The Organizational Impact of
Technological Change: a Comparative
Theory of National Institutional Factors

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This paper offers a parsimonious theory of national institutional factors that promote or inhibit the formation of start-up firms in the USA and Japan. Three factors are proposed: the technical labor market, the venture capital market and the structure of buyer-supplier ties. Complementarities between these factors cause them to work as a system, while their differences elevate or reduce the level of incentive constraints and appropriability constraints acting on incumbent and start-up firms respectively. As a result, incumbents might be displaced in an industry in one country while incumbent firms in the same industry in another country might persevere, due to the presence or absence of start-up firms. This suggests that there may be no single best way to organize for innovation in different institutional settings; rather, firms must seek to exploit the virtues of their environment, even as they act to mitigate the hazards it poses.

1. Introduction

When an industry experiences technical change, a rich variety of organizational phenomena may result. In some industries, technological changes cause organizational upheaval, as firms struggle to adapt to new possibilities and threats in their environment. In response, incumbent firms may exhibit inertia while entrant firms may move in quickly, exploiting both the opportunities the changing landscape creates and the limited ability of incumbent firms to respond. In other industries, however, technological change induces less upheaval; incumbents are able to adapt to or pre-empt competitive challenges from new entrants.

Research drawn from economic and organizational disciplines has informed our understanding of the organizational impact of technical change. One
branch of economics has noted the varying incentives different types of technology create. It has shown how some technologies provide greater advantage to incumbent firms than to entrants, while others lead to the reverse effect (Reinganum, 1989). Another branch has examined the institutional conditions surrounding innovation, from the perspectives of the decision processes within the firm and the external resources available to the industry experiencing the technological change. As Dosi (1995) points out, the former branch conceives of technology as an exogenous factor that determines economic and institutional development, while the latter views the institutional context as the exogenous factor that conditions technological and economic development. This paper follows this second branch into an inquiry of the factors that inhibit or promote the entry of new firms and the displacement of incumbent firms in technologically intensive industries.

The concept of national innovation systems (Mowery, 1992a; Mowery and Rosenberg, 1993; Nelson, 1993, 1994; Hill, 1995) has developed from this second branch of economics as a way of viewing the technical advance of industries in different countries. A related concept is the notion of technological regimes (Malerba and Orsenigo, 1997), where technological paths of development co-evolve.

A parallel literature drawn from the study of the organizational impact of innovation documents the role of inertia in how firms respond to shifts in technology. Woodward (1960), Burns and Stalker (1961) and Thompson (1967) noted that a firm’s technology created rigidities that made it hard to adapt when ‘core’ technologies changed. Abernathy and Utterback (1978) differentiated between types of innovation and their impact upon firms. Tushman and Anderson (1986) recast Abernathy and Utterback’s typology into one that differentiates between ‘competence enhancing’ innovations and ‘competence destroying’ innovations. Henderson and Clark (1990) developed this innovation typology further, showing that even seemingly minor changes in technology can sometimes create significant organizational upheaval. Christensen (1993) found this pattern as well, and related it to disruption to the firm’s value chain (Christensen and Rosenbloom, 1995) and myopic decisions in the firm’s internal resource allocation process (Christensen and Bower, 1996). Leonard-Barton (1992) has argued that these responses reflect ‘core rigidities’ within the firm.

While these economic and organizational perspectives have each increased our understanding of innovation, neither literature has had a discernable impact upon the other. The broad economic systems view of national innovation systems has not delved deeply into technical change within single industries, thereby limiting its ability to draw on that literature (for an exception see
Nelson, 1995). This may be explained in part by the literature’s focus on the role of various institutional elements in shaping economic activity across countries. By looking across many industries within multiple countries, the differences between countries are emphasized, while differences within individual industries among these countries receive less attention.\(^1\)

The individual industry studies of technical change, in turn, focus almost entirely within the industry, and take little or no account of the external environment in which those industries operate. Moreover, the USA typically is setting in which these effects are observed—partly because the studies tend to be longitudinal and in depth, and it is easier for most US researchers to observe US firms. Abernathy and Utterback (1978) focused on the impact of ‘dominant designs’ that forced many firms out of business in the (US) automotive industry. Tushman and Anderson (1986) and Anderson and Tushman (1990) examined ‘competence enhancing’ or ‘competence destroying’ technologies in the (US) airline, cement and minicomputer industries, showing that the latter type of technologies displaced earlier successful firms. Henderson and Clark studied the effects of architectural shifts in the photolithography industry that displaced earlier leading firms, while Christensen’s work probed the impact of technology changes that displaced leading firms in the hard disk drive (HDD) industry.\(^2\) These studies detail the frequent failure of US incumbent firms, with the unstated implication that incumbents in other countries face the same issues and would likely suffer the same effects from technological change.

Some emerging comparative work in the organizational impact of innovation in a single industry in different countries, however, suggests that this implication may not always be accurate. Darby and Zucker (1996) showed that similarly talented ‘star’ scientists in the USA are much more likely to be involved in forming new businesses than are their Japanese counterparts in biotechnology. The authors further document that when new entry occurs, it is generally from \textit{de novo} start-up firms in the USA, while firm entry in Japan arises from extensions of current businesses. A recent study of the computer software industry found a similar comparative pattern. Steinmuller (1996) recounted the strong influence of independent start-up firms in the US computer software industry, while in the same volume Cottrell (1996)

\(^1\) In one study, Malerba and Orsenigo (1997) find that technological development in 49 different classes is broadly similar across countries, though they note in passing (p. 93) some instances where some differences within classes arise between countries. The focus of their study, as with most studies in this vein, is upon the variation ‘between’ technologies across countries, while variation ‘within’ technologies across countries is suppressed. The theory offered here instead highlights the ‘within’ variation.

\(^2\) Henderson and Clark’s (1990) study included two Japanese firms, but all of the firms displaced in their study were US firms.
discussed the dominant role that established Japanese firms played in shaping the Japanese computer software industry. In the semiconductor industry, West (1997) found significant differences between incumbent US and Japanese firms. While he does not examine differences in entry and exit between firms in each region, he does report on organizational differences between US firms and Japanese firms in six organizational dimensions. His preliminary evidence indicates that these differences are not converging, but in fact appear to be widening. And I have shown in other work (Chesbrough, 1997, 1998) that incumbents’ responses to technological change in the worldwide disk drive industry appeared to vary between the USA and Japan. While architectural changes in HDDs frequently led to leading US incumbents being displaced, leading Japanese incumbents in the same industry undergoing the same technical changes were less likely to be so affected.

Such comparative differences suggest that the organizational impact of innovation cannot be understood unless the national institutional setting in which the firms operate is taken into account. Patterns of new business formation may be particularly important in explaining differences in the displacement of established firms. Technological change seems to promote the entry of many new firms in one region, while the same developments in the same industry do not induce much entry in another. Incumbents in one region seem better able to adapt to technical change, while they seem less able to do so elsewhere. These differences in turn may have important implications for how industries evolve in different countries, providing a new dimension to our understanding of the impact of technical change upon firms in individual industries.

2. *A Theory of Organizational Constraints in the Innovation Process*

Why might cross-national differences affect how firms adapt to technical change within a single industry? To answer this, we need to understand the relationship between incumbent ‘failure’ and entrant ‘success’. Tushman and Anderson (1986) found that technical change often rendered incumbents’ skills obsolete. Henderson and Clark (1990) noted that it was costly for firms to create and subsequently change their organizational capabilities or routines.

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3 West’s study is at the level of the semiconductor fab, and spans a shorter period of time than the other comparative studies noted here. Hence, firm entry and exit play less of a role in his analysis of differences between firms in this industry.

4 This statement could also be applied within national boundaries to regional influences (Saxenian, 1994). I suppress these intra-national variations in this paper for clarity of exposition.
(see also Nelson and Winter, 1982). Christensen (1992, 1993) and Christensen and Bower (1996) called attention to the role of the firm’s current customers in determining whether incumbents elected to provide a new architectural innovation.

