

***KNOWLEDGE INPUTS, LEGAL INSTITUTIONS AND FIRM STRUCTURE: TOWARDS
A KNOWLEDGE-BASED THEORY OF THE FIRM***

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ABSTRACT

Corporate scholars rely on traditional theories of the firm to analyze corporate organization and corporate contracting. Traditional theories of the firm, however, have long neglected the role of knowledge in shaping the internal structure of firms. Current analyses of firm structure that rely on these theories therefore suffer from serious shortcomings. This paper begins to address this gap by analyzing knowledge resources and investigating their influence on internal corporate governance structures. We propose a new typology that explains firm internal governance structure based on the *types of knowledge used in the production process*. We analyze the interaction of law and knowledge management. We investigate how firms can bind knowledge by means of patents, trade secrets and private contracting, such as covenants not to compete. We propose a principle of efficient knowledge allocation, which holds that organizational structures result from the necessity to maximize the use of knowledge resources. We discuss specific hazards that emerge from transactions with knowledge inputs. We discuss particular applications of the typology.

We show how the management of knowledge resources required in mass production, high tech and law firms differentially affects the decisional hierarchies of these firms and also their compensation structure in certain instances. We argue that knowledge resources drove the change in the organizational structure of mass production firms from the U-form to the M-form, affecting decision making rights. We show how the adoption of stock options plans in high tech firms aims at constraining knowledge hazards. Stock options prevent leakage by retaining individual knowledge and discouraging hoarding of knowledge. We argue that the model of profit splitting and the hierarchy between partners and associates in law firms are also explained by the necessity of maximizing the use of knowledge resources. We then examine how the change of knowledge types used in law firms is affecting their organization. Finally, we investigate how certain business transactions like mergers, joint ventures and licensing contracts are shaped by knowledge inputs. We show that knowledge considerations provide a positive explanation for firm structure and a normative view in that the principle of efficient knowledge allocation should be an important concern of policy makers concerned with corporate reform.

TABLE OF CONTENTS

| | |
|---|----|
| I. INTRODUCTION..... | 4 |
| II. THEORY OF THE FIRM | 8 |
| A. Traditional Theories of the Firm..... | 8 |
| 1. The Neoclassical Theory of the Firm..... | 8 |
| 2. The Transaction Cost Theory of the Firm..... | 8 |
| 3. Nexus of Contracts and Agency Cost | 13 |
| 4. Property Rights Theory..... | 15 |
| B. The Knowledge-Based Theory of the Firm..... | 17 |
| III. A KNOWLEDGE TAXONOMY | 20 |
| A. The Location of Productive Knowledge (Kp, Ko, Ki) | 20 |
| B. Tacit versus Standardized Knowledge | 23 |
| C. The Dynamics of Productive Knowledge | 25 |
| 1. Ki Can Be Transformed Into Ko..... | 26 |
| 2. Ko Can Give Rise To Ki..... | 26 |
| 3. Ki Can Be Transformed Into Kp..... | 27 |
| 4. Kp Can Give Rise To Ki..... | 27 |
| 5. Kp Can Give Rise To Ko..... | 27 |
| 6. Ko Can Be Transformed Into Kp..... | 27 |
| 7. Summary..... | 27 |
| IV. LAW AND KNOWLEDGE MANAGEMENT..... | 28 |
| 1. Law and Contract as Mechanisms of Knowledge Management | 29 |
| 2. The Co-Evolution Of Intellectual Property Rules And Firm Governance | 30 |
| a) Patents and Copyrights bind Kp | 37 |
| b) Trade Secrets Bind Kp And Ko And Ki..... | 38 |
| c) Covenants Not To Compete Bind Ki..... | 39 |
| 3. Other Bodies Of Law And Types Of Agreements | 42 |
| V. KNOWLEDGE ALLOCATION AND TRANSACTION COSTS | 42 |
| A. Efficient Knowledge Allocation | 42 |
| B. Knowledge Hazards | 45 |
| 1. The Public Goods Characteristics of Knowledge Resources | 45 |
| 2. Leakage..... | 46 |
| 3. Hoarding/Failure to Share..... | 46 |
| VI. REVISITING SOME ASPECTS OF FIRM ORGANIZATION FROM THE KNOWLEDGE RESOURCES PERSPECTIVE | 47 |
| A. Correlating Knowledge Structures and Governance (Decisional/Ownership) Structures | 47 |
| 1. Centralization vs. Decentralization of Decision Making and Knowledge Location | 49 |
| 2. The Nature of the Problem..... | 52 |
| B. The Sole Proprietorship and Small Partnerships | 54 |
| C. Mass Production Firms | 54 |
| 1. The Shift from C-Form to the M-Form Structure | 56 |
| D. High-Tech Engineering..... | 63 |
| 1. Restrictive Covenants and the Structure of High Tech Firms..... | 64 |
| 2. Employee Stock Option Plans As An Alternative Means to Binding Knowledge to the Firm | 67 |
| E. Law Firms | 72 |
| 1. A Knowledge-Based View Of The Organizational Structure Of Law Firms | 75 |
| 2. The changing organizational structure of law firms | 78 |
| F. The Implications of Knowledge Transfer for the Choice of Business Transactions | 80 |
| VII. CONCLUSION..... | 83 |

“An explanation of when, why, and how managerial hierarchies developed in certain industries and rarely appeared in others remains a challenge to economists, sociologists, practitioners of management science, and economic and business historians.”

- ALFRED CHANDLER & HERMAN DAEMS,
MANAGERIAL HIERARCHIES: COMPARATIVE
PERSPECTIVES

“Considering the acknowledged importance of knowledge and competence in business strategy and indeed the entire system of contemporary human society, it is striking that there seems to be a paucity of language useful for discussing the subject . . . there seems to be a serious dearth of appropriate terminology and conceptual schemes.”

- Sidney G. Winter, *Knowledge and Competence as Strategic Assets*

I. INTRODUCTION

The literature on the theory of the firm and corporate organization has treated extensively several variables that affect firm boundaries and internal corporate structure. Management and economic scholars have thus accounted for firm boundaries and internal corporate governance patterns by explanations based on transaction costs,¹ agency costs,² and property rights over physical assets.³

One very important variable, however, has been largely ignored by this literature, and certainly by legal scholars. This variable concerns perhaps the core ingredient that firms use to achieve their corporate objective, namely to generate the products or services they will sell on the market: The *knowledge resources* that firms use in the production process. This ingredient is tantamount to the whole business enterprise. First the entrepreneur must come up with an idea, which, in turn, requires the application of additional knowledge and skill to develop a product or service that can be sold in the market.

¹ Ronald H. Coase, *The Nature of the Firm*, 4 *ECONOMICA* 115 (FEB. 1937); OLIVER WILLIAMSON, *THE ECONOMIC INSTITUTIONS OF CAPITALISM; FIRMS, MARKETS, RELATIONAL CONTRACTS* (1985).

² Michael C. Jensen & William H. Meckling, *Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure*, 3 *J. FIN. ECON.* 305 (1976).

³ Sanford J. Grossman & Oliver D. Hart, *The Costs and Benefits of Ownership: a Theory of Vertical and Lateral Integration*, 94 *J. POLIT. ECON.* 691, 693-694 (1986); Oliver Hart & John Moore, *Property Rights and the Nature of the Firm*, 98 *J. POLIT. ECON.* 1119 (Dec. 1990).

A theory of the firm that focuses on knowledge resources required in the production process, and their differential effects on internal firm organization, is absent in the legal literature. And yet, knowledge resources affect internal corporate governance. And the reverse is also true in that internal corporate governance can affect knowledge management and production.⁴ Internal organizational practices can promote or inhibit the efficient use of knowledge resources within the firm. Moreover, largely absent from the corporate organization literature is a discussion of the effects that intellectual property rights mechanisms and private contracting involving knowledge resources exert over firm internal governance structures.⁵ To be sure, while recent literature has pointed out the importance of human capital and capabilities for corporate governance practices,⁶ there has been no consistent attempt to explain how knowledge requirements of the production process, more generally, affect internal corporate governance in concrete and specific ways, and vice-versa.⁷

This paper begins to fill this gap. Economists and management scholars have increasingly pointed to the special nature of knowledge resources as an explanation for firm boundaries.⁸ Knowledge resources can explain both why firms exist, and why firms develop a

⁴ ALFRED D. CHANDLER JR., *INVENTING THE ELECTRONIC CENTURY* 85-86 (2001), for example, attributes the failure of Remington Rand in the computer business to its failing in built an integrated learning base. So, a problem in the management of knowledge resources led to the failure of the business.

⁵ The study of Gilson provides an exception in this regard for it makes the connection between intellectual property and corporate structure. Ronald Gilson, *The Legal Infrastructure of High Technology Industrial Districts*, 74 N.Y.U. L. REV. 575 (1999). Gilson analyzes the impact of legal structure on the development of high technology industrial districts. Gilson, however, looks at the high tech industry from an aggregate perspective and does not develop the consequences of knowledge resources for firm internal governance structure. We pursue his insight further in this paper and complete his story by looking at how high tech firms in Silicon Valley have a different governance structure from high tech firms on Route 128. See also Dan L. Burk, *Intellectual Property and the Firm*, 71 U. CHI. L. REV. 3, 4 (2004) (doing the reverse, that is, “considering intellectual property in light of the theories of the firm.”) The author proposes to examine “whether existing intellectual property law provides for efficient allocation of intellectual property rights within firms in a manner that comports with property-based theories of the firm.”) There is an increasing awareness in intellectual property and employment law literature that the regulation of knowledge resources impacts the financial and organizational structure of firms. See Robert P. Merges, *The Law and Economics of Employee Inventions*, 13 HARV. L. J. & TECHN. 1 (1999); Robert P. Merges, *Intellectual Property Rights and the New Institutional Economics*, 53 VAND. L. REV. 1857 (2000); Catherine L. Fisk, *Working Knowledge: Trade Secrets, Restrictive Covenants in Employment, and the Rise of Corporate Intellectual Property, 1800-1920*, 52 HAST. L. J. 441 (2001); Katherine V.W. Stone, *Knowledge at Work: Disputes Over Ownership of Human Capital in the Changing Workplace*, 34 CONN. L. REV. 271 (2002).

⁶ Margaret M. Blair, *Firm-Specific Human Capital and Theories of the Firm*, in *EMPLOYEES AND CORPORATE GOVERNANCE* (Margaret M. Blair & Mark J. Roe, eds., Brookings Institution Press, 1999), available at SSRN: <http://ssrn.com/abstract=167848>; Thomas F. McInerney, *Implications of High Performance Production and Work Practices for the Theory of the Firm and Corporate Governance*, *COL. BUS. L. REV.* (2004).

⁷ Blair, *supra* note __, at 86 reviews the economic literature on firm-specific human capital and argues that the law and economics literature has fixated for too long on the relationship between shareholders and managers (the principal-agent approach) to model corporate governance. However, she concludes with a very general proposal: “arrangements for governing the relationships among employees, and between employees and the firm, can no longer be treated as something separate from corporate governance.” And she does not explain how the corporate governance literature should take human capital into consideration.

⁸ See, e.g., ASHISH ARORA, ET AL., *MARKETS FOR TECHNOLOGY: THE ECONOMICS OF INNOVATION AND CORPORATE STRATEGY* (2001); Kathleen R. Conner & C.K. Prahalad, *A Resource-Based Theory of the Firm: Knowledge Versus Opportunism*, 7 ORGANIZATION SCIENCE 477 (1996); Jack A. Nickerson & Todd R. Zenger, *A Knowledge-Based Theory of Governance Choice- A Problem-Solving Approach*, 1, available at <http://www.olin.wustl.edu/workingpapers/pdf/2002-06-006.pdf>. Robert M. Grant, *Toward a Knowledge-Based*

particular internal organizational structure.⁹ The corporate law literature, however, has not yet recognized these developments in economics and organizational theory. And, in turn, these theories have not fully recognized the role of legal institutions in shaping knowledge transactions and firm structure.¹⁰

In this paper, we argue that the organization of business firms cannot be explained entirely without reference to the knowledge structure of the firm. We advance the thesis that a firm's internal governance structure is influenced by the type of knowledge required by its production process. Knowledge that individuals bring to bear on production affects firm organization, while firm organization can also affect the production of new knowledge during the course of work. Knowledge-based transaction costs can help explain both why firms exist – that is why firm organization vs. market contracting is preferred in the production process – and why the firm has a particular organizational form.

The structure of the firm in a competitive environment can be viewed as a result of three imperatives: (1) A firm must produce knowledge within the firm; (2) A firm must transfer and diffuse knowledge within the firm;¹¹ (3) A firm must bind knowledge to the firm, that is, prevent the transfer of knowledge outside of the firm. How a firm produces knowledge, transfers and diffuses it within the firm, and binds it to the firm is intricately related to the organizational structure of the firm. The organizational structure varies accordingly, which variation, we imagine, is capable of being described as a complex function. The type of knowledge that is used in a firm's production process is a crucial variable in this function (though by no means determinative). We therefore propose a revision of current theories of the firm suggesting that a key element in firm organization is the *type of knowledge* that it deploys to accomplish its goals.

Theory of the Firm, 17 STRATEGIC MANAGEMENT JOURNAL 109 (1996); Richard N. Langlois & Nicolai J. Foss, *Capabilities and Governance: the Rebirth of Production in Theory of Economic Organization* (Druid, Working Paper No. 97-2, 1997), available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=77668.

⁹ Some scholars have lamented the insufficiency of the traditional theories of the firm to account for the way production is organized within the firm. See, e.g., Bengt Holmström & John Roberts, *The Theory of the Firm Revisited*, 14 JOURNAL OF ECONOMIC PERSPECTIVES 73, 90 vol. 14, note 4 (Fall 1998) (advocating a broader view of the firm and its boundaries: "...it is surprising that the leading economic theories of firm boundaries have paid almost no attention to the role of organizational knowledge." (citation omitted); see also, *id.* at 75 ("[Firms] have to deal with a much richer variety of problems than simply the provision of investment incentives and the resolution of hold-ups. Ownership patterns are not determined solely by the need to provide investment incentives, and incentives for investment are provided by a variety of means, of which ownership is but one. Thus, approaches that focus on one incentive problem that is solved by the use of a single instrument give much too limited a view of the nature of the firm, and one that is potentially misleading... Our examples suggest that ownership patterns are responsive to, among other things, agency problems, concerns for common assets, difficulties in transferring knowledge, and the benefits of market monitoring.")) See also Harold Demsetz, *The Theory of the Firm Revisited*, in THE NATURE OF THE FIRM 185 (OLIVER E. WILLIAMSON & SIDNEY G. WINTER eds., 1993).

¹⁰ ASHISH ARORA ET AL., *supra* note __, at 14 ("Intellectual property are the means for defining the object of the transaction and the property rights in the markets for technology."). Bharat N. Anand & Tarun Khanna, *The Structure of Licensing Contracts*, 48 J. OF INDUST. ECON. 103, 128 (Mar. 2000) (discussing the failure of the literature in distinguishing properly how legal institutions protect knowledge in different industries).

¹¹ The extent of knowledge diffusion or knowledge sharing will of course depend on the strategy of each firm aiming to maximize the use of its knowledge resources in the face of the knowledge hazards that it may face and the characteristics of legal institutional environment to which it is subject. A firm may adopt a strategy of restricting its knowledge to but a few top employees, or may want to share it as much as possible in order to provide an environment suitable to innovation.

We show that law and contract affect knowledge management and knowledge production in complex ways thereby ultimately influencing corporate structure. We analyze how law or contract affect the creation of organizational structures suitable to knowledge production, diffusion, and conservation, such that the relevant knowledge is efficiently collocated with decision-making authority within the firm. We propose a principle of efficient knowledge allocation according to which firms will try to maximize the use of knowledge resources in the coordination of their activities. Finally, we examine what organizational mechanisms emerge to meet the objective of efficient knowledge allocation.

Firms build less or more hierarchical structures, establish particular decision-making procedures, and design specific compensation packages and incentives because they are compelled to maximize the value of their knowledge resources in highly competitive environments. Different types of relevant knowledge resources will require different corporate strategies to maximize their value. We therefore explain the use of intellectual property protections, restrictive covenants, and features of compensation systems as responses to a firm's need to manage knowledge efficiently.

By taking such a "knowledge-based" approach, we are able to shed light on some internal organizational features of mass production, high tech, and law firms, as well as certain business transactions. Thus we show how the management of knowledge resources required in mass production and high tech firms differentially affects their decisional hierarchies, and in certain instances also their compensation and ownership structure. Further, we explain the role of more hierarchical decision-making structures in mass production firms and of flatter hierarchies in high tech and law firms, as means for achieving an efficient knowledge allocation. We show how particular characteristics of the compensation policies in high tech and law firms, such as the use of stock options and the sharing model, serve to maximize efficient knowledge allocation in these firms. We investigate how certain business transactions like mergers, joint ventures and licensing contracts are shaped by knowledge inputs.

The paper is organized as follows. In Part II, we discuss some of the major economic theories of the firm and show their shortcomings in providing a convincing explanation of a broad range of firm production organization. We then introduce an alternative view of the firm proposed by knowledge theories developed by economists and management scholars.

In Part III, we propose a typology that distinguishes between three types of knowledge resources used in the production process.

In Part IV, we explain how legal rules impact firm organization, by a) binding knowledge to the firm, b) permitting its diffusion within the firm among employees who need access to this knowledge and c) preventing knowledge transfer outside the firm. We show that certain intellectual property protections can shape firm organization, affecting knowledge production and firm organizational structure. In doing so, we begin to make use of the typology introduced in Part III.

In Part V, we present a principle of efficient knowledge allocation and discuss some specific knowledge hazards.

In Part VI, we then show that different organizational structures rely on the different types of knowledge resources. We show how knowledge inputs shape their organizational structure. We focus on mass production, high tech and law firms. We also

discuss some business transactions such as mergers, joint ventures and licensing. We explain some of the internal governance features in such organizations as responses to the necessity of achieving an efficient knowledge allocation and management.

Part VII concludes.

II. THEORY OF THE FIRM

In the following, we examine some of the most important economic theories that try to explain firm boundaries and governance structure. In order to understand the contributions of the knowledge-based theory of the firm we must revisit at least some of the most basic assumptions of the more traditional theories of the firm.

A. *Traditional Theories of the Firm*

1. *The Neoclassical Theory of the Firm*

Firms are characterized by technological transformations. In neoclassical theory, firms are, in a sense, seen as repositories of productive knowledge. Orthodoxy does not, however, engage in detailed inquiry as to the role of knowledge in the firm's organization. Sidney Winter has pointed out this shortcoming of orthodox economics:

By taking production sets or functions as given ... [orthodoxy] fails to provide a framework for explaining why society's capabilities should be packaged at a particular time in one particular way and not some other way. By treating the storage of a particular knowledge as costless – the analogue in this context of the assumption of costless and perfect contracts- it forecloses to economic analysis the performance of the very role that it claims is central.¹²

Neoclassical theory posits that all firms have the same knowledge, know-how or capacity to produce. All firms in an industry are assumed to have the same production function in the long-run. But as Winter suggests capabilities and organizational knowledge may vary even among firms that produce in the same industry and rely on similar technologies.¹³

2. *The Transaction Cost Theory of the Firm*

In *The Nature of the Firm*, Coase proposed a transaction cost explanation of the existence of the firm and its boundaries. The theory was ground breaking and it remains an

¹² Sidney G. Winter, *On Coase, Competence, and the Corporation*, in *THE NATURE OF THE FIRM*, 185 *supra* note ___, at 185.

¹³ See also Richard R. Nelson, *Production Sets, Technological Knowledge, and R & D: Fragile and Overworked Constructs for Analysis of Productivity Growth?*, 70 *THE AMERICAN ECONOMIC REVIEW* 62 (1980) (criticizing the economic theoretical constructs of production sets, technological knowledge, and research and development). Nelson argues that orthodoxy assumes that technological knowledge is in the form of codified how-to knowledge as if contained in a "blue print book" which provides sufficient guidance to any firm that has access to the book. However, there is no logical reason why this book should be available to all firms, as if it were in a public library. Furthermore, each firm will learn largely on its own, in an inimitable way, according to its particular organizational features and human capital.

extremely compelling account of governance structures in the developed form that it has assumed through the work of Williamson. Coase, however, subscribes to an account of the employment relationship that obscures the effects of knowledge resources on firm structure and boundaries.

Coase noted that the distinguishing feature of the firm is the allocation of resources by the entrepreneur, rather than the price mechanism. Coase argued that production takes place in the firm whenever transaction costs involved in firm production are lower than the transaction costs would be for that same type of production on the market. For example, in order to produce a coat on the market, one would have to seek out and contract separately with a tailor, a cloth supplier, a supplier of buttons, perhaps a furrier, and so forth. Each such transaction involves transaction costs from contracting in the form of information costs, negotiating costs, monitoring and enforcement mechanisms. By vertically integrating these activities a firm can economize on transaction costs and produce more efficiently. While contracts are not eliminated within the firm, they are greatly reduced by the authority of the entrepreneur.

Central to Coase's explanation of the firm is an understanding of the employment contract as an open-ended commitment by the employee to obey the direction of the entrepreneur over the long term (within certain limits). According to Coase, the existence of the firm can be explained by reference to the transaction cost savings associated with the employer's fiat-control over the employee.

We can best approach the question of what constitutes a firm in practice by considering the legal relationship normally called that of "master and servant" or "employer and employee.... it is the fact of direction which is the essence of the legal concept of "employer and employee" . . .¹⁴

Coase thus explains how the organization of production within the firm reduces transaction costs that would otherwise occur in the market. But his explanation relies on a very narrow understanding of firm organization, as one that is based on the fiat control of the entrepreneur. Coase uncritically adopts this view of firm hierarchy by generalizing from 19th century conceptions of the relation between employer and employee which indeed obtain in certain types of firm production, as we shall discuss below.¹⁵ But Coase thereby fails to appreciate what characterized the fundamental shift between the 19th and 20th century organization of production in firms, namely the emergence of a new class of salaried managers, who were both employees (i.e. non-owners) and decision makers.¹⁶

According to Alfred Chandler, the new type of business enterprise brought the separation of ownership from management: "The enlarged enterprises came to be operated by teams of salaried managers who had little or no equity in the firm."¹⁷ These salaried managers were employees, usually with engineering degrees, hired largely by the families who owned and ran large firms to exert control over a firm's organization and coordination of production.

¹⁴ Ronald H. Coase, *The Theory of the Firm*, in *THE NATURE OF THE FIRM* *supra* note __, at 29.

¹⁵ Coase, *supra* note __, at 30 (citing treatise by BATT, *THE LAW OF MASTER AND SERVANT*).

¹⁶ CHANDLER, *supra* note __, at 1.

¹⁷ CHANDLER, *supra* note __.

History shows that while hierarchy was crucial to the rise of the modern industrial enterprise, *entrepreneurs (owners) did not exercise fiat control over their most important employees*. As Chandler points out:

In production the new middle managers – both line and staff – had to learn intimately the technology of the products made and the processes used in the different factories under their control. So, too, in marketing and distribution middle managers had to come to know the similarities, differences, vagaries, and opportunities of different regional markets. In both production and distribution the line managers had to recruit, train, and motivate their own staffs as well as the lower-level managers under their command – the managers of plants, branch sales and purchasing offices, and laboratories. And even more than these lower-level executives, the middle managers had to learn to administer; that is, they had to learn to coordinate, to evaluate and act on such evaluations, in addition to recruiting, training, and motivating subordinates. For top managers such administrative duties were paramount. They not only had to learn to coordinate and monitor the activities of the functional departments but also to plan, allocate resources for, and implement long-term programs to maintain the enterprise's facilities and skills, if they were to retain their share of existing markets and to move into new ones.¹⁸

What is striking about the emergence of this new institutional form, as Chandler's widely accepted account of the managerial revolution describes, is the significant discretion that was given to *salaried* managers in coordinating production within the firm. The salaried managers were accorded considerable discretion, because of their technical knowledge and their training in the coordination and organization of production; in other words, because of their ability to make decisions as opposed to merely following orders. Coase's theory that the fiat relationship between employer and employee was *the key organizational feature* of the firm thus does not square well with the historical evidence.

It is true that rigid hierarchical relations frequently existed between employees at lower levels of the firm's hierarchy and were indeed necessary. More careful analysis, however, shows that the firms in which rigid, top-down authority became the defining feature of the employment relationship engaged in certain types of production. The paradigmatic example of a firm characterized by such authority relations is the Taylorist manufacturing firm that spearheaded assembly-line mass production. In firms that adhered to Frederick Taylor's principles, production was entirely restructured by the decomposition of the production process into isolatable, repetitive motions. Taylor's science of production conceived of employees as slightly more complex mechanical instruments, or machines.¹⁹ As we further develop in Section III, Taylorism involved a process of embedding knowledge in the production technology. It is this type of production, in which employees are treated like replaceable assets, that displays

¹⁸ CHANDLER, *supra* note __, at 598.

¹⁹ See FREDERICK WINSLOW TAYLOR, *THE PRINCIPLES OF SCIENTIFIC MANAGEMENT* (1916).

authority relations most resembling those that Coase describes.²⁰ Indeed, the very purpose of Taylorism was to eliminate the entrepreneur's reliance on the judgment of his employees concerning every aspect of the production process, including the movement of their own bodies.²¹

Such fiat relations in firm hierarchy, however, hardly obtain in the context of other types of firm organization. Take, for example, high-tech firms. High-tech firms are characterized by shared decision making among highly specialized employees, who exercise considerable control over their work agendas and project development.²² High tech firms depend on employees exercising significant discretion in their work. And employees could not, and would not, engage in productive cooperation if their reasoned judgments and their thoughtful approaches to problem-solving were supplanted regularly by appeals to authority.²³ Coase's fiat theory, therefore, does not supply a universal account of firm structure, although it may account for the organization of a particular type of firm – that engaged in the Taylorist organization of mass production.

Even firms that organized their production according to Taylor's principles, however, were only partially characterized by fiat relations of authority. As already described, at the level of managerial employees such firms depended on expanding the discretion of non-owners.

As has been pointed out by others, a further shortcoming of Coase's theory consists in his too general account of transaction costs.²⁴ Coase fails to sufficiently specify the nature of the transaction costs that he has in mind. Any variable can thus be invoked as a determinant of firm boundaries, as long as it is defended as a transaction cost.²⁵ In order to

²⁰ See also Richard Adelstein, *Knowledge and Power in the Mechanical Firm: Planning for Profit in Austrian Perspective* (2003) (working paper at ___, on file with authors).

²¹ See Taylor, *supra* note ___, at ___.

²² See e.g., Nicolai J. Foss, *Coase vs Hayek*, 5-6 (Copenhagen Business School, Working Paper No. ___, 2001), available at <http://www.cbs.dk/departments/ivs/wp/wp01-08.pdf>. (“Overall, a consensus seems to be emerging that tasks and activities in the knowledge economy need to be coordinated in a manner that is very different from the management of traditional manufacturing activities, with profound transforming implications for the authority relation and the internal organization and boundaries of firms” ... “[t]he increased reliance on knowledge networks tends to erode authority-based definitions of the boundaries of the firm, because authority increasingly shifts to expert individuals who control crucial information resources ...”).

²³ In a study of the retention of human capital in acquisitions of high-tech firms, Ranft and Lord find that granting autonomy and relative status to the management and employees of acquired high tech firm's enhanced retention of key employees, but that economic incentives did not. Annette L. Ranft & Michael D. Lord, *Acquiring New Knowledge: The Role of Retaining Human Capital in Acquisitions of High-Tech Firms*, 11 THE JOURNAL OF HIGH TECHNOLOGY MANAGEMENT RESEARCH 295 (2000). See also Julia Porter Liebeskind, Amalya Lumerman Oliver, Lynne Zucker, Marilynn Brewer, *Social Networks, Learning and Flexibility: Sourcing Scientific Knowledge in New Biotechnology Firms*, 7 ORGANIZATION SCIENCE 428, issue 4 (Jul./Aug, 1996) (describing decentralization of management in biotech firms).

²⁴ Demsetz, *The Theory of the Firm Revisited*, *supra* note ___, at 164 (arguing that the lack of specification of what are transaction costs deprives transaction cost theory from any predictive content).

²⁵ Coase himself has admitted that his theory is too general to provide specific applications. See Coase, *The Theory of the Firm*, in THE NATURE OF THE FIRM, *supra* note ___, at 73 (“in that article [The Nature of the Firm] I emphasized the comparison of the costs of transacting with the cost of organizing and did not investigate the factors that would make the costs of organizing lower for some firms than for others. This was quite satisfactory if the main purpose was, as mine was, to explain why there are firms. **But if one is to explain the institutional structure of**

explain firm boundaries and organization, however, we must identify the most relevant types of transaction costs.

Accordingly, we argue that the cost of coordinating knowledge turns out to be a significant transaction cost that affects firm boundaries and structure. In consequence, we focus exclusively on such knowledge costs and inquire their effects by holding constant other transaction costs in our analysis.²⁶

Coase himself had a sense of how crucial knowledge requirements are to firm organization, even as he failed to explicitly develop this variable in his analysis of firm boundaries. In explaining why all production is not carried on by one big firm, Coase appears to have identified the costs of organizing production within a firm, as primarily the result of bounded rationality²⁷: “It may be,” Coase speculates, “that as the transactions which are organized increase, the entrepreneur fails to place the factors of production in the uses where their value is greatest.”²⁸ And “[o]ther things being equal ... a firm will tend to be larger ... [t]he less likely the entrepreneur is to make mistakes and the smaller the increase in mistakes with an increase in the transactions organized.”²⁹ Coase here appears to suggest that firm size is a function of the problem solving capabilities of the entrepreneur who directs production and of the organization’s ability to provide an effective conduit for the entrepreneur’s problem solving, rather than an impediment to it.

Pursuing this insight further than Coase does himself, we advance the hypothesis that the knowledge required in the production process imposes limits on firm size, because a single firm cannot coordinate infinite types of knowledge. Each firm has command of a specific body of knowledge that it deploys in its production process. For a firm that produces food products to engage in activities in the pharmaceutical industry would be inefficient as this would require marshalling entirely different knowledge sets, i.e. those appropriate to developing chemical products and drugs. That, we suggest, is also the reason why firms tend to expand the scope of their activities to fields in which the firms’ already accumulated knowledge can afford a competitive advantage.³⁰ It seems clear from this that even if all other transaction costs that Coase sets forth were zero, not all production would be carried out exclusively in the market³¹ or

production in the system as a whole it is necessary to uncover the reasons why the cost of organizing particular activities differs among firms.) (emphasis added).

²⁶ This is not to say that opportunism is not an important factor for it can raise many hazards in knowledge exchanges as we will see.

²⁷ Adelman, *supra* note __, at 7.

²⁸ Coase, *The Theory of the Firm*, in *THE NATURE OF THE FIRM*, *supra* note __, at 23.

²⁹ Coase, *supra* note at __.

³⁰ See Sidney G. Winter, *On Coase, Competence and the Corporation in THE NATURE OF THE FIRM*, *supra* note __, at 190-91 (“Of course, when a firm grows by vertical integration, it is not just a question of “more of the same.” But it is more of something closely related, something about which the firm already has some degree of relevant knowledge.”)

