



Knowledge, Strategy, and the Theory of the Firm

Author(s): Julia Porter Liebeskind

Source: *Strategic Management Journal*, Vol. 17, Special Issue: Knowledge and the Firm (Winter, 1996), pp. 93-107

Published by: John Wiley & Sons

Stable URL: <http://www.jstor.org/stable/2486993>

Accessed: 10/02/2010 11:35

Your use of the JSTOR archive indicates your acceptance of JSTOR's Terms and Conditions of Use, available at <http://www.jstor.org/page/info/about/policies/terms.jsp>. JSTOR's Terms and Conditions of Use provides, in part, that unless you have obtained prior permission, you may not download an entire issue of a journal or multiple copies of articles, and you may use content in the JSTOR archive only for your personal, non-commercial use.

Please contact the publisher regarding any further use of this work. Publisher contact information may be obtained at <http://www.jstor.org/action/showPublisher?publisherCode=jwiley>.

Each copy of any part of a JSTOR transmission must contain the same copyright notice that appears on the screen or printed page of such transmission.

JSTOR is a not-for-profit service that helps scholars, researchers, and students discover, use, and build upon a wide range of content in a trusted digital archive. We use information technology and tools to increase productivity and facilitate new forms of scholarship. For more information about JSTOR, please contact support@jstor.org.



John Wiley & Sons is collaborating with JSTOR to digitize, preserve and extend access to *Strategic Management Journal*.

<http://www.jstor.org>

KNOWLEDGE, STRATEGY, AND THE THEORY OF THE FIRM

JULIA PORTER LIEBESKIND

School of Business Administration, University of Southern California, Los Angeles, California, U.S.A.

This paper argues that firms have particular institutional capabilities that allow them to protect knowledge from expropriation and imitation more effectively than market contracting. I argue that it is these generalized institutional capabilities that allow firms to generate and protect the unique resources and capabilities that are central to the strategic theory of the firm.

Possession is nine-tenths of the law.
(Anonymous)

INTRODUCTION

For many strategy scholars, organizational economics in general, and transaction-costs economics in particular, remains a dissatisfying theoretical framework for theorizing about the relationship between organization and competitive advantage. Perhaps the most important source of this dissatisfaction is the apparent failure of transaction-costs theory to accommodate the central notion that strategy scholars hold about firms—that firms' principal purpose is to generate rents through creating and sustaining sources of competitive advantage (Bowman, 1974; Rumelt, 1984, 1987; Barney, 1986). One weakness of transaction-costs economics in this regard is its emphasis on static comparative analysis and on identifying generalized boundary conditions that exist between firms and markets. These emphases bypass the usual concerns of strategy research, which are focused on dynamic rent-seeking behavior, and the ownership and exploitation of unique assets and capabilities. In addition, transaction-costs theory is concerned primarily with

transactions that involved fixed, tangible assets.¹ Strategy researchers, instead, understand rents as deriving in large part from intangible assets such as organizational learning, brand equity, and reputation (Penrose, 1959; Rumelt, 1984, 1987; Barney, 1986; Spender, 1994; Grant, 1996). In particular, transaction-costs theory has paid scant attention to the question of knowledge. Yet knowledge is arguably the most important asset that firms possess—a key source of both Ricardian and monopoly rents (Penrose, 1959; Winter, 1988). Without taking knowledge into account, then, transaction-costs economics stands in danger of becoming a theory that provides only marginally useful connections between organization on the one hand and competitive advantage on the other.

In this paper, I argue that transaction-costs theory can be extended to accommodate the notion of knowledge in a way that is useful for strategy research. I argue that firms, *as institutions*, play a critical role in creating and sustaining competitive advantage: that of protecting valuable knowledge. Specifically, because prop-

Key words: knowledge; intellectual property; theory of the firm

¹ Thus, transaction-costs theories of the firm in general appear to be far more appropriate to explaining the scope of manufacturing firms, than service firms or 'knowledge work' firms such as consulting practices and research firms. One exception is Teece (1980, 1986), who argues that knowledge is an important determinant of the scope of the firm.

erty rights in knowledge are weak, and are costly to write and enforce, firms are able to use an array of organizational arrangements that are not available in markets to protect the value of knowledge. Thus firms can (a) differentially prevent expropriation of knowledge and (b) differentially reduce the observability of knowledge and its products, thereby protecting against imitation. In this way, firms are able to create 'possession rights' to knowledge that are just as valuable, if not more valuable, than the limited property rights to knowledge accorded under the law.

This argument has some important implications for strategy research. First, it suggests that the condition of 'uniqueness' that is so central to strategy theory depends critically upon the deployment of protective organizational arrangements by firms. Thus, the organization of a firm can serve as an important—if not critical—'isolating mechanism' (Rumelt, 1984). Consequently, the fact that resources and capabilities are distributed asymmetrically across firms may be attributed not only to luck, success in search, history or inherent causal ambiguity (Lippman and Rumelt, 1982; Nelson and Winter, 1982; Rumelt, 1984; Barney, 1986), but also to the fact that some firms are able to protect their knowledge from expropriation or imitation more effectively than other firms.

Second, considering firms as institutions that are able to protect the value of knowledge provides a direct connection between the organizational characteristics of firms on the one hand, and their dynamic strategic behavior on the other. By protecting knowledge, firms may serve to induce investment in strategic innovation, because incentives to innovate depend on the degree to which the innovator can appropriate future rent streams. In addition, if some firms are able to protect the value of their knowledge more effectively than other firms, these firms will have more high-powered incentives to innovate. Thus, we should expect to observe a long-run correlation between a firm's rate of innovation and its success at protecting the knowledge that it generates.

Third, by identifying some of the mechanisms firms can use to protect knowledge, the argument in this paper provides some concreteness to theories of the scope of the firm that are based on knowledge-protection arguments (Teece, 1980, 1986). This potentially allows for a more detailed development of predictions about the circum-

stances under which internalization of knowledge transactions will, or should, take place.

KNOWLEDGE AND RENTS

Knowledge

In this paper, I define knowledge as *information whose validity has been established through tests of proof*. Knowledge can therefore be distinguished from opinion, speculation, beliefs, or other types of unproven information.² This definition of knowledge is intentionally very broad: it can include such codified knowledge products as written documents and blueprints, as well as tacit knowledge such as uncoded routines.

Knowledge and rents

New knowledge is produced by investment in innovation and tests of proof. Because innovation and tests of proof are costly, and because new knowledge production is inherently an uncertain process (i.e., innovation and tests of proof cannot be relied upon to produce valuable new knowledge), valuable knowledge is unlikely to be distributed evenly across innovators, so that its ownership can potentially earn both Ricardian and monopoly rents (Winter, 1988).

Ricardian rents are earned by firms when one firm possesses factors of production that are more productive than those of other firms carrying out the same activity. When Ricardo wrote his original treatise on rents (Ricardo, 1926 [1821]), he used the example of 'good land' as a rent-bearing resource. Good land produces more output per acre than poor land, so unit costs of agricultural production are lower. In the modern world, however, most factors of production are not naturally occurring factors such as land, but are deliberately created factors such as machines, trained workers, and systems of work organization. Thus, superior knowledge allows a firm to build a better piece of machinery, train its workers more effectively, or devise a more productive system of work

² This is the Socratic/Platonic definition of knowledge—*eidos*—which can be contrasted with opinions or beliefs—*doxa*. This distinction is important because knowledge establishes reliable relationships between inputs or circumstances on the one hand and outcomes on the other: what we 'know' we can use repeatedly without further experimentation or proof.

organization (Penrose, 1959; Spender, 1994). Ricardian rents in modern industrial competition, then, are commonly generated from the knowledge of the firm. Similarly, a firm with superior product design knowledge can produce a unique product and earn monopoly rents.