These studies focus attention on the cognitive and perceptual limitations of incumbent firms. But entering firms have limitations as well, which are generally not included in these views. We do not see entrants displacing incumbents in every industry. Chandler (1990) has documented the impressive expansion of incumbent firms in a number of pivotal industries during the Second Industrial Revolution. Lazonick (1991) has taken this further, showing that established firms often profit from their organizational capital in ways that newly formed firms cannot. Both incumbents and entrants have limitations that constrain their ability to innovate. No single type of organization fits best with all of the innovation opportunities that arise in the course of an industry’s evolution; rather, there are trade-offs that every prospective innovating firm must confront.

To exploit the opportunities innovation offers, firms need to mobilize their personnel resources through organizational incentive systems, which must attract employees to the firm, motivate them to perform, and retain them later on (Lazonick 1991, p. 225). Incumbents and entrants differ in their abilities to perform these essential functions. One potential constraint innovating firms experience in making these necessary changes is an incentive constraint, which reflects the problem incumbent firms may face when offering incentives to promote risk-taking within the firm. Incumbent firms confronting a new technology may be unable to provide sufficiently attractive incentives to motivate internal employees to take the entrepreneurial risks the new technology requires. What constrains established firms from providing strong incentives are internal norms of equity and fairness, which create relatively low-powered incentives (Williamson, 1975, 1985, 1991a).

Empirical evidence in the USA has supported the presence of these constraints (Baker et al., 1988; Zenger, 1994, 1996). Zenger (1994) reported that so-called merit pay systems actually decrease the variance in the percentage of salary increase awarded, creating a strong leveling tendency in the rate of salary change inside large firms. The chief benefit of such systems

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5 Lazonick does not argue that established firms inevitably realize these gains; rather, they benefit if and only if they achieve a higher degree of organizational integration through extending their planning and production systems through from management down to the shop floor.

6 The significance of these differences, though, depends on the extent to which the skills of individual people are considered central to the skill base of the firm. Incumbent firms within individual industries also differ in their ability to attract, motivate and retain employees (for illustrative examples see Lazonick and West, 1995). I am grateful to an anonymous reviewer for this observation.
is their low measurement costs. He also discovered that measuring individual employees’ contribution was complicated by highly inflated self-perceptions of performance. Thus, in a study of engineers, 33% assessed their contributions to be in the top 5% of the firm, and fully 88% rated their performance in the top quartile. These inflated self-perceptions, in turn, made the unusually high rewards paid to other employees seem arbitrary and unwarranted (Zenger, 1996). Block and Ornati (1987) examined corporate managers’ compensation in an area where the corporation explicitly was trying to promote more entrepreneurial risk taking: new corporate ventures. Yet here, too, the authors found that corporations consciously limited the maximum incentive an individual could receive. This was done for two reasons. First, if incentives were allowed to become too great, the internal norms of equity among employees would be violated. Second, these corporations had difficulty specifying in advance what the precise objectives of these new ventures would be. The authors found this to be quite different from the risk/reward packages venture capital (VC)-backed start-up firms offered. One VC manager told them, ‘The only reason for our existence is the inability of corporations to provide the financial incentives which can be achieved in an independent start-up’ (Block and Ornati, 1987, p. 44).

The very survival of small start-up firms depends upon their initial performance, so the large risk/reward packages put in place to motivate key team members are, in a very real sense, measured by the private and public equity market. In the early days, continued equity funding depends upon the firm’s ability to develop an initial market for its products. In later days, if the firm is successful, its value is measured through the valuation of the company’s stock via an initial public offering or an acquisition. Individuals in these companies understand that, if the firm succeeds in the market, they can realize tremendous rewards from their efforts.

Should a large firm attempt to compensate for this by providing very large rewards to a successful team of entrepreneurs inside its organization, however, there may be dissension among other firm members who did not participate. If the project’s success threatens established assets in the firm’s current technology, it may be rational to dampen the innovating team’s incentives, since the optimal incentives for the project’s success may not be the same as those for the overall firm. By comparison, potential start-up firms attempting to

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The constraint noted here is most serious when the firm requires individual skills to be successful in pursuing technology. Where team and group skills are far more important than individual skills, the issues raised here are of perhaps secondary importance. I am indebted to an anonymous reviewer for this point.

Innovation can also threaten established groups within a firm, and sub-goal pursuit (Williamson, 1975) can become a powerful force in the actions of the firm. These issues are suppressed here, for focus and clarity of exposition.
exploit the opportunities the new technology offers are not constrained either by these internal norms or by assets employed in an existing architecture. They may be able to align incentives more effectively within their organization to take the necessary risks, and elicit greater entrepreneurial efforts from their staff, relative to incumbent firms.

A ‘third way’ for incumbent firms to respond to innovation is by establishing new organizational entities outside the firm, such as a new subsidiary. This strategy attempts to achieve greater decentralization, higher incentives and greater focus, while preserving coordination with the parent firm. Such endeavors have had a checkered past in the USA (Burgelman and Sayles, 1986; Block and MacMillan, 1993), but are commonly done in Japan (Odagiri, 1992; Odagiri and Goto, 1993). Nevertheless, internal norms of equity constrain the incentives these subsidiary firms offer, both in the USA (Block and MacMillan, 1993) and in Japan (Odagiri, 1992).

A second potential constraint is an appropriability constraint, whereby firms wishing to produce a new innovation must gain access to such complementary assets (Teece, 1986) as manufacturing and distribution, or to complementary technologies (Chesbrough and Teece, 1996), in order to appropriate the gains that come from producing the new technology. The constraint arises when realizing that the value from an innovation requires coordination with complementary assets and/or technologies. In regimes where the protection of intellectual property (IP) is ‘tight’, firms that innovate can negotiate access to key complementary assets without fear of imitation. In weak IP regimes such protection cannot be assumed, and greater organizational coordination is required. The innovation’s full value cannot be realized unless other assets can also be accessed. If the producing firm has not obtained access to the necessary assets ex ante, holders of complementary assets can gain leverage over the firm adopting a technology.

It is likely that incumbents are less limited than newly entering firms by this appropriability constraint, since many of the necessary complementary assets may already be in place from earlier operations. The presence of such assets is an important component of scope economies that direct the path of firm diversification (Teece, 1982; Silverman, 1999). Entering firms, by contrast, must secure access to these assets on reasonable terms. If they fail to do so, holders of complementary assets can delay or diminish their successful entry, as well as extract a higher portion of the potential profits from entry (Teece, 1986).

These organizational constraints can offset one another. Incentive constraints tend to favor start-up or newly entering firms, while appropriability
constraints tend to advantage incumbent players. This implies that there is no single best way to organize for all innovations. Moreover, as suggested below, these organizational constraints are not uniform across the world. Different levels of these organizational constraints imply that incumbents may respond well to innovation in one region, while start-ups in the same industry may respond better in another region.

3 The Impact of National Institutional Factors Upon Organizational Constraints

An emerging body of research is building on the importance of the ‘institutional environment’ (North, 1990) and its effects on firm and industry development; this, in turn, has important implications for our understanding of innovation. Nations differ in their institutional environments, and differences in these ‘national innovation systems’ (Nelson, 1984, 1993, 1994) persist over time (Mowery, 1992a,b; Nelson, 1993). Moreover, these institutional differences can condition the effect of technical change upon firms in different nations, even within the same industry. They do so in part by influencing the levels of the incentive and appropriability constraints noted above.

A variety of national factors fall under the rubric of ‘institutional environment’. North (1990), for example, includes formal factors, such as the degree of recognition for property rights, and informal factors, such as ‘the rules of the game’. Nelson (1984) calls attention to the university research system and professional and trade associations. Mowery and Rosenberg (1993) extend consideration to government financing of R&D, government procurement and anti-trust policies. Hill (1995, p. 119) has gone further, to bring in the language, culture and social norms of a society, concluding that ‘[t]he institutional structure of a nation, through its influence upon transaction costs, help explain the ability of firms based in that nation to succeed or fail in a competitive global marketplace’. While this is richly descriptive, if the notion of ‘institutions’ continues to evolve, any distinctive meaning that can inform our understanding of its influence will be lost.

Moreover, such an expansive view of national institutions is hard to subject to empirical testing, and difficult to probe with counterfactual reasoning.