³¹ Transaction costs economics tends to argue that if transaction costs are zero, there is no firm as a collective entity. This is because it is assumed that each individual will act as a firm. However, Demsetz already highlighted the weakness of that argument. See Demsetz, *The Theory of the Firm Revisited*, *supra* note __ at 163: “the inference...that all production is individualized if transaction costs is zero, is wrong. Multiperson firms are fully consistent with zero transaction cost if management is subject to scale economies. Zero transaction cost inform us only that these cooperating efforts will be organized with greater reliance on explicit negotiations than would be true if transaction cost were positive.(...) ...the substance of the firm is reflected in the style of cooperative behavior that

exclusively by one big firm,³² because the cost associated with possessing and coordinating the relevant knowledge for organizing every type of transaction within the firm would be prohibitive. No entrepreneur could have enough knowledge to manage every type of production within a single firm.

Knowledge costs are, therefore, an important determinant of firm boundaries and must be studied separately. They cannot simply be subsumed within the general concept of transaction costs advanced by Coase.³³

3. *Nexus of Contracts and Agency Cost*

In *A Theory of the Firm*, Jensen and Meckling treat the firm as a nexus of contracts subject to agency costs. The firm is viewed as a “nexus of a set of contracting relationships . . . mak[ing] clear that the . . . *firm is not an individual* . . . [but] is a legal fiction which serves as a focus for a complete process in which the conflicting objectives of individuals (some of which may ‘represent’ other organizations) are brought into equilibrium within a framework of contractual relations.”³⁴ *Agency costs* are those transaction costs of contracting that result from the irreducible difference of interest between the principal(s) and the agent(s).

Agency costs can be reduced through monitoring (and enforcement) mechanisms. Monitoring is necessary to limit the agent’s pursuit of his own interest to the detriment of the principal’s interest. As such, monitoring costs count as agency costs. Similarly, the agent herself incurs costs that arise solely from the inability of the principal to fully control her agent. The agent must bond herself in order for the principal to entrust her with her interests. Thus

obtains.” We argue that knowledge gained through the coordination process within the firm will make production within the firm efficient even if transaction costs were zero.

³² See Coase, *supra* note __ at __. (“Why is not all production carried on by one firm?”; see also Demsetz, *The Theory of the Firm Revisited*, *supra* note __ at 173 (arguing that “[t]he process of product . . . refinement is halted when the next version of the product will be put to many multiple uses downstream that rely on different bodies of knowledge. A single firm if it was vertically integrated would have difficulty acquiring and maintaining the stocks of knowledge necessary to control cost and quality and to make good managerial decisions when downstream uses are multiple in this sense Roughly speaking . . . *the vertical boundaries of a firm are determined by the economics of conservation of expenditures on knowledge.*”) (emphasis added).

³³ We can find more passages where Coase implicitly admits the importance of knowledge for determining firm organization structure: “Apart from variations in the supply price of factors of production to firms of different sizes, it would appear that the costs of organizing and the losses through mistakes will increase with an increase in the spatial distribution of the transactions organized, in the dissimilarity of the transactions, and in the probability of changes in the relative prices. As more transactions are organized by an entrepreneur, it would appear that the transactions would tend to be either different in kind or in different places. . . . All changes which improve managerial technique will tend to increase the size of the firm.” (citations omitted) (25). Coase also realized, footnote 31, that inventions will not always make the size of the firm bigger. Giving the example of the telephone, Coase argues that if it reduces the costs of using the market, more than it reduces the cost of organizing production in the firm, then it will contribute to firms be smaller and not larger. And we believe this conclusion derives directly from a knowledge economizing strategy. A firm will not need to produce a telephone, if it wants to use one. This would increase the organization costs of a firm that doesn’t have knowledge or capabilities to produce a telephone to start to producing it. This cost would be prohibitively high. So the firm can buy the telephone in the market. See also the correspondence of Coase with Fowler in Coase, *The Nature of the Firm: Origin*, (“There may be technical advantages in increasing complexity **but it is decreasing returns to managerial ability which seems to set the limit.**”) (emphasis added). In our opinion, therefore, Coase appears to understand the cost of organizing knowledge as a crucial cost in determining firm’s size.

³⁴ Jensen & Meckling, *supra*, note __, at 311-12.

monitoring, bonding, and residual costs are defined as agency costs and are used by Jensen and Meckling to explain the organization structure of the firm.³⁵

It is important to note that by focusing on agency costs, Jensen and Meckling actually do not, in fact, explain why firms exist. Instead, they analyze how firms constrain agency costs, making production within the firm possible, and they explain some aspects of the financial structure of firms.^{36,37} Agency cost is the result of a conflict between the agent's self-interest and the will of the principal. The agency cost framework suggests that the greater the "gap" between the agent and the principal, the greater the agency costs. Greater autonomy for groups or individuals within an organization, on this logic, results in increased agency costs – all else being equal. If containing agency costs is viewed as the most important feature of successful business organization, then the following prescription would appear to follow: Concentrate decision making authority in the hands of as few agents as possible, who are closely monitored and directed by the principals.³⁸

Interestingly, recent developments in management strenuously question this conclusion. Contemporary CEOs and management theorists champion the value of decentralized decision making. "Traditional industrial corporations concentrated power in top management," writes Peter Senge, "yet many of the most successful corporations in recent years have implemented radical changes in governance systems."³⁹ These changes attempt to capture the gains of localism. The core dilemma, according to Senge is "how to gain the advantages of local autonomy and decision making while increasing the ability to understand and manage interdependence."⁴⁰

Shell Oil, for example, engaged in an abrupt, full-scale shift from centralized to decentralized governance beginning in 1994. It chose a federalist governance model in which "power was held as much as possible by independent entities with profit-and-loss accountability."⁴¹ The separate entities would still have interaction and responsibility to one

³⁵ Jensen & Meckling, *supra*, note __, at __.

³⁶ The criticism of C.K. Prahalad & Gary Hamel, *The Core Competence of the Corporation*, *supra* note __, applies. ("How strange that SBU managers, who are perfectly willing to compete for cash in the capital budgeting process, are unwilling to compete for people – the company most precious asset. ***We find it ironic that top management devotes so much attention to the capital budgeting process yet typically has no comparable mechanism for allocating the human skills that embody core competencies.*** Top managers are seldom able to look four or five levels down into the organization, identify the people who embody critical competencies, and move them across organizational boundaries.") (emphasis added).

³⁷ In an article not well-known in the corporate law and economics literature, however, Jensen and Meckling have recognized the crucial role of collocating relevant knowledge with decision making authority in the firm. Michael C. Jensen & William H. Meckling, *Specific and General Knowledge, and Organization Structure*, in *CONTRACT ECONOMICS* 251-274 (Lars Werin and Hans Wijkander eds., 1992) ("Knowledge considerations are one cause for the emergence of firms.").

³⁸ This is not necessarily what agency-cost theory posits, but note that this is the logic behind some current proposals for strengthening shareholder power, that is, let's contain agency costs by making the principals have more power in business decisions. Lucian A. Bebchuk, *The Case for Increasing Shareholder Power*, 118 HARV. L. REV. 833 (2005).

³⁹ PETER SENGE, *THE DANCE OF CHANGE*, 361 ().

⁴⁰ SENGE, *supra* note __, at 363.

⁴¹ Senge, *supra* note __, at 385. *But see, Shell Structure Has to Change, Investor Says*, NEW YORK TIMES, February 9, 2004 at C3 (reporting that investors called for greater centralization of Shell's organizational hierarchy).

another and to the center, but they had their own capital structures and internal debt levels, and could make their own investment decisions. Shell created internal boards of directors for advice and oversight and for sharing ideas. These boards were linked through interlocking membership. Further structures were put into place to ensure business alignment and overarching mission. In this way Shell Oil “pushed decision making, including capital decisions, down to four newly formed autonomous business units.”⁴²

This development does not square well with traditional proposals that rely on agency-cost theory. How can a firm contain its agency costs by devolving decision making authority down onto an increasing number of agents with local autonomy? Would this not raise agency costs? Would opportunism not increase? The most plausible explanation that agency cost theorists could come up with for whatever success such organizational structures produce would be a cost-benefit argument. If the benefits of such a decentralized organization outweigh the resulting agency costs, the outcome will still be desirable. But such an answer begs the question why decentralization encompasses such benefits.

Agency cost theory does not provide a sufficient theoretical framework to explain why granting agents greater autonomy is a good idea at all, without a proportional increase in ratification and monitoring mechanisms.⁴³ Clearly, however, greater dispersion of decision making authority within firms is a result of the increasing knowledge intensity of productive activity, forcing companies that want to remain competitive to make use of their human capital at every level of the company hierarchy. This development away from traditional hierarchical governance structures by companies like Shell cannot be fully understood without reference to a knowledge-based theory of the firm.

4. *Property Rights Theory*

Property Rights Theory explains firm boundaries based on the ownership of physical assets. A firm “consist[s] of those assets that it owns, or over which it has control.” Property Rights Theory, therefore, does not distinguish between ownership and control, but defines ownership as the capacity to exercise control. Control is thus achieved through the ownership of physical assets.

Property Rights Theory derives its appeal from its elegant mathematical formalizations that shed light on the firm structure of certain types of firms. For example, Hart and Grossman’s theory may be most useful in explaining the structure of mass production systems, and specifically those engaged in Taylorist production. In a Taylorist firm, the physical

⁴² SENGE, *supra* note __, at __.

⁴³ Eugene Fama & Michael C. Jensen, *Separation of Ownership and Control*, 26 J. LAW & ECON. 301, 301-302 (June 1983). In trying to explain the survival of organizations in which agents make important decisions but do not bear a significant share of the wealth effects of such decisions, Fama and Jensen state: “We contend that separation of decision and risk-bearing functions survives in these organizations in part because of the benefits of specialization of management and risk bearing but also because of an effective common approach to controlling agency problems caused by separation of decision and risk-bearing functions. In particular, our hypothesis is that the contract structures of all these organizations separate the ratification and monitoring of decisions from initiation and implementation of the decisions.” Nonetheless, when we nowadays observe the decentralization trend in some organizations, it is not clear that the process of separation between initiation and ratification occurs at all levels where important business decisions are taken. In many instances, agents may have enough power so as to initiate, implement and ratify decisions which will not even reach, for example, the board of directors, which is the organ to which Fama and Jensen attribute the ratification and monitoring authority.

ownership of machines is very important; but employees are replaceable. But this circumstance is very particular to a type of production that permits that the knowledge necessary to produce is embedded in the production process, or rather in the machines themselves.

The theory assumes that ownership gives the owner all rights to dispose of physical asset that the owner hasn't given away, or that the government hasn't taken by force.

However this theory fails to perceive that, as we know from law, ownership does not necessarily afford legal control to dispose of the property. As property law tells us, ownership consists of a bundle of rights. For example, I may own an easement on a property. But suppose that easement was donated to me, with some clause that does not give me the right to dispose of the property as I wish. If I inherited the easement, it is also not some right that I have shaped on my own terms. This is clear in corporate law, in that the shareholders own the corporation, but do not have the legal right to control the everyday business decisions of the corporation. The average shareholder also never gave away such right! Moreover, even if the shareholder wanted to retain the right to make everyday decisions, or ask that it be returned to him, he would not be so entitled under corporations law.⁴⁴ Ownership, therefore, does not always provide the right to exercise control.

Hart and Grossman define the firm "as being composed of the assets (*e.g.*, machines, inventories) that it owns."⁴⁵ Their entire focus is on physical assets. They fail to recognize that in many situations physical assets cannot be used independently of expertise. Assume that an entrepreneur owns a chemical laboratory. What is the purpose of owning such a physical asset without the knowledge required to develop drugs and thereby extract value from these assets? In the pharmaceutical or chemical industries, one may thus buy lots of physical assets, but if one does not have the knowledge capabilities to use the assets, one is making an irrational investment.

In his later work, Hart has argued that the property rights approach can explain how the purchase of physical assets will lead to control over human assets.⁴⁶ He has defended the position that a worker will better pursue the objectives of a principal, if that principal is the worker's boss. The reason for this, according to Hart, is that the boss controls the assets the worker works with. Hart believes the logic underlying his result is different from the Coasian explanation: Coase thinks a boss can tell a worker what to do, while Hart argues that it is in the worker's self-interest to obey his boss, because this will put the worker in a better bargaining position with his boss later on. "[T]he employer can deprive the employee of the assets he works with and hire another worker with these assets."⁴⁷

⁴⁴ Hart has admitted that the property rights approach cannot account for the separation of ownership and control of large publicly held corporations. Oliver Hart, *An Economist's Perspective on the Theory of the Firm*, 89 COLUM. L. REV. 1757, 1173 (1989).

⁴⁵ Grossman & Hart, *supra* note __ at 692.

⁴⁶ Hart, *An Economist's Perspective*, *supra* note __, at 1170-1171.

⁴⁷ *Id.* at 1171. See also, Hart & Moore, *supra*, note __, at __; Oliver D. Hart, *Incomplete Contracts and the Theory of the Firm*, in THE NATURE OF THE FIRM, *supra* note __, 151 ("Authority and residual rights of control are very close and there is no reason why our analysis of the costs and benefits of allocating residual rights of control could not be extended to cover human, as well as physical, assets. In fact, residual rights of control over employees and over physical assets are likely to be related. In particular, an important difference between an employment contract and a contract between independent parties is that the former allows the employer to retain the use of assets used by the employee on the event of a separation (he can hire another employee to operate them). In contrast, an

According to Hart, the control over physical assets can lead to the control of human assets that are part of an organization's capital. We believe that this constitutes a serious shortcoming of the property rights theory. There are many cases where the employees themselves are the most important assets for firm production. If employees are the most important assets, as for example in law firms or high tech firms, the physical assets are largely irrelevant to control. If the employee leaves, he may potentially take with him the main asset required for the development of a firm's products or services.⁴⁸ Hart's theory is therefore incomplete, because it can only explain the type of relationship that exists between a boss and his employees in a Taylorist firm.

B. *The Knowledge-Based Theory of the Firm*

In the previous section we have examined gaps in traditional theories of the firm, concerning their ability to account for human capital-intensive production. Proponents of the knowledge-based theory of the firm point out that the literature has unreflectively relied on a dichotomy between production costs and exchange costs. In analyzing exchange costs the literature recognizes that exchange itself is not costless, but involves transaction costs from imperfect information and opportunism. But in analyzing production costs, there has been an implicit assumption that price theory tells us all we need to know about production.⁴⁹ However, it is very likely that knowledge about how to produce and that knowledge about how to link together one person's (or organization's) productive knowledge with that of another are imperfect.⁵⁰ These issues of capabilities and coordination are distinct from the hazards of contracting that traditional theories have focused on. But these costs of production have been, until recently, largely neglected.

As Demsetz states:

Economic organization, including the firm must reflect the fact that knowledge is costly to produce, maintain, and use. In all these respects there are economies to be achieved through specialization. [W]e generally identify industries, and firms in these industries, as repositories of specialized knowledge and of the specialized inputs required to put this knowledge to work. Steel firms specialize in different stocks of knowledge and equipment than do firms in investment banking or industrial chemicals, and even firms in then same industry differ somewhat in the knowledge and equipment upon which they rely.⁵¹

Both knowledge resources and production costs can be said to differ depending on the attributes of a production process, in the same way that transaction costs differ depending on

independent contractor would typically own some of these assets and would be able to decide how they should be used if the relationship terminates.”).

⁴⁸ We refer here to situations where there are no intellectual property protections that could bind the knowledge to the firm.

⁴⁹ Langlois & Foss, *supra* note __, at 4.

⁵⁰ Langlois & Foss, *supra* note __, at 4.

⁵¹ Demsetz, *The Theory of the Firm Revisited*, *supra* note __, at 171-172.

the asset and exchange attributes of investment projects.⁵² Thus, instead of holding technology constant across alternative modes of organization as a useful strategy for explicating, for example, the influence of transaction costs on the decision to integrate, or on monitoring structures and control, we suggest holding transaction costs constant as a strategy to assess the differential impact of production costs on firm organization.

With the rise of the knowledge economy, organizational structures and relations of production have been undergoing significant changes. There has been an increasing demand for education and skill since the mid-twentieth century.⁵³ Scholars have been discussing the shift of economic paradigms from scale-based competition to knowledge-based competition.⁵⁴

The financial structure of “knowledge companies” can differ dramatically from the financial structure of more traditional industrial companies. Microsoft and IBM provide an interesting example. IBM, “the talismanic corporation of the fifties, sixties, and seventies,”⁵⁵ has sales more than fifteen times greater than those of Microsoft, and its fixed assets at the beginning of 1996 (net of depreciation) were \$16.6 billion worth of property, plants, and equipment, with a market capitalization of about \$70.7 billion. In contrast, Microsoft’s net fixed assets totaled just \$930 million. But Microsoft’s total capitalization was \$85.5 billion, despite its much lower sales. As Thomas Stewart points out, “an investor who buys Microsoft is clearly not buying

⁵² See, e.g., Williamson, *The Logic of Economic Organization*, in *THE NATURE OF THE FIRM*, *supra* note __, at 90, 97 (1993); Demsetz, *The Theory of the Firm Revisited*, *supra* note __, at 174. (“Two firms facing the same labor transaction costs may choose different employment arrangements because the benefits they derive from these arrangements differ. **Particularly important in determining these benefits are knowledge-based considerations.** Continuing association of the same persons makes it easier for firm-specific and person-specific information to be accumulated (see the large literature on specificity of human capital). Knowledge about the objectives and organization of the firm is learned “cheaply” through continuing association, and so is knowledge about the capabilities and limitations of the persons involved in this association. Continuing association, however, implies commitment, and commitment has the disadvantage of inflexibility. The benefits to be derived from continuing association must be set against the cost of inflexibility in determining the best manner in which to acquire the talents and services of many persons.”) (Emphasis added).

⁵³ Kelvin M. Murphy & Finis Welch, *Occupational Change and Demand for Skill, 1940-1990*, 83 *THE AMER. ECON. REV.* 122, (1993) (arguing there was a huge increase in the demand for skill and education between 1940 and 1990). See also Chnhui Juhn, Kelvin M. Murphy & Brooks Pierce, *Wage Inequality and the Rise in Returns to Skill*, 101 *J. POL. ECON.* 410 (1993) (finding a consistent increase in wage inequality favoring the most skilled workers).

⁵⁴ Alfred D. Chandler, Jr., & Takashi Hikino, *The large industrial enterprise and the dynamics of modern economic growth*, in ALFRED D. CHANDLER, JR., FRANCO AMATORI & TAKASHI HIKINO, *BIG BUSINESS AND THE WEALTH OF NATIONS* 33 (1977). We don’t provide an exhaustive bibliography of scholarly work that has addressed the special features of the knowledge economy, but some of the important references include: FRITZ MACHLUP, *KNOWLEDGE, ITS CREATION, DISTRIBUTION, AND ECONOMIC SIGNIFICANCE* __ (1980); THOMAS STEWART, *INTELLECTUAL CAPITAL* __ (____); Joseph Stiglitz, *Public Policy for a Knowledge Economy*, World Bank, January 1999 at 1 (“the movement to a knowledge economy necessitates a rethinking of economic fundamentals.”); PETER F. DRUCKER, *POST-CAPITALIST SOCIETY* 39 (____) (“far too few people realize that the application of knowledge to work created developed economies by setting off the productivity explosion of the last hundred years. Technologists give the credit to machines, economists to capital investment. Yet both were as plentiful in the first hundred years of the capitalist age, before 1880, as they have been since. With respect to technology or to capital, the second hundred years differed very little from the first one hundred. But there was absolutely no increase in worker productivity during the first hundred years – and consequently very little increase in worker’s real incomes or any decrease in their working hours. What made the second hundred years so critically different can only be explained as the result of *applying knowledge to work.*”); *THE KNOWLEDGE ECONOMY* (Dale Neef ed., 1998).

⁵⁵ STEWART, *supra* note __, at __.

assets in any traditional sense. For that matter, he is not purchasing much in the way of assets if he buys IBM or Merck or General Electric. A dollar invested in a corporation buys something different from the same dollar invested in the same corporation a few years ago.”⁵⁶ In other words, in many industries ownership of physical assets has become less and less important while the significance of human resources has increased tremendously. This predominance of “intangible assets” in a firm’s market value calls for a revision on traditional theories of the firm.⁵⁷

Production in a competitive economy requires different use of knowledge resources. Knowledge resources are both purchased on the market and produced by the firm. The particular nature of knowledge resources presents unique characteristics that provide powerful reasons for differentially structured firm production. The way a firm develops the knowledge it will use in its production process and the extent that the firm can bind this knowledge to its structure will influence its organizational structure.

The theory we advance distinguishes between three basic knowledge inputs. Based on different forms of knowledge applied in the production process, we can offer a more complete explanation and fulfill the gaps left by the traditional theories described above. As we will explain in the next part, knowledge can be embedded in 1) physical assets such as machines, 2) in the organization itself, and 3) in individuals. When knowledge is embedded in physical assets, our explanation has many similarities with Coase’s and Hart’s account of the Taylorist firm described. Where physical assets are important for firm production, the control of physical assets can lead to control of human assets, at least to some extent, because the knowledge necessary to the production process is embedded in the physical assets. Therefore, both Coase’s fiat notion and Hart’s physical asset control explain a part of the story. However, when knowledge is embedded in individuals, as it happens in law firms and high tech firms, a boss cannot “control” in the traditional terms an employee even if he is the owner of the physical assets, for these assets will not be the determinant assets for firm production. The type of knowledge important to the production process explain important features of law firms organizational structure and why high tech employees have much more discretion over the production process when compared to their mass production employees counterparts. In these knowledge intensive settings, both Coase’s and Hart’s theory do not make much sense. So, we argue that the particular type of knowledge applied in the productive process (being it Kp, Ko, or Ki) will shape firm governance and organization, as we further develop in the next section.

⁵⁶ STEWART, *supra* note __, at 33.

⁵⁷ Human capital is now widely regarded as a significant factor in developing and nourishing a firm’s productive knowledge. In the organizational management literature, an increasing emphasis is placed on knowledge production. Books on “the learning organization,” “intellectual capital,” “human capital” and “knowledge management” abound. Firms are considered repositories of productive capabilities. Langlois and Foss’ interpret the capabilities perspective “as reaching for a distinct theory of economic organization, one that is based on a conceptualization of the firm as a repository of productive knowledge with certain non-standard characteristics,In this story, incentive issues are suppressed in favor of a focus on problems of coordinating knowledge and expectations.” Richard Langlois & Nicolai Foss, *Capabilities and Governance; the Rebirth of Production in Theory of Economic Organization* ____, available at www.isnie.org/ISNIE98/Langlois-Foss.doc.

III. A KNOWLEDGE TAXONOMY

A. *The Location of Productive Knowledge (K_p, K_o, K_i)*

Firms depend on knowledge resources.⁵⁸ Knowledge formation within the firm is crucial to production in competitive markets. Firms that compete in mass production, however, have different knowledge requirements than firms that compete in high-technology fields.⁵⁹ In order to analyze how knowledge requirements affect firm structure, we distinguish between different forms that knowledge resources take. We use a typology that distinguishes three types of knowledge structures.

We use the term K_p to designate knowledge embedded in physical assets, such as machines or products. Taylorist production provides perhaps the best example of this type of knowledge structure. In assembly-line production, the knowledge required in the production process is embedded in machines. Assembly-line workers are largely “de-skilled.” The employee is easily replaceable in this sort of production. The machine is the principal asset that makes production feasible and embodies the knowledge required in the production process. Products also embody knowledge, allowing consumers to extract knowledge benefits without themselves having to master the knowledge. For example, most anyone can operate a computer through software that performs highly complex and/or labor-intensive procedures without knowing all the stages necessary to produce either the tool or the specific output the tool supplies.⁶⁰ In other words, products and machines embody useful knowledge that performs key functions in any production process. Such products or machines are vehicles of “knowledge-substitution” in that they permit the application of knowledge embedded in the machine (including the knowledge necessary to build the machine), by the mere use of the

⁵⁸ We distinguish between information and knowledge. Knowledge that is transferable readily and almost without cost is information. Knowledge is the processing and understanding and processing information to some means. Information can be processed into some input. This is what knowledge does. The mere knowledge of facts is likely to be information. The data we currently find in our days is mostly information. But this information can be processed and become knowledge of an individual.

⁵⁹ J. Rogers Hollingsworth, *Continuities and Changes in Social systems of Production: The Cases of Japan, Germany, and the United States* in CONTEMPORARY CAPITALISM: THE EMBEDDEDNESS OF INSTITUTIONS 265, 268 (1998) (arguing that “firms that successfully employed a mass production strategy had to engage in a particular form of industrial relations, use specific types of machinery, and relate in particular ways to other firms in the manufacturing process”); Harold Demsetz, Comments on *Michael C. Jensen & William H. Meckling, Specific and General Knowledge, and Organization Structure*, in CONTRACT ECONOMICS, *supra* note __, at 276, (advancing that different types of firms rely on different types of knowledge “because their activities are so dissimilar, biotechnology firms, steel firms, and retail establishments, by design, inventory different stocks of knowledge. Generally, these stocks are “housed” in the people employed. These firms locate control within their organizations in ways that are appropriate to these different distributions of knowledge.”) *See also*, CHANDLER, SCALE AND SCOPE 45 (____) (arguing that the rise of the multidivisional modern industrial enterprise was limited to “those industries where technologies of production had the potential for extensive economies of scale and scope and where product-specific marketing organizations provided further competitive advantages).

⁶⁰ *See* Demsetz, *The Theory of the Firm Revisited*, *supra* note __, at 173 (“Because it is uneconomical to educate persons in one industry in the detailed used in another, recourse is had to developing or **encapsulating this knowledge into products or services** that can be transferred between firms cheaply because the instructions needed to use them do not require in-depth knowledge about how they are produced...The economical use of industrial chemicals by steel firms does not generally require knowledge of how these chemicals are produced; similarly, the use of steel by industrial chemical firms does not require transfer of knowledge of how the steel is produced. A production process reaches the stage of yielding a saleable product when downstream users can work with, or can consume, the “product” without themselves being knowledgeable about its production.”).

machine. An employee performing routine work typically relies heavily on knowledge embedded in machines and other products in performing her work. In many instances, her technical expertise may be crude and limited to the ability to operate the machine. We call this knowledge embedded in machines and other products K_p .

We term K_O knowledge embedded in the organizational structure, in the group of individuals that constitute the firm.⁶¹ It comprises the habits, practices and routines of a firm's organizational structure and organizational culture.⁶² Generally this asset is transferable only by selling the firm or a part of it.⁶³ The knowledge, in this case, is embedded in a "production team," that can operate and be maintained in the absence of the owner or any one specific member.⁶⁴ Individual employees are replaceable because knowledge resources are dispersed across many different co-workers and individuals. In contrast, K_O is collective knowledge created through, and residing in, patterns of interaction among individuals within the organization.⁶⁵

We term K_I knowledge embedded in the individual. The skills of a craftsperson, an artist, or a professional athlete are paradigmatic examples of such knowledge.⁶⁶ Knowledge of this sort cannot be transferred costlessly from one person to another.⁶⁷ And often the cost of

⁶¹ Nelson and Winter identified this knowledge location in their evolutionary model of economic institutions. RICHARD NELSON & SIDNEY WINTER, *AN EVOLUTIONARY THEORY OF ECONOMIC CHANGE* (1982).

⁶² Sherwin Rosen, similarly, refers to such knowledge as knowledge vested "in the firm." Sherwin Rosen, *Learning by Experience as Joint Production*, 86 *Quarterly J. Econ.* 366, 367 (1972). See also, Ranft & Lord, *supra* note __, at 298 (discussing the acquisition of knowledge sets that are "embedded in relationships among individuals, or in a firm's more general social and organizational fabric, rather than in any particular person.").

⁶³ There is, of course, an overlap between knowledge embedded in the individual employee and knowledge embedded in the organizational and organizational structure. See Ranft & Lord, *supra* note __, at 298 ("Critical organizational competencies are often embedded in relationships among individuals, or in a firm's more general social an organizational fabric, rather than in any particular person. A significant portion of a firm's knowledge may be located in the formal and informal networks of relationships within the organization and even across organizational boundaries. In other words, a firm's valuable knowledge-based resources may reside not only in particular individuals, but also in socially complex relationships among different individuals and organizational subunits. Socially complex knowledge 'resides primarily in specialized relationships among individuals and groups and in the particular norms, attitudes, information flows, and ways of making decisions that shape their dealings with each other'. In the case of socially complex knowledge, no single person has the full set of skills and capabilities required to create a commercially viable product or service. This social complexity makes knowledge difficult to manage because critical interrelationships can be easily disturbed, such as when key individuals or teams leave the firm. Consequently, retention of key employees is not only a critical issue for retaining individual knowledge, but also for preserving valuable types of knowledge that are socially complex.") But increasingly firms that acquire certain productive capabilities have also served as vendors of their own know-how. STEWART, *supra* note __, __.

⁶⁴ *Id.* In the corporate law literature, from a somewhat different perspective. Margareth Blair and Lynn A. Stout have contributed to the development of this idea. See, *A Team Production Theory of Corporate Law*, 85 *VIRGINIA L. REV.* 247 (1999).

⁶⁵ An actual problem of mergers and acquisitions is maintaining K_O , that it, the production team responsible for knowledge development in the organization *ex post*. See Ranft & Lord, *supra* note __ at __. We assume for reasons of simplification that collective action costs are high and employees cannot organize themselves to leave the firm in a group, which will conserve K_O in the firm even if a certain amount of turnover exists.

⁶⁶ Individuals accumulate such knowledge "of the particular circumstances of time and place" through personal experience in the Hayekian sense.

⁶⁷ Sherwin Rosen, *Learning by Experience as Joint Production*, 86 *Quarterly J. Econ.* 366, 367 (1972). Rosen, for example, refers to *knowledge completely vested in the owners* (or managers) of the firm. Knowledge has to do in

knowledge transfer between persons is very high because the relevant knowledge is based on experience and is tacit.⁶⁸ Where knowledge is tacit, relocating individuals to the site where such learning takes place may be necessary to achieve knowledge transfer. K_I is defined as specialized knowledge. Its loss has a measurable effect on firm structure.⁶⁹ Knowledge that has been formalized, standardized and is thus easily transferable generally does not qualify as K_I . But the capacity of an individual to assimilate such specialized knowledge due to formal or other education is considered K_I .

Note that the bright line categories we have created here are fluid and can blur in reality. Knowledge of the K_O and K_I types is most likely to overlap. This occurs, for example, where the knowledge possessed by one individual is also possessed by other individuals that comprise the organization. In this situation, K_I will be similar to or overlap with K_O to a considerable extent. One important difference between K_I and K_O is the length of the horizon/time required for rational decision making. K_I implies a finite horizon, as the capital will vanish when the owner of the knowledge departs (retires, or passes away). K_O implies an infinite horizon, since the knowledge can be preserved within the structure of the firm and transferred with the firm.⁷⁰ Note also that these variables are interdependent to some extent. K_O may depend on K_P , for certain routines arise in order to manage certain machines and products. K_O is not readily transferable from firm to firm. Routines that work in some environments may not work in other environments. Furthermore, K_I may vary depending on different experiences that individual have with the same products or machines. This will be further developed in the next section.

this case with pure “entrepreneurship”. The asset is not salable, though the owners may rent the services of their knowledge to the firm and elsewhere. This is what we mean by K_I , the knowledge is embedded in the individual, whether she be the owner of the firm, a manager or an employee.