Of course, there are other sources of Ricardian and monopoly rents such as luck, chance, and history (Lippman and Rumelt, 1982; Rumelt, 1984; Barney, 1986). However, luck, chance, and history cannot be managed. Therefore, it is difficult to conceive of a circumstance in which a firm can be said to earn a rent from its deliberate actions—i.e., its managerial strategy—without attributing that rent at least in part to the knowledge which allowed the relevant process or product to be created.

However, the argument that rents derive first and foremost from the knowledge of a firm depends critically on the assumption that a firm can protect its knowledge from appropriation or imitation by its competitors; that is, a firm can exclude others from using its knowledge.³ By definition, an asset cannot be expropriated—stolen—unless a thief has access to it either directly, or through third parties acting on her behalf. Similarly, for an asset to be imitated, it must at least be observed by the imitator or by a third party. In many instances, imitation will only be possible if the asset itself can be used or experienced. For example, it may be relatively easy to imitate clock production because the machinery can be disassembled, and its working can be easily observed.⁴ On the other hand, it may be far more difficult to imitate the production of a Wolfgang Puck pizza, because the quality

of the pizza is determined not only by the recipe (which may be imitated through experimentation or expropriated by theft), but also by the process by which the pizza and its ingredients are made, which can only be observed directly. Thus, to the degree that observability of products or processes can be reduced, causal ambiguity is increased, and the costs of imitation are increased accordingly.

The problem of knowledge protection

For many types of asset, exclusion is a relatively simple matter. First of all, many assets can be *defined according to property laws*, so that ownership can be asserted unambiguously. In particular, tangible assets such as land, buildings, and equipment are all considered property under the law. These assets can then be protected by social institutions that enforce property ownership (e.g., the courts). Tangible property can also be given additional, private protection at relatively low cost. For example, land can be fenced, and machinery and equipment can be locked inside a building, or fitted with starter keys.

A second feature that renders most tangible assets protectable is that they are *clearly observable, and have finite productive capacity*, so that expropriation can be easily detected. For example, an owner can observe whether or not an outsider is using her machinery, or has stolen it altogether. Thus, it is relatively simple to monitor property rights in tangible assets.

However, protecting knowledge is more problematical. First of all, *property rights in knowledge—patents, copyrights, and trade secrets—are very narrowly defined under the law, and are costly to write and enforce*.⁵ For example, patents have a limited life, and apply only to products that are entirely original and have proven efficacy. Also, patents are published, and so reveal the knowledge of a firm to its rivals.⁶

³ Rents will only accrue to an asset if it can be used exclusively by a single individual or entity; if a number of different individuals can use the asset, its rent will be dissipated (Demsetz, 1967; Barzel, 1991). For instance, in the case of Ricardo's 'good land', a rent can be earned only when the land is owned individually and when others are excluded from its use. If the good land were held in common, as under the feudal system, no rent would be earned (Demsetz, 1967; Barzel, 1991). Even if the good land were held individually, the value of that ownership would be dissipated if it were very costly to exclude others from its use (Field, 1989). In this case, other parties—such as deer or thieves—could consume the crops, eroding the productivity differential between good land and poor. Exclusion, then, is critical to the capability of any asset to earn a rent for its owner.

⁴ Indeed, the first example of Japanese imitation of a 'Western' technology took place in the eighteenth century, when Japanese craftsmen imported and imitated clockmaking technology (Boorstin, 1983).

⁵ Due to restrictions on the length of this article, I provide only a very cursory discussion of the limits to intellectual property and trade secrets law here. For a detailed discussion of this topic, please see (for example) Seidel and Panich (1973); Cheung (1982); Barrett (1991); Besen and Raskind (1991); and Friedman, Landes, and Posner (1991). My comments here refer to U.S. laws on intellectual property and trade secrecy. However, intellectual property laws are similar in many other developed countries.

⁶ Publishing is a problem because it allows competitor firms to 'invent around' an issued patent. Empirical research shows

Patents are only issued after a costly proving process,⁷ and can be challenged by other parties, and even overturned.⁸ Copyrights create ownership rights only for certain encoded products such as written documents, music, artwork, films, photographs, software, and technical drawings. Copyrights also have a limited life, and are costly to enforce, because the plaintiff must prove novelty of their copyrighted product for any suit for infringement to be successful. Finally, trade secrets laws apply only to knowledge that is codified and is in continuous use; 'noncontinuous' knowledge such as contract bids, plans or prototypes, and tacit knowledge, are not protected.⁹ In addition, unlike patents or copyrights, trade secrets laws do not protect against a rival using 'fair' methods to replicate the knowledge concerned, and use it, nor are they binding on third parties. The problem of protecting knowledge through property rights or trade secrets protections is summarized in Table 1. The table shows that these protections are extremely limited or nonexistent for knowledge that is only partially original, or is tacit, or is long lived. Thus, there is a large body of knowledge that may be valuable to a given owner, but that cannot be protected from expropriation and/or imitation under the law.

Knowledge is also difficult to protect because *it is difficult to detect its expropriation, or illegal imitation*. For one, unlike most tangible assets, knowledge is inherently mobile, because it resides in the heads of individuals (Grant, 1996). There-

fore, knowledge can only be rendered immobile by deliberate actions. For instance, a blueprint can be easily transferred from one person to another by hand, by mail, or by computer; the blueprint is rendered immobile only if steps are taken such as locking it up in a safe; storing it in a computer file where access is strictly limited; or writing it in indecipherable code. Similarly, knowledge about a manufacturing technology or a new product in development is accessible to the workers and managers involved, while final products can be observed by any buyer. In addition, knowledge is a public good (Arrow, 1962); one item of knowledge can be used by many individuals or organizations at the same time, without diminishing its productivity for any one user. Thus, illegal use of knowledge can be very difficult and costly to detect.

The fact that knowledge is more easily expropriated or imitated than other types of asset is not a problem when it can be generated and commercialized by a single person. For example, a chef who produces unique and magnificent cakes can protect his knowledge by locking up his recipe and keeping other people out of his kitchen. However, in many instances, producing valuable knowledge will require the input of proprietary, personal knowledge from a number of different individuals, each of whom must exchange some of her knowledge with other team members.¹⁰ In this case, if one member of a knowledge production team can obtain and absorb the knowledge of other team members, she has an incentive to expropriate that knowledge for her own use or to 'leak' it to competitors, eliminating the monopoly on that knowledge that the team might otherwise possess. In other instances, knowledge will require 'complementary' assets to be commercialized, such as manufacturing equipment or marketing expertise (Teece, 1986). Here, the owner of the proprietary knowledge must typically exchange it with the owner of the complementary assets for commercialization to proceed. For example, a scientist must reveal some of his research findings to a venture capitalist to obtain funding for development research. Again, there is an opportunity for the owner of the

that patents provide effective protection against imitation only in the pharmaceutical and chemical industries (Mansfield, 1985; Levin *et al.*, 1987).