9 Not all entering firms need be start-up firms. They may be diversifying entrants attempting to utilize economies of scope gained from other businesses. To the extent that they do indeed possess relevant complementary assets, their appropriability constraint exposure approaches that of incumbent firms. To the extent that they can approach the business with a distinctive organization, they may be able to approximate the high powered incentives of start-ups. If, however, the entry is structured as another internal department or division, the incentive constraint exposure will be closer to incumbent firms.
Nelson's (1995) expansive account of the evolution of seven major industries in five nations, while informative and illuminating, illustrates the difficulty. His account closely follows the history of the chemicals industry in the industrialized world, and tracks a wide variety of industry, university, governmental and international influences. The research explains that the chemicals industry evolved in certain regions (Germany, the UK and the USA) that had preferential access to feedstocks. What is not explained is why that industry also developed in Japan, which lacked such feedstocks, or why very few companies arose in Saudi Arabia, which is richly endowed with petrochemical feedstocks. So it is unclear whether feedstocks were necessary or sufficient, or neither, to the industry’s evolution.

An alternative approach to assessing the impact of ‘institutions’ is to strive for parsimony: identify and isolate a few specific factors in the institutional environment, and examine their impact upon innovating firms. This approach will be taken here, in the context of incumbent and entrant responses to technology shifts. Of course, much of the richness of the above approaches will be lost, but there will be theoretical gains. With a small number of factors, one can examine how variation among them might induce varying organizational responses to innovation. Also, restricting attention to a few factors allows an analysis of how the factors might link together as a system, where each factor’s impact is influenced by the presence of the others.

This parsimonious, systemic approach is consistent with the view Aoki (1994) advocated, which argues that comparative analysis of the USA vs. Japan should pay attention to a system of attributes, rather than considering single attributes in isolation. The institutional factors he considers to be of primary importance are: the characteristics of the capital market; the characteristics of the labor market; and what he terms ‘the supply market’.10 Williamson (1991b) similarly proposes a relatively narrow focus to compare US and Japanese regimes. He identifies employment practices, the banking system and subcontracting relationships as the institutional characteristics of primary importance.

Lazonick and O’Sullivan (1996) provide an illustrative comparative analysis of industry evolution that uses a parsimonious construction of institutional factors. Surveying the industrial development of the USA, Japan and Germany over the span of each country’s industrial development, they examine the role of two institutional factors (organizational integration and financial commitment) in conditioning the ability of firms in each country to lead in their respective industries. These two factors correspond closely with the first

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10 The supply market, for Aoki, refers to the vertical relations between manufacturers and their subcontractors that are prevalent in a particular country.
two factors identified by Aoki and Williamson. Unlike the present work, however, that study compares the response of incumbent firms across the three regions in a variety of industries, and takes no account of new entrants.

I have combined a parsimonious approach towards the institutional elements noted above with findings from ongoing research on the impact of innovation on US and Japanese firms in a single industry: the HDD industry. A single industry allows potential industry and technology effects that might vary across industries to be isolated. From this, I have developed a theory of the role of these institutional elements in conditioning how both incumbent and start-up firms respond to innovation opportunities. Based on this work, I have identified three factors directly influencing the constraints that incumbents and entrants face in response to technological change: (i) the fluidity or rigidity of the technical labor market; (ii) the amount and structure of venture formation capital; and (iii) the prevalence of pre-existing buyer–supplier linkages between firms. Each factor is described below.

Limiting the factors to these three not only accommodates the desire for parsimony but also is related to the focal industry that grounds this theory development. In the HDD industry, the role of governmental R&D funding has not been of direct importance, nor has military procurement been a decisive contributor, as was true for semiconductors. There are no significant regulatory restrictions, as is often the case in the life sciences or telecommunications industries. Nor has the university research system been a primary generator of basic research in this industry. Thus, the HDD industry is not representative of all industries. It may, however, be indicative of other industries where the above additional factors have not been of great importance.

The Technical Labor Market

Fluid markets for such key technical personnel as engineers allow firms to access the technical expertise of people trained in other firms. In particular, engineers from the most advanced firms can be hired away by other firms that have made much smaller investments in internal R&D, thereby providing the latter firms with access to the technology developed by the advanced firms. This creates something of an auction market for highly qualified talent.

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11 Lazonick and O’Sullivan also raise the issue of the sustainability of each country’s institutional framework, a point not explicitly mentioned in Aoki or Williamson. I will return to this point in the conclusion. I am grateful to an anonymous reviewer for this point.

12 For a useful review of the impact of skilled labor mobility upon firms in the context of overall employment relations issues, see Capelli (1997). For a discussion of incentive problems induced by high labor mobility, see Patel and Pavitt (1994).
Talented engineers can ‘surf’ from company to company, selling their talents to the highest bidder. A fluid labor market permits even start-up firms to pioneer the commercialization of promising new technological opportunities. This elevates the impact of the incentive constraint.

Correspondingly, fluid technical labor markets impose hazards on the more technically advanced incumbent firms. Rival firms can access their extensive experience and capabilities, at a fraction of the cost of creating them, by simply hiring away ‘the best and the brightest’. The incentive constraint here functions at two levels. For individual entrepreneurs, it creates a powerful attraction to exit the larger firm for the opportunity to earn a significant reward. For the incumbent firm, a fluid technical labor market creates an unwanted spillover that reduces its ability to appropriate the returns from its investment in training technical staff. Because of incentive constraints, incumbent players cannot match the incentives of the entrepreneurial firm. If key personnel are lost, the firm’s previously difficult-to-imitate capabilities might become more imitable, and the firm might even lose some of its own ability to replicate earlier capabilities.

The mobility of experienced technical and managerial personnel plays an important role in organizations’ ability to perceive and react to technological change. Most of the architectural shifts in technology documented in Henderson (1988) and in Christensen (1992) were led by new organizations, but not new people. While the established organizations in the USA may have been slow to react to new architectures, individual engineers in those same firms were often quick to perceive the opportunities—but they had to leave the established organization to garner the resources and commitment necessary to exploit them. In HDDs, for instance, Al Shugart left IBM to go to Memorex, then left Memorex to lead the 8” disk drive architectural shift at Shugart. He then left Shugart to lead the 5.25” shift at Seagate. Finis Conner and John Squires left Seagate to lead the 3.5” shift, while engineers from Miniscribe led the 2.5” and 1.8” architectural shifts at PrairieTek and Integral respectively.

This pattern has played out in other technologies; the experience of

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13 A notorious case of improved imitability from competitive hiring came in a case litigated between IBM and Seagate (IBM vs. Seagate and Bonyhard), where the head of IBM’s magneto-resistive (MR) head program was recruited by a leading competitor, Seagate. IBM had invested hundreds of millions of dollars in its MR head technology development, and enjoyed a lead of many years over its competition in the technology. Yet, within a year of Bonyhard’s hire at Seagate, the company announced its own MR head products.

14 Intel experienced this problem when it sought to transfer its flash memory product technology from its own fab to one operated by NMB, its manufacturing partner in Japan. Intel lost two quarters of production trying to transfer technology to NMB. Trade press articles at the time attributed much of the lost time to the departure of a key Intel engineer from the firm.
engineers spinning out of Xerox PARC into new start-up firms in order to commercialize PARC technologies (Smith and Alexander, 1988) are cases in point. As we have seen, US start-up firms often can offer stronger incentives to such engineers than those they encounter in more established firms. Thus, Xerox’s ‘fumbling’ of its future may be due at least in part to the incentive constraints it faced as an established firm.

In labor markets with little mobility, by contrast, advanced technology firms can keep their expertise safe from less advanced rivals. Even quite skilled engineers might stay at a single company throughout their productive careers if no viable alternative position is available with a rival firm, thereby mitigating many of the unwanted spillovers facing US incumbents. When these skilled engineers and managers do not have the ‘exit’ option that exists in fluid labor markets, they may instead utilize the ‘voice’ option (Hirschman, 1970), and push the firm to seize new opportunities. While losing the ability to auction themselves to the highest bidder, these talented engineers can anticipate extensive investment in training: that promotes their development, which promotes greater job security. It also can promote the creation and expansion of organizational capital, above and beyond that of individual employees’ skills (Lazonick, 1991; Lazonick and West, 1995).