⁶⁸ See POLIANYI, *supra* note __.

⁶⁹ As Ron Gilson points out in his discussion of interfirm knowledge spillovers in the high tech industry, “[t]acit information associated with an employer’s technology is embedded in the human capital of its employees. When an employee changes jobs, that tacit information is available to the new employer.” Gilson, *supra* note __, at 585. See also, *id.* at 595 (“This [tacit] element of the employer’s intellectual property is embedded in the employee’s human capital, and can be most effectively transferred through proximity and, in particular, by an employee changing jobs.”).

⁷⁰ Rosen, *supra* note __, at 368.

Below we present a table that systematizes these concepts.

TABLE __: KNOWLEDGE TYPES

| KNOWLEDGE TYPE | | | |
|----------------------------|---|---|--|
| | K_p | K_o | K_i |
| General Description | Knowledge Embedded In Machines And Products. | Knowledge Embedded In A Firm's Organizational Structure (Not Codified) | Specialized, Technical, Particular Knowledge And Skills Embedded In Individuals |
| Examples | <ul style="list-style-type: none"> • Codified Production Technology • Machinery • Products • Legal Opinions | <ul style="list-style-type: none"> • Structuring Of Decision-Making Processes. • Coordination And Division Of Work • Knowledge Management Practices • Monitoring Structures • Quality Control Procedures | <ul style="list-style-type: none"> • Scientific Training • Professional Training • Craft And Skill • Acquaintance With Professional Networks • Personal Experience • Knowledge Concerning A Firm's Customers, Clients, Or Markets. |

Source: authors' elaboration

B. Tacit versus Standardized Knowledge

In the development of our taxonomy, and throughout this paper, we make reference to a crucial dimension of knowledge or competence assets: the degree to which knowledge can be articulated, codified or standardized on the one hand, and the degree to which it is *tacit* or uncodifiable, unstandardizable and unarticulable on the other hand. The distinction has been put in different ways. Some have spoken of the difference between *knowing-that* and *knowing how*. A prime example of tacit knowledge is an individual skill, such as a local pilots ability to safely bring a ship into the harbor and to its berth. "What the pilot knows are local tides and currents along the coast and estuaries, the unique features of local wind and wave patterns, shifting sandbars, unmarked reefs, seasonal changes in microcurrents, local traffic conditions, the daily vagaries of wind patterns off headlands and along straits, how to pilot in these waters at night, not to mention how to bring many different ships safely to berth under variable conditions."⁷¹ This *know-how* supercedes the general rules of navigation, cannot be codified or standardized, but depends upon sense and long experience working within a particular local context.

The point for our purposes is that individual knowledge, or K_i , is often highly tacit in the sense that "the aim of a skillful performance is achieved by the observance of a set of

⁷¹ JAMES SCOTT, SEEING LIKE A STATE __ (1998).

rules which are not known as such to the person following them.”⁷² While all knowledge (including perhaps the most formal knowledge) originated with tacit knowledge (witness Pythagoras’ contemplation of geometric figures drawn in the sand) some types of knowledge remain hard, or even impossible to articulate or codify. As Polanyi has said: “*we can know more than we can tell.*”⁷³ Such inherently tacit knowledge is hard to transfer. A person with tacit knowledge will not be able to provide a useful explanation of the rules that he is applying in the pursuit of his skillful activity.⁷⁴

Once knowledge is codified, standardized and rendered explicit, however, it is no longer embedded in the individual, but “can be communicated from its possessor to another person in symbolic form, and the recipient of the communication becomes as much ‘in the know’ as the originator.”⁷⁵ Such knowledge may take the form of manuals, blueprints, books, etc, that permit the ready dissemination of knowledge. Knowledge embedded in products, Kp, necessarily has to have been standardized and rendered explicit at some point before it was creatively deployed in a product.

Because codified and standardized knowledge is readily communicable, it is also much more susceptible to the public goods problems and the related opportunism that we discuss in Part V of this paper, which, without certain external protections, may render market transactions of this sort of knowledge more costly.

While tacit knowledge is hard to transfer and is thus less susceptible to opportunism, this does not necessarily render market transactions of tacit knowledge less complicated or costly. The very difficulty of describing tacit knowledge raises special difficulties. Tacit knowledge may not be readily transferred through an exchange, but may require context-specific learning. The non-communicable character of tacit knowledge⁷⁶ suggests it is best obtained by integrating individuals, who possess it, into a firm’s production process as employees, rather than seeking to acquire such knowledge inputs through market transactions. The production of knowledge resources may require extensive communication and

⁷² M. POLYANI, PERSONAL KNOWLEDGE 49 (1962) cited by Sidney Winder, *Knowledge and Competence as Strategic Assets*, in _____, 170-171.

⁷³ MICHAEL POLANYI, THE TACIT DIMENSION 4 (1966).

⁷⁴ OLIVER E. WILLIAMSON, MARKETS AND HIERARCHIES: ANALYSIS AND ANTITRUST IMPLICATIONS 21-22 (1975) (“Language limits refer to the inability of individuals to articulate their knowledge or feelings by use of words, numbers, or graphics in ways which permit them to be understood by others. Despite their best efforts, parties may find that language fails them (possibly because they do not possess the requisite vocabulary or the necessary vocabulary has not been devised), and they resort to other means of communication instead. Demonstrations, learning by doing, and the like may be the only means of achieving understanding when such language difficulties develop.”).

⁷⁵ Winter, *supra* note ____, at 170-171.

⁷⁶ See Richard R. Nelson, *Production Sets, Technological Knowledge, and R & D: Fragile and Overworked Constructs for Analysis of Productivity Growth?*, 70 *The American Economic Review* 62, 65 (1980) (“What if whatever it is that permits a firm to operate a technique in a particular way and with particular outcomes is only in small part describable in a blueprint, or teachable by example, or purchasable in the form of a machine? Then the fact that firm A can operate a particular technique with a particular outcome does not mean that firm B or firm C can, even if firm A helps out their learning in every way it can. The presence of particular and rather special personal talents, or important organizational features, signals that codified aspects of technique may only be a part of the story.”)

exchange of ideas and personal experience,⁷⁷ and therefore we suggest that tacit knowledge can be better shared in the structure of a firm, as opposed to the market. We develop these ideas further below.

C. *The Dynamics of Productive Knowledge*

The typology of knowledge structures given so far presents a static picture. Knowledge structures, however, change over time and we must, accordingly, incorporate such dynamics into our analysis.

Such transformations will depend, among other things, on the standardization process that knowledge deployed by organizations and individuals typically undergoes.⁷⁸ Standardization is the process through which tacit knowledge is made explicit, formalized, and then codified or instantiated in physical processes and products.⁷⁹ For example, standardization takes place, where knowledge previously embedded in an individual (Ki) is formalized, reconfigured, and embedded in a newly created machine or product (Kp). In the mature stage of the industry life cycle, “most of the technical aspects of the product have become standardized, and the nature of demand is well known.”⁸⁰ The focus of the industry becomes standardized production.⁸¹ In such circumstances, tacit knowledge becomes relatively less important to the production process and in the organization of the firm.

The transmission of tacit knowledge both within and between firms benefits from proximity,⁸² while explicit or codified knowledge renders the cost of transmitting information

⁷⁷ Kenneth J. Arrow, Classificatory notes on the production and transmission of technological knowledge. AMERICAN ECONOMIC REVIEW, vol 59, issue 2, Papers and Proceedings of the Eighty-first Annual Meeting of the American Economic Association (May 1969), 29-35. See C.K. Prahalad & Gary Hamel, *supra* note __, attributing significant importance to communication in their concept of “core competence” (“Core competencies are the collective learning in the organization, especially how to coordinate diverse production skills and integrate multiple streams of technologies...Core competence is communication, involvement, and a deep commitment to working across organizational boundaries. It involves many levels of people and all functions... The skills that together constitute core competence must coalesce around individuals whose efforts are not so narrowly focused that they cannot recognize the opportunities for blending their functional expertise with those of others in new and interesting ways”).

⁷⁸ See, e.g., Robin Cowan & Dominique Foray, *The Economics of Codification and the Diffusion of Knowledge*, 6 INDUS. & CORP. CHANGE 595, 604-05 (1997) (discussing the process of codification of tacit knowledge). But see MARYANN P. FELDMAN, THE GEOGRAPHY OF INNOVATION 53 (1994) (“Some aspects of knowledge have a tacit nature and cannot be completely codified and transferred through blueprints and instructions.”).

⁷⁹ For one attempt to theorize knowledge creation dynamics in firms, see Ikujiro Nonaka, et al., *Managing and Measuring Knowledge in Organizations: Three Tales of Knowledge Creating Companies*, in KNOWING IN FIRMS (Georg von Krogh, et al, eds. 1998) 146, and Ikujiro Nonaka & Hirotaka Takeuchi, *A Theory of the Firm’s Knowledge-Creation Dynamics*, in CHANDLER, ET AL., EDS., THE DYNAMIC FIRM 214 (____). Nonaka et al. focus on the effects of organizational structure on knowledge creation and try to understand the constraints (and opportunities) that the dynamics of knowledge creation represent for structuring organizations. Their focus is thus somewhat different from ours. They also do not isolate standardization as a distinct process, preferring instead to talk about “externalization” (from tacit to explicit) and “combination” (from explicit to explicit), and, more generally, a “knowledge spiral.” *Id.*, at 220-224.

⁸⁰ David B. Audretsch & Maryann P. Feldman, *Innovative Clusters and the Industry Life Cycle*, 11 REV. INDUS. ORG. 253, 259 (1996).

⁸¹ Gilson, *supra* note __, at 585.

⁸² See Nelson & Winter, *supra* note __, at 76-82, 115-116 (describing tacit nature of skills).

over geographic space trivial.⁸³ One result of codification and standardization of knowledge in products (Kp), for example, is that constraints on the production and distribution of products across large geographical areas (and internationally) are thus significantly reduced, enabling reproduction of this knowledge on a much greater scale.

The reverse transformation may also occur. The creation of a new machine or product, such as a software, may educate the worker/user, slowly weaning her from reliance on help screens, aids and by-the-book routines to a more efficient and sophisticated deployment of the tool's core functions by means of user-defined short-cuts and creative applications. Employees may develop routines to operate the machine in a way that avoids depreciation and affords it a longer life cycle. Kp can thus give rise to Ki, and probably to Ko, as this knowledge is spread from a single employee to others within the firm through the refinement of the firm's organizational routines.

In addition, engagement with physical assets will yield entirely new knowledge in the form of Ki that was not initially contemplated by the creator of the machine or embedded in the product. Such a transformation occurs where, by observing how the machine operates, an employee conceives of new ideas for the creation of a different type of machine or process.⁸⁴ In other words, the employee develops ideas for new technologies, which, at this stage, will still be tacit and thus knowledge embedded in this particular employee. Hence Kp gives rise to Ki.

In the following, we discuss the possible types of knowledge transformation.

1. *Ki Can Be Transformed Into Ko*

A routine or a process developed by an individual or small team can spread to the entire organization and beyond, if others find this knowledge useful. An example in this case is the Japanese system of "just in time". Because of its efficiency, this process was soon transmitted to other organizations and became embedded in the structure of organizations.⁸⁵

2. *Ko Can Give Rise To Ki*

A new employee will come into contact with organizational knowledge which is dispersed in the firm structure. She will have formal and informal orientation sessions, learn organizational routines and receive specialized training in the use of communication technology and the division of work. As she begins to share work experiences in the firm, this employee will assimilate a lot of organizational knowledge which will become Ki, knowledge embedded in

⁸³ Robin Cowan & Dominique Foray, *The Economics of Codification and the Diffusion of Knowledge*, 6 *INDUS. & CORP. CHANGE* 595, 604-05 (1997).

⁸⁴ Alfred D. Chandler, Jr., & Takashi Hikino, *The large industrial enterprise and the dynamics of modern economic growth*, in ALFRED D. CHANDLER, JR., FRANCO AMATORI & TAKASHI HIKINO, *BIG BUSINESS AND THE WEALTH OF NATIONS* 33 (1977) ("Just as the capabilities that were learned by exploiting the physical economies of scale led to capital augmentation through improvement of processes and products, so the organizational skills developed in pursuing joint production at the manufacturing establishment level led not only to improvement in existing processes and products but also to the systematic commercialization of *new* processes and products. This is particularly true in industries in which joint production rested on the systematic exploitation of chemistry, biology or physics.")

⁸⁵ Going further, the technique of just in time is now codified in management books, being transmuted into a "product" with the characterizes of Kp. However, the specific way in which a firm applies this technique may change a little bit from firm to firm, which still characterizes a type of Ko.

the individual. She may even leave the organization and start up a business based on similar organizational routines and processes and thus take this knowledge with her.

3. *Ki Can Be Transformed Into Kp*

As knowledge becomes formalized and standardized it becomes embedded in physical objects. An idea for a tool is thus developed into a machine. In this case, the knowledge that was embedded in the individual becomes embedded in the machine. This process of embedding knowledge in the machine has important consequences: the other actors that subsequently operate the machine do not need to *know how* the machine was *conceived and developed*. They will merely need a specialized technical knowledge of *how to operate* it. The result is that less educated employees are able to operate the machine in order to produce the final product envisaged by perhaps yet a different inventor, without having to acquire the knowledge sets of the machine's inventor or that of the product developer. This knowledge embedding process, therefore, effects a knowledge-substitution; it is therefore a highly economizing process that permits the use of a highly complex knowledge sets by others who do not possess them.

4. *Kp Can Give Rise To Ki*

Use of a product or a machine in the production process will give rise to large and small improvements on the equipment itself. New and different applications for the technology will be devised. Problems posed by the new product spur the development of knowledge to improve it. Thus, Kp gives rise to Ki.

5. *Kp Can Give Rise To Ko*

The classical example here are the routines that were developed by Ford in order to operate an efficient assembly line. A highly specialized organizational knowledge specific to the production of cars was developed on how to operate many machines and tools efficiently. This organizational knowledge is shaped by the characteristics of each machine and other physical assets required to operate the assembly line. In this example, Kp thus gives rise to routines and other organizational knowledge Ko.

6. *Ko Can Be Transformed Into Kp*

Imagine that the team operating the assembly line realizes that they can save time by developing a specific tool to aid in their work. The tool will be a form of Kp that originated from knowledge of the organizational routines of this assembly line, that is, from Ko. Moreover, the development of the new tool presupposes knowledge of these particular organizational routines.

7. *Summary*

The processes described give us a rough idea of how different types of knowledge can transform over time. They provide a stylized picture of how firms can change together with the nature of the knowledge they develop and deploy over time.⁸⁶ A typical mass production

⁸⁶ For discussions of the coevolution of technology and institutions, see also, RICHARD NELSON, *THE SOURCES OF ECONOMIC GROWTH* 100-119 (1996).

firm (mainly based on Kp) might engage in more knowledge intensive activities as the operation of its machinery spurs research and development in order to maintain or improve its production process.⁸⁷ The level of Ki in the firm will thus rise. A high-tech firm (mainly based on Ki) might develop a product and then engage in its mass production (mainly based on Kp) thus eventually decreasing its reliance on Ki.⁸⁸ Our thesis contends that in both situations the change in the degree to which a firm relies on a certain type of knowledge (increased Ki in the first example and increased Kp in the second example) will give rise to a change in the *organizational structure* of the firm.

IV. LAW AND KNOWLEDGE MANAGEMENT

The variables discussed so far reflect where the knowledge is embodied. We now turn to the problem of how firms appropriate knowledge.

The easiest way to bind knowledge to the firm is structurally, by restricting access to valuable knowledge to all but a handful of insiders who run the firm. This is one of the benefits of family owned businesses.⁸⁹ In its early years (just after 1800), the DuPont company, for example, guarded most of the economically valuable knowledge about the chemistry and manufacture of gun power by restricting it to DuPont family members and their close associates.⁹⁰ “The DuPonts managed the company and supervised its research throughout the nineteenth century. Thus, the company’s approach to employee intellectual property depended on close family control supported by informal sanctions and self-help.”⁹¹

Geographically isolating the firm provides another structural means to restricting the unwanted dissemination of knowledge. Thus, DuPont’s Brandywine mills, for example, were located in a remote and self-contained enclave along the banks of the river, which along with power and water, supplied security from unwanted visitors.⁹²

Companies still jealously guard their business methods and other secrets by restricting access to information through a variety of structural means. But the drawbacks of the above-described structural approaches are evident. Restricting access to business knowledge to but a few members in the firm seriously restricts the potential improvements and innovations and therefore the competitiveness and growth potential of the organization. Relevant knowledge is centralized at the highest levels of the organizational hierarchy, leaving little room for decentralized decision-making. Thus, learning and joint knowledge production among employees at lower levels of the organizational hierarchy is diminished and the benefits of knowledge sharing are decreased. Similarly, isolating the company geographically is often undesirable. Economists have long recognized the importance of regional clusters for economic and technological development.⁹³ Regional agglomeration of firms can result in significant

⁸⁷ See, e.g., CHANDLER, *supra* note ___, at ___.

⁸⁸ See, e.g., our discussion of IBM, *infra, supra* notes ___ & accompanying text.

⁸⁹ Catherine L. Fisk, *Working Knowledge: Trading Secrets, Restrictive Covenants in Employment, and the Rise of Corporate Intellectual Property, 1800-1920*, 52 HASTINGS L. J. 441, 442-443 (2001), at 469.

⁹⁰ *Id.*, at 468-69

⁹¹ Fisk, *supra* note 89, at 489.

⁹² *Id.*, at 470.

⁹³ See Michael J. Enright, *Regional Clusters and Firm Strategy in Peter Hagström & Alfred D. Chandler, Jr., Perspectives on Firm Dynamics*, in THE DYNAMIC FIRM 2 (Hagstrom & Chandler, Eds. 1998), 315, 331 (“Spillover

positive externalities, including knowledge spillover, causing input costs to decline. Thus securing a firm's knowledge from competitors by isolating its employees is likely to be a poor strategic decision.

Powerful, alternative solutions for appropriating knowledge are provided by law and contract. Legal rules and contractual arrangements regulate knowledge appropriation directly and/or indirectly and thereby affect firm structure by enabling, complicating or thwarting the efficient allocation of knowledge resources. One obvious way in which law affects corporate organization is by binding knowledge to the firm, thereby enabling the dispersion and transfer of knowledge within the firm, while preventing, or at least containing, the threat of transferring knowledge assets outside the firm to competitors.⁹⁴

Knowledge can be protected by intellectual property rules (encompassing patents, trade secrets, copyrights) but also by private contracts that are specifically designed to protect firms' knowledge assets, such as non-compete agreements, or confidentiality agreements. Protection of knowledge assets through such law or contract, however, is imperfect. As we will see, intellectual property rules do not protect all types of knowledge. In addition, the protections of knowledge rights are connected to the level of enforcement of intellectual property rights rules and contracts. We argue that the nature of the legal protection afforded will cause firms to develop specific governance structures and mechanisms to cope with the special hazards that knowledge resources pose.

1. *Law and Contract as Mechanisms of Knowledge Management*

In the following we reinterpret the existing legal framework and show that its development has affected the knowledge structure and thereby the organizational structure of firms. Several bodies of law, which are generally not considered in the corporate organization debates, have important consequences for corporate structure. For instance, the influence of intellectual property laws and covenants not compete on firm structure has been implicitly taken for granted by current corporate law literature. As we shall see, intellectual property law helps firms address the problems of unwanted knowledge transfers that arise with the increased diffusion of knowledge within the firm and also between firms. The connection between the increasing importance of human capital and the expansion of intellectual property law has become the object of increased attention.⁹⁵ But the effect of such regulation on firm organization, while it has begun to be recognized,⁹⁶ has not been considered systematically.

of innovation from firm to firm is likely to be greater in regional clusters than among dispersed firms Local suppliers, buyers, family members, friends and acquaintances can all become sources of industry and company-specific information.”); Ronald Gilson, *The Legal Infrastructure of High Technology Industrial Districts*, 74 N.Y.U. L. REV. 575 (1999), at 580-81 (arguing that “[k]nowledge as an input is subject to increasing returns as a result of geographic proximity” in certain types of Marshallian agglomeration economies).

⁹⁴ Binding knowledge is crucial, for otherwise firms would not invest in generation of new products nor in training of employees. The capacity to bind knowledge to the firm is key to competitiveness, especially in a knowledge intensive environment.

⁹⁵ See, e.g., Katherine V.W. Stone, *Knowledge at Work: Disputes of the Ownership of Human Capital in the Changing Workplace*, 34 CONN. L. REV. 721 (2002) (Arguing that disputes over human capital have increased and that courts should attend to the new “implicit contract” between knowledge workers and their employers when they enforce intellectual property rights). Stephen L. Sheinfeld & Jennifer M. Chow, *Employees' duties and Liabilities: Protecting Employer Confidences*, 582 PLI/Lit 347 (1998) (detailing the “rapidly evolving” law of intellectual property and the “veritable explosion in non-competition and trade secrets disputes in the employment area”);

2. *The Co-Evolution Of Intellectual Property Rules And Firm Governance*

Intellectual property laws do not at first appear to be connected with firm structure. Patent and copyright protections were already written into the U.S. Constitution at a time when modern firms and corporations did not exist.⁹⁷ Individuals can hold patents and copyrights just as firms can. Patent and copyright laws address the public goods problems of knowledge resources faced by all who would market such resources. These protections permit the conversion of ideas or techniques or other intangible intellectual products into marketable goods.

Patent and copyright rules, however, become more relevant to firm structure when the law or contract specifies who holds ownership rights to economically valuable knowledge gained at work – the firm or the employee. It is increasingly recognized that the tremendous economic development experienced during the late 19th and early 20th Centuries was very much fueled by technological development,⁹⁸ and that the rise of modern corporations played a crucial role in technological development.⁹⁹ *Intellectual property*, conceived in its broadest sense, accomplishes one of the most important tasks required to permit the effective use of knowledge. It binds knowledge to its proper owner (presumably owners are those who have invested in knowledge production or its purchase). Now consider the typology developed in Section III above. The different types of knowledge, Kp, Ko, Ki, raise different kinds of challenges for rules that would bind knowledge to its proper owner. Legal personality gave corporations the ability to own intellectual property. And legal doctrine increasingly evolved to favor corporate ownership of property over ownership by the employee.¹⁰⁰

William Lynch Schaller, *Jumping Ship: Legal Issues Relating to Employee Mobility in High Technology Industries*, 17 LAB. LAW. 25 (2001) (examining the legal implications of accelerated job hopping by employees in the high tech sector).

⁹⁶ Gilson, *supra* note __, at __.

⁹⁷ Such protections were seen as the hallmark of individualism. See, e.g., Lincoln's pronouncement that "In anciently inhabited countries, the dust of ages -- a real downright old-fogyism -- seems to settle upon, and smother the intellects and energies of man." But America had broken the "shackles" of the "slavery of mind" and had established "a habit of freedom of thought" that was necessary to the "discovery and production of new and useful things." The patent law nourished this habit of free thought by allowing the ingenious to profit; it added "the fuel of interest to the fire of genius." Abraham Lincoln, *Second Lecture on Discoveries and Inventions* (Feb 11, 1859), in Roy P. Basler, ed, 3 THE COLLECTED WORKS OF ABRAHAM LINCOLN 356, 363 (Rutgers 1953).

⁹⁸ See generally, RICHARD NELSON, THE SOURCES OF ECONOMIC GROWTH (1996) 100-119, *supra* note 86, at __; HAGSTROM & CHANDLER, [NEED FULL CITE].

⁹⁹ See, e.g., Chandler & Hikino, *supra* note __, at 26.

¹⁰⁰ See Fisk, *supra* note __, at __ ("A foundation of the modern law of intellectual property is that firms own some of the ideas that exist in the minds of their employees. Ownership of employee knowledge is a legal construct that is now an accepted part of our culture and economy. Today's practices and doctrines developed in the context of radical changes in the American law and workplace culture, which were brought about by the nineteenth-century industrial revolutions. The conflict between employee freedom and corporate control of intellectual property sharpened as courts realized the importance of knowledge to economic development and began to recognize workplace knowledge as an asset of the firm rather than an attribute of the employee. The invention of the trade secret doctrine in the mid-nineteenth century enabled employers to enjoin revelation of secret information by current or former employees. At the same time, courts expanded the permissible uses of post-employment covenants not to compete so as to prevent dissemination of knowledge. Together, these doctrinal developments created a new obligation – sometimes articulated as an express or implied contract, and sometimes expressed as a 'duty of trust and confidence' – not to use knowledge acquired on the job elsewhere.")

In the area of patent and copyright ownership the early nineteenth century rule was that employees usually owned the entire right to their inventions.¹⁰¹ The rule evolved into the later nineteenth century rule that employees owned their inventions but employers often had a license to use them.¹⁰² This arrangement was known as a ‘shop right’.¹⁰³ By the mid-1880s courts thus began to award employers a license to use an employee’s invention where the employee invented it on the job.¹⁰⁴ Finally, in the twentieth century, the rule became that employers own most employee inventions.¹⁰⁵

Given our thesis that knowledge regulation influences firm structure and vice-versa, it should not be surprising to learn that legal regimes governing patents and copyright evolved significantly together with the development of new organizational forms of production in the late 19th and early 20th Centuries. Significant changes in the law occurred particularly around the time that modern limited liability corporations were created by new laws, during the 1880s and 1890s.¹⁰⁶

Modern trade secrets doctrine and the enforcement of covenants-not-to-compete in the employment context only developed in the late 19th Century.¹⁰⁷ In the antebellum period patents and copyright protections were the only intellectual property protections available.¹⁰⁸ Property in ideas was thought of only to the extent that it manifested itself in a physical thing, *e.g.*, as a machine, or a secret recipe or process. Moreover, copyright and patent protections required that technologies were made explicit before they could secure protection. The concept that property could be had in the intangible ideas and even in the tacit, not-explicit knowledge embedded in another’s mind was not accepted by American courts in the antebellum period. Enticement laws existed, imposing penalties for soliciting another firm’s employees. Such laws, however, applied regardless of whether employees had any valuable knowledge and did not prevent free employees from leaving after their contract term had expired and taking knowledge acquired at work to a competitor.¹⁰⁹

There was also a long history of restrictive covenants. But prior to the Civil War, these were enforced only insofar as they concerned the protection of good will associated with the sale of a business, not as post-employment restrictions. Finally trade secrets doctrine and the

¹⁰¹ Catherine L. Fisk, *Removing The ‘Fuel Of Interest’ From The ‘Fire Of Genius’: Law And The Employee-Inventor*, 1830-1930, 65 U. CHI. L. REV. 1127, 1128 (1998).

¹⁰² *Id.*

¹⁰³ *Id.*

¹⁰⁴ *Id.* at 1151.

¹⁰⁵ *Id.* at 1128. The Supreme Court’s decision in *Standard Parts Co. v. Peck*, 264 U.S. 52 (1924), ended a period in which courts would apply a set of presumptions in favor of employee ownership of inventions in a dispute, in accordance with the “shop right” doctrine. Instead courts would now look to the intended terms of the employment contract. At the same time, employers increasingly used pre-invention assigning agreements. Fisk, *supra*, note ___, at 1179.

¹⁰⁶ MORTON HORWITZ, *TRANSFORMATION OF AMERICAN LAW* (1992).

¹⁰⁷ *See generally* Fisk, *supra* note ___, at __.

¹⁰⁸ *See generally* Fisk, *supra* note ___, at __.

¹⁰⁹ *See generally* Fisk, *supra* note ___, at 450 (citing *Boston Glass Manufactory v. Binney*, 21 Mass. (4 Pick.) 425, 428 (1827)). *See also* John Nockleby, Note, *Tortious Interference with Contractual Relations in the Nineteenth Century: The Transformation of Property, Contract, and Tort*, 93 HARV. L. REV. 1510, 1514-15 (1980).

use of contracts to control knowledge first emerged during the last two decades of the 19th Century, together with the rise of the modern corporation.¹¹⁰

These developments in intellectual property law reflect radical changes in the structure of workplace organization and workplace culture. They mark the dramatic shift from artisanal modes of production to industrial and mass production in large firms.

In the artisanal model, it was possible for individuals or families to own their own workshops. Craft knowledge was recognized as a prime resource and was transmitted from master to apprentice. While the apprentice was not prohibited by law from exercising his craft and using the knowledge so obtained at a later date, the apprenticeship indenture governed the use and guarded the secrets of the craft knowledge during the apprenticeship relation. The duty of the apprentice to guard the master's secrets during the training period was a standard term of apprenticeship agreements, corresponding to the duty of the master to instruct the apprentice. The duration of the apprenticeship period can be seen to have performed a similar function to that of a restrictive covenant, in that it permitted the master to recuperate the training invested in the apprentice before the latter could leave and begin his own workshop.¹¹¹ It thus secured the explicit knowledge conferred in virtue of a confidentiality agreement, while it secured the tacit knowledge for a time only by agreement to a limited, typically seven-year duration of the relationship.

The governance structure of the apprenticeship agreement was thus designed to preserve the knowledge (the master's Ki) within the "firm" structure of the master's shop. The knowledge differential was also the criterion that determined the hierarchy between masters and apprentices in the firm, thus reflecting an efficient allocation of knowledge resources. The apprenticeship agreement, however, did not confer the same type of static property status on craft knowledge as did the later trade secrets doctrine,¹¹² which permits, at least in principle, the indefinite exclusion of the employee or any competitor. Interestingly, the apprenticeship relation did, however, also allow the growth of the "firm" to include a broader circle of initiates.¹¹³

¹¹⁰ See, e.g., MORTON HORWITZ, *TRANSFORMATION OF AMERICAN LAW, 1870-1960* (1992) ("The first sustained effort to reconceptualize the corporation in light of the triumph of general incorporation laws began during the 1880s.").

¹¹¹ See generally Fisk, *supra* note ___, at 451.

¹¹² According to the UTSA, which has been adopted by many states, including California, a trade secret is: "Information, including a formula, pattern, compilation, program device, method, technique, or process, that: 1) Derives independent economic value, actual or potential, from not being generally known to the public or to other persons who can obtain economic value from its disclosure or use; and 2) Is the subject of efforts that are reasonable under the circumstances to maintain its secrecy. CAL. CIV. CODE § 3426.1(d). A court may enjoin "actual or threatened misappropriation" of a trade secret. CAL. CIV. CODE § 3426(a). A corporation misappropriates a trade secret when (1) it discloses or uses the trade secret of another without express or implied consent, and (2) at the time of the disclosure or use, it knew or had reason to know that its knowledge of the trade secret was derived from a person who owed a duty to the entity seeking relief to maintain the trade secret's secrecy or limit its sue. CAL. CIV. CODE § 3426.1(b)(2)(B)(iii).

¹¹³ "The secrecy of recipes and techniques that passed from generation to generation enabled a family or a firm to gain a reputation and to retain exclusive control of production. Apprenticeship indentures recognized the value of guarding secrecy while ensuring the passage of knowledge by specifying that the master was to instruct the apprentice and to reveal his "mystery" to him, and, in return, the apprentice pledged to keep these techniques secret during the term of the apprenticeship." Fisk, *supra* note ___, at ___ (citations omitted).