⁷ The inventors of any given patent are determined in the U.S.A. by the federal Patent and Trademark Office (PTO). If an inventor cannot be clearly identified, the PTO will not issue a patent. For instance, the PTO took over 4 years to issue the Cohen-Boyer gene-splicing patent (1978-82) due to concerns over discovery credit, as well as other matters.

⁸ For example, Texas Instruments (TI) opposed a broad software patent issued by the Patent Office in 1994. As a result of TI's efforts, this patent was overturned 2 years later.

⁹ According to the first Restatement of Torts, section 757 comment b, a 'trade secret' is 'any formula, pattern, device or compilation of information which is used in one's business, and which gives him an opportunity to obtain an advantage over competitors who do not know or use it'. Trade secrets laws do not create property rights in knowledge *per se*, but are similar to laws of theft in that they create sanctions for illegal possession of codified materials. See Seidel and Panich (1973), Cheung (1982), Barrett (1991), Besen and Raskind (1991), and Friedman, Landes, and Posner (1991) for further details.

¹⁰ Examples of team production of knowledge are scientific discovery teams; product design teams; strategic planning teams; and consulting teams.

Table 1. Limits to legal protections for knowledge

	Patents	Copyrights	Trade Secrets
A. <i>Limits to scope</i>			
Codified knowledge only qualifies; tacit or inchoate knowledge is excluded	X	X	X
Applies only to products; processes excluded		X	
Applies only to entirely original products or processes	X	X	
Protection has limited lifetime	X	X	
No protection against <i>de novo</i> imitation by third parties			X
No protection against observation/publicity	X		
B. <i>Costs of definition, registration, and enforcement</i>			
Costly to define and/or register	X		
Costly to enforce	X	X	X
Requires supplementary protections to be enforceable			X

complementary asset to expropriate the knowledge for her own use and benefit.

Given the considerable limitations to intellectual property and trade secrets protections, and their costs, it may be more effective and more efficient to conduct knowledge transactions within firms than across markets, where legal protections are the only protections that are broadly available and enforceable.¹¹

FIRMS AND KNOWLEDGE PROTECTION

Transaction-costs economics suggests that a firm may have three types of advantage relative to markets for managing, or 'governing,' knowledge transactions. First, by unifying ownership of knowledge and other assets within a firm, the incentives of the contracting parties can be better aligned, attenuating incentives for opportunistic behavior. Second, a firm can substitute an employment contract for a market contract for human capital services, increasing the scope of control over knowledge workers' actions and/or reducing the costs of such control by replacing legal contracting with managerial fiat. Third, a

firm can alter the futurity of rewards relative to market contracts, thereby reducing employee mobility.

Incentive alignment and knowledge protection

In general, market contracts that govern exchanges of goods and services are costly to write and enforce (Coase, 1937; Klein, 1980). Consequently, such contracts are typically 'incomplete': some terms and conditions of the anticipated exchange are left uncontracted, subject to later negotiation between the parties (Williamson, 1979). These uncontracted dimensions of the exchange, which are in essence property rights, are called 'residual rights of control' (Grossman and Hart, 1986; Hart and Moore, 1990). When residual rights of control accrue to separate parties, these parties may have incentives to use them in their own favor, motivating self-interested and even opportunistic behavior. When the ownership of the assets involved in a transaction is unified within a single firm, instead, the firm becomes the sole owner of the residual rights, allowing these rights to be administered by a single managerial hierarchy.

In the traditional 'incomplete contracting' situation, residual rights of control can earn 'quasi-rents' when an exchange is characterized by specific asset investments (Klein, Crawford, and Alchian 1978; Grossman and Hart, 1986). In the case of knowledge transactions, however, the nature of the contracting problem is different: it

¹¹ It is possible that 'social networks' may provide some protection against expropriation or imitation in knowledge transactions in some specialized circumstances, such as exchange of valuable knowledge within certain professional networks. For an example, see Liebeskind *et al.* (1996).

resides in the fact that many types of valuable knowledge cannot be defined as property under the law. This *lack of contractability* then creates incentives for parties to knowledge exchanges to expropriate uncontractable but valuable knowledge from one another. Consider, for example, the case of two scientists who are involved in a joint research project aimed at discovering a new patentable substance.¹² In the course of this research, the two must exchange their research findings with one another for the project to progress. However, prior to the issue of a patent, neither scientist can legally protect their knowledge against expropriation by the other. Meanwhile, each scientist has a strong financial incentive to expropriate the other's knowledge and gain sole patent rights. Knowing this, the two scientists will rationally restrict the amount of knowledge they share with each other, and the success of the research project will be jeopardized. However, if the two scientists form a jointly owned firm together with a third party to conduct the project, and agree in advance to invest all intellectual property stemming from the collaboration in the firm, their incentives to expropriate unprotected knowledge from one another are attenuated.¹³ In essence, the firm converts uncontractable property interests into contractable corporate ownership interests that can be monitored and enforced through the courts by the interested third party owner, as well as the two scientists themselves. Similar considerations apply to knowledge transactions with owners of complementary assets; in this case, the firm can also constitute a credible gainsharing contract between the parties.¹⁴ Thus, internalization of knowledge transactions within a firm can extend protection of knowledge where legal protections are absent or are costly to write and enforce because incentives to expropriate are reduced.¹⁵

¹² This example is drawn from a real-life situation.

¹³ Note that in this case the third party is acting to retain residual rights of control for the benefit of the firm (vs. other parties), rather than allocating them as in the usual arguments (e.g., Grossman and Hart, 1986).

¹⁴ Incentives to expropriate in this case may be attenuated by competition for inventions (Anton and Yao, 1994).

¹⁵ One interesting question I do not have space to explore here is: when will knowledge workers from firms themselves (as in the case of the two scientists), and by implication, hire capital and management as they need, and when will the owners of capital hire knowledge workers? This is a bilateral bargaining game. Thus, theory suggests that owners of highly valuable knowledge will be able to hire capital and will

Essentially, firms create quasi-property rights in knowledge. I call these quasi-rights 'possession rights.'

Employment and knowledge protection

A second institutional capability that allows firms to protect knowledge is their ability to write employment contracts—be they formal, written contracts or unwritten contracts. When an individual becomes an 'employee,' she is agreeing, contractually, to obey the orders of her employer. Thus, a primary feature of an employment contract is rules—rules that pertain to the duties to be performed, the reporting hierarchy, and a myriad other items. Through such rules, a firm can restrict the actions of an employee in ways that would not be permitted in a market contract for human capital services (Masten, 1988). Thus, employment supports the enforcement of possession rights to knowledge. Two types of rules are particularly important in relation to knowledge protection: employee conduct rules, and job designs.

