economists, sociologists, business and military strategists, psychologists and technical historians among others, there remains limited consensus, among the disciplines, as to what innovation is and how it should be best encouraged. Broadly defined, innovation is the *implementation* of something *new* and *useful*. Part of the problem in defining the concept more precisely is that the dynamics

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of innovation appear to be strongly related to the environment in which innovation occurs[1] (Nelson, 1993; Rothwell and Zegveld, 1994) and the choice of the "unit" of innovation[2] (Utterback & Abernathy, 1975; Henderson & Clark, 1990).

Since the choice of these parameters – context and product unit – often relates to the domain interests of the investigator, multiple seemingly contradictory explanations have emerged. For example, individual characteristics and the structure of organizational relationships have both been shown to be primary drivers of innovation (Susskind & Zybkow, 1978). Similarly, von Hippel's emphasis on lead users as an important source of innovation (Morison, 1966; von Hippel, 1988) contradicts the notion that innovation is catalyzed by visionary leaders in a position to enact change from the top-down (Rosen, 1994). In fact "factors found to be important for innovation in one study are found to be considerably less important, not important at all, or even inversely important in another study. This phenomenon occurs with relentless regularity" p. 700 (Downs & Mohr, 1971). Another study found that of 38 propositions about innovation identified by academics in the field, they disagreed on 34 of them. Of the four that they did not disagree about, none had received more than limited peer review (Rogers & Schoemaker, 1971). Rather than being contradictory, it is likely that different studies are accurately observing different pieces of an extremely complex phenomenon (Faberberg, Mowery, & Nelson, 2005). If a consistent system-level picture is to emerge, attention must be given to the ways in which insights from the various innovation disciplines complement each other.

One area where this is particularly important is in the context of a government agency's acquisition of complex technological products. Sectors like space and defense have several key attributes in common. There is an expectation for each system to be vastly superior to its predecessor, between generational improvements occur at multiple levels of the technical architecture, and with only a single viable customer in many cases, much of the technology development burden falls to the government (Sherwin & Isenson, 1967; Adams & Adams, 1972). As a result, complex organizational systems have been put in place with the goal of catalyzing a particular type of innovation: breakthroughs relevant to complex product innovation (Szajnfarber, Richards, & Weigel, 2011). To do this, these government agencies must contribute to all aspects of the innovation process, from defining appropriately advanced requirements to doing basic science in dedicated research labs. Thus, insights from the commercial innovation literature regarding the differences between environments that foster entrepreneurial behavior and structured incremental change (Utterback, 1994), or how incentive structures are best designed to encourage innovation (Teece, 1986) may be equally as relevant as the more traditional insights derived from "grand historical narratives, operational histories, or bureaucratic-political case studies," characteristic of public sector innovation studies (Grissom, 2006).

In order to assess the relevance of existing explanations, the paper integrates the diverse literatures in terms of the innovation sources they identify. In order to assess the coverage of the explanations, it then overlays the explanations on a conceptualization of the process of innovation in the government space sector. It finds that the existing explanations individually cover particularly parts of the process, but no theory explains the system as a whole. Based on the identified gaps in the stitched-together view, the paper concludes by suggesting productive areas of future research.

REVIEW: INNOVATION MECHANISMS IN COMPLEX ORGANIZATIONAL STRUCTURES

This section reviews a wide range of studies that have addressed the question of "what drives innovation?" empirically. The process of complex product innovation - developing