Where labor markets are relatively rigid, rival firms seeking to compete must build their own capabilities, rather than buy them through hiring away some key technical talent from another firm. Rigid technical labor markets therefore increase the benefit of incumbency over newly entering firms. Internal research and development becomes the primary method to develop and deepen firms’ technical capabilities (Mowery and Rosenberg, 1989), and absorb new technology from outside (Cohen and Levinthal, 1990). By the same token, a rigid labor market makes the environment for start-up firms more harsh. It is harder to find highly trained, experienced engineers to start new firms. It can be particularly difficult to pull people out of more advanced firms to join emerging start-up firms.

Institutional Differences in the Technical Labor Market Between the USA and Japan

Many scholars have noted the relative immobility of Japanese labor markets, from observations of lifetime employment practices, company unions and the use of seniority-based incentives (Dore, 1987; Aoki, 1990, 1994; Odagiri,

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15 These perceptions usually ignore the higher rate of turnover for women, young men under 25 and older men over 55 in Japan. As Sako (1997) reports, the retirement age for men has now reached 60, and is expected soon to extend to age 65.
1992; Nakahara, 1993; Sako, 1997). This immobility has emerged primarily in the post-war era; earlier Japanese labor practices were more akin to the at-will employment systems in the USA (Moriguchi, 1998). The engineering sector of the labor market also exhibits such differences. Although there appear to be no data comparing these sectors continuously over time, occasional studies do directly compare engineers’ labor mobility. Lynn et al. (1988) compared US and Japanese engineering graduates from two well-regarded universities, and found that the rate of job turnover was far higher in the USA than in Japan. They also discovered that US engineers were more personally responsible for their careers, while Japanese engineers relied more on their firms for their career moves (see also Lynn et al., 1993). Westney (1994) points out the severe limits restricting Japanese firms in the use of incentives to lure engineers away from other firms.

Mobility differences among engineers are even more pronounced within specific technology-based industries. In semiconductors, Appleyard (1996) found that Japanese semiconductor engineers had a markedly lower turnover rate than their US counterparts. Of the integrated circuit engineers she surveyed, none of the 25 Japanese engineers had changed employers during their careers to that point, while the 53 US engineers had worked for an average of 1.1 other integrated circuit companies and 0.3 semiconductor equipment makers. In the computer industry, Westney and Sakakibara (1985) compared the mobility of R&D engineers in three US computer systems companies with those of three Japanese computer systems companies and found very similar patterns. They also found much less technical specialization by Japanese R&D engineers relative to their US counterparts. While mobility across firms was commonplace in the US firms they studied, none of the three Japanese companies even had an established mechanism for recruiting mid-career engineers.

This relative immobility appears to typify the Japanese HDD industry as well. I interviewed the four surviving Japanese HDD manufacturers, and asked them each to review their recollections and record the number of engineers that were hired away from their firm by a competing firm, as well as the number of engineers they hired in from other competing firms. These data are reported in Table 1, which indicates the total number of engineers hired in and lost over the past 20 years.

At the same time, the Japanese labor force has evolved methods for allocating technical labor within the firm, or within the industrial group encompassing the firm, that are not found in the US system (Ito and Rose, 1994). Within the firm, engineers are rotated through a number of areas, with talented engineers receiving more frequent transfers than less talented ones.
(Kusunoki and Numagami, 1998). Engineers are also transferred outside the firm, but remain under the firm’s control. One method is the temporary assignment of workers called shukko (Brunello, 1988; Gerlach, 1992, pp. 132–135; Odagiri, 1992), whereby personnel are seconded from their company to another by mutual consent for a limited period. Workers can also be permanently assigned to firms in the same industrial group, in a process called tenseki. Another institutional response to mismatches between labor supply and demand is the creation of ‘buffer firms’ to absorb temporarily unneeded personnel, a solution that Japanese labor unions strongly support as an alternative to lay-offs (Brunello, 1988; Fujimura, 1997). While only 14% of all Japanese firms have workers seconded to other companies, 91% of firms with more than 5000 employees had workers stationed at other companies (Odagiri, 1992, p. 149).

My interviews found evidence of these external transfers in the HDD industry. Fujitsu and Hitachi established a joint venture firm called Nippon Peripherals, Ltd (NPL) in 1975. They then transferred engineers into and out of NPL over the next 12 years. When NPL was shut down in 1987, engineers still working there returned to Fujitsu and Hitachi. Similarly, when NTT ceased its own internal development program of HDDs in 1988, one of its researchers was placed at Fujitsu (though most NTT program members went to work as researchers in Japanese universities). 16

The prevalence of seniority-based incentives is partly responsible for constrained labor mobility. The nenku system provides strong disincentives for employees to leave. Employees who do leave and join another firm are assigned a new, low level of seniority and therefore defer their receipt of any long-term incentives at the new firm (Aoki, 1994; Hill, 1995; Sako, 1997). This effectively punishes employees who switch firms later in their career.

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<table>
<thead>
<tr>
<th>Company</th>
<th>No. of HDD engineers in the firm in 1997</th>
<th>Cumulative no. of engineers hired into the firm</th>
<th>Cumulative no. of engineers lost to competitor firms</th>
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<tbody>
<tr>
<td>1</td>
<td>225</td>
<td>0</td>
<td>0</td>
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<tr>
<td>2</td>
<td>250</td>
<td>0</td>
<td>1</td>
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<tr>
<td>3</td>
<td>400</td>
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<td>1–2 per year</td>
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<tr>
<td>4</td>
<td>250</td>
<td>0</td>
<td>1–2</td>
</tr>
</tbody>
</table>

*Sources: Itozaki and Makuta (1998), Kamimura (1998), Nagai (1998) and Sugihara et al. (1998).*

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16 Other examples of these transfers are discussed below in the section on Japanese affiliate formation.
Even if a hiring firm wishes to induce an experienced manager to leave his current employer, regulatory restrictions on the use of stock options exacerbate disincentives to leave; this further constrains Japanese firms’ ability to motivate employees of competitor firms to switch to them. While the law in this area was changed effective from June 1, 1997,17 as of October 1997, only 47 firms had notified the Ministry of Finance that they intended to use incentive stock options in their company (Japan Weekly Monitor, October 27, 1997). Moreover, the tax treatment of these incentive options has yet to be determined, further delaying their diffusion (Zukis, 1997). The liquidity of these incentives differs substantially as well. A typical incentive stock option plan in a US firm vests the stock over four or five years, and the recipient can sell the stock at that point if a public market exists for it. In Japan, the options must be held for 10 years before being exercised (Economist, August 3, 1996), and the listing requirements for a public offering are more onerous in Japan than in the USA. Thus, it will take much longer for Japanese engineers to receive their stock, and it is less likely that they will ever be able to sell it.

By contrast, the flow of engineers switching to competing companies occurs frequently in the USA, and is almost legendary in places like Silicon Valley. This flow can disrupt the continuity of internal research and development activities (Okimoto and Nishi, 1994). One can construct a genealogy of disk drive firms from the diaspora of engineers emanating from IBM, Memorex, Control Data and a few other early industry entrants. A similar genealogy of semiconductor firms also could be developed from firms that emerged out of AT&T, Fairchild or Texas Instruments. This supply of talented people is crucial to the formation of capable start-up firms. Start-ups cannot and will not pay for training; instead, they benefit from the training and experience that established firms provide. Were these established firms to disappear, the lost pool of talent would severely impact future start-up firms.

Incentive stock options were one of the key mechanisms US start-up disk drive firms used to induce senior engineers to depart from these established firms and join them. A typical US firm’s incentive option plan vests stock with the employee over 3–5 years in monthly increments, with the first tranche available for exercise and subsequent sale after just 12 months. By contrast, longer-term incentives—retirement plans, for example—are much weaker than in Japan. The portability of retirement plans such as 401K programs even further diminishes long-term incentives: now these benefits travel with the worker who decides to leave one employer and join another.