Employee conduct rules

A number of commonly found employee conduct rules serve to reduce the mobility of employees, and thereby reduce the mobility of the knowledge they possess. First, most employment contracts stipulate that a full-time employee must work exclusively for the employer in question for the duration of her employment. This restriction would be considered anti-competitive in a market contract, as it would prevent a worker from practicing her trade freely and may result in market foreclosure. Second, employment contracts frequently contain confidentiality or nondisclosure clauses, whereby the employee agrees in writing not to discuss the business of a firm with outsiders, and even with other employees. In market exchanges, such broad confidentiality agreements may also be considered anti-competitive, and are likely to be considered as infringing rights to privacy and to free speech (Alderman and Kennedy, 1995). Third, a firm can demand that an

collect the rents to their own knowledge, whereas workers who use the knowledge of a firm will be hired by management and capital, who will garner the rents. For a discussion of this issue in relation to corporate ownership, see Blair (1995).

employee conduct her work in a particular place within its premises (and not enter other areas of its premises), and that the employee communicate with, and report to, particular other employees (and not communicate with other specific employees). Finally, a firm may write an employment contract that contains a 'non-compete' clause that forbids an employee from working for a competitor for a given period of time after leaving the firm.

Firms may also have lower costs of monitoring and enforcing such conduct rules. In market transactions, one party to a contract has only limited rights to monitor the activities of another. Within firms, rights to monitor are far more extensive: a firm can legally monitor its employees' telephone conversations, e-mail communications, and mail; use visual monitoring systems; and monitor and search individuals who enter and exit its premises.¹⁶ In addition, requiring that work be conducted in a particular place and with particular others reduces the costs of monitoring employee actions: it is far more difficult and costly to monitor employees when they work alone, or in unsupervised premises.

With regard to enforcement, legal protections for knowledge can only be prosecuted once incontrovertible proof of expropriation is available. Within firms, instead, employees may be sanctioned for actions that merely appear to increase the chance that expropriation may take place. For instance, an employee can be dismissed for visiting another firm's premises without permission, without any evidence indicating that she imparted valuable information during the visit. In addition, violations of intellectual property rights and trade secrets laws must be prosecuted through the courts—an expensive, lengthy, and public process. Instead, firms can resolve disputes that pertain to internal transactions of knowledge at low cost, rapidly, and in privacy. While dismissal is a less severe sanction than being convicted of a crime, dismissal nonetheless can have severe economic consequences, and therefore may serve as a sufficient deterrent to expropriation in many circumstances. Indeed, the reduced costs of monitoring and enforcing restrictions within a firm

may alone justify internalizing knowledge transactions.

One example of a firm that makes extensive use of employee conduct rules to protect its knowledge from competitors is Procter & Gamble (P&G): the firm's management forbids its employees to discuss business in public places where they may be overheard; forbids its plant managers from belonging to industry associations; and even forbids employees from tagging their luggage to indicate that they work for the company, for fear that this will attract unwelcome attention (Swayse, 1994). However, less draconian restrictions are a common feature of firms' employee conduct rules. For instance, most firms restrict their employees from discussing important company business with outsiders.

Job design

Many security systems follow a design in which access to valuable knowledge can only be obtained when a number of subsystems have been put in place. Consider the simplest of all security systems, a safe. Here, a person who wants to open the safe must (a) know where the safe is located; (b) know what it contains; (c) have access to the place where the safe is located, and (d) possess a key to the safe, or have other means of opening it. By compartmentalizing this information in some way, theft can be more effectively prevented. For instance, a person may illegally obtain the key to the safe, but have no idea where it is located. Almost all types of security architecture are characterized by such 'disaggregation.'¹⁷

Within a firm, disaggregation can be achieved by adjusting job designs. Consider, for example, the team production of a highly valuable software program. If knowledge protection were not an issue, this program might best be produced by four programmers working in close collaboration. However, this job design would allow all four workers access to the final product. The firm can reduce this number to one by mandating that the four programmers work separately on different

¹⁶ These statements are generalized. In some jurisdictions, firms have more extensive rights to monitor employees than in others.

¹⁷ Disaggregation has developed to its highest level within the government security establishment; organizations such as the Central Intelligence Agency and the Executive Offices of the U.S. Government have very sophisticated systems of disaggregation established for the purpose of protecting sensitive knowledge. See, for example, Andrew (1995).

subcomponents of the system, and by having their work supervised and integrated by a single manager. The key advantage of the firm here is that it can mandate job specialization and enforce it through the employment contract. Parties to market contracts cannot credibly commit to such specialization, because they have incentives to acquire and expropriate the knowledge of others.

Disaggregation of tasks in this way is a common feature of many firms (and other organizations) that possess highly valuable knowledge. For instance, in defense contracting, the production of defense systems (such as aircraft, rockets, missiles, or satellites) is frequently disaggregated. Thus, employees of a division providing some part of an intelligence-gathering satellite system will receive incomplete blueprints and will not be a party to meetings that discuss the satellite's overall design.¹⁸ Similarly, laboratory technicians in a pharmaceutical firm will be given a substance to test without being given information about its therapeutic properties.¹⁹ Note that this disaggregation of tasks will require the concomitant disaggregation of the firm's production technology. For example, an assembly operation may be divided into separate stages to limit observation of the complete process. Task disaggregation efforts can also be reinforced by spatial isolation: valuable knowledge-production or knowledge-use processes can be located far away from the other activities of a firm, or from outsiders. Thus a well-known software firm has located its new product development department in a remote area of Oregon, while the premises of Lockheed's famous 'Skunk Works' are closed to all but Skunk Works employees (Rich and Janos, 1994); other Lockheed workers are excluded.²⁰

A firm's hierarchy also serves to disaggregate knowledge. For instance, information on takeov-

ers, mergers, and other sensitive business negotiations is typically restricted to managers who work in the corporate office. To the degree that upper echelon managers have worked for a firm for a long time, so that their personal characteristics are known, this hierarchical knowledge structure can be designed to conform with the established trustworthiness of the managers involved (Luhman, 1988; McCleod and Malcolmsen, 1988).

Reordering rewards and knowledge protection

A third institutional capability that may allow a firm an advantage in protecting knowledge relates to their ability to reorder rewards over time. In markets, the owner of a property can sell that property freely at any time she wishes, provided the property is unencumbered by other claims. In particular, an individual is free to sell her human capital services to any buyer that she wishes at any point in time. This right to sell is particularly problematical in relation to knowledge protection. Because knowledge—and most particularly, legally unprotected knowledge—resides in the heads of individuals, an individual who possesses valuable knowledge always has an incentive to sell her knowledge to the highest bidder, most especially by leaving a firm and going to work for a rival.

An employment contract can place only limited restrictions on an employee's freedom to leave the firm. However, because a firm is a long-lived institutional form, a firm may be able to increase an employee's costs of leaving by deferring the timing at which an individual receives payments for her knowledge—so-called 'golden handcuffs' (Milgrom and Roberts, 1992). These deferred rewards include deferred stock options; pension plans with delayed vesting; and promotions over time. All these arrangements impose exit costs on employees (Milgrom and Roberts, 1992).²¹

It is important to note that deferred rewards will reduce employee mobility only to the degree

¹⁸ Information provided to the author in interviews.

¹⁹ Information provided to the author in interviews.

²⁰ Before the advent of the corporate form, craft guilds operated as 'quasi-firms' in protecting the production of silk and other fine crafted goods in Italy and elsewhere. Exclusion from observation played a key role in protecting these crafts. For example, in the early seventeenth century, the London Pewterer's Company sanctioned 'divers of the company who worketh openly in shoppes'. (Welch, 1902: 34). The company forced one of its members to erect a partition in his shop to conceal the practice of his craft from passers-by. Only apprentices, the equivalent of employees of the guild, were allowed to discover the 'secrets' of the guild's manufacturing processes (Greif, Milgrom, and Weingast, 1994).