Industrialization changed the production process through new technology and dramatically different organization. Work performed in the work shop in several steps coordinated by the master was scaled up and mechanized. Craft knowledge previously embedded in master and apprentice now became embedded in machines and work routines.¹¹⁴

Therefore, legal mechanisms were required that could make possible the propertizing of knowledge embedded in physical assets (Kp). Such propertizing was achieved through the development of intellectual property law. Entrepreneurs were thus able to rely on the protection afforded by patents in order to bind technology and expertise to the firm.¹¹⁵ Such propertization, however, also afforded toolmakers to sell their technology on the market thus encouraging investment in such products and their ready supply.

Work on the factory floor required less skill and knowledge, substituting craft knowledge for machine specific work routines. However, certain types of knowledge could not be simply stored in a product. Mechanics and engineers with significant expertise were required to build and maintain machines used in production. Chemists and other experts in the sciences were needed to develop and oversee new production processes. And the coordination of production required increased managerial and technical knowledge and experience. Accordingly, the legal structure evolved to accommodate firms needs to bind organizational and individual knowledge.

Trade secrets law originally recognized only the existence of property rights in physical things, but not in intangible information. Until the mid-nineteenth century, there was no standard legal protection that would allocate to firms the value of an employee's knowledge.¹¹⁶ Courts were initially hostile to the enforcement of restrictive covenants, as a reflex of the tradition of the guild system.¹¹⁷ Judges were reluctant to understand intangible knowledge to be a firm's asset. But seminal cases in the development of intellectual property law began during the mid- to late 19th Century to recognize complaints by factory owners seeking to restrain

¹¹⁴ The industrialization changed the production process, permitting that the "master knowledge" (Ki) become embedded in machines (Kp). After industrialization, the work that was coordinated by the master became largely standardized, due to the application of scientific methods to the production process. With the division of work, non-skilled employees became able to operate machines that produced various units of the product which was previously hand made. An unprecedented change in knowledge organization in the firm took place. The type of knowledge necessary to be bound changed.

¹¹⁵ *See id.* at 447. "The expansion of scientific and technological research at universities and the first corporate efforts to systematize the development of new technology through research and development also made their mark on the law. These profound changes in the organization of knowledge both contributed to the new legal rules and were made possible because judges and lawyers were prepared to regard knowledge as a business asset to be bought, managed, and sold."(quotation omitted).

¹¹⁶ *See generally* Fisk, *supra* note __, at 466 (arguing that: "The court's belief that patent was the only legal protection for technology reflects a widely held view during much of the nineteenth century". Fisk discusses the case of DuPont which as early as 1904 started to require employees to assign patents to the firm. The DuPonts were one of the pioneers to realize that knowledge was a valuable asset and to engage in activities that would protect it. DuPont's attention to the value of maintaining the secrecy of its production methods is not typical of all nineteenth-century firms. Fisk argues that "The difference may be attributable to the fact that DuPont's chemistry-based industry, as compared to an industry where employee skills are mechanical, used knowledge which was most easily characterized as secret information rather than as general skill or technique. The difference may also be attributed to the DuPonts' view that they were more likely to be innovators than imitators, and thus they were generally likely to be more at risk from others learning their methods than from being unable to learn methods of others.")

¹¹⁷ *Id.* p. 455

machinists, designers, engineers and chemists from taking their knowledge to competitors or using it to set up their own factories in competition with their former employer.

For example, the first case in which a court articulated the duty of an employee to protect the trade secrets of his employer, involved a machinist. In *Norfolk v. Peabody* (Mass. 1868), plaintiff shop owner sued defendant machinist whom he allegedly had employed to assist in inventing and developing certain machinery. The machinist, Norfolk, had agreed in writing not to reveal information about the machinery used in Peabody's factory, which produced gunnery cloth from jute. Norfolk, however, had quit his employment and had joined others in building a factory. Peabody sought and obtained an injunction against Norfolk, restraining him from revealing "any knowledge of said machinery or of the models and plans of the same, from building any such machinery for any other person or persons, from communicating said secret process of manufacturing Jute cloth from Jute butts as aforesaid, and from using said process in company with any other persons or persons or by himself."¹¹⁸ Norfolk had misappropriated certain drawings, which he was also ordered to return.¹¹⁹

This development of trade secrets protections and the enforcement of restrictive covenants beginning in the 1890s accompanied and reflected the new shape of industrial organization in the modern corporation. The new legal protections and doctrines of contract were directed at engineers and other experts with access to explicit and with tacit knowledge critical to a corporation's competitiveness. Drafts of machine designs and other knowledge embedded in machines received protection in addition to patents and copyright protection. The move to implying duties of trust, confidentiality and to guard trade secrets into employment contracts "fit closely with the courts' new understanding that firms, not individuals, had now become pioneers of new technology and that firms hired employees precisely for their knowledge . . ."¹²⁰

Gradually, courts started to recognize a firm's property rights to general knowledge of its business activities.¹²¹ From 1890 to 1930, there were profound doctrinal changes expanding trade secrets and accepting restrictive covenants doctrines as a means to control the use of a broad range of workplace knowledge. The duty to protect trade secrets came to be considered an implied term in employment agreements, where previously it depended in an

¹¹⁸ Fisk, *supra* note __, at 486 (citing *Peabody v. Norfolk*, 98 Mass. 452 (1868) (internal citations omitted)).

¹¹⁹ Norfolk's new employer sought to dismiss the complaint, arguing that the confidentiality agreement was void as a restraint of trade in that it prevented Norfolk from ever using his skill and knowledge acquired at work during his life at any time or place. He further argued that the design and operation of the machinery was not secret because it could be observed by anyone who visited the factory. The court here saw the injunction as solidly within the tradition of patent law, given that theft of particular drawings was involved. Fisk, *supra* note __, at 484-85.

¹²⁰ Fisk, *supra* note __, at 500. *See, e.g.*, *Eastman Kodak, Co. v Reichenbach*, 20 N.Y.S. 110, 116 (Sup Ct. 1892) (finding that it was Kodak's "exercise of much skill and ingenuity [that built the business,] the capital of which consists largely in certain innovations and discoveries made by its officers, servants and agents").

¹²¹ "The judges' growing understanding of the alienability and the value of employee skill led courts to recognize ever more legitimate uses for restrictive covenants. Courts eventually agreed that covenants could be used to protect "trade secrets," a concept that became more capacious over time. Some courts further recognized that covenants could be used to protect an undefined category of "proprietary information" in addition to trade secrets. Similarly, courts changed their assessments of which relationships with customers were business goodwill, and hence company property, and which were simply an aspect of an employee's personality or experience. Moreover, in applying the Mitchell rule that a covenant must be reasonably limited, the scope of a permissible covenant expanded to keep pace with the expanding category of knowledge that could be deemed as corporate asset." Fisk, *supra* note __, at 458.

express agreement. The type of knowledge to be protected by this doctrine expanded from physical things to know-how embedded in the structure of the firm that had originated in improvements made by employees. Employers were assigned ownership not only of drawings or objects, but also of ideas and mental concepts expressed in them.¹²² Thus trade secrets came to be applied to bind knowledge of organizational processes (Ko) to the firm. To the extent that restrictive covenants prevented employees from using their own tacit knowledge in potentially competing activities after leaving their firms, restrictive covenants now succeeded in binding knowledge embedded in individuals (Ki) to the firm's structure as well.

As this brief history suggests, intellectual property protections were not neutral with regard to firm structure, but accompanied changes in firm structure. Modern intellectual property protections, such as patents, copyright, trade secrets protections bind knowledge to the firm. Patents and copyright protections mainly secure knowledge or technology embedded in physical things or products (Kp). Trade secrets protections also secure knowledge embedded in the organization (Ko), such as business methods, that are not amenable to patenting or copyright protection, and knowledge embedded in the individual (Ki) but acquired during the course of work. Finally, intellectual property protections based on contract, such as covenants not to compete and confidentiality agreements are solely focused on securing knowledge embedded in the individual (Ki). It is, further, worth noting that patents and copyright protections are only effective in order to secure explicit or codified knowledge, but not tacit knowledge. In contrast, restrictive covenants, especially covenants not to compete, are aimed at securing tacit knowledge. Trade secrets protections lie somewhere in between.

The expansion of technological research and the increased use of different forms of knowledge (Kp, Ko, Ki) in the production process made their mark on the law. Legal developments have shaped the internal organization and governance of firms by assuring that they could bind employee knowledge developed during the course of work.¹²³ The development of trade secrets, post-employment covenants not to compete, and non-disclosure agreements contributed to preventing the dissemination of knowledge outside the firm. All these legal developments have not only affected competition, as is frequently claimed by scholars, but also internal firm structure. If the law had not permitted such extensive appropriation of knowledge by the firms, we would expect to find different mechanisms to encourage employees to stay longer in the firm, and to bind themselves voluntarily to the firm in order to prevent knowledge losses or a different type of firm structure.

We suggest that not just ownership rights to intellectual property were implicated by this shift in the law, but ownership of the corporation itself was implicated. Without the

¹²² Fisk, *supra* note __, at 493-494, 504.

¹²³ Fisk, *supra* note __, at 445 ("In devising new rules to govern ownership of ideas and skill, judges, treatise-writers, and lawyers perceived the issue as one of economic policy and used the law to achieve certain economic goals. In enforcing contracts -- at first, only if they were express, and later by recognizing such contracts as implied -- to maintain secrecy of the employer's methods, courts created a new species of "intellectual" property at the expense of older notions of artisanal independence." As courts became aware of the value of employee knowledge to firms, they sought an expanded role for the law in facilitating economic development by allocating rights in that knowledge. Contract was rapidly becoming the dominant legal construct for analyzing the rights and obligations of all employment relations. At the same time, when the popularity of Frederick Winslow Taylor's scientific management made it seem imperative that firms rationalize and control every detail of employment and production, contract provided the most powerful legitimating discourse for the significant loss of workplace autonomy that Taylorism entailed. *Id.* at 503.

ability to tie valuable knowledge resources to the corporation, the purchase of shares would have been considerably less attractive to investors. Conversely, without the ability to pool financial resources to acquire machines, technologies and physical assets, which provided a fertile environment for further knowledge creation within the firm, technological advances could not have been accomplished as rapidly, or perhaps at all.¹²⁴

One effect of creating a legal presumption in favor of corporate ownership of employee knowledge, however, and of enjoining employees from taking that knowledge with them to create their own new firms, was to reduce the stake that knowledge workers could demand in the corporate enterprise, thus favoring the separation of (stake) ownership and control. Where the partnership model explicitly contemplated that a firm eventually would have to make an employee into a partner, if it wanted to retain his skill and expertise, the corporate model did not contemplate conferring such an ownership stake as an employee rose through the ranks. For this reason, we suggest, firm structures would not have developed in quite the same way had it not been for the development of the above described legal doctrines of intellectual property that have helped bind knowledge to the firm. The fact that such a relationship between intellectual property regimes and the separation of ownership and control obtains can be supported with the help of the following example: the relationship between stock option grants in Silicon Valley and California's prohibition against restrictive covenants. We develop this thesis in item VI.D.

Below we provide a quick summary of the intellectual property protections and the types of knowledge that they bind according to our typology.

¹²⁴ Chandler & Hikino, *supra* note __, at 26 (“An understanding of how the large industrial firm came to play the aforementioned roles requires an awareness of the complementary relationship between investment in plant and equipment (physical or tangible capital) and the human skills and knowledge developed in their operation (intangible capital). Extensive investments in large-scale plant and equipment created a fertile ground for managers and other personnel to educate themselves about both the technical skills and the organizational process of new technology.”). This was also recognized by courts in the late 19th Century.

TABLE __: MECHANISMS AND RULES THAT “PROPERTIZE” KNOWLEDGE

| Kpr (“Propertized” Knowledge) | | | |
|---|--|--|--|
| | Kp | Ko | Ki |
| Legal Rules And Private Contracts That Propertize Knowledge Structures | <ul style="list-style-type: none"> • Patents • Copyrights¹²⁵ • Trade Secrets | <ul style="list-style-type: none"> • Trade Secrets • Corporate Law Rules That Centralize Control In A Board Of Directors¹²⁶ | <ul style="list-style-type: none"> • Restrictive Covenants • Trade Secrets • Copyrights • Confidentiality Agreements |

Source: authors' elaboration

a) *Patents and Copyrights bind Kp*

Recall our distinction between codified (standardized) and tacit knowledge. Codified knowledge is knowledge that has been expressed in mathematical formulas, graphics, drawings, books, writing notes, or even by voice. When the knowledge is codified, it becomes easier to transfer it: a person who has never studied or heard of that knowledge is able to understand its basics by having access to the formal information regarding the knowledge.¹²⁷ But, when knowledge becomes codified, it also becomes a public good.¹²⁸ This means that people may engage in free-riding, extracting benefits from the knowledge without paying its value. One imperfect way to solve this problem is through intellectual property protection. Patents and copyrights provide ownership rights to codified knowledge.

According to the statute, any person who “invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent,” subject to the conditions and requirements specified in the law.

In order to obtain a patent, it is necessary to codify all the know how, knowledge and processes. The right conferred by the patent grant is “the right to exclude others from making, using, offering for sale, or selling” the invention in the United States or “importing” the invention into the United States. In exchange of making the knowledge codified, and available to the public at large, the person receives from the government exclusive rights to use the patent for a limited period of time. Patent law permits that codified knowledge embedded in new products, Kp, is bound to its proper owner. Patent rights solve the appropriability problem that come from the “impure public good” nature of knowledge, even in an imperfect way. As

¹²⁵ Copyrights can both support Kp and Ki, depending on to whom the legal systems assigns property of copyrightable assets. The American legal system assigns property to the firm while the German legal system assigns property to the employee. These different legal rules may contribute to shaping different firm governance structures.

¹²⁶ CHANDLER, *supra* note __, at 73. Rules that centralize decision making in the board of directors can support or undermine knowledge structures depending on the type of knowledge structure that exists in the organization. As we have been arguing if K_i is the predominant type of knowledge, a decentralized system of control is likely to produce more efficient results.

¹²⁷ Tacit knowledge is the knowledge which has not been codified yet. It can be embedded in the organization and in the employee.

¹²⁸ See below in section V..

explained, any person, by having access to the codified knowledge could steal the knowledge, without paying its value and use it. Patents provide a means so that the firm can bind the new knowledge to its structure, and extract economic value. These intellectual property protections enable the creation of a market for propertized knowledge.

b) Trade Secrets Bind Kp And Ko And Ki

The organization embodies knowledge of processes and routines. Specific know how is protected by trade secrets doctrine. The courts increasingly prevent employees from revealing the knowledge that they have acquired through learning and sharing knowledge while part of a firm's organization.¹²⁹

As we explained, from a historical point of view the law of trade secrets has been changing and is being interpreted more expansively by courts since the end of the nineteenth century. Where previously trade secret law was concerned with the protection of technical information, the definition now covers all commercially valuable information.¹³⁰

The Uniform Trade Secrets Act, which now has been adopted by more than 30 jurisdictions,¹³¹ has broadened the definition of a trade secret to include "any formula, pattern, device, or compilation of information which is used in one's business, and which gives one the opportunity to obtain advantage over competitors who do not know or use it."^{132, 133, 134} Agreements to refrain from using or divulging trade secrets in competition are frequently made. And courts will enforce such contracts if they are deemed "reasonable."¹³⁵

¹²⁹ "The focus shifted from the drawings of a machine to the design innovations contained in them; from the list of the customers to the knowledge of their identities, locations, needs and their goodwill; and from the precise written formula for a substance to the **general knowledge of the process and techniques for making it**. Negative knowledge (i.e., what does not work to achieve a particular purpose) came to be recognized for the first time as a trade secret so that an employee could be restrained not only from using knowledge about what works to make a product, but also from using knowledge of what does not work. Compilations of publicly available facts gained protection. As the category of trade secrets expanded, the category of general knowledge, or even specialized skill and experience, diminished." Fisk, *supra* note __, at 504 (Emphasis added. quotations omitted.)

¹³⁰ Stone, *supra* note __, 757.

¹³¹ 114 WILLISTON ON CONTRACTS § 13:14, n. 69 (4th ed. ____).

¹³² RESTATEMENT (____) OF TORTS § 757, comment b (____).

¹³³ UNIF. TRADE SECRETS ACT § 14 U.L.A. 50 (____).

¹³⁴ According to the UTSA, which is adopted by many states, including California, a trade secret is:

"Information, including a formula, pattern, compilation, program device, method, technique, or process, that: 1) Derives independent economic value, actual or potential, from not being generally known to the public or to other persons who can obtain economic value from its disclosure or use; and 2) Is the subject of efforts that are reasonable under the circumstances to maintain its secrecy. CAL. CIV. CODE § 3426.1(d). A court may enjoin "actual or threatened misappropriation" of a trade secret. CAL. CIV. CODE § 3426(a). A corporation misappropriates a trade secret when (1) it discloses or uses the trade secret of another without express or implied consent, and (2) at the time of the disclosure or use, it knew or had reason to know that its knowledge of the trade secret was derived from a person who owed a duty to the entity seeking relief to maintain the trade secret's secrecy or limit its sue. CAL. CIV. CODE § 3426.1(b)(2)(B)(iii). Courts may order affirmative acts to protect a trade secret in appropriate circumstances.

¹³⁵ Courts have used a variety of factors in determining whether information is a trade secret which a former employee is not entitled to use when he leaves the firm. These factors include: "the extent to which the information is know outside of the employer's business; the extent to which it is known by employees and others engaged in his business; the measures which have been taken by the employer to ensure the continued secrecy of the information;

In order to be enforced a trade secret must be secret. When information is deemed “general knowledge” available to outsiders then it cannot be property enforceable at law. The requirements that should be met for the enforcement of trade secrets may restrict the application of trade secrets doctrine in the task of binding knowledge to the firm. The diffusion of knowledge throughout the firm that is needed for production vitiates to some extent the ability of the employer to prevent the employee from transferring it outside the firm by the threat of law suit. So, to the extent that trade secrets bind only “specific knowledge”, other methods are necessary to bind more “general” knowledge to the firm, including structural solutions. These will be discussed next.

It is interesting to observe that the “specialized knowledge” which the courts aimed at protecting has been becoming more general knowledge in the sense that it is not codified but tacit. Trade secrets protect the tacit knowledge developed in the organization (Ko). Moreover, trade secrets doctrine aim nowadays at protecting *tacit knowledge that an employee acquired when he was sharing experiences inside de firm’s organization* (Ki). To be sure, trade secrets also protect codified knowledge, such as drawings and design of machines (Kp) which don’t enjoy the benefits of protection by means of patents.

However, trade secrets still are insufficient to protect the type of tacit knowledge that is embedded in the employee (Ki). Covenants to compete play this role. Trade secrets are legitimate to protect business interests that can be enforced where there is a restrictive covenant.¹³⁶ So, when combined with a restrictive covenant, the threat of revelation of trade secrets can very well allow an employer to restrain an employee from working for a competitor. This connection between trade secrets law and restrictive covenants does not only expand restrictive covenant law, but also the scope of the enforcement of trade secrets. Trade secrets law complements and works together with restrictive covenants to bind knowledge to a firm.¹³⁷

c) Covenants Not To Compete Bind Ki

When the firm contracts a covenant not to compete with its employee, it aims at not only protecting the knowledge that is possessed by several members in the organization, but also protecting the specific, tacit knowledge that each employee will develop while participating in the firm’s organization, and which the firm is not yet aware of its content (Ki).¹³⁸

the value of the information to him and to his competition; the amount of money and effort expended in developing the information; the ease or difficulty with which the information could be properly applied or duplicated by others.” 6 WILLISTON ON CONTRACTS §13:14 ([4] citing UNIFORM TRADE SECRETS ACT 14).

¹³⁶ A potentially significant change in that general direction has been the acceptance of the “doctrine of inevitable disclosure” by the 7th Circuit in *Pepsico, Inc. v. Redmond*. The doctrine has prevented employees from taking their valuable knowledge to a competitor, even where they had not signed restrictive covenants, 54 F.3d 1262 (7th Cir. 1995). The case has received much attention and criticism, and the doctrine has been rejected by New York and California courts, but it remains good law in many jurisdictions. See, e.g. *Bayer Corporation v. Roche Molecular Systems*, 72 F.Supp. 2d 1111, 1112 (N.D. Cal. 1999) (“The theory of ‘inevitable disclosure’ is not the law in California and, at trial, plaintiff will have to demonstrate actual use or disclosure, or actual threat thereof”), is still valid in other states.

¹³⁷ Generally, in trade secret’s law and in restrictive covenants there’s been stronger enforcement in favor of employers.

¹³⁸ Much of the increasing critiques to covenants not to compete is that they are trying to transform tacit knowledge embedded in the employee in codified knowledge. For a critique of current policy regarding covenants not to compete see Stone, *supra* note __, at 271.

In knowledge intensive environments a firm's competitive edge significantly depends upon highly knowledgeable and skilled employees.¹³⁹ Firms compete fiercely to attract, enhance and retain "talent."¹⁴⁰ To achieve this purpose, firms thus provide extensive employee training, upskilling and networking opportunities, investing heavily in human capital. In this regard, the R&D policy and the firm organization will pretty much depend on the ability that these firms have to bind their employees (or restrain the employees from using this knowledge outside the firm), and to bind the knowledge produced by them inside the firm's structure. Hence, the importance of laws that regulate ownership of employee inventions and the compensation to be paid to these inventors.

Restrictive covenants now appear in almost every employment contract.¹⁴¹ Where previously non-compete clauses and other post-employment restraints were reserved for high-level management, they are now written into the contracts of at will employees and litigated much more frequently.¹⁴² While cases have proliferated, "courts have become increasingly receptive to employer efforts to limit employee use of human capital."¹⁴³

Restrictive covenants fill important gaps in trade secrets law. They provide protection where the information an employer seeks to protect is non-confidential information relating, for example, to actual customers or prospective customers with whom the employee had sustained contacts. Trade secrets law can, for example, be applied to protect customer lists that have been kept confidential, but not to customer information which has not been kept confidential. The most difficult problem with trade secrets law is the definition of what constitutes a trade secret, and its identification. Restrictive covenants obviate this issue.¹⁴⁴ However, with the relaxation of what type of knowledge can constitute a trade secret, there is now a greater overlap.

¹³⁹ "Information and knowledge are the thermonuclear competitive weapons of our time." STEWART, *supra* note __ at 3-4.

¹⁴⁰ Stone, *Knowledge at Work*, *supra* note __, at 722.

¹⁴¹ Cavico says that "one now sees these non-compete clauses in practically every employment contract." "employers are fearful that their more ambitious, entrepreneurial, and mobile employees soon will be competing against them. Employers contend that they need these restrictive covenants to cope with ever-escalating competitive challenges. Moreover, the increasing amount of mergers and acquisitions, layoffs, bankruptcies, and concomitant 'downsizings,' 'rightsizings,' and 'flexible' staffing arrangements, including the increased use of 'temporary' employees, engenders a growing number of terminated, and very likely disgruntled, employees. These former employees likely are sophisticated and knowledgeable, and were privy to sensitive information....Employers are alarmed, and not without reason, that these ex-employees will possess, and offer a new employer, a significant competitive 'edge.' This 'edge' is perceived as a real threat to a firm's profits, and possibly even its existence. A very volatile and risky business environment thereby is created, and a prudent firm must take care to guard its competitive advantages. Restrictive covenants, therefore, have emerged as a prevalent and efficacious means for an employer to protect its business interests and hard-earned competitive 'edge.'" Cavico, *supra* note __, at 3.

¹⁴² ABA SECTION OF LABOR & EMPLOYMENT LAW, COVENANTS NOT TO COMPETE: A STATE-BY-STATE SURVEY (Brian M. Malsberger et al. eds, 2d ed. 1996); ABA SECTION OF LABOR & EMPLOYMENT LAW, EMPLOYEE DUTY OF LOYALTY: A STATE-BY-STATE SURVEY (Brian M. Malsberger et al. eds. 2d ed. 1998); *See also* Stone, *supra* note __, at 739.

¹⁴³ Stone, *supra* note __, at 739.

¹⁴⁴ *See, e.g.,* Water Servs., Inc. v. Tesco Chems., Inc., 410 F.2d 163, 170-71 (5th Cir. 1969) ("[S]ince it may be difficult to determine, as a matter of law, what is a trade secret, the covenant not to compete is a pragmatic solution to the problem of protecting confidential information").

The enforcement of covenant not to compete depends on the observation of some requirements. One example is the rule of reason, which most states came to adopt. Under the rule of reason approach noncompete clauses are enforced if they (1) serve to protect and employer's legitimate business interest, and the restrictions are (2) temporally and (2) geographically narrowly tailored to this purpose.¹⁴⁵ As a rule, courts would strike down noncompete agreements in their entirety, when they imposed restraints that were broader than necessary to protect the employer's *legitimate* interests, considering them unenforceable contracts in restraint of trade, or unconscionable contracts oppressive to the former employee. This has changed and courts now increasingly reform noncompetition agreements when they are drafted too broadly.¹⁴⁶ This means that post-termination restrictions are more likely to be enforced.

The most common argument for the enforcement of noncompetition clauses is the disclosure of trade secrets and confidential information.¹⁴⁷ These are clearly legitimate business interests courts deem worthy of protection when they assess restrictive covenants in employment contracts. Even in California, where Business and Professions Code section 16600 generally prohibits covenants not to compete, and public policy strongly favors employee mobility, covenants not to compete are enforceable if "necessary to protect the employer's trade secrets."¹⁴⁸

The law of trade secrets (also state law) and restrictive covenants are thus complementary. And in assessing whether to enforce a noncompetition agreement, courts will therefore frequently discuss the factors that apply to trade secret protection. Accordingly, courts will be more willing to enforce a noncompetition clause where an employee has acquired confidential information that would afford a competitive advantage to another business, but less willing where the employee could import only general knowledge of the business or industry.¹⁴⁹ The law and economics literature of the adequacy of covenants not to compete is now numerous. Many arguments pro or con the enforcement of covenants to compete have been

¹⁴⁵ [Complete]

¹⁴⁶ See, e.g., *Solari Industries, Inc. v. Malady*, 55 N.J. 571, 576, 264 A.2d 53 (1970) (adopting the judicial rule that noncompetitive agreements may receive total or partial enforcement to the extent reasonable under the circumstances).

¹⁴⁷ See, e.g., *Vender Werf v. Zunica Realty Company*, 59 Ill.App.2d 173, 208 N.E.2d 74,76 (1974) (Legitimate interests is only another term to describe those 'special circumstances' which render employee's restraint necessary, but protection against ordinary competition itself is not sufficient. The authorities indicate that the 'special circumstances' which have been controlling and important in determining the reasonableness of the restraint imposed generally involve elements of trade secrets and unfair dealings").

¹⁴⁸ *Muggill v. Reuben H. Donnelley Corp.* (1965), 62 Cal.2d 239, 242, 42 Cal.Rptr. 107 (Traynor, J.). See also *Metro Traffic Control, inc. v. Shadow Traffic Network*, 22 Cal.App.4th at 859. California also does not invalidate a noncompetition agreement that merely prohibits solicitation of the former employer's customers. See generally, *Whyte v. Schlage Lock Co.*, 101 Cal.App.4th 1443 at 1482, 125 Cal.Rptr.2d 277 (2002).

¹⁴⁹ See, e.g., *Whitmyer Bros. Inc. v. Doyle et al.*, 58 N.J. 25, 28-30, 274 A.2d 577 (N.J. Supreme Court, 1971) ("matters of general knowledge within the industry may not be classified as trade secrets or confidential information entitled to protection nor will routine or trivial differences in practices and methods suffice to support restraint of the employee's competition"; referring to defendant's argument that highway safety construction employee's knowledge of bidding procedures and constituent elements were general business knowledge in the guard rail construction industry).

advanced.^{150, 151, 152} However, we advance here a still unexplored connection of the law of restrictive covenants and its impact to firm internal governance structure (see part VI.D below).

The enforcement of such restrictive covenants affects firm governance in the sense that if these contracts cannot be enforced in courts, employers and corporations may have to give employees greater incentives to stay in the firm, perhaps even ownership stakes.

3. *Other Bodies Of Law And Types Of Agreements*

While in this paper we only develop the idea of how law binds knowledge of K_p , K_o and K_i type by means of intellectual protections and agreements such as covenants not to compete, it is important to point out that other bodies of law do play a role in this regard as well. Employment regulation, for instance, may establish employee rights, assure job security and therefore help bind the knowledge embedded in an individual to firms structure. Rules that affect co-decision procedures may also cause this effect to some extent. Rules of Professional Conduct such as the ABA Model Rule of Professional Conduct also can function as away to prevent knowledge transfer outside the firm. Other types of agreements such as confidentiality agreements are also largely used in business practice and they do play an effect in helping firms bind knowledge to its structure.

V. KNOWLEDGE ALLOCATION AND TRANSACTION COSTS

A. *Efficient Knowledge Allocation*

In order to analyze firm structure, we develop the following theoretical assumption: Firms will try to maximize the use of knowledge resources in the production process. This assumption is similar to the assumptions underlying certain economic models that firms will maximize profits and consumers will maximize their utility. In order to maximize the use of knowledge resources, we now posit that firms should collocate decision-making authority with the relevant knowledge available within or to the firm. A firm uses its knowledge resources most efficiently when it allocates decision-making authority to those (persons or groups) that have the relevant knowledge to make such decisions at the various levels of the firm hierarchy.¹⁵³

¹⁵⁰ Eric A. Posner & George G. Triantis, *Covenants Not to Compete from an Incomplete Contracts Perspective*, John M. Olin Program in Law and Economics Working Paper No. 137 (2d series), University of Chicago Law School, (arguing that the employers have incentives to overinvest in specific training, which is worthless to any other employer, if a third employer is going to reimburse them. Therefore, employers will tend to expand covenants not to compete to externalize the cost of worker training to as many prospective future employers as possible. To prevent this from happening and to promote the design of efficient covenants, given the possibility of renegotiation, the courts should investigate whether the restrictive covenant protects specific or more general training, enforcing the covenants only in the latter case.)

¹⁵¹ Stone, *Knowledge at Work*, *supra* note __, at 271. (“the terms of new employment contract – specifically, the promise of training and networking opportunities – are undermined when courts are expansive in their approach to enforcement of restrictive covenants and the definitions of trade secrets.”)

¹⁵² Paul H. Rubin & Petter Shedd, *Human Capital and Covenants Not to Compete*, 10 J. Leg. Stud. 93 (1981). Rubin and Shedd consider efficient/inefficient the enforcement of covenants depending on the case.

¹⁵³ See Jensen & Meckling, *Specific and General Knowledge*, *supra* note __, at 251-274 (“When knowledge is valuable in decision-making, there are benefits to collocating decision authority with the knowledge that is valuable to those decisions. There are two ways to collocate knowledge and decision rights. One is by moving the knowledge to those with the decision rights; the other is by moving the decision rights to those with the knowledge. The process

Knowledge resources are costly. All else being equal, knowledge resources are wasted where decision-making authority is withheld from those with the knowledge required to make certain decisions. There will be knowledge available in the organization without putting it to its most value-enhancing use. Conversely, where a particular task or position within the firm hierarchy can be accomplished by substituting the knowledge of a supervisor/manager for that of an less knowledgeable employee, i.e. through direction of the employee, there is no need to pay the higher wage for the manager, because (from an economizing perspective) the task could be performed by a lower level employee. To put it differently, if a position in the firm is occupied by someone who has more knowledge than is required to perform his work, knowledge resources are being wasted through inefficient allocation of knowledge resources.¹⁵⁴

From these observations it follows that: *Decision-making authority should be collocated with relevant knowledge within the organization in an economizing way.*¹⁵⁵ We call this the *Principle of Efficient Knowledge Allocation*.

