Innovation, the Firm, and Society

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Business historians have traditionally been preoccupied with the inner workings of firms. Their methodology, however, has been less effective in elucidating the connections between the activities of firms and macroeconomic variables such as income, productivity, and national competitiveness. There are now available a number of models to explain this crucial connection. Alfred Chandler's recent, *Scale and Scope*, the competitive advantage framework proposed by Michael Porter and the evolutionary economic theory of Richard Nelson and Sidney Winter offer models connecting firm level behavior with larger social and economic processes [5, 33, 29]. In this essay, I would like to assess the state of knowledge about firms and innovation. Then, I propose to evaluate how well this knowledge links up with the theoretical models that relate firms to the macroeconomy. Finally, I will offer my own model of technological innovation that places the firm in the larger context of society.

This task requires me to answer two questions: How do firms contribute to technological innovation, and does anything guarantee that firms will in fact remain innovative actors contributing to economic growth? In regard to the first question, there is an emerging literature that examines firm-level innovation and the intimate relations between technological change, firm strategy and market structure. On the basis of this material, I believe that we can at least begin to resolve the second question--what keeps firms innovative.

The Firm and Innovation

It might be worthwhile to contrast this new body of work with the older view of technology adopted by business historians. In *The Visible Hand*, Alfred Chandler made technology the prime mover of business development. Technology in the form of communications and transportation systems created the markets that made big business possible, while technologies of production provided opportunities for firm growth through the realization of scale economies. Astute entrepreneurs recognized that technological imperatives required them to integrate backward and forward, coordinate operations through managerial hierarchies and diversify into new markets in order to achieve the high levels of throughput necessary for full utilization of

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productive capacity. Technology, in short, was one of the key determinants of business strategy.

This version of the story, however, has been challenged by studies of technology which stress the socially determined nature of what for business historians has stood beyond the scope of their analyses. Business historians have yet to reconceive technology fully along the lines of the "social constructivist" school. In the concise phrase of John Staudenmaier, technology is the "integration of design and ambience." This definition implies that technological artifacts cannot be abstracted from their place in the social context or environment [41]. That context might be a community of engineers and scientists experimenting with new artifacts and knowledge. Or it might a market where technology is purchased by consumers. The former case describes technology as invention--that is, a new artifact, skill or form of knowledge still being refined by inventors and engineers. The latter case describes innovation, or technology that has been made available to the wider society through private consumption.

Conceived in this way, technology cannot be treated as an "uncaused cause" of business evolution. Consider the standard proposition that the rise of big business was predicated on the growth of mass markets made possible by the railroad and telegraph. These technologies were actually complex systems composed of artifacts, knowledge and skills, business acumen, consumer wants and wishes, legal rules and political regulations which fostered rapid transportation and communications. Before the integration of all these components, the crucial transportation and communications systems did not exist. That is, they lacked the power to affect business or transform society. Similarly, if by technology we mean indivisibilities that give rise to scale economies in production, then without complementary organizational and managerial structures such technology would never have been realized. There is no point, in short, where technology exists distinct from its social environment [3]. One implication of such a view is that since an important part of the social environment of technology in modern capitalist societies consists of business organizations, the evolution of business and the evolution of technology are coterminous phenomena.[1]

By calling into question traditional patterns of causality, social construction raises important new questions. In the old world of autonomous technology, we could take comfort from the thought that firms merely responded to external forces. In the new world of social construction, strategy and structure are cut loose from their places in the chain of causality. Business historians must ask, how large a role do firms play in innovation and how much freedom do firms have to determine the technology that guides their strategic choices?

Contextualist studies also link up with a growing economics literature attempting to get inside the "black boxes" of both the firm and technology.

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[1] The problem is not avoided by distinguishing between innovation and invention, since these abstractions are only a convenient way of separating into artificial phases that which in reality takes place simultaneously.

Such work has drawn empirical support from findings that demand side forces alone cannot explain technological change. Despite resource mobility, levels of productivity and inventiveness have varied widely between nations for many years [35]. To explain such divergence, economists have turned with renewed interest to the role of firms and other supply side factors in explaining how technology is created and diffused.