Another difference in the technical labor market is the technical specialization of engineers in the USA compared with the more generalist role

17 I am indebted to an anonymous reviewer for this point. See Japan Economic Newswire, May 16, 1997.
played by engineers in Japan. US engineers in the disk drive industry might spend their entire careers as servo engineers, read–write engineers, materials engineers, etc. Engineers in Japan performing the same tasks, however, likely began in another technology area (e.g. videotape recorders), and will likely be working on yet another technology area in five years’ time (Kusunoki and Numagami, 1998). In Japanese HDD firms, a small cadre of core engineers specializes in technical disciplines as engineers do in the USA. However, 80–90% of Japanese HDD engineers will rotate from research to advanced development, and then perhaps to production. US engineers invest in developing greater skills in narrow technical specialties, and these confer greater rewards upon them in the fluid external labor market for those skills. Most of their Japanese counterparts invest in broader skills that are more organization-specific, thereby conferring greater rewards in an immobile labor market.

While technical specialization provides obvious advantages to US firms, many researchers have noted the benefits of the greater cross-function coordination that less specialized Japanese engineers offer (cf. Clark and Fujimoto, 1991; Wheelwright and Clark, 1992). Greater ability to coordinate across functions can create sustainable advantages where team and organizational skills are far more important than individual expertise (Lazonick, 1990, 1991). The point in this paper is not which approach is ‘better’; rather, it is that the two systems function differently when innovation shocks occur, and that these differences affect the organizational constraints of incumbent and start-up firms differently as a result.

The Venture Formation Capital Market

One key difference between large and small firms may be the extent to which large firms’ projects are buffered from the external capital market’s selection pressures, at least in the short term. Instead, their projects compete for capital through an internal capital market, while the external capital market constrains the overall portfolio of projects. Dosi (1995) has argued that capital markets can be competitive or institutional, with the latter supplying capital through direct institutional links on a basis that transcends arm’s-length processes. In contrasting the response of US, European and Japanese semiconductor manufacturers to the same innovation shocks, Levinthal (1992) notes that the Europeans in particular were for many years isolated from capital-market pressures to adapt.

While the overall capital market is vitally important, the focus here is on the institutional parameter of the venture formation capital market. Capital
for new venture formation can come from external sources like VC firms, or from such internal sources as parent firms’ creating new spin-offs or subsidiaries. External VC strengthens the effects of the incentive constraint upon innovating firms and reinforces the impact of the technical labor market. When readily available, such VC allows new firms to enter the industry by creating high risk/high reward positions for talented managers and engineers.

When individual engineers and managers perceive new opportunities arising from an innovation that their current organization is not addressing in a timely manner, they can opt to form new firms. If subsequent events prove unfavorable for the venture, its financial backers will shut it down. In that event, the engineers and managers themselves cycle back into other companies (which is made much easier in a fluid technical labor market). At the same time, such VC poses a hazard to incumbent firms, since individual personnel can be offered large compensation packages to join new start-up firms that the incumbent firm finds difficult to match. This relationship is essentially parasitic, because the VC community depends on an available pool of experienced engineering and management talent at incumbent firms. It is unwilling and unable to pay for on-the-job training and experience, and relies on the established firms it raids to continue to train people who, in turn, may be lured away in the future.

Correspondingly, when there is relatively little external capital available for new venture formation,18 incumbent firms do not confront the prospect of losing people or customers to new start-up competitors. Veteran engineers and managers who perceive opportunities must devote their energies to getting their current employer to respond to the new opportunities. This undoubtedly takes time. The absence of aggressive new start-up entrants suggests that prospective new technologies may not be commercialized as rapidly as they might be when start-up entrants are present. This may diminish an industry’s ability to rapidly discover and subsequently develop new technologies.19 Or, the employer may elect to form a new venture or subsidiary to focus part of the organization on the execution of the new idea (Ito and Rose, 1994). But this also reduces the risks once established firms do

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18 The availability of venture funding is itself related to other institutional parameters. A key factor is the ability of firms to be listed on the public equities market. Going public is relatively easy in the USA, while it has been heavily taxed in Japan. Relatedly, the cost to firms of using bank financing varies greatly with the regulatory regime. The US venture capital system developed in part because of restrictions on bank ownership in companies imposed by the Glass–Steagall Act. See Charkham (1994) and Prowse (1996) for discussions of these issues.

19 Another possibility for Japanese firms is to look outside their own environment for US start-up firms to act as ‘pilot fish’ for potential new technologies. Japanese incumbent firms may learn from US start-ups, while they may be less exposed to some of the constraints these start-ups pose, such as raiding their top technical talent and largest customers. That US start-up firms may be of value in this way to Japanese firms has been noted by Kogut et al. (1993).
decide to invest in those technologies. While they may enter later, they do so with greater confidence that they will be able to protect their people from rivals upon entry. The effect of the incentive constraint here is sharply diminished.

Institutional Differences in the US and Japanese Venture Formation Capital Markets

The role of VC is quite different in the USA and Japan. The US industry is highly developed—professional VC firms invested over $16 billion in 1998 (Venture Economics, 1999). This large amount of venture funds is in part a response to the historically attractive returns earlier VC funds have earned. However, it is also the result of, among other things, a long history of regulation and law regarding access to bank financing, legal constraints placed on bank ownership of firms, taxation of capital gains, pension fund investment regulations and potential liabilities to which large shareholders are exposed under US law (for discussions see Charkham, 1994; Prowse, 1996).

The amount of VC in Japan amounted to $1.2 billion (172.1 billion yen) in 1997, according to a recent survey (Nikkei Weekly, July 6, 1998). This is down 20% from 1996 levels in yen terms. Moreover, funds invested in domestic companies fell 26%, which was partially offset by an increase in foreign, chiefly US companies. The recent drop reflects the current troubles of the aggregate Japanese economy, but there are other factors that are likely to keep VC investing well below US levels. Equity investors care deeply about eventual liquidity for their investments, and the US public stock market is far more available to successful young companies than are the public equities markets in Japan. The prospect of eventual liquidity reduces the risks facing venture financing firms, and allows them to make distributions back to their investors. To put it another way, were Japan to expand its pool of venture monies without changing its requirements for equities listings, venture investors would still face greater liquidity risks relative to those faced in the USA.

The way such monies are structured is equally important. The US VC industry is largely funded through institutional investors such as pension funds, university and foundation endowments, and wealthy individuals (see Table 2), who invest as limited partners in VC funds managed by general partners of VC firms. There are important credible restrictions upon investors in venture funds20 that cause them to leave investment decisions to the

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20 As Prowse (1996) discusses, limited partners who appear to be intervening may jeopardize their limited liability or tax exempt status, and become treated as general partners in the eyes of the courts and the Internal Revenue Service.
general partners. This structure frees US VC managers to fund the formation of new companies, no matter which industry they decide to enter, and to hire away people from any firm of their choosing, no matter which incumbent firms might be disadvantaged by their success. Indeed, such start-up firms often enter by utilizing the key personnel of leading incumbent firms. For instance, it is entirely possible that some portion of IBM’s pension funds were invested with VC firms, which in turn invested in start-up disk drive firms that raided IBM’s engineers, competed with IBM’s products and sold to former IBM customers.

The structure of VC is quite different in Japan. In 1994, fully 72% of Japanese VC funds were in the form of debt (Hulme, 1994, p. 8; Prowse, 1996, p. 6). The sources of these funds are quite different from the sources of venture funds in the USA, and <5% of these funds were extended to seed stage or early stage start-ups, vs. 35% in the US (see Table 2).

The average age of a company receiving ‘new venture business’ financing in Japan is 15–20 years old, compared with 5 years in the USA (Vonk, 1988; Hulme, 1994). In fact, Japan’s approach to venture financing provides relatively little support for new venture formation, and is closer to what is termed ‘mezzanine financing’ in the USA.

The background of Japanese venture partners also is consistent with the close links between VC and the main banking system. The profile of Japanese VC managers differs markedly from that of US venture partners. As Hiroaki Ueda, president of Nippon Enterprise Development Bank (the first Japanese VC institution), noted, ‘[M]ost Japanese venture capitalists are from banks or securities companies, and have either a background in accounting or taxation, rather than training in engineering or science (like the US venture capitalists)’ (Bolton, 1992, p. 64).