Relationships between decisional hierarchies and knowledge distribution within the firm emerge in connection with this principle. The first is that the firm hierarchy should be flatter and more decentralized, the greater and the more complex the knowledge distribution among the firm's personnel.¹⁵⁶ In contrast, decisional hierarchies should be steeper, and decision-making authority should be more centralized, the less knowledgeable the firm's personnel and the less complex the organization's knowledge capabilities. In this situation, we will expect to find people who are more knowledgeable exercising top executive functions and therefore the pyramid of hierarchy will have a large base with few persons in the top positions.¹⁵⁷

The principle of maximizing the use of knowledge resources is a valuable tool for explaining how governance structures are shaped, from a positive perspective, or how governance structures should be shaped, from a normative perspective.

Knowledge inputs in the form of human capital, as suggested by our discussion so far, directly affect the governance structure of an organization in a way that other inputs, such as physical assets, capital and raw materials, do not. The value of knowledge consists in solving problems and making good decisions.¹⁵⁸ Purchasing knowledge, but not making full use of it, or

for moving knowledge to those with decision rights has received much attention from researchers and designers of management information systems. But the process for moving decision rights to those with the relevant knowledge has received relatively little attention in either economics or management.” at 5-6)

¹⁵⁴ This assumes, of course, that the employee is being fully compensated for her skills.

¹⁵⁵ Jensen & Meckling, *supra* note __, at 19 argue: “The key to efficiency is to assign decision rights to each agent at each level to minimize the sum of the costs owing to poor information and the costs owing to inconsistent objectives.”

¹⁵⁶ See, e.g., Stephen R. Barley, *The Turn to a Horizontal Division of Labor: On the Occupationalization of Firms and the Technization of Work*, paper prepared for the Office of Educational Research and Improvement, U.S. Department of Education, January 1994, pp. 21, 32 (“As firms hire increasing numbers of professionals, as professions spawn specialties, and as new technologies create work that requires esoteric knowledge, expertise becomes more balkanized and firms begin to resemble confederacies of occupations rather than sleek pyramids of control When those in authority no longer comprehend the work of their subordinates, chains of command should cease to be viable for coordination.”).

¹⁵⁷ Demsetz mentions that those who are to produce but don't have knowledge must have their activities directed by those who possess more knowledge. Demsetz, *The Theory of the Firm Revisited*, *supra* note __, at 171-172.

¹⁵⁸ The most significant economic value of knowledge consists in its problem-solving potential. And problem-solving ultimately results in decision. Problem-solving capabilities, for the most part, are only fully engaged and

relying on those less knowledgeable to make the relevant decisions, is inefficient, and may well bring about failure in a competitive environment. The purchase of knowledge is efficient only if it gets reflected in the governance structure or allocation of decision making authority of the organization, just as the purchase of a physical asset only makes sense if it is used in a productive way, or the borrowing of capital if applied to its best rate of return.¹⁵⁹

However, knowledge resources are not allocated in the firm by the price mechanism. Therefore, the efficient allocation of decision making authority within organizations is subject to special difficulties that have to do with the nature of hierarchical organizations themselves, that is, with their relative rigidity. As Jensen and Meckling point out, the fact that intrafirm decision making rights are typically not themselves alienable may, over time, lead to the inefficient allocation of knowledge resources:

[T]he internal organization of the capitalist firm is also an instance of the absence of alienable decision rights. Indeed, we distinguish activities within the firm from activities between the firm and the rest of the world by whether alienability is transferred to agents along with the decision rights. In this *view transfers of decision rights without the right to alienate those rights are intra-firm transactions*. While firms can sell assets, workers in firms generally do not receive the rights to alienate their positions or any other assets or decision rights under their control. They cannot pocket the proceeds. This means there is no automatic decentralized process which tends to ensure that decision rights in the firm migrate to the agents that have the specific knowledge relevant to their exercise, and that there is no automatic performance measurement and reward system that motivates agents to use their decision rights in the interest of the organization. Explicit managerial direction and the creation of mechanisms to substitute for alienability is required.¹⁶⁰

Because there are no clear property rights in knowledge assets inside the firm, the assignment of decision rights to promote efficient knowledge allocation faces special difficulties. Problems of information or knowledge asymmetry make it difficult to evaluate knowledge resources. In the case of tacit knowledge, the asymmetry problem is exacerbated: individuals themselves may not have information about what and how much they actually know. Thus, one

sharpened when the problem-solver is confronted with real choices. Problem-solvers must therefore be genuinely engaged in a decision-making process, even if they do not have the last word. While decision-makers do not need to have a grasp of all the details of a decision, and thus can delegate some, or even much of the problem-solving, good decisions require a good grasp of the alternatives, or on the reliance of those better informed. While formally a decision might be ratified at a higher level of hierarchy, boundedness of rationality necessarily implies the diffusion of actual decision-making within an organization if this is the approach that will efficiently allocate knowledge resources. The contract-based explanation of the firm, explaining its transaction cost savings by the fiat relationship between employer and employee as advanced by Coase simply ignore those considerations.

¹⁵⁹ See Sherwin Rose, *Contracts and the Markets for Executives in CONTRACT ECONOMICS*, *supra* note __, at 184. “Scarce talents of the most capable managers are economized by assigning them to positions at or near the top of the largest firms, where their ability is magnified to greater effect by spreading it over longer chains of command and larger scales of operations.”

¹⁶⁰ Jensen & Meckling, *supra* note __, at 14-15.

of the most important, and perhaps most difficult, problems that a firm has to solve, and one which can lead to its success or failure in a competitive environment is the one identified here: the collocation of decision making authority with relevant knowledge. The use of knowledge is not frictionless and will always generate a certain amount of waste. There are also costs due to mistaken decisions. These are exacerbated where decision making authority is not collocated with the relevant knowledge. These costs have to be taken into account in assessing the efficient allocation of knowledge resources.¹⁶¹

B. *Knowledge Hazards*

In addition to the difficulties of efficient knowledge allocation already described, there are additional hazards that may impede efficient knowledge use by the firm, even if proper care has been taken to collocate decision rights with relevant knowledge. While traditional moral hazards such as shirking will occur through an employee's failure to apply her knowledge with the expected effort, there are additional hazards that are specific to the use of knowledge resources. These specific knowledge hazards are caused by the public goods characteristics of knowledge resources, but also by the tacit nature of knowledge. This is because tacit knowledge may not be observed at all if it is not communicated.

1. *The Public Goods Characteristics of Knowledge Resources*

Knowledge resources, as already indicated, have public goods characteristics. A public good has two critical features: non-rivalrous consumption and non-excludability. Non-rivalrous consumption means that the consumption of the good by one individual does not detract from the ability of others to enjoy its consumption. Non-excludability means that it is difficult, if not impossible, to exclude an individual from enjoying the good.¹⁶²

Thus, knowledge resources are subject to significant hazards in market transactions. If a seller wants to sell knowledge in the market, she will have to disclose something about what she intends to sell so that the buyer develops an interest in buying. However, in this process, the seller already loses some of her property.¹⁶³ Worse yet, once revealed that knowledge may be used not merely by the transferee, but by others to whom it is communicated, including potential competitors, thus undermining the ability of its proprietor to extract rents from her ownership.

As we already discussed in section IV, while intellectual property protections are directed precisely to solving the problems of knowledge transfer, they rarely confer perfect

¹⁶¹ Jensen & Meckling at 28. Thus, if knowledge valuable to a particular decision is to be used in making that decision, there must be a system for assigning decision rights to individuals who have the knowledge and abilities or who can acquire or produce them at low cost. In addition, self-interest on the part of individual decision-makers means that a control system is required to motivate individuals to use their specific knowledge and decision rights properly.

¹⁶² See, e.g., Joseph E. Stiglitz, *Knowledge as a Public Good, World Bank Lecture*, available at <http://www.worldbank.org/knowledge/chiefecon/articles/undpk2/> ("Knowledge of a mathematical theorem clearly satisfies both attributes [non-rivalrous consumption and non-excludability]: if I teach you the theorem, I continue to enjoy the knowledge of the theorem at the same time you do. By the same token, once I publish the theorem, anyone can enjoy the theorem. No one can be excluded. They can use the theorem as the basis of their own further research. The 'ideas' contained in the theorem may even stimulate others to have an idea with large commercial value").

¹⁶³ Joseph Stiglitz, *Public Policy for a Knowledge Economy*, World Bank Lecture, January 1999, at 13.

appropriability,¹⁶⁴ and do not apply to all kinds of knowledge. Markets for knowledge and information therefore depend critically on reputation, on repeated interactions, and on trust.¹⁶⁵

It is easy to see the benefits of integrating knowledge production rather than procuring such resources through market transactions when the knowledge used in the production process is most susceptible to hazards – as, for instance, in the case of Ki. We develop this latter point in sections VI.A and VI.F, below.

To avoid moral hazards, firms also must design other mechanisms, such as compensation strategies, in accordance with the knowledge type that they deploy. In this respect, we will discuss particular compensation systems used by high tech firms and law firms in sections VI.D and VI.E.

Because such mechanisms ameliorate the hazards to which knowledge resources are susceptible, even if imperfectly, knowledge is usually distinguished as an *impure public good*.¹⁶⁶

2. Leakage

Knowledge transfers are thus vulnerable to “leakage.”¹⁶⁷ Leakage refers to the unwanted transfer of knowledge by its proprietor, permitting a third party to benefit from the knowledge without compensating the knowledge proprietor.

3. Hoarding/Failure to Share

Not only markets transactions, but also knowledge transfers within organizations are subject to special problems, given that knowledge that is not actively communicated may not be observed at all.

Actors may fail to share knowledge in order to secure their decision making authority or to extract other advantages. Such hard to detect opportunistic behavior could potentially provide very significant gains for the individual and lead to significant inefficiencies for the organization. *Hoarding* or failure to share knowledge is potentially attractive to an employee (including, or especially, managers), because the employee may establish a monopoly over such knowledge and thereby extract rents. One form of such behavior is the withholding of knowledge from the employer or other employees, because an actor wants sole credit for possessing such knowledge. Whatever the motivation, hoarding or failure to share are hard to detect or measure. As a result, knowledge resources existing within the firm may, therefore, be

¹⁶⁴ Products are easily reverse engineered. Sidney G. Winter, *Knowledge and Competence as Strategic Assets*, in THE THEORETICAL CONTEXT OF STRATEGIC MANAGEMENT, (____, eds., ____); see also, David J. Teece, *Profiting From Technological Innovation in _____* 186.

¹⁶⁵ *Id.*

¹⁶⁶ Stiglitz, *Knowledge as a Public Good*, (“because the returns to some knowledge can, to some extent, be appropriated there is some degree of non-excludability, knowledge is often thought of as an *impure public good*.”).

¹⁶⁷ We borrow this term from Merges & Arora. _____.

underutilized.¹⁶⁸ Thus, even if decision rights are collocated with the most appropriate knowledge, there are opportunism costs peculiar to the use of knowledge resources.¹⁶⁹

Underutilization, however, may also occur in the absence of opportunism where the knowledge transferor is committed to sharing his knowledge. This may result from insufficient communication skills, insufficient knowledge on the part of the transferee, insufficient organizational opportunities for knowledge exchange, lack of appropriate settings within which to communicate tacit knowledge, etc.

VI. REVISITING SOME ASPECTS OF FIRM ORGANIZATION FROM THE KNOWLEDGE RESOURCES PERSPECTIVE

A. *Correlating Knowledge Structures and Governance (Decisional/Ownership) Structures*

In this part, we apply our typology to different types of firm production. We advance the hypothesis, for which we then produce evidence in subsequent sections, that firm organizational structures are influenced by the knowledge types that predominate in their particular production process.¹⁷⁰

We argue that production will be organized within a firm (as opposed to the market), as long as it can sell some kind of knowledge or expertise, or it can add some type of knowledge or expertise to a product or service which is already being sold in the market.

Holding all the other variables constant, then, we argue that the level of knowledge specialization will delimit firm structures.

Therefore, we advance the following hypotheses:

Hypothesis 1: The more the production relies on Kp/Kpr, the more we will expect production to be organized by means of market mechanisms.

¹⁶⁸ Note that we are not referring here to the problem of bounded rationality, which, per se, will generate constant underutilization of knowledge. We refer a particular situation where the knowledge could be effectively used if disclosed by its donor.

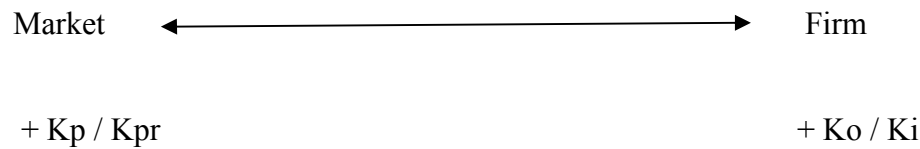
¹⁶⁹ Jensen & Meckling, *supra* note __, at 24 argue: “Because all individuals in a firm are self-interested, simply delegating decision rights to them and dictating the objective function each is to maximize is not sufficient to accomplish the objective. A control system that ties the individual’s interest more closely to that of the organization is required. The control system specifies (a) the performance measurement and evaluation system for each subdivision of the firm and each decision agent, and (b) the reward and punishment system that relates individual’s rewards to their performance.”

¹⁷⁰ Demsetz, *Comments on Michael C. Jensen & William H. Meckling, supra* note __, at 279-280. Demsetz has advanced some of the relations between knowledge resources and firm governance structure: “Some firms, for example, earn revenues by performing repetitive and routine activities most of the time. Others are preoccupied with highly innovative activity. The difference in the tasks faced by these firms, I believe, dictates differences in their organization structures and compensation systems. Less hierarchy can be tolerated by firms engaged in innovative activity, and decision rights are probably dense in the middle of the hierarchy that exists. This is because the problems faced by such a firm, relative to one engaged in repetitive activities, cannot be solved as easily as routinizing procedures with rules and regulations. It should also be the case that a difference in compensation methods is required because decisions must be more decentralized for firms that engage in, for example, genetic research. Greater reliance on profit-based compensation is required to bring objective functions of dispersed holders of decisions rights into closer accord.”

Hypothesis 2: The more the production relies on K_o and K_i , the more we will expect production to occur within the firm.

Thus if we imagine a continuum of knowledge inputs from purely K_p inputs at one extreme to purely K_i inputs at the other extreme, we would expect to find production taking place exclusively through market transactions in the first instance, but exclusively within firms in the second instance.

FIGURE 1: KNOWLEDGE TYPE AND PRODUCTION ORGANIZATION



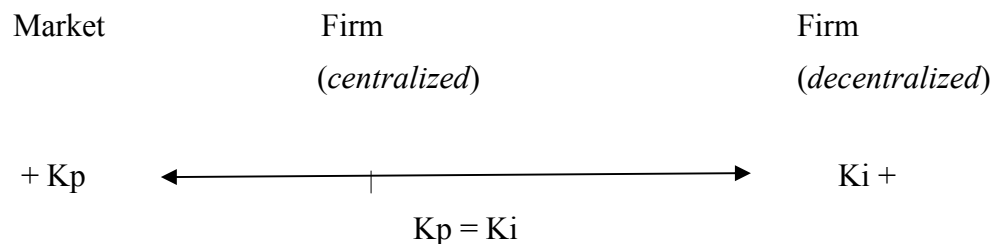
Assume now that some level of tacit knowledge or K_i is applied in the production process. Production will thus take place in the firm. The structure of the firm hierarchy governing the product process will then be more or less centralized depending on the level of K_p that is added. Because tacit knowledge is embedded in an individual, and because the more the knowledge is embedded in an individual, the less effective the management of knowledge through centralized governance structures, it follows that:

Hypothesis 3: The greater the reliance on K_i , the more decentralized the firm decisional hierarchies that will govern the production process.

Hypothesis 4: The greater the level of K_p/K_{pr} , and the less reliance is placed on K_i , the greater the centralization of decisional hierarchies that govern firm production.

So on the continuum that describes the organizational structure of the firm, we can expect that, if at one extreme we have a firm that predominantly relies on K_p , this firm will have a centralized governance structure. At the other extreme, if a firm uses exclusively K_i , then this firm will have a very decentralized governance structure, as follows.

FIGURE 2: KNOWLEDGE TYPE AND ORGANIZATIONAL STRUCTURE



In the table below we distinguish some basic types of industries according to the nature of the knowledge that they use. The knowledge type that is used (viz. Kp, Ko, Ki) varies depending on the different production technologies/techniques in a particular industry, and the organizational structure reflects the deployment of different knowledge types.¹⁷¹

TABLE __: THE STRUCTURE OF KNOWLEDGE AND THE STRUCTURE OF THE FIRM

| Firm Structure | Example | Knowledge Structure |
|--|-----------------------|----------------------------|
| 1. Taylorist Mass Production | General Motors | Kp + Ko + Ki – |
| 2. High Tech Engineering | Microsoft | Ki + Ko Kp – |
| 3. Low level service industry | McDonalds | Kp Ko + Ki – |
| 4. High level Professional Services | Law firms | Ki + Ko Kp – |
| 6. Risk Management/ Venture Capital Firms | Venture Capital Firms | Ki+ Ko + Kp – |

Of course there is a mixture of Kp, Ko and Ki in all types of firms. What change is the degree to which these variables enter into each firm type as suggested above.

1. *Centralization vs. Decentralization of Decision Making and Knowledge Location*

Different and somewhat contradictory approaches have been taken with regard to the impact that knowledge resources have on the organization of the production process.

Some scholars have proposed that the centralized organization of a firm is conducive to knowledge transfer and diffusion within the firm. Kenneth Arrow, for example, argues that “authority, the centralization of decision-making, serves to economize on the transmission and handling of knowledge.”¹⁷² Similarly, Coase’s reliance on the superior

¹⁷¹ In future elaborations, we intend to rely on SIC codes for which it should be easier to identify existing bodies of empirical data in the relevant specialized literatures.

¹⁷² KENNETH J. ARROW, *THE LIMITS OF ORGANIZATION* 69 (1974).

allocation of resources through the fiat-control of the entrepreneur within the firm hierarchy appears to endorse the virtues of centralization for the efficient use of knowledge resources. As one scholar contends, “Coase’s notion of authority” after all “assumes that a directing principal is at least as knowledgeable about the relevant tasks as the agent being directed.”¹⁷³

One of the ways in which firms economize in deploying knowledge resources is by “knowledge-substitution.” If X and Y are independent contractors in the market, then Y’s own knowledge is the final guide to his behavior. In contrast, if X and Y are coordinating their productive activities within a firm, Y can act on the basis of X’s knowledge without internalizing it. In the firm, “knowledge-substitution” can thus allow an employee to perform a particular job relying on the knowledge of others without first engaging in laborious internalization.¹⁷⁴ This expands the employees’ productive capabilities.¹⁷⁵

Knowledge substitution is even more important in the case of tacit knowledge, which cannot be easily assimilated. “[D]irection substitutes for education (that is, for the transfer of the knowledge itself).”¹⁷⁶ In this way, a manager’s knowledge can leverage the productivity of an employee. And more generally, it is possible “to generate more and richer coordinative activity [within the firm] than can be accomplished in markets.”¹⁷⁷

In contrast, Hayek argued that the market mechanism is superior and more efficient in producing goods, because knowledge is distributed throughout society and there are significant cognitive limitations faced by any set of decision makers in a centralized coordination process. Hayek tried to explain the superiority of market production by reference to the characteristics of tacit knowledge. He argued that the ability of the market to allocate knowledge resources was superior to their allocation in a managed economy, because of the inherently local and tacit character of much of the knowledge required in the production of goods.¹⁷⁸ Tacit knowledge is not easily communicable, but is locally specific and can only be acquired through experience. Tacit knowledge, therefore, cannot be readily gathered by a centralized decision making authority in the manner that data can be gathered and stored in a centralized computer.

¹⁷³ See Nicolai J. Foss, *Coase vs Hayek*, Copenhagen Business School, 2001, at 22, <http://www.cbs.dk/staff/njf.html>

¹⁷⁴ Kathleen R. Conner & C. K. Prahalad, *supra* note __. There are instances where knowledge substitution is performed by means of products. Suppose I am using a product that was built relying on the knowledge of a third party. In this case, as the knowledge is embedded in a product (as we shall call Kp), knowledge substitution is can be achieved in the market..

¹⁷⁵ According to Conner & Prahalad: “knowledge substitution is a fundamental response to cognitive limitations, having the effect on economizing on them A primary effect of firm organization – of the authority relationship – is to cause an individual to use the knowledge of another *before* the former fully understands or agrees with it. Conversely, a main effect of market contracting – of an autonomous relationship – is to oblige knowledge to be internalized before the individual agrees to modify its actions on the basis of that knowledge.” *Id.*, at 485.

¹⁷⁶ Demsetz, *supra* note __ at 172.

¹⁷⁷ R. P. Rumelt, *Inertia and Transformation in* (C.A. MONTGOMERY, ED.) RESOURCE-BASED AND EVOLUTIONARY THEORIES OF THE FIRM 124 (1995).

¹⁷⁸ F.A. Hayek, *The Use of Knowledge in Society*. 35 AMER. ECON. REV. 519, 521-522 (Sep. 1945) (“It is with respect to this that practically every individual has some advantage over all others in that he possesses unique information of which beneficial use might be, but of which can be made only if the decisions depending on it are left to him or are made with his active cooperation. We need to remember only how much we have to learn in any occupation after we have completed our theoretical training, how big a part of our working life we spend learning particular jobs, and how valuable an asset in all walks of life is knowledge of people, of local conditions and special circumstances.”).

As a consequence, Hayek argues, decentralization achieved through the market is necessary, because it assures that the knowledge of particular circumstances of time and place will be promptly used by means of the price mechanism.¹⁷⁹

Summarizing the discussion, some scholars such as Arrow and Coase seem to point out the benefits of firm authority centralization in economizing knowledge resources by means of a process that can be described as “knowledge substitution.” Other scholars such as Hayek point out the benefits of a decentralized structure that relies on knowledge specialization which occur in the market.

However, the relations between producers that are rearranged within the firm also include a division of knowledge among different persons involved in a production process.¹⁸⁰ Firms restructure the decision making procedures of a production process, *centralizing* certain decisions and *decentralizing* others. Indeed, the decentralization achieved through specialization in the firm is at least as important as the centralization of decision making achieved through steeper hierarchies. The efficient use of knowledge resources requires decentralized decision making under some circumstances – in markets or firms – and centralized decision making under others.¹⁸¹

The *degree* to which knowledge-substitution takes place within a firm will certainly affect firm organization. The potential for knowledge substitution is a necessary condition for greater centralization and steeper hierarchies. But it is not a sufficient condition. Where knowledge substitution is counterproductive or impossible, employees must rely on their own knowledge and firm organization will tend to be characterized by greater decentralization

¹⁷⁹ Hayek, *The Use of Knowledge in Society*, at 528: “Though [the price system] not only a division of labor but also a coordinated utilization of resources based on an equally divided knowledge has become possible.” However Hayek does not explain why there is organization of production inside firms at all, and what implications firm organization would imply for knowledge development. Hayek treats large firms, which do not use the price mechanism to allocate knowledge resources in their internal structures, as individuals. We believe this is so because Hayek, at the time he wrote, was concerned with pointing out the virtues of market allocations when compared to centralized allocations performed by the State in the function of an economy planner. This was a current theme in his writing, reflecting the debate posed by the Socialist regime at that time. See FRIEDRICK A. HAYEK, *THE ROAD OF SERFDOM*.

¹⁸⁰ Hayek was the first to point out the importance of the division of knowledge: “Clearly there is a problem of the *Division of Knowledge* which is quite analogous to, and at least as important as, the problem of the division of labour. But while the latter has been one of the main subjects of investigation ever since the beginning of our science, the former has been as completely neglected, although it seems to me to be the really central problem of economics as a social science . . .” F.A. von Hayek, 4 *Economics and Knowledge*. *ECONOMICA*, NEW SERIES 33-54, at 49 (1937).

¹⁸¹ Conner & Prahalad, *supra* note __: “An essential function of market contracting . . . is to enable individuals to specialize in different aspects of business activity. Each person need not possess the full range of understanding or skills necessary to complete all aspects of the work by itself. The provisions of the market contract coordinate the individuals’ efforts, so that a unified product (and hence specialization itself) can emerge. On the other hand, firm organization also enables specialization, since it too provides a means for coordinating individual efforts. However, unlike market contracting, the firm entails a second means for minimizing the impact of limited cognitive abilities. Again looking at polar cases, because the employment contract creates the authority necessary for knowledge-substitution, but a market contract does not, an employee need not internalize all the insights required to choose and carry out an action, while an independent contractor must. The firm organization economizes on cognitive limitations through two methods: specialization and knowledge-substitution. In contrast, market contracting economizes through specialization alone.

and flatter hierarchies.¹⁸² Law firms, architectural firms, and partnerships are, more generally, examples of the latter, as we shall see.

So a question that should be addressed is, after all, when is centralization or decentralization – in firms or in markets – the most desirable organization process so as to promote efficient knowledge allocation in the firm structure.

2. *The Nature of the Problem*

Jack Nickerson and Todd Zenger argue that markets are best at handling one type of problem (*low-interaction/decomposable problems*), whereas hierarchies are best at handling another type (*high interaction/non-decomposable problems*).¹⁸³

A problem is a *low-interaction/decomposable problem*, if its solution depends very little on interactions among different knowledge sets. In searching for solutions to such problems, groups of individuals can independently apply their knowledge. The aggregation of their independent efforts with the independent efforts of others who possess different knowledge sets can be expected to uncover a valuable solution to the problem. One example of such a problem is the design of a higher-performing personal computer. Performance can be increased by independently improving any number of subsystems, such as the disk drive, the monitor, the CPU, etc. Such problems “can be subdivided into subproblems each of which draws from rather specialized knowledge sets.”¹⁸⁴ A method of “directional search” is appropriate to the solution of such problems. In directional search, individuals independently pursue trials and independently observe performance. Individual actors perform multiple searches, altering design features associated with their knowledge sets, and then observe whether performance is increasing or declining as a result of the variation. This method of problem-solving is efficient when there are low-interaction problems that are fully decomposable into subproblems.¹⁸⁵

A problem is a *high-interaction/non-decomposable problem*, if its solution is highly dependent on interactions among different knowledge sets. Such problems cannot be separated into subproblems and therefore cannot be addressed by individuals familiar with one particular knowledge set.¹⁸⁶ In order to solve such problems, directional search is inadequate, and instead, what Nickerson and Zenger call “heuristic search” must be used.¹⁸⁷ Heuristic search requires the development of heuristics about the patterns of knowledge interactions, which will permit the selection of trials that maximize the probability of finding a high-value solution. Thus extensive communication and knowledge transfer are required to solve such problems.

¹⁸² See Stiglitz, *Public Policy for a Knowledge Economy*, *supra* note __, at 19: “In the firm, moving from simple repetitive work under central control (Taylorism) **to more complex knowledge-based** work requires a move towards a more decentralized and participative workplace.”

¹⁸³ Jack A. Nickerson & Todd R. Zenger, *A Knowledge-based Theory of Governance Choice—A Problem-Solving Approach*, __ (Working Paper No. __, October, 2001).

¹⁸⁴ *Id.* at 4-5.

¹⁸⁵ *Id.* at 6.

¹⁸⁶ The design of a leading edge microprocessor circuit is currently such a problem that “demands numerous knowledge sets that extensively interact in determining the value of solutions . . . the value of any particular design change will interact with a host of other potential design changes determined by actors possessing distinctly different knowledge sets.” *Id.*, at 5.

¹⁸⁷ *Id.* at 7.

The different types of problems identified above are handled most efficiently by different knowledge sets and governance structures. Markets are ideally suited to conduct directional search for the solution of decomposable problems. Markets support directional search, encouraging specialists to pursue trials that exploit their particular expertise. This division of knowledge could be used to explain why, for example, the personal computer is produced from components created worldwide. In the computer industry, Chandler explains how IBM outsourced the production of the components that would compose the personal computer: "...Estridge completed contracts with suppliers of components. Tandom made the disk drives in California; Zenith the PC power supplies in Michigan; the Silicon Valley division of SCI systems (a contract manufacturer) the circuit boards; a Japanese firm, Sieko Epson, the printers; IBM's plan at Charlotte, North Carolina, the board assemblies; and its plant at Lexington, Kentucky, the keyboards."¹⁸⁸

The costs of using markets increase, however, when problems become increasingly non-decomposable.¹⁸⁹ In this case, their solution will require a mechanism that mitigates knowledge based exchange hazards that arise from the public goods nature of knowledge. This mechanism is the firm hierarchy.¹⁹⁰

The firm can apply distinct solutions to the governance of knowledge formation: authority-based hierarchy and consensus-based hierarchy. Authority-based hierarchy is consistent with centralized management of knowledge by individuals who supposedly are more knowledgeable. It is appropriate to solving problems of relative complexity, while economizing on knowledge transfer. In contrast, the solution of highly complexity problems requires greater decentralization and thus consensus-based hierarchy, as no particular actor will be knowledgeable enough to direct heuristic search.

Therefore firm organization will differ depending on the nature of the problem that a firm needs to solve and its underlying knowledge requirements. The degree of interaction among knowledge sets required for the solution of problems encountered during the production process will influence whether firm production is more efficient than market production, and if so, whether steeper or flatter decisional hierarchies are appropriate.

In the following, we discuss some characteristics of different types of firm production, the different types of knowledge resources that predominate in each, and examine organizational consequences that their respective knowledge structures have for the firm's internal governance structure.

¹⁸⁸ Chandler, *THE ELECTRONIC CENTURY*, *supra* note __, at 137-38.

¹⁸⁹ Nickerson & Zenger, *supra* note __, at __. The authors argue that markets exacerbate knowledge exchange hazards, discouraging investments in co-specialized knowledge and development of a common language that are essential to a heuristic search. Individuals don't have appropriate incentives to deal with the public good nature of knowledge.

¹⁹⁰ *Id.*, at 13. Markets are efficient when knowledge transmission is directed at solving decomposable problems. When problems are decomposable, knowledge is embedded in products and services and knowledge transmission is largely limited to that which can be contained in prices and bundled into products and services. However, bundling knowledge sets within a single firm and exercising authority to direct search becomes efficient when problems become complex and efficient search demands extensive knowledge sharing and coordinated action. Authority in hierarchies economizes on the extensive and costly knowledge sharing and education that would need to occur were the governance of solution search for complex problems organized through a market interface.

B. *The Sole Proprietorship and Small Partnerships*

The typical American enterprise before the Civil War, was the sole proprietorship or small partnership. These forms of business organization had easily identifiable individuals who were fully responsible for the obligations of the business.¹⁹¹

The system that was common in small factories prior to 1870 had certain particular features: large investments were seldom required; there were no formal employment contracts; work rarely required complicated or costly machinery; work was mainly done at home by workers who owned their tools; workers had a considerable degree of personal autonomy; timing and pace of work, within limits, were left to workers; there was no need to tie up capital in expensive equipment.¹⁹²

We attribute the fact that we observe personal autonomy and decentralization in the production process to the type of knowledge required in the production process. Workers were artisans who had command of their work. They had the tools and, most importantly, the knowledge necessary to perform the work. As the knowledge required to perform the handiwork was, relatively speaking, not very complex or technologically sophisticated, most of the manufacturing process depended on the expertise and work experience embedded in each worker (Ki). Because of this, the governance structure of the production process was significantly decentralized and workers were assigned autonomy to control their tasks. This governance structure was the most efficient considering that the artisans had sufficient knowledge to perform their tasks independently.