²¹ The question arises why scientists should accept such contracts. The answer is, because they know that these contracts protect the knowledge of the firm, and so increase their own wealth in the long run. These contracts are therefore incentive-compatible. For a discussion of the role of firms in resolving individual preference inconsistencies over time, see Postrel and Rumelt (1994).

that the firm can commit to paying them in future periods. For instance, a deferred stock option will only serve as an inducement to stay with a firm if the stock value of the firm is expected to appreciate more over time than that of its rivals. Similarly, expectations of promotion within a given firm must be more attractive than those of rival firms. Thus, deferred reward schemes will be more credible when the firm offering them is financially stable; when the firm is committed to not laying off its employees; when the firm hires only from within (thereby protecting promotion prospects); and when the firm is protected from takeover.²²

By providing credible long-term incentives, a firm also increases the incentive for an employee to invest in forming personal relationships with other employees, thereby increasing the likelihood that an employee will become emotionally attached to other employees or to the organization as a whole. These attachments will also increase the employee's costs of exit (Bowlby, 1969; Abt, 1988). Although these mechanisms of attachment are second-order effects that depend on expectations of long-lived employment, they may nonetheless play a critical role in inhibiting employee mobility. Long-term employment also allows management to observe the behavior of an employee over a long period of time, and better determine their trustworthiness (Luhman, 1988; McCleod and Malcolmsen, 1988).

Finally, long-term employment increases an employee's exposure to a firm's acculturation mechanisms. Firms can influence employees' attitudes in numerous different ways, such as advocating certain personal values or attitudes (e.g., loyalty to the firm), and providing social rewards to individuals who demonstrate certain desirable behaviors (e.g., maintaining confidentiality). Attempts to influence attitudes are more effective, the longer an individual is exposed to them, and the less that individual is exposed to countervailing influences (Cialdini, 1984; Simpson, 1994). Long-term employment serves both these ends.

The costs of knowledge protection

While firms may be able to protect knowledge from expropriation and imitation more effectively than markets, all of the protective capabilities discussed in this section have their costs. The most important of these are increases in sunk costs, increases in administration costs, and the costs of loss of communication.

Any investment in a firm-specific asset is a sunk cost. Thus, if these investments cannot be amortized over the expected useful life of the asset in question, they will increase a firm's costs of doing business. Investments in knowledge-protection infrastructure are particularly susceptible to obsolescence, because outsiders have incentives to circumvent the protections they offer. For instance, a computer protection system may be rapidly compromised by advances in code-breaking technology. Similarly, an investment in a secret research facility in a remote location will become worthless when a competitor firm moves into the same area. However, arguably the most important source of sunk costs in terms of knowledge protection is employment: commitments to employ knowledge workers for long periods of time have high direct costs, relative to short-term contracting. These commitments also have high indirect costs in the form of reduced flexibility. Because commitments to existing employees must be upheld to maintain credibility in the future, a firm cannot simply lay off some workers and hire others should its employment needs change. As a result, when the knowledge required to conduct a business successfully changes rapidly from period to period, the costs of internalizing knowledge workers may become prohibitive (Teece, 1986, 1992).

Internalization of knowledge transactions will also necessarily incur costs of organization, both direct and indirect. For instance, monitoring employee conduct rules may not only require a firm to install costly monitoring technologies of various kinds; it may also demotivate employees, and lead to difficulties in hiring and retention (Strickland, 1958; Deci and Ryan, 1985; Liebeskind, 1995).

Finally, many of the mechanisms that serve to protect knowledge transactions within a firm do so by impeding communication (Liebeskind, 1995). Such a loss of communication can, however, be very costly. First of all, communication

²² One effective protection from takeover is having a large proportion of shares owned by employees (Blair, 1995). Thus, there is a close relationship between ownership structure and credible, high-powered, deferred rewards.

enhances coordination: recent evidence from such organizational innovations as concurrent engineering and product design teams show that teamwork significantly increases innovation, productivity and speed-to-market. (See, for example, Allen, Lee, and Tushman, 1980; Hayes and Clark, 1988; Eisenhardt, 1989; Jelinek and Schoonhoven, 1990; Henderson and Cockburn, 1994; Adler, 1995.). Therefore, if communication is impeded by protection considerations, productivity and speed-to-market can be expected to fall. Indeed, communication of knowledge is considered so important to the achievement of these strategic goals that much of the existing literature on knowledge management within firms (e.g., Nonaka, 1994; Spender, 1994) and within strategic alliances (e.g., Grant, 1995, 1996) places primary emphasis on improving communication of knowledge.

Second, communication may increase a firm's access to new knowledge. In many industries, new knowledge arises from a variety of different sources, such as university research laboratories; small research or design firms; or individual experts outside the firm. Firms in these industries may need to be able to access these external sources of knowledge in order to stay abreast of the competition (Von Hippel, 1988; Foray, 1991; Teece, 1992; Saxenian, 1994; Liebeskind *et al.*, 1996). However, accessing external sources of knowledge may require the firm to reveal some of its own valuable knowledge (e.g., Schrader, 1991). For instance, a pharmaceutical firm that sponsors a university professor to conduct research on its behalf may need to provide that professor with some proprietary information or research materials for the research to progress. Similarly, if the firm wants the professor to provide advice on one of its internal research programs, that advice will be more valuable if the professor is given more detailed information.

Finally, the value of a firm's knowledge itself may depend on the degree to which that knowledge is communicated to outsiders. In particular, publication of new, private knowledge exposes it to the rigors of 'social proof,' providing a comprehensive and unbiased test of its validity (Kuran, 1993; David, 1992). Impeding publication, then, can be costly. For instance, a product design firm may be able to significantly reduce its costs of development by showing early-stage designs to potential customers. Similarly, a manu-

facturing firm may save many millions of dollars by sharing its process innovation ideas with competitors who may already have tried and failed to implement similar technologies.

DISCUSSION

Synthesis

In this paper, I have argued that firms have generalized institutional capabilities that may allow them to protect knowledge from expropriation and imitation more effectively than the limited and costly legal protections that are available in markets. These capabilities and their consequences for knowledge protection are summarized in Table 2. However, I have also argued that it is costly for a firm to protect its knowledge. Thus, the costs and benefits of protection must be weighed very carefully.

First of all, firms must resolve the question of *what knowledge should be protected and what should not*. Because knowledge protection is costly, over-protection will incur excess costs. Thus, to economize, firms should only protect their unique, valuable knowledge which can repay the costs of protection; other knowledge should not be protected. However, exactly what knowledge of a firm is valuable to that firm may be difficult to discern, especially in the early stages of knowledge creation. Once knowledge has been commercialized processes or products, its value may be more easily ascertained.

The second critical question for a firm is *what mechanism or combination of mechanisms should be used to protect its valuable knowledge*. Using too many protective measures at the same time will incur excess costs; insufficient protection, on the other hand, may result in significant losses of value. Moreover, some mechanisms will be more effective than others, depending on the particular circumstances of the firm. Because protection may inhibit the very knowledge flows that are essential for innovation to take place, firms also may need to make difficult trade-off decisions between protection on the one hand, and innovation on the other. This 'innovation-protection trade-off,' however, may be more or less stark, depending on the protective mechanisms used.

