

## Introduction

This volume contains a selection of previously published articles on technological innovation, technology transfer, and the multinational enterprise. Different business models to effectuate technology commercialization are analyzed, along with licensing and the technology transfer process itself. Both management and public policy issues are addressed.

The papers in Part I focus on international technology transfer, which was the focus of my dissertation research at the University of Pennsylvania. It was at the University of Pennsylvania in the 1970s that I developed my interests in the transfer and licensing of know-how.

The first chapter in the volume, originally published in *The Economic Journal*, contains the results of my dissertation research on the resource cost of international technology transfer. This study provided the first published scientific evidence of the real costs of technology transfer. It also provided some insights into the factors that determine those costs. The study found that, in general, technology transfer costs decrease with each subsequent transfer of the same or similar technology, particularly in the chemical industry. The age of the technology was most important in the cost of transferring technology machinery. This paper also evidences that, even back in the mid-1970s, I had begun to recognize and analyze the role of “capabilities” and the effort, time and cost of conveying these capabilities across international borders.

Chapter 2, from *Management Science*, was also research done as part of my doctoral dissertation. This paper investigates the tradeoff between reduced time and higher cost that a multinational corporation faces when transferring technology internationally. I estimated that the elasticity of cost with respect to time was greater than one, and was significantly greater for technology that had not been previously commercialized, for projects that were large, and for projects carried out by larger firms.

Chapter 3 contains my first attempt to elucidate the distinctive issues associated with exchanging knowledge (as compared to tangible assets), and to analyze how these characteristics of knowledge affect the choice of organizational arrangements for international technology transfer. This chapter highlights the advantages that internal transfer within a multinational corporation has over arms-length transfer (between independent firms) in overcoming these problems. It also explains some of the practices used by multinational firms to

control the transfer of technology, and advocates against restrictions on the flow of technology.

Chapter 4 in this volume, written for the *Journal of Technology Transfer*, extends this analysis, emphasizing how the nature of knowledge compounds the difficulties of technology transfer. It also explains how a multinational enterprise (MNE) overcomes some of these difficulties. This is the first chapter in this volume to mention and challenge the Hymer hypothesis — that the MNE is a tool for the extraction of monopoly rents and, by implication, the amplification of poverty. The chapter also relates my work on international technology transfer to Edwin Mansfield's earlier work on technological innovation more generally, and highlights the significant influence that Mansfield had on my understanding of research and development and innovation.

The series of articles in Part II discuss licensing issues.

“Profiting from Technological Innovation” (Chapter 5 in this volume) has become a highly cited article in technology management, and was selected by the editors of *Research Policy* as one of the ten best papers that the journal had published for the period 1971–1991. It is perhaps the most cited article ever published in *Research Policy*. This article analyzes the optimal strategy of a firm commercializing an invention, and seeks to explain why innovating firms often fail to capture the economic returns from their inventions. Drawing on my understanding of the nature of knowledge and functioning of the markets for know-how, I introduce a new framework based on three basic concepts — the appropriability regime, complementary assets, and the dominant design paradigm — and a set of alternative organizational modes — or business models — available to entrepreneurs to commercialize their inventions. Applying this framework, this chapter argues that in order to capture value from its innovation when the appropriability regime is weak (i.e., when imitation is easy), an innovating firm must often integrate into the complementary assets as soon as a dominant design is becoming established. If imitation is easy, however, there is no guarantee of success even when the innovating firm follows this strategy.

Chapter 6, written with Peter C. Grindley and first published in the *California Management Review*, investigates intellectual property (IP) management and licensing strategies in the semiconductor and electronics industries. The article discusses how royalty-free cross-licensing evolved as a response to regulatory and judicial constraints; but, as the regulatory environment changed, global competition sharpened, and the value of intellectual capital increased, thus IP owners began to enforce their intellectual property rights more aggressively. This chapter illustrates how preferred licensing strategies change with the

importance of intellectual capital, and provides lessons for managing intellectual capital.