There also existed at the time systems of apprenticeship, where an artisan controlled and managed the production process and exercised decision-making authority. This governance structure also can be explained in terms of the nature of the knowledge resources necessary for the production. Here, the older artisan who had more technical knowledge (Ki+) retained the decision rights as the apprentices were in the process of learning the skills and abilities necessary to develop the product (Ki-).

C. *Mass Production Firms*

The governance structures typical of small manufacturing partnerships began to change with the advent of new production technologies after 1870.¹⁹³ These technologies yielded significant inventions and new products. Small factories gradually became manufacturing companies; their focus changed to large-scale production. The ownership of large amounts of immobilized capital in the form of special machinery located on the production floor (Kp) thus became a key asset in the mass production system. We argue that this predominance of Kp in the productive process determined many of the organizational features of the emerging mass production corporations.

¹⁹¹ Richard Adelstein, *supra* note __, at 25, 29-30.

¹⁹² *Id.* at 31-32.

¹⁹³ *Id.* There was a growth in the number of engineers, and a new emphasis on formal science. There were efforts to rationalize the operations of the machine shop. The role played by engineers in the development of American manufacturing became extremely significant. At this time there was a rationalization of the accounting processes, necessity of coordination and scheduling, operational scale, monitoring and coordination by managers, creation of formal procedures in a hierarchized structure. It is important to note that this is also the beginning of rationalization of Ko. There was a development of professional management tools, development of the knowledge embedded in the organization, knowledge of the organization process in the improvement of routines.

Once knowledge became embedded in machines and work routines, workers increasingly became more replaceable. Taylor's system of scientific management perfected the mechanization of the production floor, taking the logic of mass production further than anyone had before. The goal of Taylor's scientific management was to embed all of the decentralized knowledge previously dispersed among employees into machines and production routines, thus bringing it under the more perfect control of management:

Taylor's alternative solution to the planner's problem in the shop was to break the worker's monopoly with the hammer of science and replace the decentralization of power based on craft knowledge with a hierarchically organized workplace in which expert managers told ignorant workers precisely what to do and how to do it. Every task in the shop would be reduced to a series of minute "elementary operations" performed by a man on a machine, and with the aid of a stopwatch and a strong, agile worker, the time needed to complete each such operation would be computed...

Management could gain possession of all the knowledge needed to control the shop. It could then systematize and codify it, and return it to workers in the form of detailed instructions.¹⁹⁴

This "physical separation of thinkers and doers" required a separate class of managers. At the top of the hierarchy were well-educated employees – the managerial class – who planned, executed and controlled production and marketing with the help of scientific knowledge. These highly skilled employees were responsible for the organization of the firm. They were assigned most of the legal decision making rights. At this level of the hierarchy, the new corporations of the 20th century thus dramatically increased the level of technical learning and tacit knowledge – the level of Ki. In contrast, the heavy use of machines (Kp) and organizational routines (Ko) permitted the deskilling of workers on the production floor, requiring very little specialized knowledge of these lower-level workers, who thus became readily replaceable without causing any measurable loss to the company.¹⁹⁵

¹⁹⁴ *Id.* at 41-42. See also at 46 [SOURCES MISSING] "The general principles of 'working smarter' and the practical core of scientific management - the institutionalization of systematic analysis in the workplace, the division of mental as well as physical labor, the emphasis on planning and the separation of thinkers from doers, the substitution of theory for intuition and rules of thumb quickly took root in American industry and formed the conceptual basis for the nation's emerging system of mass production."

¹⁹⁵ We are not necessarily saying the line worker will be less knowledgeable. Our argument is that the system is designed in a way to reduce the reliance on knowledge embedded in the employee in the operation of the assembly line. See William Lazonick & Mary O'Sullivan, Big Business And Skill Formation In The Wealthiest Nations: The Organizational Revolution In The Twentieth Century, in ALFRED D. CHANDLER, JR., FRANCO AMATORI & TAKASHI HIKINO, BIG BUSINESS AND THE WEALTH OF THE NATIONS 501 (1977) discusses the relative absence of skill formation on the shop floor in American industry. "In contrast to Britain, however, American reliance on skilled shop-floor labor to coordinate production activities was generally short-lived, as U.S. industrialists developed technological and organizational alternatives to leaving skills, and the control of work, on the shop floor. By employing unskilled immigrants from Eastern and Southern Europe, by investing in deskilling technological change, and by elaborating their managerial structure to plan and coordinate the productive transformation, U.S. industrial capitalists attacked the craft control that workers – typically of British and German origin - had staked out during the 1870s and 1880s." The author describes that in the first decades of the last century, the top management positions were occupied increasingly by university graduates in search of careers with the incumbency of applying science to

As our theory predicts, governance structures become more centralized when Kp predominates in the production process. This is necessary to achieve an efficient allocation of knowledge resources: decision rights must be assigned where costly Ki is located, at the upper-levels of the firm hierarchy. Conversely, decision making will be more decentralized the greater the reliance is on Ki at different levels of the firm hierarchy, because, again, efficient knowledge allocation requires that decision rights are collocated with costly knowledge resources.

1. *The Shift from C-Form to the M-Form Structure*

Chandler distinguishes three main stages in the evolution of American manufacturing firms. Between 1880 and the first World War, after the first wave of new technologies, there was a period of capital accumulation, characterized by large investments in physical assets and the expansion of production in order to achieve gains of scale in scale-dependent technologies.¹⁹⁶ During this period, a heavy reliance on Kp, i.e., the embedding of technology in multiple machines, coincided with a rationalization of production processes that lead to the centralization of decision-making. (C-Form corporation).

The second period, from 1914 to 1950, was dominated by the new internal combustion engine and its applications in the motor vehicle industry. In this period too, firms made large investments in tangible capital-accumulation and augmentation.

The third period, from the end of World War II to the 1980s, was characterized by a shift from the accumulation of tangible capital to the predominance of intangible capital.¹⁹⁷ Growth was increasingly more knowledge-intensive and science-intensive.

We argue that the historical development of American manufacturing firms supports our theory that firms that rely heavily on Kp will centralize their decisional hierarchies, but firms that increase their reliance on Ki and Ko will be inefficient unless they decentralize decision-making at least to some degree. When American firms relied mostly on Kp, they dramatically centralized their governance structures. (C-form). After the second war, when firms deployed increasing levels of Ki and Ko in R&D for product improvement, innovation, and

industry. The shop-floor investment strategy has been to substitute machines and materials for the skills of workers. *Id.* at 519

¹⁹⁶ Alfred D. Chandler, Jr., *The United States: Engines of Economic Growth in the Capital-Intensive and Knowledge-Intensive Industries* in CHANDLER, ET AL., *BIG BUSINESS AND THE WEALTH OF NATIONS*, *supra* note ___, at ___.

¹⁹⁷ *Id.* at 64. Empirical evidence shows that since the 1960s the number of R&D scientists and engineers substantially increased. The private business sector, mostly manufacturing enterprises played a dominant role. R&D scientists represent full-time employees. The number increased from 348.4 thousands in 1965 to 726 thousands in 1989. *Id.* at p. 38-39 Chandler & Hikino, *supra* note ___, at ___.

diversification, they began to decentralize¹⁹⁸ and take on a multi-divisional structure (M-form).¹⁹⁹

Chandler shows that after the 1890's the great manufacturing companies centralized their headquarters. The headquarters were responsible for the decisions concerning nearly all the activities of the enterprise's plants or marketing units.²⁰⁰ The embedding of knowledge inputs in products and machines and the standardization of production processes enabled economies of scale.²⁰¹ According to industry insiders, the most important benefits of the new unified form of organization included the utilization of machinery and equipments to their fullest capacity, the ability to replace striking workers by switching operations to other plants, and the benefits from skilled managers at the top of the hierarchy undertaking decisions and supervising the enterprise in its entirety.²⁰² Hence the major significance of Kp for such firm organization and the diminished use of Ki, concentrated at the upper levels of the organizational hierarchy.

After the first stage of centralization, firms began to make use of their existing knowledge and skill-sets to diversify into related products and industries. This diversification,

¹⁹⁸ *Id* at 42-43, *see also* at 45: "In those industries most affected by the new markets and new technology, growth came more by going overseas and still more by diversification. Of these two strategies, diversification was far more responsible for the adoption of the "decentralized" structure than overseas expansion. Diversification came when leading companies in these technologically advanced industries realized that their facilities and the scientific know-how of their personnel could be easily transferred into the production and sale of new goods for new markets. (...)"

¹⁹⁹ According to Chandler's definition, "An enterprise can be said to have adopted the new [M-] form if it came to have a general office with executives whose primary tasks were general rather than functional and if it also had at least two major multidepartmental, relatively autonomous divisions." Alfred D. Chandler, Jr. STRATEGY AND STRUCTURE: CHAPTERS IN THE HISTORY OF THE AMERICAN INDUSTRIAL ENTERPRISE at 325. *Id.*, at 42. This pattern of organization was gradually adopted by more industries as they started to expand their activities through diversification after the Second World War. Chandler mentions the examples of Hercules Powder and Monsanto (before 1940) and Celanese Corporation of America, Columbia Carbon, Carborundum, American Cyanamid, Koppers, Pittsburgh Coke & Chemical, Glidden, Atlas Powder, ...Shell Oil and Phillips Petroleum. *See also* at 48, discussing the effect of product diversification in oil enterprises. Shell, Standard of California, Phillips Petroleum, Texaco, Standard (Indiana), Standard of Ohio, and continental Oil set up autonomous divisions to administer their new chemical products.

²⁰⁰ ALFRED D. CHANDLER, JR. STRATEGY AND STRUCTURE: CHAPTERS IN THE HISTORY OF THE AMERICAN INDUSTRIAL ENTERPRISE 31 (____).

²⁰¹ According to Chandler, "The transformation of a loose alliance of manufacturing or marketing firms into a single consolidated organization with a central headquarters made possible economies of scale through standardization of processes and standardization in the procurement of the materials. Of more significance, consolidation permitted a concentration of production in a few large favorably located factories. By handling a high volume of output, consolidated factories reduced the cost of making each individual unit..." CHANDLER, SCALE AND SCOPE *supra* note __, at 31.

²⁰² See a comment from Charles R. Flint, organizer of the United States Rubber Co. in 1899, regarding the benefits of consolidated management. "The following are the principal ones: raw material, bought in large quantities is secured at a lower price; the specialization of manufacture on a large scale, in separate plants, permits the fullest utilization of special machinery and processes, thus decreasing costs; the standard of quality is raised and fixed; the number of styles reduced, and the best standards are adopted; those plants which are best equipped and most advantageously situated are run continuously in preference to those less favored, in case of local strikes or fires, the work goes on elsewhere, thus preventing serious loss (...); greater skill in management accrues to the benefit of the whole, instead of the part; and large advantages are realized from comparative accounting and comparative administration..." *Id.*, at 33, 34.

however, typically brought about a measure of decentralization, given the different expertise required to run different types of businesses. (M-Form corporation).

In the beginning of the twentieth century, the leading enterprises came to face increasingly complex administrative problems, because of the great technological advances and the systematic application of science to industrial production.²⁰³ According to Chandler, these developments exposed serious weaknesses in these centralized firm structures: there were too few decision makers for the great number of complex decisions that needed to be made.²⁰⁴

We argue that this shift to the M-form structure was driven by changes in knowledge requirements necessary to support production. The more bodies of knowledge a firm needed to master, the more decentralized their organizational structure needed to become. A single management team in the top of the hierarchy could no longer master the many different bodies of knowledge needed to run different lines of business, especially in science intensive industries. Different types of Kp deployed in the different production processes added significant complexity. Supply lines and margins responded to different market conditions in different businesses. Different organizational routines were required: getting quotes for the price of raw materials differed significantly from one business to the next; so did the establishment of supply lines and related logistics. Supply lines were subject to different hazards, market fluctuations, environmental events, etc. for the different products, thus requiring the creation of new and specialized organizational routines in each case, affecting both supply, production, and marketing of the products in each line of business. This increasing complexity required different types of management experience – with different types of Ki.²⁰⁵

Organizations evolved by devolving discretion and decision rights upon those employees/managers who had greater specialized knowledge concerning the different products, and within each division, upon department heads with functional responsibilities. This decentralization process was conducted in order to optimize the management of knowledge requirements according to an efficiency-enhancing knowledge allocation.

DuPont is an interesting case study that illustrates the theory we have proposed above. DuPont built large research departments to generate new products and improve existing ones. The application of science through institutionalized research resulted in diversification as new products were developed.²⁰⁶ Diversification, in turn, resulted in increased complexity of operational and entrepreneurial capabilities.²⁰⁷ Recognizing the centralized control placed ultimate decision-making authority in the hands of executives who did not possess the relevant knowledge in each case to manage the line of business, DuPont's Chairman, Harry Haskel, exempted DuPont's dye business from centralized control, even as DuPont was concentrating all decision-making authority concerning manufacturing operations in a single executive Vice

²⁰³ CHANDLER, STRATEGY AND STRUCTURE, *supra* note __, at 42.

²⁰⁴ *Id.* at 41.

²⁰⁵ Chandler and Hikino argue that as capital-intensive and science-based industries grew entering in new product markets, the initial centralized structure (unitary or U-form) became inefficient. "Senior managers became acutely aware that they did not have the time or the competence to coordinate and monitor – or to devise and implement long-term strategies for their units operating in different geographical and product markets." They started to adopt a decentralized structure to meet their organization necessities. (the multidivisional M-form) note __, at 35. *The large industrial enterprise and the dynamics of modern economic growth*, in _____, *supra*.

²⁰⁶ *Id.* at 43.

²⁰⁷ *Id.* at 44.

Presidency around 1919. Haskell explained, for example, that “it would be better for a few years to carry on the dye business as a separate entity.... because it is a developing, unstandardized industry and should merit independent attention just as the Parlin chemical mixtures business was better by itself until standardized – when it was merged with the regular sales and operating departments.”²⁰⁸

Haskel, who at the time was one of the leaders of American industry, thus recognized both that standardized production techniques permitted centralized control, but that decentralization of decision-making authority was necessary where complex non-decomposable problems needed to be addressed by specialized managers with tacit knowledge in a specific field.

When the government imposed antitrust restrictions on DuPont’s military powder business, DuPont saw itself with idle capacity in one of its plants and intensified its strategy to diversify its product lines. DuPont’s search for potential products was clearly guided by a concern for making use of its existing knowledge sets. According to Chandler, the products that DuPont chose were in “a field where the company’s technological experience, training, and resources could pay off.”²⁰⁹

Seeking diversification based on its nitrocellulose experience with gunpowder, DuPont bought the International Smokeless Powder & Chemical Company, a manufacturer of both explosives and pyroxylin lacquers. Subsequently, DuPont set up a small pilot plant to produce pyroxylin-based artificial leather. The operation proved successful upon which DuPont’s Executive Committee decided to purchase one of the leading firms in the field, Fabrikoid Co., to “learn more about the business” instead of building its own artificial leather plants.²¹⁰

DuPont also pursued the production of pyroxylin from nitrocellulose based on short-staple cotton. However, upon investigation, it was concluded that DuPont would have difficulty supplying companies with their nitrocellulose requirements. Firms would not buy from outsiders, because they would not sacrifice control and supervision of their products. To act as a supplier, DuPont would have to become knowledgeable about the details of manufacturing or composition of their customers’ products. But firms regarded these details as valuable trade secrets, which they would not share with a potential competitor.²¹¹ Because of the close coordination required between supplier and manufacturer in the industry, DuPont instead pursued a policy of vertical integration.²¹²

DuPont’s increasing diversification resulted in inefficiencies in knowledge allocations. According to Chandler, “[t]he development of plans and the appraisal of activities were made harder because executives with experience primarily in explosives were making decisions about paint, varnishes, dyes, chemicals and plastic products. Coordination became more complicated because different products called for different types of standards, procedures

²⁰⁸ *Id.* at 68

²⁰⁹ *Id.* at 81.

²¹⁰ *Id.*

²¹¹ *Id.* at 82

²¹² *Id.* at 82.

and policies.”²¹³ As a consequence, the company’s new ventures suffered from extremely poor performance.²¹⁴

Initially, DuPont stuck with its old centralized organization that concentrated decision rights in the hands of executives specialized in explosives. Proceeding under this familiar organizational structure, DuPont lost money on every product except explosives, accumulating high deficits in the area of paints, varnishes and cellulose products.²¹⁵ The company studied the problem and, after a six-month investigation, concluded that a new management structure was necessary.²¹⁶ In a report that envisaged the restructuring of DuPont, it was concluded that “no member of the Executive Committee should have the direct individual authority or responsibility which he would if he was in charge of one or more functional activities of the Company. His relation to such functions should be advisory only...”²¹⁷ Further, according to the new plan, “the head of each Industrial Department [would henceforth] have full authority and responsibility for the operation of his industry, subject only to the authority of the Executive Committee as a whole.”²¹⁸

In the face of product diversification, DuPont thus decentralized its decisional hierarchy. The new General Managers would handle the day-to-day administration of the divisions, whereas the Executive Committee would henceforth be responsible for over-all coordination, appraisal and policy planning.²¹⁹ DuPont thus established autonomous, multi-departmental divisions and a general office with staff specialists and general executives in 1921. Each division had several departments and its own central office to administer them.²²⁰

The new multi-divisional structure – called the M-Form – promoted an efficient allocation of knowledge resources.²²¹ Chandler cites as one reason for the success of the decentralized structure that it removed executives responsible for the destiny of the entire enterprise from the more routine operational activities, providing them with more time, information and psychological commitment for long-term planning.²²² Senior executives of the Company increasingly specialized, began to carry out entrepreneurial activities, and focused on strategic decisions. Decentralization further resulted in the collocation of decision rights with relevant knowledge in that General Managers of the divisions were granted authority to manage

²¹³ *Id.* at 91.

²¹⁴ *Id.* at 92.

²¹⁵ *Id.* at 104. (“The strategy of diversification seemed to promise little more than difficulties and deficits”).

²¹⁶ *Id.* at 94.

²¹⁷ *Id.* at 107.

²¹⁸ *Id.*

²¹⁹ *Id.* at 107.

²²⁰ *Id.* at 111.

²²¹ Chandler argues that “If the general offices were better equipped to handle over-all strategic decisions, the division managers had full authority and the necessary facilities to make the day-to-day tactical ones. As each controlled the functional activities needed for making and selling one major line of products, each could determine, within the framework set and funds allotted by the Executive Committee, the most efficient ways to use the resources at his command.” *Id.* at 11.

²²² *Id.* at 309.

operations in their own areas of expertise. Once the new structure was in place, losses were soon converted into profits.²²³

DuPont's development shows that the decentralization of decisional hierarchies became necessary where the development and production of new products required mastery of new knowledge sets that had not yet been standardized, as well as research and individual expertise to find solutions to new and complex problems. According to Chandler, "[d]iversification ... brought the new decentralized structure, not because it increased the total output or size of operations, but because it so quickly enlarged the number and complexity of both tactical and strategic administrative decisions."²²⁴ As discussed above, the nature and complexity of the problems to be solved affects the degree of decentralization required by the decisional hierarchy. More complex and non-decomposable problems require more decentralization. In the case of DuPont's new product lines, the problems encountered were both complex and industry specific, and thus could not be analyzed and processed in the same fashion by a single management team. They required "the creation of a multidivisional autonomous division for the administration of each major line of products. (. . .)"²²⁵

In the electrical (including electronics), power machines (including automobiles) and chemical industries, nearly all the leading enterprises followed DuPont's turn toward the new multidivisional form. These industries devoted the most resources to systematic research and development.²²⁶ Institutionalized research brought diversification, which, in turn, brought decentralization of the organizational structure.²²⁷

The evolution of organizations in other, much less diversified industries did not follow the same path.²²⁸ Among seventy companies studied by Chandler, those that did not adopt the new multidivisional structure by 1960 were concentrated in the metals and materials industries.²²⁹ In the areas of copper, nickel and zinc, moreover, major technological and market

²²³ *Id.* at 112.

²²⁴ *Id.* at 362.

²²⁵ *Id.*, STRATEGY AND STRUCTURE: CHAPTERS IN THE HISTORY OF THE AMERICAN INDUSTRIAL ENTERPRISE at 362.

²²⁶ Not coincidentally, according to Chandler, the two major science-based industries were electrical equipment and chemicals. "They led the way both in the employment of highly skilled non-production workers and the creation of large research and development organizations. In chemicals (SIC 28), scientific personnel in 1921 accounted for 30.4 percent of total scientific personnel employed in the U.S. manufacturing, followed by primary metals with 8.2 percent and electrical equipment with 7.2 percent. By 1946 the figure for chemicals remained almost exactly the same, 30.6 percent. Electrical had risen to 15.5 and metals had dropped to 5.3." Chandler, *The United States: Engines of Economic Growth*, *supra* note __, at __; Chandler, Amatori & Hikino, *supra* note __ at 80.

²²⁷ CHANDLER, STRATEGY AND STRUCTURE, *supra* note __, at 378. ("Those enterprises whose technological potential rests on modern science, as well as few food companies, have been able to turn diversification into a highly rational and systematic strategy of growth. Stimulated by institutionalized research, diversification in turn brought decentralization.") *See also*, p. 393: "In the chemical, electrical and electronic, and power machinery industries, the same personnel using much the same facilities using much the same supplies of raw materials were able to develop new engines, new machines, new household appliances, new synthetic fibers, new films or plastics, or new electrical and electronic devices. Since the enterprises in these industries required the highest of technological skills, their administrators invested increasingly large amounts of their total resources in research and development. Such resources became less and less tied to any specific product line. (...)"

²²⁸ *Id.* at 327-328.

²²⁹ *Id.* at 326.

changes were absent.²³⁰ This permitted the standardization of operations and the routinization of decision-making procedures.²³¹ In these industries, the centralized structure remained the most efficient one. The centralized structure was similarly the most efficient in the oil industry, where “the fundamental purpose of structure [was] to unite all activities of the enterprise in meeting changing market demand.” More generally, Chandler concludes that “[w]here a company’s line of end products was produced by the same manufacturing process from the same supply of raw materials for a relatively few sets of customers, the centralized, functionally departmentalized form provided that essential coordination.”²³² The centralization structure therefore fit well in industries that relied on less diversified Kp, where problems were substantially less complex and the standardization of routines enabled an efficient knowledge allocation.

A more recent example of a relatively hierarchical and centralized firm structure is that of IBM in the 1980s and 1990s. While IBM initially defined the path of the computer industry, its business strategy for the personal computer was to develop expertise on mass production.²³³ Instead of developing all the required components, IBM decided to purchase most components from outside suppliers in order to rapidly benefit from new inventions and products available on the market.²³⁴ Thus IBM heavily relied on knowledge/technology embedded in products (Kp) that it purchased from suppliers, while still adding their own know-how in organizing the assembly, marketing and servicing of the personal computers it produced (Ko) and (Ki). IBM created a service force to provide national support for its clients and developed a worldwide marketing strategy, spreading its franchised dealers worldwide.²³⁵ Thus focusing on mass production where profits largely come from increasing returns to scale and scope,²³⁶ IBM also developed a highly centralized organizational structure similar in certain respects to other mass production industries to manage its large structure. Important decisions were typically initiated by Central Management Committee.²³⁷

Chandler argues that as “Compaq and Apple began to build their global enterprises, IBM’s Entry Level System Division was becoming integrated back into the long-established, relatively centralized operating structure of one of the world’s largest industrial enterprises.”²³⁸ IBM’s focus on mass production and reliance on Kp, acquired from its suppliers in the form of technology embedded in products, thus made a more centralized, hierarchical structure the most efficient allocation of knowledge and decision rights.

IBM’s open system based on market outsourcing created a demand for other companies to enter this market, in order to supply the components that IBM required. These

²³⁰ *Id.* at 329.

²³¹ *Id.*

²³² *Id.* at 360.

²³³ ALFRED CHANDLER, *INVENTING THE ELECTRONIC CENTER*, at 132.

²³⁴ Chandler, *id.* at 136.

²³⁵ *Id.*

²³⁶ *Id.* at 139.

²³⁷ *Id.* at 136, 137 (“IBM’s Central Management Committee approved Lowe’s report, upgraded the task force to a full-scale project development group, appointed Philip ‘Don’ Estridge its chief, and gave him precisely *one year* to have the product on the market...”); “In 1983 IBM’s Central Management Committee created an entirely new Entry Level System Division to manage his explosive growth.”)

²³⁸ *Id.* at 146.

high-tech companies had to master a demand for increasing innovation. Because these suppliers of innovation and technology relied heavily on the scientific knowledge and skill of their employees, they had to resort to a very different organizational structure in order to manage their knowledge resources and remain competitive.

D. High-Tech Engineering

The organizational structure of firms engaged in constant innovation is different from the one of mass production firms. These firms are concerned with solving problems, which require high levels of interaction and knowledge exchange.²³⁹ The knowledge necessary for achieving these tasks is mostly embedded in individuals (Ki) and therefore we suggest that these firms should develop more decentralized business structures if they are to maximize their gains from an efficient knowledge allocation. Employees will enjoy more autonomy in performing their tasks.

Scholars have already studied the changes required in organizational structures in order to stimulate knowledge creation and knowledge retention.²⁴⁰ The success of new biotechnology firms, for example, depends on their ability to create rights over scientific knowledge. These firms need continuous innovation to find valuable and patentable products. The asset necessary for product development is an intellectual resource characterized by “severe immobility,” because there are few star researchers who have made commercially valuable discoveries, and many of them work at universities.²⁴¹

In these cases, where scientific knowledge is critical, different organizational arrangements are necessary. By permitting scientist-employees to maintain exchanges with universities, new biotechnology firms have turned out to be flexible organizations where the knowledge used is mainly managed in a decentralized way by its employees.

Knowledge production in the university structure to which such firms are linked is itself characterized by a unique governance structure. This has influenced the structure of biotechnology firms. In order to “attract and retain such scientists . . . each [New Biotechnology Firm, or] NBF needed to maintain a ‘university-like’ organizational context as it developed. That is, the NBF’s organizational policies had to support both the formation and maintenance of boundary-spanning social network relationships as well as numerous other complementary activities such as rapid publication of research results and freedom of scientific inquiry.”²⁴²

Not just the New Biotech Firms, but Silicon Valley firms more generally avoided hierarchies, creating organizations with considerable dispersed decision-making and flat

²³⁹ Nickerson & Zenger, *supra note* ___, at ___.

²⁴⁰ See e.g., Tomas Hellström, Ulf Malmquist, John Mikaelsson, *Decentralizing Knowledge: Managing Knowledge Work in a Software Engineering Firm*, 12 JOURNAL OF HIGH TECHNOLOGY MANAGEMENT RESEARCH 25 (2001) (Arguing that top-down management decisions may be misleading in software engineering firms).

²⁴¹ Julia Porter Liebeskind, Amalya Lumerman Oliver, Lynne Zucker, & Marilynn Brewer, *Social Networks, Learning and Flexibility: Sourcing Scientific Knowledge in New Biotechnology Firms*, 7 ORGANIZATION SCIENCE 428 (1996).

²⁴² *Id.* at 439. (internal quotations omitted).

authority structures.²⁴³ Decision making and coordinating activity by managers is reallocated in favor of self-coordination among experts.

1. *Restrictive Covenants and the Structure of High Tech Firms*

One example of the impact of intellectual property regimes on the ownership and decisional structure of firms emerges from Ron Gilson's comparative analysis of Silicon Valley high tech firms. Gilson has tried to show that different patterns of economic development between the high tech industrial districts of Silicon Valley, on the one hand, and Boston's Route 128, on the other hand, are connected to differences in intellectual property regimes in California and Massachusetts. While Massachusetts has a long history of enforcing covenants not to compete and other post-employment restrictions, California's civil Code prohibits them.

Gilson argues that the inability to enforce non-competes thus supported a high velocity labor market in Silicon Valley, in which employees with significant technological expertise could move rapidly between competitor firms or leave their employer to start up their own companies in direct competition with their former employers.^{244, 245} Because employees could not be prevented by contract from appropriating tacit knowledge resources, the resulting knowledge spillovers permitted start-ups to thrive and allowed a greater number of smaller firms to specialize in developing technology required for new products.²⁴⁶

In contrast, Massachusetts's willingness to enjoin employees, who signed noncompete clauses, from competing with their former employers, discouraged employee mobility and knowledge spillovers, leading to the decline of the high tech industry along Route

²⁴³ ANNALEE SAXENIAN, *REGIONAL ADVANTAGE: CULTURE AND COMPETITION IN SILICON VALLEY AND ROUTE 143* (1994).

²⁴⁴ See also, in *THE COMPANY OF OWNERS* (Joseph Blasi et al. eds., 2003). Blasi describes how the Nobel Laureate William Shockley left AT&T's Bell Labs to create a semiconductor lab in Palo Alto, only to lose eight of his young researchers, who walked out on him to start their own company, Fairchild Semiconductors. Fairchild, in turn, was stripped of much of its talent when it shed eight of its most promising researchers, who went on to create companies such as Intel. "Fairchild exploded like a seed pod and scattered the germs of new firms throughout the valley. By 1970, forty-two new semiconductor companies had been founded by former Fairchild employees or by the firms they had started . . ." *Id. at 11*.

²⁴⁵ Gilson, *supra* note __, at 594 ("The web of knowledge spillovers, personal relations, start-up businesses, and absence of vertical integration owes its existence to the ease with which employee move from employer to employer, from established company to start-up, from customer to supplier, taking their employer's tacit knowledge with them and applying it in their new situations. Lacking the ability to prevent knowledge spillovers, Silicon Valley companies adapted to their environment, and the characteristic Silicon Valley industrial organization evolved.") (emphasis added).

²⁴⁶ Gilson's explains the ability of the legal infrastructure to affect the price of knowledge inputs for firms in high tech industrial districts by promoting Marshallian factor market externalities. A Marshallian factor market externality is the propensity for an input's relative price to be lower when the number of firms in a region that call for that input is higher. Such a region constitutes an "agglomeration economy." Applying the Marshallian theory of agglomeration economies, and more particularly the principle of Marshallian factor market externality, Gilson shows the standard law and economics position that firms should be allowed to capture the gains of their knowledge investments, fails to appreciate the significance that knowledge spillovers played in lowering the price of knowledge inputs for firms in high tech industrial districts. Gilson *supra* note __, at 581.

128. “Route 128 firms, in contrast, developed in a more traditional fashion, imitating the vertically integrated structures of the large mass-production company.”²⁴⁷

While Gilson’s focus is on explaining legal factors that contributed to the creation of Silicon Valley’s regional agglomeration economy, we rely on his analysis to establish the relationship between differences in internal governance structure of high tech firms in Silicon Valley and Route 128 and the respective legal protections available to employers for binding tacit knowledge embedded in their employees (Ki) to the firm. The traditional large, vertically integrated and more rigidly hierarchical corporate culture in Massachusetts was supported by a legal regime that bound tacit knowledge embedded in employees to the firm. IBM provides the prime example of such a vertically integrated firm. In contrast, a less integrated and less hierarchical firm structure was supported by a legal regime that did not recognize a firm’s property rights over employees’ tacit knowledge (Ki).