Consider, for example, a new biotechnology firm (NBF). This firm is conducting business in

Table 2. The institutional capabilities of firms and their implications for knowledge protection

Institutional capability	Knowledge protection benefits relative to market contracting
1. <i>Incentive alignment</i>	Extends the scope of control over knowledge transactions to include residual rights and their associated rewards Reduces the cost of negotiating and enforcing rights
2. <i>Employment</i>	
(a) Employee conduct rules	Extend the scope of control over individuals' actions Reduce employee mobility, reducing the mobility of knowledge and increasing the effectiveness of employee monitoring
(b) Job designs	Allow for protection of knowledge through disaggregation and the coordination of disaggregated production
3. <i>Re-ordering</i>	Increasing futurity of incentives reduces employee mobility

a rapidly, evolving technological environment—biotechnology—where the sources of innovation are diffuse, research costs are high, investment funds are limited, and there are many competitors (Liebeskind *et al.*, 1996). For these new firms, sourcing a large part of their knowledge from university scientists can economize on R&D costs and may increase their chances of making a new discovery by allowing them access to 'star' scientists (Zucker, Darby, and Brewer, 1994; Liebeskind *et al.*, 1996). In conducting these external exchanges of knowledge, however, an NBF increases the likelihood that its own knowledge will be expropriated or exposed to observation, more particularly so because university scientists are acculturated and motivated to publicize their research findings. For instance, Werth (1995) describes how scientists at one NBF, Vertex, struggled over the issue of collaborating with an external scientist, Stuart Schreiber of Harvard University:

The combination of Schreiber's personality and ambition posed [an] immediate threat. ... Schreiber loved to talk about himself and what he was thinking, and how he had the world's ear. 'I am not concerned that Stuart will find a compound that will compete with ours' Boger [Vertex's CEO] said. 'I am concerned he may tell everyone in the world what we're doing.' ... Boger feared that Schreiber was persistently naive about the need for secrecy. (Werth, 1995: 71)

Thus, NBFs must manage external access to their valuable knowledge very carefully. First of all, these firms have rules regarding presentations at professional meetings and journal publications

that are aimed at restricting dissemination of their most valuable research findings (Hicks, 1995; Rabinow, 1996). NBFs also restrict outsiders' use of their research materials (Eisenberg, 1987; Werth, 1995; Rabinow, 1996). However, an NBF must exchange some information and research materials in order to advance its own scientific research and to fulfill norms of reciprocity within the scientific community (Eisenberg, 1987; Schrader, 1991). Thus, NBFs also typically offer very high-powered deferred incentives to their employee scientists, which motivate them to act in the long-term interests of the firm when conducting research collaborations with outsiders.

Where the costs of communication loss with outsiders are lower, a firm may depend more on employee conduct rules and adjustments to use-rights to protect its valuable knowledge. Consider, for example, the investment firm, D. E. Shaw & Co. (Welsh, 1996):

Shaw's penchant for secrecy is legendary ... To make sure that nothing gets out that isn't supposed to get out, Shaw has all his employees sign nondisclosure agreements, and these gag orders do their job well ...

The secrecy is understandable when it comes to the firm's proprietary technology—what Shaw calls 'our life's blood.' Shaw's market-beating [security-trading] algorithms are so secret, even limited partners [in the firm] such as Morgan Miller ... aren't entirely sure what's going on behind the curtain. (Welsh, 1996: 110)

While the basic argument of this paper has been that firms are able to protect knowledge more effectively, or protect knowledge at lower

costs, than legal protections, there may be situations where legal protections are more effective or less costly than internalization. For instance, if a process is patentable, patenting may prove less costly than using a firm's institutional capabilities, so long as patent rights are sufficiently broad that the entire process is protected, and so long as a firm expects to develop a new process before patent rights expire. Patent rights will play a particularly important role in protecting knowledge that is embedded in a firm's products, because this knowledge must perforce be publicized, if the products are to be sold to a broad market.²³ In other cases, combining firm protections with legal protections may outperform the use of one or the other. For instance, a firm may deliberately file for a patent on part of a valuable process technology, and use various organizational arrangements to conceal the other parts of the technology from its competitors.

Finally, while the discussion here has focused on identifying some general institutional capabilities of firms, it is important to note that these capabilities are highly dependent on the legal-regulatory context in which a firm operates. For instance, in some jurisdictions, a firm may be able to control the actions of its employees more extensively than in other jurisdictions. Similarly, noncompete and confidentiality clauses may be more binding in some jurisdictions than in others. In some jurisdictions, protections may be weak; in others, enforcing legal protections may be prohibitively costly, or there may be a lack of effective enforcement institutions. We should expect to observe that the scope of firm will vary according to such differences. Specifically, in a legal-regulatory context where legal protections are narrow, enforcement costs are high, or enforcement mechanisms are weak, we should expect to observe more knowledge transactions carried out within firms concomitantly, where legal protections are more broad reaching, enforcement costs are relatively low, and enforcement mechanisms are strong, we should expect to observe more knowledge transactions carried out through contracting between firms or individuals.

²³ There are instances where a firm will restrict sales of its products to reduce the chance of expropriation or imitation. Such restriction is most feasible when products are customized.

Implications

The argument that firms can protect knowledge from expropriation or imitation more effectively than market contracting has a number of important implications for strategy theory and research. First of all, it has implications for the strategic theory of the firm. According to Bowman (1974) and Rumelt (1984, 1987), firms' primary purpose is to create, exploit and defend sources of economic rents. The managerial strategies of firms, then, can be understood as representing rent-seeking behavior, directed both at innovation—the discovery or creation of new processes and products—and at the discovery or creation of 'isolating mechanisms' that serve to protect a firm's innovations from expropriation or imitation by rivals (Rumelt, 1984). The argument in this paper suggests that a firm's own organization is a critically important isolating mechanism. I have argued that firms can both extend the scope of knowledge protection, and/or reduce the costs of such protection, relative to legal protections. Thus, firms are able to replace the limited and costly property rights in knowledge with far more extensive possession rights.

Although this argument is generated by appealing to the generalized institutional capabilities of firms, it is important to note that *it is only because firms have these generalized protective capabilities that we observe so many different types of unique assets*. If all knowledge were rapidly and costlessly imitable, no firm would possess unique assets outside those whose protection were provided by laws of property definition and protection, or which were inherently very difficult to imitate. However, by deploying their generalized institutional capabilities, firms can ensure that knowledge that arises within their organizational boundaries—be it arrived at through luck, history, or deliberate investment—remains their own, unique asset for extended periods of time. In this way, my argument provides a clear link between the generalized institutional capabilities of firms on the one hand, and the unique capabilities and resources of any given firm on the other.

Of course, not all firms may be equally competent at deploying their institutional capabilities to protect their knowledge. Just as some firms may be more efficient at coordinating knowledge flows, some firms may also be more efficient

than others at impeding knowledge flows to rival firms. Thus, one reason we would expect to observe differences in profits among firms is that firms have differences in their protective capabilities.