Chapter 7, written with Deepak Somaya, analyzes the strategies for commercializing innovation in “multi-invention” contexts — that is, where innovation requires the combination of a very large number of inventions. This article builds on the framework developed in Chapter 5 by adding a set of “patent strategies” that support the entrepreneur’s choice of organizational mode. It revisits the analysis of IP management in semiconductors and electronics. In Chapter 7, we examine the patent strategies most appropriate to support the integrated commercialization modes chosen by AT&T, IBM, and Texas Instruments. We also examine the patent strategies used to support non-integrated licensing or “component” modes chosen by ARM and Kentron Technologies.

Chapter 8, co-authored with Edward F. Sherry and published in *Research Policy*, discusses methods for calculating “reasonable royalty” rates when a patent is found to be valid and infringed. The article draws the distinction between the value of innovation and the value of intellectual property, and explains how the value of intellectual property changes over the different stages of the life of a patent. The value of patents proven valid and infringed through litigation should have higher royalty rates attached to them as compared to royalties negotiated in licensing agreements for the equivalent but untested patents. The article argues that the standards used to calculate “reasonable royalty” rates in litigation, and thereby to set intellectual property damage awards, have a huge impact on the incentives not only to litigate patent disputes to trial, but also to invest in innovation in the first place.

Chapter 9, also written with Edward F. Sherry and first published in the *Minnesota Law Review*, looks at patent licensing issues that arise in the context of setting design and compatibility standards for technological products. There has been debate over whether, when the patented technology of a participant in a standard-setting organization (SSO) overlaps with a voluntary standard, that firm has an obligation to license its patents to other participants, and on what terms. We carefully examine the standard-setting process and the roles played by the different participants in these SSOs, and argue that there are very limited situations in which a patent holder can exercise “hold up” by “manipulating” standards. We discuss the problems with mandatory search, disclosure and compulsory licensing rules that SSOs contemplate to try to prevent hold up. We conclude that the most important requirement is that the rules of SSOs be clearly stated.

Chapter 10, written with Michaelyn Corbett and Mohan Rao, outlines licensing issues in trademarks. We discuss the economic principles behind the granting of a trademark, and relate these to the different approaches for valuing them — namely the cost approach, the market approach, and the income approach.

Part III focuses on the organization of research and development.

Chapter 11 attempts to move the economic debate on technological innovation beyond its preoccupation with market structure (or market power) to explore how different organizational arrangements inside and amongst firms affect the rate and direction of innovation. I develop a framework based on considering the depth of hierarchy, the scope of product market activities, the degree of vertical integration, the strength of organizational culture, and the number of external linkages. I use this framework to analyze how different organizational types — or governance modes — suit different forms of innovation.

In the *Economica* article reproduced in Chapter 12, Edwin Mansfield, Anthony Romeo and I examine the amount and reasons for overseas R&D investment by US-based firms three decades ago. We find a significant relationship between the percentage of R&D carried out overseas and the percentage of sales derived overseas. However, the relationship between sales and R&D is stronger when the sales are made by foreign subsidiaries than through direct exports. Meanwhile, we found that those R&D activities carried out overseas had large minimum efficient scale and the firm had access to inputs at substantially lower cost than in the US. In addition, those activities were focused more on development than research, on product and process improvements rather than developing new products and processes, and on relatively short-term, technically “safe” work. The data is not available to know just how the situation differs today.

The article reproduced as Chapter 13 assesses the importance of inter-firm and inter-organizational linkages for the development of and commercialization of new technology. These include linkages between firms in an industry and universities, the users of its products, the suppliers of its inputs, and other firms engaged in similar activities. The chapter compares the merits of market-based cooperation (or contractual arrangements) and vertical integration for establishing and managing these linkages.