In addition, how Japanese venture investment decisions are made differs from the US system of passive limited partners investing through general

<table>
<thead>
<tr>
<th>Source</th>
<th>Japan (%)</th>
<th>USA (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturers and financial firms</td>
<td>90</td>
<td>11</td>
</tr>
<tr>
<td>Institutions/endowments</td>
<td>0</td>
<td>27</td>
</tr>
<tr>
<td>Pension funds</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>Individuals</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>% of funds for seed stage</td>
<td>&lt;5</td>
<td>35</td>
</tr>
</tbody>
</table>

partners described above. Until the early 1990s, the Ministry of Finance prohibited venture investors from owning >49% of any of the firms they invest in and from being members of the board of directors of these firms (Tall, 1995). Because most Japanese venture firms get their funds directly from their main banks and their syndicated banks21 or leading financial firms, which in turn have strong ties to the leading industrial firms in Japan, there are ‘strings attached’ to these investment decisions (Sheard, 1991). The IBM pension fund example above would be unthinkable, given the structure of venture financing in Japan. No bank would consider jeopardizing a long-standing relationship with a multi-billion dollar client for the sake of a small probability of a one-time equity gain.

A final structural limit on venture financing in Japan is the lack of ‘exit’ options for venture investors. The requirements for becoming a publicly traded stock are much more onerous in Japan than in the USA. The market for corporate control in Japan is not as established as in the USA, making the sale of a successful company (a second exit option) a more unlikely event in Japan. Mergers and acquisitions, a third potential option, are also far less frequent than in the USA (Odagiri, 1992, p. 105; Prowse, 1996). The restrictions upon these exit vehicles further constrain investor willingness to invest more in start-up firms in Japan.22

Indeed, the primary source of new business formation capital in Japan is not _de novo_ start-up firms financed through external VC but the burgeoning formation of new subsidiary companies financed through internal capital sources of the parent firm23 (Odagiri, 1992; Ito and Rose, 1994; Sako, 1997). These subsidiary firms are not intended to pioneer new technologies but to explore and pursue already-identified technical opportunities that do not fit well with the parent firm’s core competences (Ito and Rose, 1994). They also provide greater organizational flexibility in terms of wage policies for Japanese firms to meet their commitments to lifetime employment for certain classes of workers (Sako, 1997).

The Institutional Factor of Buyer–Supplier Relations

The third institutional parameter of interest, prevailing buyer–supplier linkages, primarily influences the appropriability constraint for innovating

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21 Japanese banks are not prohibited from owning part of a firm, as are banks in the USA (see Charkham, 1994; Prowse, 1996). Thus, the lack of availability of banks as sources of finance for US firms in part explains the US development of the institution of private VC, separate from the banking system.

22 Indeed, many Japanese VC firms are increasingly deploying their resources outside Japan, in the USA, Europe and other parts of the Pacific Rim (Yunker, 1988; Bolton, 1992; Bygrave and Timmons, 1992).

23 I am indebted to two anonymous reviewers for this point.
firms. Unless an innovating firm can gain access to important complementary assets, its ability to profit from its innovations will be impaired. Close linkages with key customers are usually required to achieve this. Where there are complementary technologies, both the innovation itself and the adjustments the complementary technology requires must be closely coordinated for the innovation to realize its potential (Chesbrough and Teece, 1996). This has important implications for how the firm organizes, and will likely vary between start-up firms and incumbents. Incumbents can apply leverage to established asset positions from current activities, which provide ready access to required complementary assets. *De novo* start-up firms, by contrast, usually lack such assets, and must develop access to them in parallel with developing the technology that requires them. Here, I focus on the complementary asset of linkages with customers, though the concept of complementarities extends to many facets of business (Milgrom and Roberts, 1990, 1995).

Customer–supplier relations can be structured in one of three ways: arm’s-length relations, internal integration or some intermediate relationship between those extremes. As new innovation opportunities arise, they must be commercialized through one of these types of relationships. Because these differ structurally in terms of the amount of incentives they provide and the degree of hazards they involve in coordinating mutual adaptation (Williamson, 1991a), commercialization of the same technology may develop quite differently when the type of customer linkage varies.

Where complete independence between the supplier and the buyer is the norm, an innovation’s adoption is coordinated through the market, with its attendant high-powered incentives and potential hazards. The competition between supplying firms is akin to a jump ball in basketball: whoever has the best product at the right time at the right price can expect to win the customer’s business. Buyers have little supplier loyalty a priori, and try to design their systems to use products from many alternate suppliers. Suppliers must refrain from becoming locked into a particular customer, since it might go elsewhere in the next round of product competition. Part of the customer’s decision will depend on the supplier’s ability to provide the right product at the right time. However, the customer is unwilling to make any extended commitment *ex ante* to allow suppliers to secure the requisite complementary assets in advance. The appropriability constraint here can therefore be quite high, since companies that have a great product but are unable to produce and deliver it in a timely way might fail to win the business.

At the other end of the organizational spectrum, complete integration of upstream supply with downstream use allows firms to coordinate the adoption of an innovation and the requisite provision of complementary assets
through internal processes. While the incentive intensity inside the firm is low, and the organization may react more slowly to new innovation opportunities, the resulting ability to coordinate complementary activities is high. The appropriability constraint is lowest here.

An intermediate level of linkages, which might include partial equity ownership or sustained business relationships (such as keiretsu linkages), fall in between purely arm’s-length coordination and internal integration. Pre-existing links between buyers and suppliers may mitigate the constraints the supply firm encounters when trying to access complementary assets. Moreover, the relationships often extend to multiple businesses. Here, any incentive to behave opportunistically in one business is offset by the many relationships in others that might be placed at risk by such behavior. These ties reduce the risk of having such assets exploited by the other party.

Customers may share information on upcoming projects, and suppliers may make investments more specific to that customer given the presence of these relationships (Dyer, 1996a). Other ties, such as cross-shareholdings, shared banking relationships and keiretsu membership, can constitute a further credible commitment to ongoing business dealings (Gerlach, 1992). When firms have enduring relationships with their customers, that is itself an important complementary asset and lowers the appropriability constraint below the level it would be if such relationships were coordinated entirely through markets.

Institutional Differences in Buyer–Supplier Relations between the USA and Japan

It has been common practice for US firms to cultivate multiple supplier sources so as to preserve market power in negotiations with them (Porter, 1980; Clark and Fujimoto, 1991; Helper, 1991). It is similarly common for customers in many technology industries to insist on having a supplier license its technology to a second source before the customer will use it (Shepard, 1987). These practices have evolved in a legal and regulatory regime that for many years was suspicious of vertical relationships not conducted at arm’s-length (Williamson, 1975, 1985; Teece, 1982). It is only in the very recent past that US anti-trust law has adopted a rule-of-reason standard (vs. the earlier per se standard of illegality) for vertical relationships where restricted or exclusive dealing was involved.

These general institutional patterns are typical of the personal computer

24 This has been found both in private contracts in high technology, and in the US government in its defense procurement contracts. As Dyer (1996b) notes, this was also the practice until very recently in the US automobile industry as well.
and HDD industries as well. Relationships in the USA between suppliers of disk drive products and their computer customers exhibit little or no loyalty; firms typically rise and fall with the success of particular product development programs, and customers move from one supplier to another whenever a better product is available. Computer customers tend to nurture at least a couple of alternative suppliers for every major computer development program to avoid lock-in to a particular supplier. For a salient example, see Table 3, which lists the vendors from whom IBM purchased disk drive storage products for its PC product line.