The argument presented here also has implications for dynamic strategic behavior by firms. Incentives to invest in innovation—be it process innovation aimed at earning Ricardian rents or product innovation aimed at earning monopoly rents—depend on the degree to which a firm can appropriate the expected rent streams. Thus, because firms can protect their knowledge from expropriation and imitation, it can be understood that *it is the generalized institutional capabilities of firms that engender and promote strategic innovation.*

We should also expect to observe higher rates of innovation in those firms that have superior organizational capabilities in terms of knowledge protection. However, innovation and protection will only be correlated to the degree that a firm can devise organizational arrangements that resolve the innovation–protection trade-off. To the degree that these organizational arrangements are difficult and costly to identify, and to the degree that they can themselves be protected from expropriation or innovation, firms with these arrangements in place will also earn Ricardian rents. Thus, over time, we should expect to observe firms investing in generating organizational arrangements that promote innovation on the one hand, while protecting innovative outputs on the other.

Finally, by describing the mechanisms that firms can use to protect knowledge, this paper provides some concreteness to Teece's (1986) argument that, if knowledge can only be commercialized when it is combined with complementary assets, it will be more valuable when it is commercialized within a firm. Argyres (1996) provides evidence that appropriability considerations influence internalization. More generally, we observe relatively little industrial R&D being conducted in R&D-specialized firms; most industrial R&D is conducted within the boundaries of vertically integrated firms.²⁴ The argument here also

suggests that managing knowledge within strategic alliances may be particularly problematical, unless the alliance can be structured in a way that obviates the parties' incentives to expropriate knowledge from one another.

Concluding remarks

While this paper has focused on the relationships between knowledge, strategy, and the theory of the firm, issues of knowledge protection have broad implications for strategy theory and research, as I have attempted to illustrate in this final section. Moreover, knowledge protection is likely to become an increasingly important issue to our field. There is a widespread consensus that we are moving towards an economy where competitive advantage will be determined by knowledge rather than by access to raw materials and cheap labor. In this economy, knowledge protection will play a critical role, just as much as innovation. In addition, global expansion has increased many firms' exposure to expropriation and imitation efforts. Within the U.S.A. and other countries, overseas firms (and governments) are becoming increasingly involved in industrial espionage activities. Meanwhile, U.S. and European firms undergoing global expansion are finding that, in many countries, legal protections against expropriation and imitation are extremely weak. Thus, protective organizational arrangements can be vitally important to sustaining competitive advantage in the global competitive context. This paper has taken a first step towards developing some arguments about the protective institutional capabilities of firms. Hopefully, it will serve to stimulate more work on this interesting and economically important topic.

ACKNOWLEDGEMENTS

Thanks to Nick Argyres, Vai-Lam Mui, Gabriel Szulanski, Todd Zenger, and the Editors of this Special Issue for providing detailed comments on various drafts of this and related papers. Thanks also to Jennifer Bethel, Rajesh Chandy, Timur Kuran, Josh Lerner, Sharon Traweek, and seminar participants at the University of Southern Califor-

²⁴ One possible exception is NBFs. However, many NBFs are becoming vertically integrated over time, either through the acquisition of complementary assets themselves (e.g., Amgen), or through partial or complete mergers with large

pharmaceutical firms that possess such assets (e.g., Genentech's acquisition by Hoffman LaRoche).

nia, the University of California, Irvine, and the University of California, Riverside for useful comments and suggestions. Any errors are mine alone.

REFERENCES

- Abt, T. (1988). *Progress Without Loss of Soul*. Chiron Press, Wilmette, IL.
- Adler, P. (1995). 'Interdepartmental interdependence and coordination: The case of the design/ manufacturing interface', *Organization Science*, **6**, pp. 147–167.
- Alderman, E. and C. Kennedy (1995). *The Right to Privacy*. Alfred A. Knopf, New York.
- Allen, T., D. M. Lee and M. L. Tushman (1980). 'R&D performance as a function of internal communication, project management, and the nature of work', *IEEE Transactions on Engineering Management*, **EM-27**(1), pp. 2–12.
- Andrew, C. (1995). *For the President's Eyes Only*. Harper Collins, New York.
- Anton, J.J. and D.A. Yao (1994). 'Expropriations and inventions: Appropriate rents in the absence of property rights', *American Economic Review*, **84**, pp. 190–209.
- Argyres, N. (1996). 'Some evidence of firm capabilities in vertical integration decisions', *Strategic Management Journal*, **17**(5), pp. 395–410.
- Arrow, K. (1962). 'Economic welfare and the allocation of resources for invention'. In *The Rate and Direction of Inventive Activity*. National Bureau of Economic Research, Princeton, NJ, pp. 609–625.
- Barney, J. (1986). 'Strategic factor markets: Expectations, luck, and business strategy', *Management Science*, **32**, pp. 1231–1241.
- Barrett, M. (1991) *Intellectual Property*. Smith's Review, Larchmont, NY.
- Barzel, Y. (1991). *Economic Analysis of Property Rights*. Cambridge University Press, Cambridge, U.K.
- Besen, S. M. and L. J. Raskind (1991). 'An introduction to the law and economics of intellectual property', *Journal of Economic Perspectives*, **5**, pp. 3–27.
- Blair, M. (1995). *Ownership and Control: Re-thinking Corporate Governance for the 21st Century*. Brookings Institution, Washington, DC.
- Boorstin, D. (1983). *The Discoverers*. Random House, New York.
- Bowlby, J. (1969). *Attachment and Loss*. (2 Volumes). Basic Books, New York.
- Bowman, E. H. (1974). 'Epistemology, corporate strategy, and academe', *Sloan Management Review*, **15**, pp. 35–50.
- Cheung, S. (1982). 'Property rights in trade secrets', *Economic Inquiry*, **20**, pp. 40–53.
- Cialdini, R. (1984). *Influence: The Psychology of Persuasion*. William Morrow, New York.
- Coase, R. (1937). 'The nature of the firm', *Economica*, **4**, pp. 386–405.
- David, P. A. (1992). 'Reputation and agency in the historical emergence of the institutions of "Open Science"', unpublished manuscript, Stanford University.
- Deci, E. and R. M. Ryan (1985). *Intrinsic Motivation and Self-determination in Human Behavior*. Plenum Press, New York.
- Demsetz, H. (1967). 'Towards a theory of property rights', *American Economic Review*, **57**, pp. 347–359.
- Eisenberg, R. (1987). 'Proprietary rights and the norms of science in biotechnology research', *Yale Law Journal*, **97**, pp. 177–231.
- Eisenhardt, K. (1989). 'Making fast decisions in high velocity environments', *Academy of Management Journal*, **32**, pp. 543–576.
- Field, B. (1989). 'The evolution of property rights', *Kyklos*, **42**, pp. 319–345.
- Foray, D. (1991). 'The secrets of industry are in the air: Industrial cooperation and the organizational dynamics of the innovative firm', *Research Policy*, **20**, pp. 393–406.
- Friedman, D.D., W.M. Landes and R.A. Posner (1991). 'Some economics of Trade Secret Law', *Journal of Economic Perspectives*, **5**, pp. 61–72.
- Grant, M. (1995). 'A knowledge-based theory of inter-firm collaboration', *Best Papers Proceedings*. 55th Annual Meeting of the Academy of Management, Vancouver, Canada pp. 17–21.
- Grant, R. (1996). 'Prospering in dynamically-competitive environments: Organizational capability as knowledge integration', *Organization Science*, **7**, pp. 375–387.
- Grief, A., P. Milgrom and B. R. Weingast (1994). 'Coordination, commitment and enforcement: The case of the Merchant Guild', *Journal of Political Economy*, **102**, pp. 745–777.
- Grossman, S. and O. Hart (1986). 'The costs and benefits of ownership: A theory of vertical and lateral integration', *Journal of Political Economy*, **94**, pp. 691–719.
- Hart, O. and J. Moore (1990). 'Property rights and the nature of the firm', *Journal of Political Economy*, **98**, pp. 1119–1158.
- Hayes, R. and K. Clark (1988). *Dynamic Manufacturing*. Free Press, New York.
- Henderson, R. and I. Cockburn (1994). 'Measuring core competence? Evidence from the pharmaceutical industry', *Strategic Management Journal*, Winter Special Issue, **15**, pp. 63–84.
- Hicks, D. (1995). 'Published papers, tacit competencies and corporate management of the public/private character of knowledge', *Journal of Industrial and Corporate Change*, **4**, pp. 401–424.
- Jelinek, M. and C. B. Schoonhoven (1990). *The Innovation Marathon*. Basil Blackwell, Oxford, U.K.
- Klein, B. (1980). 'Transaction cost determinants of "unfair" contractual relationships', *American Economic Review*, **70**, pp. 356–362.
- Klein, B., R. G. Crawford and A. A. Alchian (1978). 'Vertical integration, appropriable rents, and the