Chapter 14, written with my Berkeley colleague David C. Mowery, examines the decrease in in-house R&D by US firms, and the corresponding increase in firm participation in alliances and research consortia. The chapter considers three

broad forms of R&D collaboration that have developed over the past 20 years or so — international strategic alliances, pre-commercial research consortia, and university–industry research collaborations. The chapter examines the comparative advantages of each of these arrangements for R&D, as well as the limitations of each as a substitute for in-house R&D.

In Chapter 15, in an article co-authored with Henry W. Chesbrough for the *Harvard Business Review*, I counter the sometimes popular arguments for organizing innovation through “virtual” structures. We argue that virtual corporations, which do not have control over all the important aspects of technology development, are likely to lose out in races to develop systemic innovations. We show several examples of firms that have failed to capture the economic returns to an innovation when they have contracted out the important aspects of technology development. Meanwhile, we illustrate how Motorola in wireless communication, and the successful firms in chemicals, steel and railroads during the late 19th and early 20th century, were companies that made major internal investments to shape markets, rather than relying on others to do the R&D for them.

Chapter 16, written with John M. de Figueiredo, examines the hazards to which downstream, non-integrated firms in leading-edge industries are exposed when they procure important inputs from vertically-integrated competitors. The paper outlines the main strategic hazards in such procurement, and examines the conditions under which a constellation of transaction-specific and relational safeguards — rather than (upstream) integration by the downstream firm or (downstream) divestiture by its supplier — can be used to protect the downstream firm against these hazards.

Part IV contains a collection of papers focused on the multinational enterprise.

Chapter 17, which originally appeared in a 1981 book titled *Technology Transfer and Economic Development*, examines the role of the MNE in stimulating technology transfer to and R&D activities in developing countries. Drawing on the “Markets & Hierarchies” (or “transaction-cost economics”) approach, I demonstrate how the MNE can attenuate some of the problems of transferring technology through an international market transaction between distinct firms. This chapter discusses the types of technology transfer and R&D activities that are conducted by MNEs, and examines the role of the MNE in affecting technological choice in the host country.

Chapter 18 discusses whether the MNE has efficiency-enhancing or market power (i.e., efficiency-reducing) effects. Although the theory identifies certain

instances in which the organizational structure of the MNE may be used to support anticompetitive behavior, in general it suggests that the MNE structure is efficiency-enhancing. Moreover, I argue in this chapter that domestic antitrust regulation should be adequate to deal with those instances where the MNE structure has anticompetitive consequences.

Chapter 19, published in the *American Economic Review*, analyzes the development of economic theory on the MNE from an arbitrageur of capital, through an arrangement for achieving monopoly power (as argued by Hymer), to an efficient organizational structure for overcoming failures in the market for know-how. This paper argues that in order to understand the MNE, it is necessary to compare it against a feasible alternative, rather than against an unrealistic benchmark of a product market with perfect competition. Using this framework, it illustrates that the MNE's anticompetitive properties are overblown. The paper also analyzes the desirability of host countries imposing controls on MNEs, and MNEs requiring investment safeguards from the host country.

Chapter 20 contrasts the transaction-cost analysis of the MNE with the "internalization school", which emphasizes the advantages and costs associated with internalizing economic activity within the MNE. The distinctive feature of the transaction-cost approach as against the internalization school is the emphasis on a comparative institutional analysis of the MNE against feasible alternatives. This chapter highlights the tradeoffs between the governance costs associated with transactions in MNEs and the transaction costs associated with international market transactions. The chapter also uses the transactions cost approach to analyze the relationship between the MNE and the host country with respect to foreign direct investment, as well as the implications of nationalization on that relationship.

Chapter 21 extends the theory on the MNE to incorporate the recent developments in the field of strategic management, particularly the development of the "dynamic capabilities" approach. The chapter reflects on Penrose's contribution to the resource-based theory of the firm, in the context of the capabilities theory, which holds that the source of a firm's competitive advantage derives from distinctive and non-imitable capabilities. It argues that the distinctive feature of the MNE is the ability to leverage these non-imitable, firm-specific assets across international borders.

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