A decade ago, Richard Nelson and Sidney Winter lamented that the "vast and heterogenous" studies of technological change comprised "semi-isolated clusters of facts organized by special purpose theories" [29]. Recently, this research has been converging at several points. New economic models of technological change note that the creation of technology is inherently a venture into the unknown. Innovative actors operate with little fore knowledge of consumer desires, market conditions, or even technological possibilities. Rather than choosing among well-understood alternatives, they must search for the technology that they need, or create it as they go along. Since search and creation are time-consuming and expensive, innovators wisely investigate only a limited subset of all possible avenues of change. Even the most innovative actors are forced to focus their efforts, narrow their sights, and make choices about what to do before they begin.

Innovation of this sort is a problem-solving rather than rational choice process. Actors grope in the dark for solutions to problems, moving locally rather than globally from one technology to another [29, 12]. New technologies emerge out of existing ones, as innovators investigate possibilities for improvement in the immediate neighborhood of those things that they already know. Such a process helps to explain why many technical improvements take the form of small, incremental steps along a fairly predicable trajectory of change rather than bold departures.

Under these conditions technology evolves according to certain typical patterns. It often begins with a radical phase, when virtually everything is up for grabs. Early versions of bicycles in the nineteenth century, for example, embraced a wide array of functional characteristics. Though they shared some features in common, they appealed to different markets of users. Only gradually did the modern form of the bicycle emerge. The same pattern of change has been found in the history of the automobile before Henry Ford's Model T and again in the 1920s before General Motors introduced the closed steel body design. In each case, technology gradually converged around a "dominate design." Further innovation took the form of important but incremental changes and improvements in that design. Closure occurred in part because focused innovation on a narrower set of criteria could yield substantial and fairly predictable results. Efforts to change the design dramatically were fraught with risks [3, 1, 6]. Eliminating contending designs also permitted scale economies in production. These lowered prices and compensated consumers for the losses they sustained from reduced variety.

In deciding among possible paths and directions of change, innovators consider a wide array of social determinants. As George Basalla has noted, a variety of functionally equivalent technologies exist at any given time [2]. The selection of those that survive must be related to values beyond the purely technical. When working with machines and systems of machines, for

example, innovators are commonly guided by what Nathan Rosenberg has termed "focusing devices and inducement mechanisms" [34]. Technologists increase their odds of finding profitable innovations by paying attention to a number of economic and technical criteria. When one factor price is on the rise--wages, for example--they can expect to achieve a substantial payoff by focusing on innovations that reduce the labor component of production. Systems of interrelated components themselves sometimes suggest ways of narrowing the field. Engineers caught up with emerging systems of technology often perceive problems and bottlenecks that they can work on. Thomas Hughes has generalized this process by proclaiming that much technological innovation takes place along an advancing salient of progress which contains redoubts or reverses. The task of the innovator is to remove such reverse salients [19].

If technology takes the form of knowledge, then models or paradigms conceived by innovators guide innovation. These determine the purpose of innovative activity, the ends to which it should be directed, the methods to be used to achieve those ends, and the relevant measurements of success or failure. "Normal" innovation follows the path marked out by these guideposts. Paradigm formation itself is an activity of the "community of technological practitioners." Only when some anomaly occurs which frustrates the progress and perfection of the paradigm does it change [7, 3].

Like systems and paradigms, firm strategy provides a way of determining the general purposes, directions or parameters of innovation. Strategy is an effort to achieve competitive advantages over other firms. Under competitive conditions some firms can be expected to search for and exploit economies of scale. Others may decide to pursue a policy of product differentiation, targeting specific groups of customers. Still other firms may seek to create radical new versions of old products and processes that dramatically shift the cost curve of the industry. Firms adopt a "technological position" during innovation, which includes an "agenda" of the "salient problems to be resolved." Different strategic decisions result in different systems of technology [37, 18, 17].

One reason that firms have been willing to make investments in research has to do with these connections between technology, strategy and society. Hard and fast distinctions between science and technology, research and development, invention and innovation, commercial and speculative research break down under a definition of technology that integrates knowledge, artifacts, and social environment. When firms invest in research they are really seeking the necessary skills and knowledge that will allow them to perfect or add to an existing technological system. Possibilities for improvement and productivity gain may come at any point in the stream of activities that begin in the laboratory and end with the sale of the final product. The technical knowledge needed to realize such gains is not reducible to blueprints or information that can be purchased in the open market [29]. Much of it, even abstract laboratory science and engineering, is specific to a particular production process or products under manufacture.