IBM’s determination to resist locking itself into a particular supplier caused it to do business with a large number of firms, but when that business ceased, many of them were severely damaged. IBM’s decision to discontinue IMI’s 10 MB 5.25” drive in 1984 caused the company to go out of business. IBM purchased its 20 MB 5.25” drives from CMI, and CMI went out of business shortly after IBM discontinued its buying in 1986. When IBM attempted to introduce its own MicroChannel bus architecture for the PC, it produced its own 3.5” drives, and again cut off its earlier suppliers. This pattern of buying from multiple sources is typical of many firms in PCs.25

These arm’s-length relationships create tremendous incentives for suppliers to take the necessary risks to advance technology.26 However, given the uncertainties in rapidly evolving technology, no supplier can be assured of having its customers’ business in the next product cycle. Should the company

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Table 3. Independent Suppliers to IBM’s PC Division, 1983–1994

<table>
<thead>
<tr>
<th>Company</th>
<th>When supplied IBM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seagate</td>
<td>1983–1985</td>
</tr>
<tr>
<td>Miniscribe</td>
<td>1983–1984</td>
</tr>
<tr>
<td>IMI</td>
<td>1983–1984</td>
</tr>
<tr>
<td>CMI</td>
<td>1984–1986</td>
</tr>
<tr>
<td>Conner</td>
<td>1989–1990</td>
</tr>
<tr>
<td>Maxtor</td>
<td>1990–1993</td>
</tr>
<tr>
<td>Western Digital</td>
<td>1992–present</td>
</tr>
<tr>
<td>Quantum</td>
<td>1993–present</td>
</tr>
</tbody>
</table>

Source: Chesbrough (1997).

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25 Compaq is buying drives from Western Digital, from Quantum, from JTS and from Fujitsu as of Fall 1996 for its various desktop computer products, and it is buying from Seagate for its server line of storage products. Apple Computer also is careful to limit its reliance on any single disk drive supplier. As of 1996, it is buying hard disk drives from Quantum, Western Digital, Seagate and even IBM (Chesbrough, 1997).

26 One successful US HDD start-up firm, Conner Peripherals, managed to garner $111 million in its first 12 months of shipping product, the fastest period of time that any US company had built sales to over $100 million, as of 1987.
fail to get its products to market on time, in high volume, with good quality and with the desired specifications, it risks losing much if not all of its customer base.

This uncertainty in each product generation means that suppliers to ‘jump ball’ customers must be careful not to invest in know-how specific to individual customers. Such specific know-how might be forfeit in a subsequent competition for a design win, or might not earn any return for the supplier. Dyer (1996b) argues that General Motors has suffered from managing its suppliers in this fashion, while Chrysler has improved its asset utilization and its cost position by shifting its management of suppliers to more long-term, specific investment relationships.

The situation between customers and suppliers in Japan is organized along a very different structure of financial ties that link them much more closely than would an arm’s-length arrangement. The presence of sustained cross-shareholdings between customers and suppliers promotes relationship-specific investments, and acts as a vital part of both contractual governance and overall corporate governance (Gilson and Roe, 1993). It is common for suppliers to be single sources of many components in Japanese products, and to act as a source of innovations for their customers (Aoki and Rosenberg, 1987; Clark, 1989; Dyer, 1996a). The total costs of these products can be quite competitive, and can speed time-to-market and reduce the customer’s engineering investment. The risk of lock-in from such arrangements is managed in a number of ways, including ongoing business relations across multiple businesses, equity shareholdings by the customer, shared ties to a main bank and presidents’ clubs where representatives of supplier divisions meet with the top management of their leading customers. These ties are further solidified by transfers of personnel from customers to suppliers.

While the nature of cross-shareholdings has been documented for Japan in general (Kester, 1991; Sheard, 1991; Gerlach, 1992; Odagiri and Goto, 1993; Aoki, 1994), this pattern of control has been less well understood within the personal computer industry. The central firms in the Japanese computer industry are Fujitsu, Hitachi, NEC and Toshiba. While each of these firms has in-house disk drive production, each also has close links with affiliated producers.

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27 This discussion focuses on so-called ‘vertical keiretsu’ relationships and suppresses ‘horizontal keiretsu’ relationships in the interest of brevity. Also suppressed are the varying empirical definitions of a keiretsu linkage. See Kester (1991, pp. 54–62) and Gerlach (1992, pp. 63–86) for discussions of these definitions and issues.

28 Mitsubishi Electric and Oki are the other two firms which also participated in Research Associations in the computer industry in Japan (Odagiri and Goto, 1993), but neither has achieved much market success in the computer industry in Japan or elsewhere. In addition, neither firm has had much success in HDDs (Disk/Trend Report, various years).
One such affiliate is Tokico, of which 21% is owned by Hitachi. Tokico also shares Hitachi’s main bank (which owns additional shares of Tokico) and the managing director of Tokico was posted there from Hitachi. Similarly, Fuji Electric is both a HDD supplier to Fujitsu and also a subsidiary of Fujitsu’s original Fujiwara group, which both owns shares in Fujitsu and is in turn partly owned by Fujitsu (Gerlach, 1992). NPL was a 50–50 joint venture between Fujitsu and Hitachi, and was an important early participant in the Japanese HDD market. Another entrant firm, Nippon Electric Industries (NEI), is a close affiliate of NEC, which owns 34% of NEI. Tokyo Electric is linked with Toshiba as well (Chesbrough, 1998).

These affiliates have played a useful role for Japanese HDD manufacturers by exploring emerging markets for new, smaller HDDs. In 1977, for example, NPL was the first Japanese company to reverse-engineer the IBM 3340 and 3350 drives, and that knowledge was then transferred back to Fujitsu and Hitachi. NPL was also an early developer of the first 8” and 5.25” drives in Japan. Hitachi actually transferred a team of engineers to Tokico to develop a 5.25” drive. When that drive went into production, the team moved back to Hitachi to work on a Hitachi 5.25” design (Disk/Trend, 1984; Nagai, 1998). NEI and Fuji Electric acted as production subcontractors for NEC and Fujitsu respectively, and when each affiliate exited the HDD business, it turned its production facilities over to NEC and Fujitsu (Disk/Trend, 1988; Disk/Trend, 1994).

Fujitsu provides an important contrast to the sourcing behavior of IBM in its PC division described in Table 3. Its successful internal products allowed the firm to service much of its own needs and purchase most of the drives it did not produce internally from an affiliate supplier, Fuji Electric, until Fuji left the market in 1994. For capacity points that Fujitsu did not manufacture internally, or when its internal or affiliated sources were not competitive, its downstream market competition at the PC level forced the company to source from outside. Fujitsu appears to have increased this practice in recent years, as its affiliated supplier (Fuji) has withdrawn from HDD manufacturing. Even here, though, we see evidence of longer-term supply relationships than those followed by IBM. See Table 4 for Fujitsu’s PC purchasing from external suppliers.

In cases where Fujitsu has shifted to unaffiliated suppliers, its affiliated supplier network has remained in operation outside of the HDD business, and continues to supply the company in a number of other businesses. As such, the multiple points of contact in the relationship between Fujitsu and its affiliates remains even after the withdrawal of an affiliate from a single business.

Close vertical links remain for other Japanese firms beyond the primary
computer companies. One example is Matsushita, which markets personal computers under its Panasonic brand. In the 3.5″ hard drive industry segment, at least four HDD suppliers, all majority-owned by Matsushita, entered the market: JVC, KME, MKE and MCI (Japan Company Handbook, 1993). These entities compete fiercely for Matsushita’s business as well as that of other firms. This rivalry offsets the complacency that can arise within sole-source relationships (Asunama, 1992).

A related organizational option for Japanese computer firms is to ‘hive off’ (Odagiri, 1992) one or more subsidiary firms from the parent to focus on particular elements of computer technology. These subsidiary firms are managed differently from the parent firm in terms of labor policies, pay packages and sometimes even union relationships (Fujimura, 1997; Sako, 1997). Generally not enjoying the parent firm’s status, these subsidiaries must recruit from second- and third-tier universities for their personnel. As such, observers believe that such firms provide technology that is ancillary to the core technology of the parent firm (Okimoto and Nishi, 1994; Odagiri, 1992). This perception may change over time, however, as numerous computer companies in Japan began as ‘hive offs’ themselves (Odagiri and Goto, 1993, pp. 93–100). Because of the pressures on lifetime employment, observers also feel that these subsidiaries are increasingly important to the Japanese employment system, and that ‘lifetime employment’ is now promised within the enterprise group rather than within the parent firm (Sako, 1997).

