

Reflections on Mansfield, Technological Complexity, and the “Golden Age” of U.S. Corporate R&D

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ABSTRACT. We focus on two themes, among those in Mansfield's work, particularly relevant to understanding the role of large corporations in the U.S. innovation system: (1) the development of science-based inventions into market-ready innovations, and (2) the imitation by one firm of another's technology. Both of these phenomena, we propose, depend critically on the extent of technological and organizational complexity characteristic of current products and potential innovations. Reporting on recent survey research of our own, we argue that the origins and potentially the future of U.S. leadership in technology-based economic growth lie in the complementarity of large corporations and entrepreneurial start-ups, each exploring and exploiting the market potential of different types of science-based innovations.

Key words: complexity, corporate research and development (R&D), imitation, invention, innovation, military, technology

JEL Classification: L22, L23, O31, O32

The management of technology entails a great deal more than the establishment of an R&D laboratory that produces a lot of good technical output. A central problem facing a firm that attempts to be innovative is to effect the proper coupling between R&D, on the one hand, and marketing and production on the other. Many R&D projects are designed without sufficient understanding of market and production and realities. Many marketing and production people are unnecessarily impervious to the good ideas produced by R&D people and people in other parts of the firm, there being considerable evidence that person-to-person contacts are the most effective way of transferring ideas and technology.

—Mansfield (1993, p. xix)

1. Introduction

In papers and books spanning decades, Edwin Mansfield meticulously explored the nature of the innovation process. Notably for the purposes of this paper, Mansfield's work focused on corporate research and development (R&D) in the U.S. during an era of previously unmatched U.S. scientific, technological, and economic dominance. A contribution to a volume published in Mansfield's honor is thus a natural place to raise the question: Has the golden age of science-based innovation in large corporations drawn to a close? Our paper seeks to address both policy and theoretical dimensions of this question, informed by recent research on investments in early stage technology development (ESTD) in large corporations—the “coupling between R&D, on the one hand, and marketing and production on the other” described by Mansfield in the above quote.³

On the policy side, we begin with the view—seemingly uncontroversial, but actually quite debatable—that to understand the future role of U.S. corporations in the innovation system, we have to understand its past. Since World War II, industry in the United States has (notably, during the Cold War) vied, successfully in the main, with other nations for leadership in technological capabilities. Once other nations recovered from World War II, particularly in the 1980s, U.S. firms in some industries failed to capture the returns from products they originally prototype as rapidly as foreign competition. Yet during what we are referring to as the “golden age” of U.S. corporate R&D from 1950 to 1980, the leadership of the U.S. in both science and commercial inventiveness was nearly absolute.

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Of the themes in Mansfield's work, we focus on two that are, in our view, fundamental to understanding the role of large corporations in the U.S. innovation system past and future: (1) the development of science-based inventions into market-ready innovations by large firms (Mansfield, 1969, 1981, 1993, 1995), and (2) the imitation by one firm of another's technology (Mansfield 1961, 1963; Mansfield *et al* 1981).⁴ Both, we will argue, depend critically on the extent of technological and organizational complexity of both current products and potential innovations. Referring to Mansfield's findings, we will suggest that the origins and potentially the future of U.S. leadership in technology-based economic growth lie in a unique complementarity between large corporations and entrepreneurial start-ups, each exploring and exploiting the market potential of different types of science-based innovations.

In Section 2, we describe the ascendancy of U.S. corporate research and development operations, which we argue was driven to a substantially extent by the disruptive impacts of World War II and subsequent military dominance of support for U.S. research and development (R&D). In Section 3, we discuss technology-based innovation in large corporations in the 1960s and 1970s, viewed via the early works of Mansfield and his contemporaries—notably, other contributors to the 1962 volume on *The Rate and Direction of Inventive Activity: Economic and Social Factors*, edited by Richard Nelson. In Section 4 we turn to current trends. We propose a conceptual model of the process of technology-based innovation in corporations, then report the findings from recent survey research based upon that conceptual model. In Section 5, we summarize the implications of the paper for the future role of large corporations in the U.S. innovation system.

2. World War II and the ascendancy of large, research intensive, U.S. firms

Rosenberg and Birdzell (1985) document the advent, at the end of the 19th century, of the corporate research laboratory. The dramatic trend toward the consolidation of American business in the first quarter of the 20th century had a direct

impact upon the organization of industrial innovation. As early as 1928, Joseph Schumpeter observed that in the new era of oligopolistic markets dominated by large trusts, "innovation is ... not any more embodied *typically* in new firms, but goes on, within the big units now existing, largely independently of individual persons Progress becomes 'automatised', increasingly impersonal and decreasingly a matter of leadership and individual initiative" (Schumpeter, 1928, pp. 384–385).⁵ To Schumpeter, the routinization of innovation was a global phenomenon with profound implications. It meant the end of entrepreneurship, and thus the *de facto* end of capitalism: "Capitalism, whilst economically stable, and even gaining in stability, creates, by rationalizing the human mind, a mentality and a style of life incompatible with its own fundamental conditions, motives and social institutions, and will be changed, although not by economic necessity and probably even at some sacrifice of economic welfare, into an order of things which it will be mere a matter of taste and terminology to call Socialism or not".

The evolutionary economic and social trajectory that Schumpeter in 1928 sought to anticipate—already volatile in the aftermath of the "Great War"—was violently disrupted by the World War II. In 1913, prior to World War I, dynamic centers of production capable of developing new products competitive in world markets existed in many countries (notably Czechoslovakia, France, Germany, Italy, Japan, the U.K., and the U.S.). The U.S. accounted for only 17% of world GDP while Western Europe, Russia, Japan, and China together accounted for 74%. World War II devastated U.S. competitors for science and technological leadership at the same time that it drove a surge in U.S. productive capabilities. By 1950, five years after the end of World War II, the U.S. was thoroughly dominant in commercial innovation. More broadly, the U.S. now accounted for 27% of world GDP while Western Europe, Russia, Japan, and China together accounted for only 50%—a degree of economic concentration exceeded in the past 500 years only in the case of China during the early 19th century.⁶ The return home of 12 million veterans not only fueled an immediate demand-driven postwar boom but also created within the labor pool a deep reservoir of management and