- competitive contracting process', *Journal of Law and Economics*, **21**, pp. 271–296.
- Kuran, T. (1993). 'The unthinkable and the unthought', *Rationality and Society*, **5**, pp. 473–505.
- Levin, R., R. Klevorick, R. Nelson and S. Winter (1987). 'Appropriating the returns from individual research and development', *Brookings Papers on Economic Activity*, **3**, 783–820.
- Liebesskind, J. (1995). 'Keeping organizational secrets: Institutional protective mechanisms and their costs', University of Southern California working paper.
- Liebesskind, J. P., A. L. Oliver, L. Zucker and M. Brewer (1996). 'Social networks, learning and flexibility: Sourcing scientific knowledge in new biotechnology firms', *Organization Science*, **7** (forthcoming).
- Lippman, S. and R. P. Rumelt (1982). 'Uncertain imitability: An analysis of interfirm differences in profitability under competition', *Bell Journal of Economics*, **13**, pp. 418–438.
- Luhman, N. (1988). 'Familiarity, confidence, and trust'. In D. Gambetta (ed.), *Trust: Making and Breaking Cooperative Relations*. Basil Blackwell, Oxford, U.K., pp. 94–108.
- Mansfield, E. (1985). 'How rapidly does new technology leak out?', *Journal of Industrial Economics*, **34**, pp. 217–224.
- Masten, S. (1988). 'A legal basis for the firm', *Journal of Law, Economics and Organization*, **4**, pp. 3–47.
- McCleod, W. B. and J. Malcolmsen (1988). 'Reputation and hierarchy in dynamic models of employment', *Journal of Political Economy*, **96**, pp. 832–854.
- Milgrom, P. and J. Roberts (1992). *Economics, Organization and Management*. Prentice-Hall, Englewood Cliffs, NJ.
- Nelson, R. and S. Winter (1982). *An Evolutionary Theory of Economic Change*. Harvard University Press, Cambridge, MA.
- Nonaka, I. (1994). 'A dynamic theory of organizational knowledge creation', *Organization Science*, **5**, pp. 14–37.
- Penrose, E. (1959). *The Theory of the Growth of the Firm*. Wiley, New York.
- Postrel, S. and R. P. Rumelt (1994). 'Incentive, routines, and self-command', *Industrial and Organizational Change*, **3**, pp. 397–425.
- Rabinow, P. (1996). *Making PCR*. University of Chicago Press, Chicago, IL.
- Ricardo, D. (1926 [1821]). *Principles of Political Economy and Taxation*. Everyman, London.
- Rich, B. and L. Janos (1994). *Skunk Works: A Personal Memoir of my Years at Lockheed*. Little, Brown, Boston, MA.
- Rumelt, R. P. (1984). 'Towards a strategic theory of the firm'. In R. B. Lamb (ed.), *Competitive Strategic Management*. Prentice-Hall, Englewood Cliffs, N.J.
- Rumelt, R. P. (1987). 'Theory, strategy, and entrepreneurship'. In D. Teece (ed.), *The Competitive Challenge*. Ballinger, Cambridge, MA, pp. 556–570.
- Saxenian, A. (1994). *Regional Advantage*. Harvard University Press, Cambridge, M.A.
- Schrader, S. (1991). 'Informal technology transfer between firms: Cooperation through information trading', *Research Policy*, **20**, pp. 153–170.
- Seidel, A. and R. Panich (1973). *What the Practitioner Should Know about Trade Secrets and Employment Agreements*. American Law Institute, Philadelphia, PA.
- Simpson, C. (1994). *Science of Coercion: Communication Research and Psychological Warfare 1945–1960*. Oxford University Press, Oxford, U.K.
- Spender, J.-C. (1994). 'Organizational knowledge, collective practice and Penrosian rents', *International Business Review*, **3**, pp. 353–367.
- Spender, J.-C. (1996). 'Organizational knowledge, learning and memory: Three concepts in search of a theory', *Journal of Organizational Change Management*, **9**, pp. 67–79.
- Strickland, L. H. (1958). 'Surveillance and trust', *Journal of Personality*, **26**, pp. 200–215.
- Swayse, A. (1994). *Soap Opera: The Inside Story of Procter & Gamble*. Simon & Schuster, New York.
- Teece, D. (1980). 'Economies of scope and the scope of the enterprise', *Journal of Economic Behavior and Organization*, **1**, 223–247.
- Teece, D. (1986). 'Profiting from technological innovation', *Research Policy*, **15**, pp. 286–305.
- Teece, D. (1992). 'Competition, cooperation and innovation: Organizational arrangements for regimes of rapid technological progress', *Journal of Economic Behavior and Organization*, **18**, pp. 1–25.
- Von Hippel, E. (1988). *The Sources of Innovation*. Oxford University Press, New York.
- Welch, C. (1902). *A History of the Worshipful Company of Pewterers of the City of London*. Blades, East & Blades, London.
- Welsh, T. (5 February 1996). 'Extreme investing', *Fortune*, pp. 108–112.
- Werth, B. (1995). *The Billion Dollar Molecule*. Simon & Schuster/Touchstone, New York.
- Williamson, O. E. (1979). 'Transaction cost economics: The governance of contractual relations', *Journal of Law and Economics*, **22**, pp. 3–61.
- Winter, S. (1988). 'Knowledge and competence as strategic assets'. In D. Teece (ed.), *The Competitive Challenge: Strategies for Industrial Innovation and Renewal*. Ballinger, Cambridge, MA.
- Zucker, L., M. Darby and M. Brewer (1994). 'Intellectual capital and the birth of U.S. biotechnology enterprises', NBER working paper no. 4653, NBER, Cambridge, MA.