As forms of organization, business firms have been uniquely capable of carrying out the tasks of innovation. In the United States, they have provided

the crucial nexus bringing together different agents in the process of innovation. Coordinating specialized divisions of labor, they have sought to integrate many different skills and forms of expertise [22]. Communities of technologists, engineers, scientists and other professionals such as legal, financial and marketing experts have grown up within the confines of firms.[2] These communities commanded their own special fields of knowledge and built important links between the firm and its external environment. Firms have drawn on this knowledge and expertise to define and carry out innovative strategies [30, 27]. But the firm hierarchy has coordinated these skills and provided a means of deciding among projects and ideas brought up from below by allocating resources.

Firms have also brought together specialists in technology and related disciplines with the market [25, 4]. They have invested in "receiving mechanisms" to turn scientific breakthroughs and inventions developed by others into profit-making commercial innovations [36]. They have provided environments whereby multiple forms of technical knowledge and expertise could be combined with manufacturing, marketing, financial, and legal expertise and brought to bear on the specific problem of innovation in a market context. They have learned through doing and interacted with their customers in order to refine their products. By doing so, firms have connected the work of technical communities to society, contributing to the social shaping process [23][3].

In discussing the role of the firm in innovations this manner, it is difficult to maintain separation between internal firm structure and the outside world. For if we allow firms to innovate in self-conscious fashion, determine basic goals, and shape the markets for their products, then the line between the firm and its environment becomes blurred and indistinct. Innovative firms do not merely select from available technologies, they participate in the process of innovation, including setting the basic parameters that determine success and bringing artifacts and knowledge together with ambience. Firm strategic choices are crucial to the type of technology made available in the market. By working within and attempting to perfect one system or paradigm, they help to sell that system or paradigm of technology to the public. They do so not merely to gain market power, but also because selection and focus are necessary parts of the innovative process. In short, innovative firms are involved both in the creation of new technology and in the formation of the environment in which those technologies must sink or swim.

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[2]Hughes [19] maintains that the system contains these diverse social groups and interests. But system is an abstraction, where as business organizations are concrete institutions with formal and informal powers to command individual behavior.

[3]Sometimes, communities of inventors and users come together without the mediation of firms. Susan Douglas has noted how amateur radio enthusiasts defined radio technology and created the new technical system of broadcasting before business organizations recognized the potential of this new technology. Such instances are rare, however, and firms continue to be crucial intermediaries of innovation[14].

For these reasons, when studying technology and technical changes intimately caught up with the evolution of business, an internalist approach that draws a rigid line between the firm and its environment is no more acceptable than one which divides technology from society. Just as historians of technology have had to abandon the internalist perspective to understand their subject, business historians will need to admit of more permeable barriers between the firm and its surrounding culture. In a world in which technology is a social product, business historians cannot separate factors affecting the evolution of firms that relate to technology from politics, culture and society.

Firm Behavior and the Macroeconomy

Although existing work elucidates the ways in which firm contribute to innovation, it does not answer our second question: Does anything assure that even capable firms will remain innovative? Here it is useful to distinguish between four categories of firm behavior: adaptive and innovative; incremental and radical. William Lazonick has explored the significance of the first pair, contrasting firms (or nations) that merely live off of past investments with those that innovate [22]. We can also subdivide innovative behavior further into radical and incremental forms. Radical innovation refers to periodic sweeping changes in technology or organization. Incremental innovations are the more usual refinements, additions, and improvements on a basic design. Improvements of this sort usually follow patterns set down by the various focusing devices of systems, paradigms, and strategies.

The prevailing Chandlerian model of business evolution contains a latent contradiction between incremental and radical innovation. Empirically, Chandler's work has established how the same firms in the same industries over and over again came out on top. Those firms which made the three-pronged investment in technology, management and marketing acquired the capital and managerial talent and gained the experience, knowledge, and technical skills needed to innovate and move into new lines of business. First mover advantages obtained in this way allowed the same firms again and again to diversity and remain atop their industries over the past century. It is not clear, however, why firms' first mover advantages do not lead to complacency and safe, adaptive behavior rather than continued innovation. Indeed, the interlocking of firm organization, managerial strategy, technology, labor policy, and regulation which makes firms successful would seem to impart a strong momentum to business regimes developed in a particular time or particular place, keeping them on the same historical path even when that path leads to ruin.