We argue that the legal regulation of Ki had an effect on firm structure in an industry, which relies heavily on this type of knowledge. Tacit knowledge plays a different role in the different phases of innovation, product development and commercialization in an industrial district’s production life cycle. Tacit knowledge is “critical to taking an innovation from conception to commercialization.”²⁴⁸ But it plays a lesser role during later stages in an industry’s life cycle once “most of the technical aspects of the product have become standardized, and the nature of demand is well known.”²⁴⁹ In the initial phases of a high tech industries life cycle, tacit knowledge is transferred from one firm to another through interfirm employee mobility.

There is considerable evidence for the proposition that inter-firm mobility in Silicon Valley is exceptionally high.²⁵⁰ But clearly Silicon Valley’s high tech firms also needed to bind knowledge to the firm. Gilson’s account of Silicon Valley knowledge of spillovers leaves us with a critical question: If employee mobility was so pervasive how did the firms survive at all? Key employees must have been retained for significant periods because otherwise most firms would have collapsed. Presumably firms did find a way to keep employees. Gilson does not pursue this aspect of the problem. Firms’ adaptation to their regulatory environment and business culture in Silicon Valley was not limited to supporting their employees’ transfer of valuable knowledge assets outside of the firm to their competitors. Lacking certain legal protections (*viz.* enforcement of covenants not to compete), firms were thus relegated to employing alternative devices to bind Ki to the firm. While the threat of enforcing a restrictive

²⁴⁷ Gilson, *supra* note __, at 591-92 “In contrast to the Brownian motion of Silicon Valley’s high velocity employment, career patterns of employers and managers in Route 128 companies were much more linear. Knowledge workers anticipated long-term employment with a single employer and career development that contemplated rising vertically within an organization, rather than success through lateral movement, as in Silicon Valley... ‘[t]he practice of leaving a large company to join a small firm or a promising new start-up was virtually unheard of.’ Consistent with this pattern, Route 128 gave rise to traditionally vertically integrated companies. In this locality, knowledge transfer took place within, rather than across firms.”)

²⁴⁸ Gilson, *supra* note __, at 582.

²⁴⁹ Gilson, *supra* note __, at 584-585. *See also* MARYANN P. FELDMAN, *THE GEOGRAPHY OF INNOVATIVE CLUSTERS* 254 (1994) (“[T]he propensity for innovative activity to geographically cluster will tend to be shaped by the stage of the industry life cycle...[T]he importance of tacit knowledge in generating innovative activity shapes the degree to which innovative activity will cluster. And the relative importance of tacit knowledge in generating innovative activity varies considerably across the various stages of the industry life cycle.”).

²⁵⁰ *See* Gilson *supra* note __, at 590-92.

covenant provided disincentives for employees to strike out on their own in Massachusetts, high tech firms in Silicon Valley had to devise a new internal governance structure to provide incentives for employees to stay. One aspect of this governance structure is compensation packages. Firms employed the substantial incentive of employee stock option plans to bind Ki to the firm. This device, in turn, encouraged and reflected a different type intrafirm decisional structure and different modes of financing.

We argue that there is a reciprocal relationship between non-compete and compensation – and ultimately ownership - structure. If there is no possibility to enforce a covenant not to compete, that is, to bind Ki by means of private agreements, then firms are forced to use other mechanism in order to retain these employees. But if firms can enforce a non-compete, then essentially they can prevent a employee from leaving, and make it much harder for him to take the knowledge and information elsewhere. In firms where the use of covenants not to compete are widespread, we hypothesize that stock options should become less common, because the two are related in this way. The necessity of the firm to bind knowledge embedded in its employees can be managed in two ways: (1) through enforcement of these restrictive covenants; or (2) through offer of special compensation packages and potential ownership rights.

What is more, Gilson seems to attribute the performance deterioration of Route 128 high tech district in Boston to the lack of knowledge spillover effects that were associated with employee mobility in Silicon Valley.²⁵¹ While this should be a relevant factor, we believe that this is not the whole story. The predominance of vertically integrated firms in Route 128 which were developed imitating the structure of the large mass-production company²⁵² may well be considered another key factor in this respect. According to our theory, the deterioration of firms performance in Route 128 would be an example of how internal governance structures can affect the creation of knowledge resources and innovation. Our hypothesis is that the development of firm structures in Route 128 towards a mass production oriented structure, with steep hierarchical and centralized knowledge, may well have constrained new knowledge development and therefore affected innovation patterns. According to Saxenian: “Route 128’s technology enterprises imitated the structure of the traditional mass production corporation. While Silicon Valley’s entrepreneurs rejected the corporate practices of the large, established East Coast producers, the managers along Route 128 saw the same corporations as their models. One senior vice president at Data General (DG) commented: “I constantly study the way larger companies organize themselves looking for ideas. I look at Texas Instruments, at IBM, at ITT, and at GE and GM.”²⁵³ Relying on interviews with industry executives, Saxenian describes what she calls “hierarchy and formalism” in the companies of Route 128. Managers conceived formal decision-making processes, conservative workplace procedures and work styles.²⁵⁴ “Vertical lines of decision-making authority ensured that flows of information and communications were formal and hierarchically controlled. Corporate Divisions were generally subject to the final

²⁵¹ Gilson *supra* note __, at 591-592.

²⁵² SAXENIAN, *supra* note __, at 128, 70.

²⁵³ *Id.*

²⁵⁴ *Id.* at 73-74.

authority of a central office.”²⁵⁵ There was a system of corporate ranks where salaries, benefits, and authority relations created barriers between functions.²⁵⁶

As we have suggested centralized structures tend to operate by means of knowledge-substitution mechanisms, which may not be efficient to promote the diffusion of knowledge in firm’s structure and to foster knowledge of Ki type. So the internal governance structure of the firm may well have affected the generation and development of new knowledge and products.

2. *Employee Stock Option Plans As An Alternative Means to Binding Knowledge to the Firm*

Authors typically view stock option grants as a means for containing agency costs and aligning the incentives of managers (the agents) with those of the shareholders (the principals). Stock option grants, according to these proponents, is the “the best compensation mechanism we have” for “getting managers to act in ways that ensure the long-term success of their companies.”²⁵⁷ Thus critics of stock options plans in the wake of recent executive pay scandals²⁵⁸ who focus exclusively on incentive alignment grouse that the spread of stock option grants to employees “had the effect of transferring a growing portion of the future value of the company from the hands of shareholders into the hands of employees and managers.”²⁵⁹ Such critics single out especially the much higher percentage of outstanding stock devoted to stock option plans in the high tech industry, as compared with general industry companies who typically restrict stock options to executives: “the percentage of outstanding stock devoted to stock option plans increased dramatically, rising from 3 to 5 percent in 1990 to 12 to 15 percent among general industry companies in 2001. In high-technology companies the average is much higher – 18 to 25 percent, with some companies as high as 30 to 40 percent.”²⁶⁰

When viewed from the knowledge-based perspective, however, the extension of stock options to mid- and lower-level knowledge workers in the high tech sector serves the goal of binding knowledge to the firm, as well as giving employees ownership-type stakes in the firm that have the effect of flattening the organizational hierarchy in a manner suitable to the knowledge-intensive environments of high tech production. Stock options for employees in the high tech sector (in which broad employee stock options plans prevail)²⁶¹ have a different purpose and function than stock options for executives in other sectors, who rarely have any

²⁵⁵ *Id.* at 76.

²⁵⁶ *Id.* at 77.

²⁵⁷ Hall, *supra* note __, at *2. Hall also believes that options are “the best compensation mechanism we have for getting managers to act in ways that ensure . . . the well-being of their workers and stockholders,” but he lumps together the stock options for executives with broad ESOPs without recognizing their distinct tendencies. Note that the view that stock options provide incentives to managers (reducing agency costs) is based on an agency-cost explanation of stock options. Paul Oyer & Scott Schaefer, *Why Do Some Firms Give Stock Options to All Employees?: An Empirical Examination of Alternative Theories*. 76 JOURNAL OF FINANCIAL ECONOMICS 99 (2005).

²⁵⁸ See, for example, most recently the stock options back-dating scandals. *The Perfect Payday. Some CEOs Reap Millions by Landing Stock Options When They Are Most Valuable. Luck – Or Something Else?* WALL STREET JOURNAL, March 18, 2006.

²⁵⁹ DELVES, *supra* note __, at 39.

²⁶⁰ *Id.*

²⁶¹ See generally BLASI ET AL., IN THE COMPANY OF OWNERS (2003).

incentive to leave their positions voluntarily, and whose centralized power of the company is only underlined by outsized compensation packages and huge stock options awards. Further, there are ways for executives to side-step the incentive-structure of stock options awards, for example, by accelerated vesting of their own awards (so long as the board agrees). Stock options for employees in the high tech industry in which they prevail are aimed at retention of knowledgeable employees.²⁶² In addition they are viewed as a crucial tool for startups in the high tech industry and smaller firms with limited capital to attract talent. These knowledge management considerations were neglected in the wake of the recent executive pay scandals.

Employee stock options plans typically specify that the options only vest on some future date (for a period of years) and can only be exercised while the employee is employed by the company. Thus, stock options act as a mechanism to bind employees to the firm (and thus avoid *leakage*). A recent empirical study by Oyer and Schaefer investigates alternative explanations for stock option compensation in the high tech sector but concludes by rejecting the agency cost explanation that has been broadly adopted. This study analyses three alternative explanations for stock options:

1) Agency Theory Explanation. Stock options provide incentives to employees. They attach the employee's wealth to the value of the firm in order to overcome agency problems and motivate the employee to perform according to the firm's interest.

2) Sorting Explanation. Stock options induce employees to sort. Employees differ in their beliefs regarding firm's prospects. Options attract optimistic employees, willing to take the risk, and reduce overall compensation costs for the firm.

3) Retention Explanation. Stock options help firms retain employees. Options are a form of deferred compensation. They have a vesting period attached that increases the costs to employees of departing from the firm. Options thus help firms retain employees.²⁶³

²⁶² The "retention" explanation better explains empirical evidence according to Oyer & Scott. *Id. See, e.g.*, the following Associated Press account of the debate on the new FASB requirement that stock options be expensed beginning in 2005:

Proponents of mandatory counting of stock options as an expense, including Federal Reserve chairman Alan Greenspan and billionaire investor Warren Buffett, argue that without it investors will continue to get misleading information on companies' financial performance. Awarding options to executives, which can be sold within a short time, gives them an incentive to recklessly pump up the stock price without regard to the company's long-term future, proponents say.

"But business interests -- especially high-tech companies that are generous campaign donors to both parties -- stiffly oppose such a change and their allies in Congress are moving against it. They are predicting dire consequences for high-tech, biotechnology and startup companies, and the U.S. economy, if businesses are required to treat employee stock options as an expense.

"Rank and file employees would be the ones who lose out,' Rep. Anna Eshoo, a California Democrat whose district embraces Silicon Valley, testified at a House hearing.

"Broad-based stock option plans have turned employees into corporate partners by tying the interest of the employee together with the company and its shareholders,' Eshoo told the House Financial Services subcommittee on capital markets. "Small, entrepreneurial companies with little or no capital use stock options to attract and retain bright and talented employees critical to that company's success."

Possible Stock Option Bans Split Congress, AP, June 4, 2004.

²⁶³ Oyer & Schaefer, *supra* note __, at __.

The study sample encompasses firms that offer broad-based stock option plans. The study focus is on options offered to middle-level executives. These plans tend to be adopted at small firms knowledge intensive firms. Oyer and Schaefer remark that new economy firms (that manufacture computers, semiconductors, telephone equipment, create software, or computer-related products) make up a substantial portion of the firms with broad stock options plans.²⁶⁴

Oyer and Schaefer reject the incentives-based (agency-cost) explanation for broad-based stock option plans, because the risk premium stemming from option-based pay dwarfs the cost to the employee of the associated increase in effort. If effort were contractible, the employee would be willing to exert additional effort for a payment dramatically smaller than the risk costs imposed on the firm by providing stock options.²⁶⁵ Given the existence of other means to evaluate subjective performance and to reward employees for the value they create, the authors conclude that stock options appear to be a very inefficient means to provide incentive to employees.²⁶⁶

Interestingly, sorting and retention explanations are consistent with the data. The authors regard sorting or retention first-order determinants of the decision to adopt a broad-based stock option plan. They believe that “firms that adopt broad option plans are those where the returns to cost effectively attracting and retaining employees is particularly high.”²⁶⁷ Skill-based industries, such as new economy firms, which rely on the intensive use of knowledge to deliver their services, are significantly more likely to grant stock options than other firms.²⁶⁸

New economy firms tend to face more difficulty in hiring enough talented people.²⁶⁹ So firms need to pay special attention in designing incentives and compensation packages that will be suitable to stimulate employees to stay in the firm. While firms may design several packages of deferred compensation, granting options to workers that have higher skill levels is certainly one mechanism that serves the purpose of binding knowledge to the firm.²⁷⁰

²⁶⁴ *Id.* at 9.

²⁶⁵ *Id.* at 23.

²⁶⁶ *Id.* at 23. Stock options-as-incentives could perhaps be a sensible explanation under a very limited set of circumstances, where employees have the power to take actions that have large value implications for the firm, at very limited cost to the employees taking such actions, and where it is extremely difficult for firms to monitor such employees.

²⁶⁷ *Id.* at 43. In order for the sorting explanation make sense, it must be the case that employees strictly prefer the observed salary plus options to all-cash package. At a expected return of 25% annual stock appreciation, the employees at nearly all the firms of the sample value their options packages significantly more than they would value comparable all-cash package. Authors believe this explanation to be significant. *Cf.* Hall, *supra* note __, at __. (“Adobe Systems, Apple Computer, E*Trade, Netscape, PeopleSoft, and Sybase have all repriced their options in recent years, despite the bad will it creates among shareholders. As one Silicon Valley executive told me, “You have to reprice. If you don’t, employees will walk across the street and reprice themselves.”) This shows that retaining employees is a first-order concern in Silicon Valley firms.

²⁶⁸ *Id.* “The fact that firms with higher volatility and in the new economy are more likely to have option plans could also be consistent with the retention model if market wages vary more for volatile firms or firms in the new economy.”

²⁶⁹ *Id.* p. 42.

²⁷⁰ *See also* Rebitzer & Taylor, *supra* note __, at 27. “In high technology firms, many of the key assets of the enterprise are bound up in the brains of crucial employees. Property rights to some of these intellectual assets can be secured through patents or copyrights. When adequate control *cannot* be attained through intellectual property

Industry leaders believe that, in an environment of intensive competition for highly mobile employees trained in hardware and software engineering, stock options in Silicon Valley “act[ed] like financial magnets, binding employees to their companies for the long term.”²⁷¹ As John Chambers, the CEO of CISCO Systems recognized that “[n]ot long ago . . . the output of machines was the fundamental driver of competitive advantage. We taught our managers to focus on physical assets, the cost of capital, and the value chain. Successful companies built more, for less. In the internet economy, the dynamics are radically different. Intangible ideas – the output of people, in an economic sense – are the drivers of competitive advantage.”²⁷²

CISCO’s extensive stock option plans were based on the understanding that acquiring and retaining human capital was key to success in the high tech industry: “Each year Cisco gives employees the right to purchase \$25,000 worth of company stock at 15 % off the opening or closing price of the previous six months, whichever is lower.”²⁷³ In stark contrast to the confinement of stock options to executives in the more traditional public corporations, CISCO’s stock options plan typically gives nonexecutives more than 90 % of all options handed out.²⁷⁴

One analysis based on a benchmark group of the top 100 largest internet-based companies by revenue shows that “[ninety-eight] of these companies handed out options to at least 51 percent of their employees, compared with just six percent in a group of comparably sized, mostly non-tech companies traded on the New York Stock Exchange.”²⁷⁵ So the distinction between stock options for executives and stock options for employees deserves particular attention for the use that high tech companies have made of stock options seems very different from the way they were used mainly as an executive compensation tool in the rest of the economy.

Employee stock option plans became a central feature of the high tech firm culture in Silicon Valley. They resulted from a mixture of intense competition for talent, the need to bind tacit knowledge to the firm in face of the regulatory regime, and a drive for recognition on the part of talented scientists and other well-trained employees working in the

tights, one should expect to see innovations in the employment relationship that reduce the firm’s vulnerability to losing valuable assets. In some instances, high technology companies reduce the incentive of key “knowledge workers” to leave through the use of stock options and other forms of deferred compensation that become dramatically less valuable when the employee exits the firm.”

²⁷¹ BLASI, *supra* note __, at 42; DELVES, *supra* note __, at 40 (“Like many other technology companies, the chip maker [Intel] has used options heavily as a recruiting and retention tool”) (citing *The Wall Street Journal*).

²⁷² Speech of John T. Chambers, quoted in BLASI, *supra* note __, at 37.

²⁷³ Blasi et al., *In The Company Of Owners* 53 (2003).

²⁷⁴ *Id.* at 53-4. Chambers took over as CEO in the mid-1990s after working at Wang Labs and IBM, both traditional corporate hierarchies with top-down cultures, which he regarded as imposing significant constraints on creativity and innovation. At CISCO Chambers was committed to making the Silicon Valley business culture a principal resource. Part of CISCO’s strategy under Chambers has been “to use stock options and a bottoms-up culture of employee ownership to propel phenomenal growth in the late 1990s much of it stemming from the acquisition of other small startups.” *Id.* at 52. Chambers said in 2000: “Our industry is not like the banking industry where you are acquiring branch banks and customers. In our industry, you are acquiring people. And if you don’t keep those people, you have made a terrible, terrible investment . . .” *Id.* at 54.

²⁷⁵ *Stock Options Benefited Workers*, San Jose Mercury News, 1/10/2003, available at www.mercurynews.com (last visited 7/10/2004).

private sector. The ownership stake afforded to workers in high tech firms supported nontraditional, decentralized decisional structures.²⁷⁶ Such changes, in turn, promoted the creation of fertile environments for knowledge production in an industry that required constant and rapid knowledge innovation. Thus, stock options also served to avoid the knowledge hazard of *hoarding* or failure on the part of an employee to fully disclose his knowledge at work.

The change in ownership structure due to the need to bind tacit knowledge to the firm thus altered not only decisional hierarchies, but also information flows within the firm. [It furthered bottom up decision making and innovation and frequently blurred the lines between worker and management.²⁷⁷ Finally, giving employees a greater stake and voice in the management of the firm can serve as an effective workplace monitoring device. Knowledge of what goes on in the workplace is as crucial to monitoring as is the actual incentive to monitor. But independent monitors don't have the same access to everyday problems as do the employees themselves.²⁷⁸

While such anecdotal evidence has its limits, and the alternative business culture in Silicon Valley, to be sure, generates its own counterproductive tendencies,²⁷⁹ it is not in dispute that quite different organizational structures and financial arrangements characterize the

²⁷⁶ See SAXENIAN, *supra* note __, at __; Stiglitz, *Public Policy for a Knowledge Economy*, (World Bank, Jan. 27, 1999), available at <http://www.worldbank.org/html/extdr/extme/jssp012799a.htm>, at 1 (“the shift towards a knowledge-based economy involves a shift in organization away from top-down hierarchical structures to flatter structures such as networks of semi-autonomous teams. Tayloristic vertical structures were designed to enforce and coordinate certain physical behaviors while knowledge-based work organization involves greater recognition of the autonomy and self-direction of the mind.”).

²⁷⁷ BLASI, *supra* note __, at 40, 45. The following anecdotal evidence describes what has been termed the new “partnership capitalism” reflected in such high tech firm culture: “Employees come to see taking important issues right to the door of management as appropriate, even to the door of the top executive. In fact, some companies already have a term for walking problems and issues up to management. They call it escalation, as in “She felt she had to escalate the issue, to bring it to the attention of the decision-maker who could sort the problem out.” “Sometimes, if an issue is important enough and involves the broadest interests of the company, an employee may even take it directly to the CEO. Jack, the Portal employee, told us how that very morning he had talked to John Little, the company’s founder and CEO. His advice: Portal desperately needed a chief operating officer, someone to take over the day-to-day job of running the company. Jack felt that the task had become too much for Little now that the company had grown to 1,500 employees.” “My exercise price [on my options] is way lower than some of the other people at this table. So I can make a lot of money even at \$8.81 a share [the price Portal’s stock was trading at that day]. But a fifty- or sixty- or seventy-dollar stock price to me means a hell of a lot. So I’m willing to talk to the CEO and tell him things that might in any other job limit my career. I wasn’t afraid of doing it, escalating it, because of my strong financial stake.” In early 2002, Portal did indeed create the position of President and Chief Operating Officer.” *Id.*, at 46. While Portal was one of the companies that suffered a melt-down in 2000 & 2001, and is cited as an example of a “dark side” the late-1990s tech boom, workers below top management nevertheless benefited. *Stock Options Benefited Workers, San Jose Mercury News, 1/10/2000*, at www.mercurynews.com (last visited 7/10/2004) (“Even when tech stocks were melting down in 2000 & 2001, workers below top management pocketed an estimated \$25 billion – or an average of \$125,000 – at companies that ranged from stalwarts such as CISCO Systems and Yahoo to flame-outs such as Excite@Home and Portal Software.”); *How Portal leaders reaped a Huge Windfall*, Dec. 9, 2002, at www.mercurynews.com (last visited 7/10/2004).

²⁷⁸ BLASI, *supra* note __, at 43. For example, at a Palo Alto, California, company named Tibco Software Incorporated, a thirty-something events planner named Jennifer told us: “When you have ownership in the company, you . . . watch costs. We’re going to Hawaii next week for a sales trip. Well, one person didn’t get their travel [arranged] . . . so I called him and said: ‘What are you doing, book your travel, if you wait your ticket is going to be so much higher.’ You’re constantly watching that stuff when you’re an owner.

²⁷⁹ See, e.g., DELVES, *supra* note __, at 40-41 (discussing the “skewed incentive system” set up by the get-rich-quick culture of high tech start-ups).

Silicon Valley high tech firms.²⁸⁰ Employee stock options are widely regarded as an essential component to the partnership-style organization of these firms. We suggest that this concern with designing compensations packages in a way to retain key employees was knowledge-based driven. But, it could be argued that the main reason why the firms were adopting broad stock options plans was accounting-driven instead of knowledge-driven. In such reasoning, firms were issuing stock options because they had accounting incentives to do it, because of the non-expensing rule at that time.²⁸¹ But then, if this incentive was the same for all the companies why just a few companies really adopted stock options as a broad plan available to non-executive employees as well? Most companies did give stock options to their executives – trend well documented – as there was an explosion in stock options.²⁸² But why some companies, instead, gave options not only to managers, but also to other employees? The accounting-driven view cannot explain why there was a difference in the pattern of stock options distributed – namely to non-executive employees in some high tech firms.

While the accounting rules may well diminish the incentives for firms to adopt broad stock option plans as a compensation mechanism,²⁸³ we conjecture that if stock options are an efficient way of binding *K_i*, they should continue to be used by high techs regardless of the expensing rule. Alternatively, managers may try to design alternative compensation plans based on deferred compensation in order to substitute stock options. If our view is accurate, high tech firms must employ some mechanisms to provide sufficient incentives in order to retain key employees.

E. Law Firms

Several commentators have argued that human capital is the most important asset of law firms.²⁸⁴ Based on our theory, we expect to find that key features of the internal organization of law firms can be explained by the need to allocate human knowledge resources efficiently. The literature, however, has so far underestimated the impact of knowledge allocation on the structure of law firms.

²⁸⁰ Among the voluminous literature on the subject, *See, e.g.*, SAXENIAN, *supra* note __, at 128.

²⁸¹ Under rules initially published by the Accounting Principles Board (ARB) – the precursor to the Federal Accounting Standards Board (FASB) – stock options did not need to appear as an expense on a corporation's income statement, so long as they met certain criteria such as having a fixed exercise price and a fixed number of shares. DELVES, *supra* note 130, at 44 (citing APB Opinion 25). This meant that they were essentially free. Allowing companies to take the expense of stock options off their expense sheets to be sure, inflated earnings thus making such companies look much more profitable than they actually were. This in effect created a significant subsidy in the form of the correspondingly lower cost of capital available to high tech firms.

²⁸² *See e.g.*, LUCIAN BEBCHUK & JESSE FRIED, PAY WITHOUT PERFORMANCE. THE UNFULFILLED PROMISE OF EXECUTIVE COMPENSATION __[__].

²⁸³ After years of fruitless attempts to change the rules to require expensing of stock options in order to correct for the distortion of firm values, the FASB, in the wake of the dot.com bust and corporate compensation scandal in 2001/2002, presented Congress with a rule require expensing since in 2005. In addition to the new accounting rules, the SEC signed off on new stock-exchange rules (passed by the NYSE and the NASDAQ), that will require putting stock options and other compensation plans to a shareholder vote. Representatives from Silicon Valley firms strongly argued that the new accounting rules would harm their ability to recruit and retain employees.

²⁸⁴ Ronald J. Gilson, Robert H. Mnookin, *Sharing Among the Human Capitalists: an Economic Inquiry into the Corporate Law Firm and How Partners Split Profits*, 37 STAN. L. REV. 313, 324 (1985), Ronald J. Gilson & Robert H. Mnookin, *Coming of Age in a Corporate Law Firm: the Economics of Associate Career Patterns*, 41 STAN. L. REV. 567, 570 (1989).

Gilson and Mnookin's portfolio and agency theory approach to law firm structure provides an example. Gilson and Mnookin argue that diversification provides an explanation for the existence and structure of large law firms. On their theory, law firms eliminate unsystematic risk by diversifying the areas in which they provide legal services.²⁸⁵ From this perspective, when an individual lawyer is admitted to partnership he exchanges his human capital for participation in a diversified portfolio with respect to the personal characteristics of lawyers and their expertise in the firm.²⁸⁶ The diversification will be achieved by sharing the future income of the firm equally between the partners according to a seniority system.²⁸⁷ Gilson and Mnookin argue that law firm organization is shaped by the effort to diversify and the difficulty of doing so.²⁸⁸

Gilson and Mnookin further posit that "it is striking just how well diversified the portfolios of established firms are,"²⁸⁹ although they do not provide evidence for this claim. Whether law firms are really diversified is a question that can be answered only by the empirical evidence. In a recent empirical study, sampling all law offices in the United States, Garicano and Hubbard analyze confidential office-level data from the 1992 Census of Service on the hierarchical organization of law firms and on field-specialization by attorneys and firms. Their results show that "[l]awyers are more likely to work at the same firm with lawyers in the same field than in any other field."²⁹⁰

Garicano and Hubbard find evidence that a firm's boundaries narrow as lawyers specialize in ex-post fields (resolving disputes):

We also find that lawyers in ex ante fields that serve business demands tend to work at the same firm as lawyers in any of the ex ante business fields, and tend not to work at the same firm as lawyers in either ex post business fields or fields that serve individual demands. For example, specialists in corporate law tend

²⁸⁵ Ronald J. Gilson & Robert H. Mnookin, *Sharing Among the Human Capitalists: an Economic Inquiry into the Corporate Law Firm and How Partners Split Profits*, 37 STANF. L. REV. 313 (1985). The authors argue that a portfolio composed of a sufficient number of assets will neutralize the effects of an event that lowers the value of one asset by a favorable impact of the same event on the value of other assets. If the portfolio is fully diversified it will not be subject to unsystematic risk. Therefore, a law firm that can diversify the areas in which it provides legal services, can reduce its exposure to unsystematic risk. Equity owners of a law firm thus can achieve gains from the diversification of their human capital, just as securities investors can achieve gains from the diversification of their securities portfolio.

²⁸⁶ Ronald J. Gilson & Robert H. Mnookin, *Sharing Among the Human Capitalists: an Economic Inquiry into the Corporate Law Firm and How Partners Split Profits*, 37 STANF. L. REV. 313 (1985), p. 342.

²⁸⁷ See *id. ibid.*, p. 339–343.

²⁸⁸ *Id.*, p. 322-323. Gilson and Mnookin argue that "... the creation of a full-service law firm – an agreement among lawyers that each will make human capital investments in different specialties and that the return to those investments will be shared on a predetermined basis rather than in accordance with actual outcomes – can be understood as an institutional innovation that allow lawyers to take advantage of gains from diversification." (p. 329). The authors give an example of a securities and a bankruptcy lawyer, arguing that when there is a bear market the lack of business in the securities area will be counterbalanced by the increase of work load in the bankruptcy area and vice-versa.

²⁸⁹ *Id. ibid.*, p. 342.

²⁹⁰ Luis Garicano & Thomas N. Hubbard, *Specialization, Firms, and Markets: The Division of Labor Within and Between Law Firms*, Univ. Chic. Law & Econ. Olin Working Paper No. 213, available at 213. Available at SSRN: <http://ssrn.com/abstract=404280>, at 2.

to work at the same firm as specialists in real state law, but not specialists in insurance or criminal law.²⁹¹

This evidence is contrary to Gilson and Mnookin's explanation of law firms' organization based on diversification and risk-avoidance. The evidence suggests that the typical law firm has a very imperfectly diversified portfolio at best. Law firms may diversify across specializations with a given legal field. This occurs, for instance, in the area of business law. Even in business law, however, firms seem to specialize in either ex-ante or ex-post legal services, that is in either consulting or litigation, but not both.²⁹² A firm that provides services in securities law for the purposes of performing an IPO is less likely to also provide securities litigation services for the same client than a different firm. This decreases the explanatory power of the diversification theory, because a well-diversified firm would want to offer the right balance between ex-ante and ex-post legal services. In times of recession, litigation tends to be more profitable than consulting and other ex-ante transaction fields. One would thus expect an optimum mix between ex-ante and ex-post areas if law firms aimed at portfolio-type diversification. But such a business mix is not borne out by the average practice.

The fact that ex-ante and ex-post legal services are mostly provided by different firms seems to point to a story based on knowledge specialization. This is also consistent with the existence of law firms specializing in different types of litigation. Litigation work requires mastering a body of legal knowledge and interactional skills (litigator vs. negotiator of transactions vs. regulatory compliance counselor) which are very specialized, producing gains from knowledge specialization.

The data also reveal that specialists in patent law tend not to work together with specialists in any other field.²⁹³ They tend to work in firms specializing solely in intellectual property. Garicano and Hubbard conclude that “[b]roadly, these patterns provide no support for the hypothesis that law firms’ field boundaries strongly reflect the risk-sharing benefits of revenue-sharing arrangements. Lawyers in the same field or fields where demands are closely related tend to work at the same firm more than lawyers in fields where demands are less closely related.”²⁹⁴ Portfolio theory may provide an explanation – albeit a very incomplete explanation – for the organization of a small number of large law firms that service large corporations. But it does not explain why the average law firm is specialized rather than diversified.

A final piece of data derived from the research conducted by Garicano and Hubbard is revealing. According to the study, 28 percent of law firms are specialized in a single field.²⁹⁵ The fact that such a significant number of law firms operate in one single area clearly points to specialization as an important factor in the structure of law firms. The empirical evidence available on boundaries of law firms thus suggests a knowledge-based explanation. Garicano and Hubbard advance a knowledge-sharing explanation of law firm structure and develop a model of hierarchy in which increasing returns are associated with the utilization of

²⁹¹ Garicano & Hubbard, *supra* note ____, at 2.

²⁹² Specialists in ex ante business law tend to work in the same firm as one another. According to the authors' definition, business law includes banking, corporate, governmental, environmental, tax and real state law, but at 27.

²⁹³ Garicano & Hubbard, *supra* note ____, at 27. The only exception found by Garicano and Hubbard is that specialists in probate law tend to work in the same firm with ex ante business specialists. *Id.*

²⁹⁴ *Id.*, at 27.

²⁹⁵ *Id.*, at 14.

knowledge. Specialization and hierarchical organization, according to the Garicano and Hubbard, reflect an optimal use of costly knowledge resources.²⁹⁶ Lawyers are more likely to work together within the same firm when knowledge sharing provides added value. Knowledge sharing can take the form of collaboration and referrals.²⁹⁷ When knowledge sharing is less valuable, lawyers may opt to work separately and cooperate where desirable through market exchanges.

1. *A Knowledge-Based View Of The Organizational Structure Of Law Firms*

The data supports our theory that firm structure is influenced by the efficient allocation of knowledge resources.

We have hypothesized that when firm production relies more on *Ki*, the organizational structure of a firm will be less hierarchical. Because law firms rely primarily on human capital, or *Ki*, we should expect that law firms will have flatter hierarchies compared to firms in other industries.

This is indeed the case. According to Garicano and Hubbard's data, 73% of law offices have no associates. These "non-hierarchies" include single-lawyer offices and offices where there are several lawyer partners.²⁹⁸ The authors report that associate/partner ratios are low, even when the analysis is restricted to law firms that serve primarily business clients and have at least one associate.²⁹⁹ Nineteen percent of all law offices have associate/partner ratios greater than zero and less than or equal to one. Only eight percent of all law offices have associate/partner ratios greater than one.³⁰⁰ This shows that law firms have very flat hierarchies, a consequence that we infer from the predominant type of knowledge used in its production process, that is, knowledge embedded in individuals (*Ki*).

An interesting finding from this vantage point is that a law firm's level of hierarchy correlates with the degree to which its lawyers are field-specialized.³⁰¹ In other words, hierarchical organization reflects the human capital that lawyers bring to the table. The share of lawyers who field-specialize is directly proportional to the associate/partner ratio of the firm. The level of field-specialization tends to be higher at offices where the associate/partner ratio is greater. According to the data, it increases from 45% at offices where the associate/partner ratio is zero to over than 80% at offices where the ratio is at least one.³⁰² When the lawyer specializes, she is expected to be more knowledgeable in her field of expertise, an important

²⁹⁶ Luis Garicano & Thomas N. Hubbard. *Hierarchies, Specialization, and the Utilization of Knowledge: Theory and Evidence from the Legal Services Industry*, (March 2004). Univ. Chic. Law & Econ. Olin Working Paper No. 214, available at SSRN: <http://ssrn.com/abstract=533183>, at 2. ("Hierarchies enable individuals to increase the utilization of expert knowledge by shielding experts from simple problems and allowing them to specialize in problems they have a comparative advantage in addressing.")

²⁹⁷ Garicano & Hubbard, *Specialization, Firms, and Markets*, *supra* note ____, at 9.

²⁹⁸ Garicano and Hubbard, *Hierarchies, Specialization, and the Utilization of Knowledge*, *supra* note ____, at 5.

²⁹⁹ *Id.*, at 6.

³⁰⁰ *Id.*

³⁰¹ *Id.* Field-specialization occurs when a lawyers work primarily in one of the thirteen fields defined by the Census (e.g. corporate, tax, probate law).

³⁰² Garicano and Hubbard, *Hierarchies, Specialization, and the Utilization of Knowledge*, *supra* note ____, at 6.

condition for her to be a partner held responsible of the quality of the service provided. The augmentation in hierarchical levels is thus explained by the increase in disparity of knowledge that individuals possess.

So the data shows that even within the flatter hierarchies of law firms we can identify gradations of knowledge among employees and a corresponding hierarchy of decision making authority. Accordingly, our typology can accommodate the fact that law firms, which rely predominantly on K_i , have hierarchies too, by distinguishing among individuals with varying degrees of technical or context specific knowledge (K_i^- , K_i , and K_i^+). When applying the principle of efficient knowledge allocation, we would expect to find the most knowledgeable employees (K_i^+) in top positions of a firm's hierarchy, and less knowledgeable employees (K_i ; K_i^-) at lower levels. We would expect individuals with greater expertise to engage in significant "knowledge substitution", guiding the behavior and decision making of those less knowledgeable, while conserving their own time by allowing those less knowledgeable to make judgments that are appropriate for them to make without the involvement of more senior personnel.³⁰³

Law firms that follow the "Cravath system" fit this pattern. They have traditionally had partners and associates.³⁰⁴ This distinction marks the attorney's position in the firm hierarchy the relative distribution of knowledge and experience, and corresponds to a division of labor.³⁰⁵ Partners direct, guide, coordinate, train, and monitor the quality of associates' work. Partners exert decision making authority in law firm matters and get (most of) the residual claims. Associates engage in tasks requiring less knowledge and experience, that are also more routine.³⁰⁶ Further, the associateship functions as a kind of apprenticeship.³⁰⁷ At the time of the initial hiring decision, the law firm does not yet foresee which associates will develop enough knowledge and personal attributes that the firm requires in a partner.³⁰⁸ The associate's legal skills, ability to deal with existing clients and attract new ones is judged during the associateship period to determine whether he or she has the qualities necessary to become a partner. In our framework, the associate thus has K_i^- or K_i , whereas the partner, who is more knowledgeable, has K_i^+ .

While law firm hierarchies are flat when compared with firms in other industries, there is thus nevertheless a hierarchy based on observed differences in K_i among the various

³⁰³ Another example of flatter hierarchies would be universities. The distinction between tenure and untenured professors is also based on the amount of knowledge and personal experience that professors have. In order to manage this knowledge in an efficient way universities shaped their organizational structure by creating a system in which tenured professors are guaranteed stability through the privilege of tenure as well as greater decision rights than untenured professors.

³⁰⁴ Ronald J. Gilson, Robert H. Mnookin. *Coming of Age in a Corporate Law Firm: the Economics of Associate Career Patterns*. Stanf. L. Rev. 567 (1989). P. 567

³⁰⁵ Luis Garicano & Thomas N. Hubbard. *Hierarchies, Specialization, and the Utilization of Knowledge: Theory and Evidence from the Legal Services Industry*. (March 2004). U Chicago Law & Economics, Olin Working Paper No. 214. Available at SSRN: <http://ssrn.com/abstract=533183>, p. 5.

³⁰⁶ Ronald J. Gilson, Robert H. Mnookin, *Sharing Among the Human Capitalists: an Economic Inquiry into the Corporate Law Firm and How Partners Split Profits*, 37 STANF. L. REV. 313, 359 (1985).

³⁰⁷ Ronald J. Gilson, Robert H. Mnookin. *Coming of Age in a Corporate Law Firm: the Economics of Associate Career Patterns*. 567 STANF. L. REV. 574- 577 (1989).

³⁰⁸ Ronald J. Gilson, Robert H. Mnookin. *Coming of Age in a Corporate Law Firm: the Economics of Associate Career Patterns*. 567 STANF. L. REV. 573 (1989)..

knowledge workers in the firm, as our theory predicts. Because the firm must allocate knowledge resources efficiently, it will give decision making authority to the partner who is more knowledgeable, able to make better decisions, and to coordinate the work of associates. When associates gain knowledge their decision making authority increases, they are gradually less supervised, afforded greater autonomy, and are charged with supervising the work of lower-level associates.

To summarize, the “Cravath system” gives greater decision making authority and greater residual claims to the lawyers who have the greater knowledge and experience. The partners retain control over client relationships, they concentrate the most complex work in their own hands and they train, supervise and monitor associates. Partners have a surplus of human capital. They lend this surplus out and monitor associates (human capital sharing). Younger associates borrow knowledge distributed by senior partners until they develop their own professional expertise. Partners who concentrate greater knowledge in their hands are the residual claimants of the partnership. In contrast, associate lawyers with less knowledge tend to receive a fixed salary.³⁰⁹

More associates are hired than can be promoted to the partnership, and many associates will be dismissed before they acquire sufficient client knowledge to “grab and leave”. Rebitzer and Taylor argue that organizational features such as the use of “up-or-out” promotion contests and the practice of having winners become residual claimants in the firm, emerge as a consequence of the knowledge intensive setting in which these firms operate.³¹⁰ The winners of the promotion contest become partners, with residual claims, because this solves the problem of binding knowledge assets to the firm.³¹¹

Associates tend to be promoted into the partnership or dismissed, in order to avoid their acquisition of a key knowledge asset, the long-term client relationship. This practice reduces the risk of leakage of client knowledge. Associates tend to leave the firm as soon as they find out they will not be promoted, and law firms even help their associates find new jobs. However, if the firm can limit direct contact between clients and associates (and limit associate work experience) by restricting their work (and learning) to small pieces of more complex

³⁰⁹ See Ronald J. Gilson & Robert H. Mnookin, *Sharing Among the Human Capitalists: an Economic Inquiry into the Corporate Law Firm and How Partners Exploit Profits*, 37 STAN. L. REV. 313 (1985). See also, Ronald J. Gilson & Robert H. Mnookin, *Coming of Age in a Corporate Law Firm. The Economics of Associated Career Patterns*, 41 STAN. L. REV. 567 (1989).

³¹⁰ James B. Rebitzer & Lowell J. Taylor, *When Knowledge Is an Asset: Explaining the Organizational Structure of Large Law Firms*, September 2001, at 3. Working Paper on file with authors. (“Attorneys are “knowledge workers”, who differ from other employees because they carry around many of the firm’s assets in their brains. The knowledge assets these lawyers control - an understanding of the needs and interests of clients - are obviously of greatest value when used with specific clients. This specificity gives individual attorneys considerable leverage over their employers. By threatening to “grab and leave” with an important client, attorneys can leverage an increased share of their firm’s revenues. The up-or-out partnership system found in large law firms has evolved over time as a workable resolution to this particular problem. By forming partnerships and firing experienced attorneys who are not promoted to partnership positions, law firms limit the opportunity for experienced attorneys to grab and leave with the firm’s valuable clients. Grabbing and leaving is more important in legal partnerships than in conventional firms because law firms cannot readily establish property rights over the knowledge essential for serving particular clients.”).

³¹¹ *Id.*, at 4: (“net worth is tied to the knowledge of it’s senior employees.”).

operations, the length of the associate period can be increased. If client contact could be eliminated entirely, associates could be employed indefinitely by the firm.³¹²

Another organizational feature that can be explained from a knowledge efficient allocation perspective is the law firm's sharing model of compensation. Gilson and Mnookin defended the view that the sharing model serves the purposes of risk-sharing by splitting the profits on a predetermined basis to allow attorneys to take advantage of a "diversified portfolio" in their law firm's equity.³¹³ We propose a different explanation. Knowledge considerations suggest that profits are split so as to provide attorneys with the necessary incentives to pass on cases or clients they acquire to other attorneys within the firm who are more knowledgeable in the areas in which the services are being demanded; or share and consult with other more knowledgeable attorneys in the firm on such cases and clients. Where profits are shared, attorneys will direct clients to other attorneys within the firm who have more expertise in solving a particulate legal problem. Moreover, other attorneys in the firm will be more willing to devote their time and efforts to applying their knowledge in assisting another partner's clients where profits are split. This arrangement thus enhances efficient knowledge allocation within the firm in that each lawyer will have the proper incentives to perform those services for which she is most qualified. Otherwise lawyers would have incentives to supply services to clients regardless of expertise.

2. *The changing organizational structure of law firms*

The structure of law firms has been changing during the past 15 years. Law firm structure was characterized by only two categories of attorneys, partners and associates, but is expanding to include new non-equity partners,³¹⁴ special counsel, permanent or superannuated associates, staff attorneys, and contract attorneys. This expansion of different levels of personnel is in addition to the increase in different levels of paralegals and other layers of professional staff, such as word processors, IT personnel, practice support, etc. that have increasingly augmented large firm practice. These new professionals add new layers of hierarchy to the organizational structure of law firms.

What is striking from our point of view is that this expansion of law firm hierarchy is occurring in conjunction with the increasing reliance of law firms on a different knowledge type, that of knowledge embedded in products and machines (Kp) capable of being claimed or held by the firm as a kind of property.

Law firms have increasingly been storing knowledge in precedent information systems, client databases, and other sophisticated knowledge management systems. Thousands of drafts contracts, legal opinions, briefs and client specific data are stored in the larger law firms' proprietary electronic storage systems by the large corporate law firms. Departments of "Knowledge Management" have emerged to maintain internal databases and to train the professionals who will operate and use them. The knowledge base of large law firms has therefore been transforming from knowledge embedded almost exclusively in individuals (Ki) to knowledge embedded increasingly in information systems (Kp).

³¹² *Id.*, at 18.

³¹³ *Supra* note __, at __.

³¹⁴ Ronald J. Gilson, Robert H. Mnookin, *Coming of Age in a Corporate Law Firm: the Economics of Associate Career Patterns*, 41 STAN. L. REV 567 (1989).

While record keeping devices have always been used in one form or another, the new transformation of knowledge through internal precedent systems and other database resources special and internal to the firm increasingly accomplishes the separation of knowledge from the attorney. Knowledge is thereby standardized and made available to the next associate who can take up the case two years down the line to perform a particular task (e.g. write a brief, or summarize a past transaction, or prepare a term sheet based on client precedents), without prior experience in a particular case, or even firm style or format. All that the associate needs to know is how to use the precedent system in order to apply more general professional knowledge to the replication of a typical firm product by following the example. This dramatically reduces the need for partner involvement not merely in the initial stages of any project, but at every stage that can be sufficiently routinized and standardized. The separation of the knowledge through codification and standardization thus turns the work of attorney's into more of a production routine, and permits partners to assume a more managerial role with regard to their associates.

According to our theory, when Kp's importance increases in the productive process, the organizational structure of the firm will become more centralized and display steeper decisional hierarchies. This shift from Ki to Kp has indeed brought about a corresponding change in law firm decision making structures. In the new corporate law firm, low-level attorneys become more replaceable, as they increasingly rely on Kp to do their tasks. Thus large firms now hire large numbers of staff attorneys who, for example, organize documents and databases, retrieve documents, and help prepare document reviews. Staff attorneys can attend depositions, take notes and record information where necessary. But they perform only a limited number of specific tasks and exercise judgment – though perhaps very expert judgment -- only within limited parameters. Staff attorneys are directed by partners and associates or senior staff attorneys (who in turn are directed by partners) and tend to have no client contact at all. Staff attorneys also tend not to do any legal research at all. In order to provide the client with competitively priced services while maintaining high quality, large corporate law firms thus employ professional staff attorneys as assistants to associates. Such staff attorneys perform certain routine and standard tasks that do not require the knowledge and judgment demanded of an associate, in order to lower the cost of legal services by conserving more expensive associate and partner time. Staff attorneys are not on a partnership track. Thus their use has the added benefit of a potentially much more long-term relationship without the need to share residuals.

In addition to staff attorneys, large law firms also hire so-called contract attorneys to fill fluctuating demand for additional legal work that is much more mechanical even than the work completed by staff attorneys. In the litigation setting, for example, contract attorneys are hired as document “coders” to assist in processing the mammoth document productions characteristic of large, complex multi-party commercial disputes. Such coders are given specific instructions on identifying and coding documents in order to load them onto a database and render them searchable. Such work is mechanical work done at a computer terminal and controlled by software templates that permit only certain types of inputs.

We therefore observe that the hierarchy of law firms is becoming steeper and more centralized in those firms in which the ratio between partners and other professionals (including staff lawyers, contract attorneys and paralegals) is higher than it used to be. The embedding of knowledge in products has made many of these professionals who now perform more standardized routine work more easily replaceable, increasing the similarities between the structure of contemporary law firms and mass production firms. It is in this context, that many

of the large law firms have changed their business form and have moved from a partnership structure to the form of a limited liability corporation.

F. *The Implications of Knowledge Transfer for the Choice of Business Transactions*

A variety of motivations have been recognized for mergers and acquisitions, including for example such drivers as operating and financial synergy, portfolio diversification, and other strategies based on finance theory.³¹⁵ But traditional mergers and acquisitions theory does not make knowledge considerations central.³¹⁶ A knowledge based perspective, we argue, can provide important insights on why firms engage in a range of transactions, such as mergers and acquisitions, joint ventures and licensing agreements.

The literature has identified strength of intellectual property protections as a crucial variable in determining whether companies will purchase knowledge inputs (primarily in the form of Kp) through licensing agreements or whether they will produce them, either jointly or through integrating the activity. Anand and Khanna have argued that licensing occurs in industries with strong intellectual property protections, but that joint ventures “should be more likely to occur in industries with weak IPRs [intellectual property protections] to the extent that it is easier to monitor and control the activities of partners in such arrangements than via arms-length licensing contracts.”³¹⁷ Arora and Merges argue that if there are strong patent protections related to a technological input, spin-offs would be more likely, because the benefits from greater customization afforded by the independent research firm would outweigh rent dissipation by the spin-off.³¹⁸ According to this literature, markets for technology depend significantly on intellectual property protections. Thus, it is only because technological innovation can be protected, even if imperfectly³¹⁹, that markets for technology can develop and flourish.³²⁰

³¹⁵ RONALD GILSON & BERNARD S. BLACK, *THE LAW AND FINANCE OF CORPORATE ACQUISITIONS*, 259ff. (discussing the theoretical sources of operating synergy such as economies of scale, economies of multiplant operation, economies of scope and others).

³¹⁶ Generally knowledge problems are indirectly treated under the more general heading of “synergies,” or “economies of scope”. Problems of knowledge hazards have been developed by studies mainly in the management area. See e.g. the excerpt by David Teece, *Economies of Scope and the Scope of the Enterprise*, in GILSON & BLACK, *THE LAW AND FINANCE OF CORPORATE ACQUISITIONS* 288 (discussing how intrafirm transfers of know how ameliorate the hazards of opportunism because transactions become more idiosyncratic).

³¹⁷ Bharat N. Anand & Tarun Khanna, *The Structure of Licensing Contracts*, 48 J. OF INDUST. ECON. 103, 128 (Mar. 2000).

³¹⁸ Ashish Arora & Robert Merges, *Property Rights, Firm Boundaries, and R & D Inputs*. Working Paper, 2001, at 17.

³¹⁹ See David Teece, *Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy*, in David Teece (ed.), *THE COMPETITIVE CHALLENGE: STRATEGIES FOR INDUSTRIAL INNOVATION AND RENEWAL*. 188 (1987), (“Rarely, if ever, do patents confer perfect appropriability although they do afford considerable protection on new chemical products and rather simple mechanical innovations. Many patents can be “invented around” at modest costs. They are specially ineffective at protecting process innovations. Often patents provide little protection because the legal requirements for upholding their validity or for providing their infringement are high.”).

³²⁰ ARORA, ET AL., *MARKETS FOR TECHNOLOGY* (___).

The traditional corporate R&D strategy was to retain technologies in-house.³²¹ But markets for technologies offer technology-based firms and high-tech start-ups the opportunity to specialize in technology development without having to invest in costly downstream assets.³²² The development of downstream markets for technologies, permits the existence of smaller, specialized technology producers.³²³ At the same time, greater specialization in the production of technological inputs upstream benefits downstream users of technology. With the increased development of markets for technology, integrating down- or upstream therefore becomes less attractive. In this manner, markets for technology – and by extension legal mechanisms for appropriating innovations – “can imply a fundamental reconsideration of the appropriate boundaries of the firm.”³²⁴

The knowledge taxonomy we have discussed can be helpful to generate hypotheses about when vertical integration or market contracting will take place. For instance, it can explain which type of transaction will be chosen according to the knowledge type that is the main object of the transaction. Not all knowledge can be propertized.³²⁵ The ability/inability of the firm to bind a particular type of knowledge and avoid knowledge hazards, given the intellectual property regime available, thus shapes business transactions and contractual arrangements.

We hypothesize that, holding all the other variables constant, when knowledge is more perfectly embedded in the product (Kp), and no tacit knowledge (in the form of Ki or Ko) needs to be exchanged to render the product functional at the manufacturing plant, the buy decision becomes very attractive. If there are gains from specialization, the manufacturer will not vertically integrate, but each company will focus on producing a product it has a comparative advantage to produce. Therefore, manufacturers will try to buy the complementary assets necessary to their business by means of market transactions, so that they do not have to incur costly learning (Ki) or acquire the human and organizational resources (Ki, Ko) necessary to produce the input. The decomposable nature of Kp also accounts for the ability to outsource and

³²¹ Chandler, SCALE AND SCOPE; *see also* the management literature on rent dissipation. Leavy (1996:50): “Even in the closest of outsourcing relationships, the partners will always remain potential future competitors.” (from Arora and Merges).

³²² Arora, et al., *supra* note ___, at 224.

³²³ DAVID C. MOWERY & NATHAN ROSENBERG, PATHS OF INNOVATION: TECHNOLOGICAL CHANGE IN 20TH CENTURY AMERICA 41 (1998).

³²⁴ ARORA et al., MARKETS FOR TECHNOLOGY 224; *see also*, ALAN S. GUTTERMAN, CORPORATE COUNSEL’S GUIDE TO TECHNOLOGY TRANSACTIONS, VOL. I (2005) § 5.007.

³²⁵ Tacit knowledge frequently cannot be rendered specific enough in order to be codified in the form of a patent. *See Teece, supra* note ___, at 189 (arguing that codified knowledge is easier to transmit and to be subject to imitation. Tacit knowledge is harder to be transferable because of its difficult to articulate nature). Sidney Winter classifies knowledge continua that have the following polar dimensions: tacit vs. articulable, not teachable vs. teachable, not articulated vs. articulated, not observable in use vs. observable in use, complex vs. simple, an element of a system vs. independent. He argues that a position close to the left dimension of each continua is indicative that the knowledge may be difficult to transfer, while a position close to the right dimension is indicative of easy transferability. Sidney Winter, *Knowledge and Competence as Strategic Assets*, in DAVID TEECE (ed.), THE COMPETITIVE CHALLENGE: STRATEGIES FOR INDUSTRIAL INNOVATION AND RENEWAL, 170.

license codified technologies.³²⁶ Thus where production requires increased Kp-inputs, a firm will tend to rely more heavily on market transactions to procure such inputs.

However, if the technology is such that a great deal of tacit knowledge needs to be exchanged between the producer of the technology input and the manufacturer in order to render the product functional at the plant, the buy decision becomes less attractive, and integration or other forms of joint production become more attractive, *ceteris paribus*. This is so, because tacit knowledge is more difficult to propertize, increasing the risk of exposure to hazards.³²⁷ The ability to capture the gains from investment in the production of tacit knowledge requires a variety of strategies.³²⁸ Therefore, the relative quantity of tacit knowledge a given business transaction affects the choice of the form of the transaction.

Mergers and other forms of joint production such as joint ventures or R&D partnerships, are particularly appropriate to the development of innovations that rely on the use of Ki. Mergers and joint ventures also allow the transfer of organizational knowledge (Ko) which cannot be easily blueprinted or packaged in licensing or market transactions.³²⁹ These integrated or quasi-integrated structures diminish the risk and decrease the cost of knowledge hazards.

Looking only on the strength of intellectual property rights regimes does not tell us anything about the inputs required for production. Even when there are strong intellectual property rights for the manufactured products (Kp), if the knowledge required in the production process is mostly Ki/Ko, then we will expect that joint production will occur anyway. The development of hybrid automobile designs, currently the object of intense competition among car manufacturers provides an example. Toyota was the first to dominate the technology. This technology is now embedded in a product (Kp) and it is well- propertized so that Toyota can sell the hybrid cars and retain ownership of the technology via its patent(s). GM and DaimlerChrysler have recently announced a hybrid engine joint venture. Even if the property

³²⁶ To the extent that the production process can be broken down and compartmentalized into decomposable problems, outsource can occur. In the chemical and pharmaceutical industries, outsource has been increasing due to the availability of strong intellectual property regimes (and other factors). ARORA, ET AL., *MARKETS FOR TECHNOLOGY* 231 (___).

³²⁷ Costs derive from the public nature of knowledge and include the possibility of leakage and problems of underutilization as described above.

³²⁸ Each firm chooses the strategy of knowledge management according to a wealth maximization perspective. A firm may want to hinder involuntary transfers of knowledge, and therefore try to keep its knowledge sets as much non-codified as possible to avoid imitation by competitors. On the other hand, a firm may want to share its technological and organizational capabilities in order to benefit from licensing agreements, joint ventures or mergers. In this case, it may pursue a strategy in order to articulate its knowledge and make it teachable. Sidney Winter, *supra note* ___, at 174. Harbir Singh & Maurizio Zollo, *The Impact of Knowledge Codification, Experience Trajectories and Integration, Strategies on the Performance of Corporate Acquisitions*, 27-29 Working Paper, The Wharton School, University of Pennsylvania. The authors analyze knowledge management strategy in acquisitions. They measure codification by the number of post-acquisition processes developed in the organization to address several areas such as financial evaluation, due diligence, information systems, human resources and sales/product integration. Their results suggest that the high codification of post-acquisition processes have a positive effect on the performance of highly complex post-acquisition processes. On the other hand, high codification of post-acquisition processes can harm performance in the context of non-complexed processes, because it can lead to excessive bureaucratic load. These findings suggest that there is an optimum level of codification of knowledge necessary to make knowledge transfer effective.

³²⁹ Kogut, *Joint Ventures*.

rights are strong enough to assure that the product likely to be generated by the joint venture will be marketed, these companies decided to engage in a type of joint production, that can be viewed as quasi-integration. They did so because of the type of knowledge required in the production process, and not because of the weakness of intellectual property type of rights in this industry, which, as the case of Toyota reflects, provide significant protection. In this case, the nature of the knowledge input (and not the output) helps determine which type of transaction will take place.

This discussion suggests that the stage of the technological cycle may impact the business form. Knowledge generation that relies mostly on Ki is more suitable to joint-production arrangements in opposition to market arrangements.

There are at least two reasons for this. First, there are special moral hazards associates with knowledge transfer contracts. Leakage of knowledge resources both on the side of the producer, but also on the side of the manufacturer can occur. Hoarding or failure to share knowledge may be enhanced in market transactions.

Second, transfer of tacit knowledge is costly, because it involves costly knowledge exchange and learning on the part of employees of the manufacturer and the producer of the technological input. If a firm must spend a great deal of time learning about how to use a knowledge input, then producing the input inhouse becomes more attractive.³³⁰

The analysis of knowledge inputs, we suggest, is a very important variable influencing the form of business transactions. While a thorough development of these relationships goes beyond the scope of this paper, we note the promising avenues for further inquiry.

VII. CONCLUSION

The present article seeks to provide a new approach to corporate organizational structures, by focusing on knowledge inputs, an important variable that has remained largely neglected by legal scholars.

We presented a typology that identifies the types of knowledge resources that firms employ in their production processes. We further analyzed how legal institutions impact firm organizational structure by showing how they bind these knowledge types to the firm structure. With respect to law and knowledge management we showed that the development of intellectual property protections has deeply affected the internal structure of business entities. We then discussed how important characteristics of firm organizational structure are influenced by the predominance of each knowledge type and the legal and contractual mechanisms used to protect it.

³³⁰ Arora et al., *Markets for Technology* 115 (“[T]here is a greater cognitive distance between organizations, which raises the cost of transferring tacit and context dependent information. Different units within an organization are more likely to evolve a common shared understanding and a common code for communicating the knowledge than different units in separate organizations. The shared context lowers the relative cost of transferring tacit knowledge inside an organization.”).

Firms will try to maximize the use of knowledge resources in order to maximize profits. Firms will also try to diminish the occurrence of knowledge hazards such as leakage and hoarding. To cope with the problems of achieving an efficient knowledge allocation and preventing the occurrence of knowledge hazards, firms will create particular organizational arrangements. These organizational arrangements include, for example, the existence of steeper or flatter hierarchies, the adoption of particular compensation systems, and the engagement of certain types of business transactions. Our article analyzed such features in the cases of mass production, high tech, and law firms as well as in business transactions.

Hierarchies can be seen as a mechanism to provide knowledge-substitution so that a firm can efficiently use its costly knowledge embedded in individuals. The adoption of steeper hierarchical organization systems in mass production firms and of flatter hierarchies in high tech and law firms have been explained in such terms. Based on our principle of efficient knowledge allocation, we proposed that these different organizational structures result from the necessity to maximize the efficient use of knowledge resources.

In our analysis of the development of American manufacturing firms, we argued that the change from the C-form structure to the M-form structure was largely driven by changes in corporate knowledge requirements.

In high tech companies, the necessity to retain employees and deal with knowledge hazards such as leakage and hoarding has lead companies to adopt broad stock options plans in their compensation packages. Therefore, knowledge considerations enable the distinction between the standard agency cost view in which stock options are used to incentivize the top management team and a retention view according to which stock options are assigned to other employees as a means of stimulate them to stick with the firm and share their knowledge. As a normative conclusion, our analysis would warn against the current one-size-fits all approach in the debate of the use of stock options.

Knowledge considerations also have a strong explanatory power concerning the organization of law firms. These firms are organized so as to achieve increasing gains of knowledge specialization. The hierarchy among partners and associates is designed so as to efficiently allocate decision and residual rights to those considered more knowledgeable. Client relationships are usually conducted by those who already share the residuals in order to avoid leakage from associates. The sharing model of splitting profits, also promotes an efficient distribution of client cases among those most capable of handling them. Recent changes in the organizational structure of law firms such as the increasing number of staff and contract attorneys, and the consequent increase of hierarchy levels are also explained by a change in the type of knowledge used in these organizations.

In the case of business transactions, we suggested that deals that rely on different types of knowledge will assume different legal forms. Market transactions will occur when knowledge is mostly embedded in products and arrangements of joint-production will tend to occur when individual knowledge is more important for a given transaction.

Our paper initiates a new debate concerning the relation between law and knowledge resources for firm organization. We have put forward several hypotheses that have to be empirically investigated and theoretically modeled. We hope scholars accept the challenges posed by the ideas set forth in this article which is

intended to serve as an outline for a larger research agenda, that goes far beyond the points we discuss in this article

At the same time, we hope to contribute to the development of the knowledge based theory of the firm in the economics literature. Organizational economics has already recognized the importance of legal rules to the knowledge structure of firms in the case of patents. The impact of law on knowledge management, however, is much more extensive and will hopefully continue to be of increasing interest to economists.

We believe that the typology we have developed for distinguishing different types of knowledge in the production process provides an important new perspective on the development of different types of firms. It enables us to reframe some of the standard positive explanations for firm structure. The principle of efficient knowledge allocation is also an interesting guide for normative proposals. Policy makers should analyze the impact that intellectual property rights exert over internal knowledge management. They should also consider and promote efficient knowledge allocation in corporate reforms. Crucial to successful coordination and decision-making is the collocation of relevant knowledge with the decision-making rights/authority at the various levels of hierarchy within the business organization. An interesting avenue would be to discuss whether the recent governance changes of Sarbanes-Oxley promoted this rationale. We leave this endeavor for future publications.

E.G.

M.H.