The issue becomes particularly acute when we keep in mind the difference between radical and incremental technological change. Both contribute to progress, the first by dramatically changing the costs and quality of products and processes, the latter by slowly but surely refining the potential unleashed by radical changes. Incremental change may in total be more important and all innovation eventually turns incremental. But if the law of diminishing returns holds, we should expect that at some point the value to be squeezed from further incremental improvements will shrink until it is little

greater than the profits obtainable through adaptive behavior. Innovation may depend, therefore, on periodic radical changes. Yet the logic of business development points mainly to incremental forms of change.

Competition has been the traditional answer to those who fear firms will fall off the track of innovation. In his broad survey of business across ten nations, Michael Porter argues that rivalry keeps firms sharp and productive. Firms, in Porter's view, are naturally lazy and tend to regress to adaptive behavior. External pressures, therefore, are necessary to knock successful and complacent ones off the road to dissipation. Only those with strong domestic competitors, tough customers and demanding suppliers, operating on a global scale, continually testing themselves by seeking entry into foreign markets remain innovative [33].

Pleasing as this answer sounds, it runs directly counter to some of the most important insights that have come out of the study of technological change. Emphasis on systems, paradigms and firm-level learning all suggest that it should be fairly difficult to change dramatically the direction of technology once it begins down a certain path. After all, if incremental improvements in an existing system are a crucial source of productivity growth, then there should be a strong tendency for firms even in competitive markets to keep innovation on a constrained path. Rather than seeking out all possible sources of cost saving or improvement, firms confine themselves to those avenues they know best. Investments in firm specific assets, organizational learning and network externalities make the beaten trail more attractive than a venture into the unknown. Even firms that desire to extend themselves into new fields may have difficulty doing so. The formation of technological paradigms is vital to innovation, but such paradigms operate by screening out some avenues of change and concentrating attention on others. Astute managers and technologists will have trouble rejecting paradigms with which they have been long and successfully engaged.

Thomas Hughes has noted the tendency of complex systems to develop a "momentum" which constrains the path of innovation. The natural tendency is for innovation to progress from an open phase when design is unstandardized and technology has yet to coalesce around accepted problems, to a closed phase when there is less flexibility. Following closure may be a long period of incremental improvement. But eventually, closed systems fall into senility, at which point further innovation is possible only through alteration of basic system parameters. The forces behind momentum include economic and physical properties of technology, such as component interdependency and network externalities. Vested interests of managers, engineers, workers, and politicians who have a stake in the existing system may also preclude change. Once large and powerful interests form around technology, they will likely seek to resuscitate it long past the point of viability [19].

When challenged by innovators, vested interests do sometimes succeed in reviving old technology through further innovation. Wooden ships enjoyed their greatest days after they faced the challenge of steamships. Charcoal burning iron forges competed successfully with more efficient coke burning ones [38]. But by and large, more pessimistic results seem to obtain,

particularly if continued innovation requires periodic bursts of competition to sweep through and revive moribund industries. The very process of innovation sets into motion forces that tend to undercut the competition which might assure continued innovation.

In *Capitalism, Socialism and Democracy*, Joseph Schumpeter predicted that large and monopolistic firms would eventually gain the upper hand over smaller, competitive ones. In light of the recent work on innovation within firms, we can see that Schumpeter had in mind not just the relationship between market structure and innovation, but also how various levels of organization, from firms to markets, contribute to the process of technological change. Monopoly per se may or may not be important, but all the factors of learning, know-how, paradigm formation, systems effects, and coordination of knowledge contribute to the advantage of large over small firms. Since a substantial portion of new technical knowledge results from doing and since this knowledge is frequently embodied in assets specific to firms, market mechanisms for diffusing the fruits of research may be less important than firm investment and expansion [40, 39].

This perspective on the dynamics of competition has received its most sophisticated rendering in the work of Richard Nelson and Sidney Winter, who have built an evolutionary model of economic change as an alternative to the equilibrium model of neo-classical theory. In their model market structure is determined by innovation, rather than the reverse. Far from enjoying only briefly the fruits of their labors before being overtaken by swarming imitators, innovative firms build on their initial advantages until they defeat their slower moving rivals. First movers are able to exploit their favored position to fend off new entrants offering superior technology. The costs associated with dramatically changing an established system of technology are high enough to keep new entrants out. The result is greater industry concentration over time [29, 32, 20, 15].

Firm growth under these conditions may indicate not inventiveness, but the ability of a well protected firm to live off its past successes. For business historians whose common methodology is the case study of successful firms, this conclusion challenges them to construct their narratives in new ways. Firms and the historical experience of firms are a key part of innovation, but the long term results of firm behavior remain problematic and contingent. There is no reason to expect innovation to continue forever. Nor is there any guarantee that successful innovation means optimal technology, or even technology that is superior to defeated alternatives. Such conclusions will not surprise historians of technology, who have been arguing for a more contingent perspective on technological change that avoids the Whiggism endemic to internalist approaches.

How might business historians go about their task in a complicated and contingent world? One way would be to add more work on failures and to ask what might have been as well as what was successful. Another would be to stress the difficulties of change, particularly radical change which involves breaking apart the tight combinations of paradigms, strategies, organizational structures and social relations that constitute firms. Short term or incremental progress is still possible, of course, and remains a key source of economic

growth. The fracture on the link between short term incremental change and long term radical restructuring suggests, however, that incremental improvements alone may not guarantee the most socially desirable results. Successful firms may trade-off the riskier but bolder outcomes possible through radical innovation for the steady and predictable perfection of existing technical systems.

If business historians recognize these trade-offs and this contingency, then they will have to turn once again to the relationship between individual firms and other social institutions of innovation. Work of this sort should be particularly valuable in the study of radical change. In light of the substantial inertia surrounding the innovation process, radical changes may require special types of actors or the participation of institutions beyond the firm. These may be needed to breakup existing patterns of thought and behavior before they decay into adaptionism. Oligopolistic competition among successful firms in normally functioning markets where innovation is proceeding along incremental lines probably cannot induce such radical change. As noted above, the normal course of technological change tends to limit the force of competition, and competition itself can take place along normal lines without challenging dominant technological designs. Different societies, therefore, may depend on different institutions to propose radical alterations in technology even as firms continue to carry out important incremental improvements in existing systems of technology.

Some recent work has begun to open the dark and mysterious process of radical innovation to the light of day. One example can be found in the work of economists concerned with historic or path dependent dynamics. Paul David and others have generally focused on the patterns of change once the path is set, but their dynamic models allow for new paths to emerge out of small shifts in initial conditions. Like water running down a hill, one chance groove cut under unique circumstances may over time deepen into a Grand Canyon. In this model, fortune and contingency have genuine and important roles to play in history [10, 11]. They generate to new and radical departures in technology.

Although chance is no doubt more important than we care to admit, historians have a special interest in intentionality and human creativity. Looking at the rise of big business at the end of the nineteenth century, for example, William Lazonick has argued that dramatic cost lowering innovations came about in capital intensive industries because firms made the investments and undertook the learning necessary to translate high fixed costs into low unit costs. His account implies that a dramatic sort of entrepreneurial daring was necessary to break out of existing patterns of thought and action, shift the heavy weight of equilibrium to disequilibrium, and bring together the resources necessary for a system of production that could realize such potential. In cases of networks and systems, the hand of the entrepreneur may be present as well. Although network externalities are said to characterize telecommunications, studies of regional network development have found that until entrepreneurs made a series of investments that affected consumer perceptions of the technology, such externalities failed to exert much influence over growth.

Entrepreneurial daring produced the conditions that made possible the emergence of the network [24, 42].

The radical entrepreneur in these cases is a Schumpeterian character. He or she searches for the advantages and supernormal profits that come from being the first to introduce a new design or new system of technology. Profits accrue to those who set up the new system of technology from which flow later improvements in productivity from incremental innovations. Indeed, because of the connection between radical change and later incremental change, even incumbent firms may devote a portion of their organizational resources to plotting against the survival of the existing technological paradigm. But given the likelihood of entrenched interests at the top of firms--interests, it should be noted that may reflect continuing success with incremental improvement--such subversives are likely to lurk at the lower rungs of the corporate hierarchy.

The radical component of innovation may also involve non-business actors. In the case of technologies that enter into the business world from the realm of science, for example, it may be a community of scientists or engineers that injects radical ideas into the normal course of thought. Edward Constant has argued that scientific knowledge of aerodynamics convinced aircraft designers that prop airplanes would never be able to reach desired performance levels. So they experimented with a radical departure in technology--the turbojet [7]. In a like manner, the military, government officials, regulators, and law enforcers may fill the role of outsider who intervenes to force technology in a new direction. Even "unwanted" intervention from consumer advocates, environmentalists or government bureaucrats may be necessary periodically to stave off business complacency [33].

A New Model of Innovation and the Firm

The conception of technology as a social product and innovation as a social process, I would argue, means that a complete model of the innovative firm must locate business in a larger set of relations. The intractable questions that surround the creative process of innovation quickly force investigation to move beyond the confines of the firm. A complete model of innovation must acknowledge all the various interests that bear on technology. It must be capable of accounting for both combinations of interests that foster radical innovation, as well as those which tend to keep innovation moving along existing paths in incremental fashion.

I would characterize such a model as a political economy of innovation. It is political in the broad sense of involving power conflicts. Politics enters innovation at various levels. Within firms, managers battle over how to deploy organizational resources [31]. Firms also struggle with consumer groups and government agencies over the design, purpose, level of access, degree of safety, redundancy and other defining characteristics of technological systems [26]. Bureaucrats and public officials have been especially important in setting standards and design parameters for technologies that exhibit strong externalities [9]. Even in the design of production technology and

manufacturing processes, however, politics frequently enters the picture. Firms and governments have fought over the rate at which radical new innovations should be introduced, as in the case of war-time mandates for strategic metals, energy, and synthetic materials [28, 16].

Cultural power is also a part of the process. Given the indeterminacy of goals and results that marks the beginning of innovation, some actors make choices based on ideology, belief, faith or supposition [8]. Power--social, cultural and economic--plays an especially important role in radical change. Successful innovators in the radical phase are those who muster all the various resources necessary to win acceptance of one design over another or fight against the prevailing tides pushing along existing systems of technology.

Innovative firms are caught up in the political process of selling to society a new concept of technology. They propagate the criteria, parameters or goals as to what an artifact, or system of artifacts, or community of technique and knowledge should aim to do. The contending interests that swirl around firms engaged in innovation may include conservative users, suspicious suppliers, opposing competitors with their own designs, a host of public sector agents with mandates to regulate various aspects of the industry. Within the firm as well there will be some coalitions who oppose and others who favor change.

Many battles over technology have been fought within the corporate sector, and within individual firms, rather than between private and public sector actors. In general private firms have had greater power than government actors, reflecting the rapid growth of the corporation and slow maturity of state bureaucracies. On the other hand, as the capacity of the state has grown and strengthened over the twentieth century, more of the conflict has entered the public realm.

Whether shaped through internal organizational battles or by public debate, the technologies that emerge from this process are compromises among contending interests. Not every group can be perfectly satisfied. Some designs are incompatible with others. And multiple basic designs can exist only to the extent that consumers are willing to sacrifice price reductions possible through economies of scale for greater variety. Beyond the consumers of new technology, moreover, there are also other groups to be satisfied or challengers to be turned away. Those vested in incumbent systems may have to be opposed in the courts, the press, or the legislatures. Innovative firms, like other actors, succeed to the extent that they are able to satisfy the largest number of contending interests--or at least the most powerful among them--while fighting the inevitable forces of opposition.

The firm, in this model, becomes one actor among many, but a crucial one because of its resources, organizational abilities, and cultural prestige. As I have suggested, in capitalist societies business firms sit at the crucial juncture points of all the interests that converge on technology. They are one interest among many, though they possess special powers to shape technology in market economies. A political economy approach explicitly recognizes both interests and the relative power of interests. For this reason it is superior to a "systems" approach which tries to locate the crucial decisions in some "firm

transcending" structure, thereby slighting the real institutional power and resources at the command of private business.

This conception of the innovative firm blends politics and culture with strategies, structures and capabilities. It recognizes only a fuzzy line between the firm and its environment, especially when radical new technologies are in the air. But it is an appropriate one for business historians to work with, since it also highlights the special place of the firm in innovation. In using it, business historians will have to bring to the center of their analysis politics and other matters usually confined to the periphery. No longer can business organization be separated from other social institutions. Even when dealing with something as fundamental as the technology which lies at the heart of the definition of the firm, business historians must pay attention to multiple interests, values, groups and organizations. For all of these intersect in the formation of technology.

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