Subsidiary companies have arisen frequently within Japanese HDD manufacturers. Hitachi initially established NPL with Fujitsu, and went on to create Hitachi DECO for disk drive testing equipment, Hitachi Electric Service for maintenance of disk drive subsystems, Hitachi Metal for the development and production of disk drive heads and Hitachi Custom Manufacturing for LSI chips (Nagai, 1998). Fujitsu established FDK for such disk drive components as heads, and Fujitsu-Yamagata for manufacturing. In contrast to Sako’s (1997) observations of subsidiary policies, though, Fujitsu

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**Table 4. Fujitsu’s Personal Computer Disk Drive Supply Sources, 1984–1994**

<table>
<thead>
<tr>
<th>Company</th>
<th>When supplied Fujitsu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuji Electric</td>
<td>1984–1994</td>
</tr>
<tr>
<td>Quantum/MKE</td>
<td>1990–1994</td>
</tr>
<tr>
<td>Seagate</td>
<td>1989–1994</td>
</tr>
<tr>
<td>Western Digital</td>
<td>1992–1994</td>
</tr>
</tbody>
</table>

*Sources: Chesbrough (1997) and Sagishita et al. (1998).*

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and Hitachi appear to manage their subsidiaries in a more autonomous manner. As the CEO of the FDK subsidiary explained:

The rules for these subsidiaries are different than they are for the parent. Each subsidiary has its own employment policies, even when we own 100% of it and even if the management of the subsidiary comes from Fujitsu. This frees them from our policies to pursue their own. It would not make sense, for example, in an agricultural area of Japan to pay the same wages we must pay in Tokyo and Osaka. . . . And of course, if the subsidiary does well, then their salaries and bonuses could be higher than those in the parent firm. . . . This was actually the case for Fujitsu back when it was a subsidiary of the Fuji Electronics group. (Tatsuta and Adachi, 1998)

In an institutional environment with these dense linkages, the competition among disk drive suppliers for customer acceptance is not ‘winner takes all’, open to all comers. Rather, there appears to be an inside group of affiliates and subsidiaries, and an outside group of less favored sources (including most foreign suppliers). While Japanese customers do not put their eggs into a single basket, neither do they open the competition to any and all potential suppliers on a level playing field. This elevates the appropriability constraint facing start-up firms.

For any single affiliated or subsidiary supplier, these dense linkages dampen incentives to take the risks necessary to pioneer a new technology. Because the supplier’s available market is more likely to be confined to its current ‘group’ of affiliated companies, and not the entire market, the rewards for success are more limited than in a ‘winner takes all’ environment; the incentives are stronger to wait and then follow someone else’s lead. Once a new technology has reached a more mature level of demand, a supplier knows that it has an inside track at its group of affiliated companies. The risks of being late to market are fewer, since the customer will defer purchases for some period of time, or purchase on a spot basis until the preferred supplier can catch up. In turn, there is greater incentive for coordination between the favored supplier and buyer, since both know that the relationship will continue beyond the current transaction, thus safeguarding each from opportunistic behavior by the other.

In addition, these subsidiary and affiliate firms provide important organizational flexibility to Japanese computer and HDD makers (Ito and Rose, 1994). While not enjoying the status and prestige of their parent firms, they have had sufficient capabilities to explore new markets within the computer industry and then transfer their learning back to the parent firms. These
affiliate and subsidiary firms may provide an important resolution to the
dichotomy of ‘explore’ vs. ‘exploit’ choices that companies face in determining
their technology strategies (Levitt and March, 1988; Christensen, 1997).

3. The Systemic Nature of these National Institutional Factors

The institutional differences between the USA and Japan outlined above raise
some important questions. Why do we not observe cross-national exchanges
that would exploit these differences and eventually ‘arbitrage’ them away?
If firms competing in global markets are forcing these national institutional
factors to compete with one another, will this competition not force them to
converge? Put somewhat differently, how sustainable are these institutional
characteristics?

Past predictions of such convergence have been premature (Mowery, 1992a;
Sako, 1997) and what convergence that does occur will likely vary by
industry. The automotive sector may experience more differential arbitrage
between institutional factors (such as transplant factories in the USA built
by Japanese producers, who bring over their Japanese suppliers) than the
electronics sector, where both US and Japanese factories are moving to such
Pacific Rim countries as Singapore, Malaysia, Thailand and the Philippines.
Where team or organizational capital is critical to firm success (as in
automobiles), Japanese firms have shifted multiple elements of their system
to their US and European transplant factories. These multiple elements
include their hiring and training strategies (Sako, 1994), locating affiliate
supplier plants near the transplant factories and bringing in Japanese
management. In the electronics industry this team element appears to be less
critical, and the Japanese move to offshore production is being organized
through subsidiary firms in the local countries such as the Philippines and
Thailand. The policies towards workers and suppliers differ noticeably from
those that Japanese firms follow in Japan (Gourevich et al., 1997; Isozaki and
Mukuta, 1998).

Moreover, complementarities among the individual institutional factors
will likely inhibit convergence. Analysts who have compared US and Japanese
economic systems highlight the systemic dimension of the differences (Aoki
and Dore, 1994). This systemic character means that these elements exhibit
complementarities and move together, and must, therefore, be analyzed
together, not just in piecemeal fashion (Williamson, 1991b; Aoki, 1994).
Indeed, piecemeal adaptation can be ineffective in environments where strong
complementarities are present (Milgrom and Roberts, 1990, 1995).

Consider the possible arbitrage between entrepreneurs and VC. If Japanese
VC is constrained by the lack of an available labor pool, why does it not seek US entrepreneurs to fund instead? The answer reflects the complementarities within the Japanese system. Japanese VC relies in part on its links with the larger main banking system to monitor and discipline its venture investment companies. Moving venture money to the US market forfeits this network of linkages, which allow Japanese venture capitalists to exercise control and discipline over their investments. They would have to finance US entrepreneurs under the US institutional structure, doing so without the linkages they benefit from in Japan.

Alternatively, if Japanese entrepreneurs cannot obtain sufficient seed stage equity in Japan, why do they not seek US financing instead? US venture capitalists are supported by a dense network of previous entrepreneurs, angel investors, previous co-workers, customers, suppliers, and legal and professional services firms (Saxenian, 1994). This network allows them to rapidly evaluate the quality of both entrepreneurs and their plans, and helps access the resources needed for the venture to grow quickly. It also promotes rapid replacement of the CEO if the venture fails to meet its commitments to its investors. Venture capitalists would have a difficult time evaluating the quality of the Japanese entrepreneur, however. Moreover, the Japanese entrepreneur would have a hard time attracting other talented Japanese engineers and managers to the firm. Japanese customers with established relations might be reluctant to buy products from the start-up, limiting its ability to grow. US venture capitalists would also need to see an ‘exit strategy’ for how they would achieve liquidity for their investments, and this, too, is more problematic in Japan. In short, US VC requires a supporting institutional infrastructure in order to commit to seed stage equity investments.

Another reality of these institutional characteristics is that they have been formed over a long period of time but not primarily as a result of conscious social policy (Mowery, 1992a). The accidental nature of these factors, combined with their systemic linkages, imply that it will be difficult for one environment to imitate piecemeal aspects of the other. As such, the ‘convergence’ between the US and Japanese institutional environments that some researchers argue is in prospect (for a prediction of convergence in financial structures see Prowse, 1996) may well prove illusory, given the historical causes of these institutional factors and the fact that they are complementary to each other.

A related question is how sustainable these institutional factors themselves are. Does the logic that binds the individual characteristics into a system permit that system to shift over time? It has already been noted above that the US system contains some internal, parasitic tensions between the individual
employees and the venture capitalists on the one hand, and the established incumbent firms on the other. If the former are too successful, the pool of talent that the system relies upon may be depleted. For example, the ability of US HDD firms to commercialize IBM’s R&D breakthroughs relied on IBM’s ability to continue to create those breakthroughs. IBM has in fact greatly reduced its R&D spending in storage over the past five years (Wall Street Journal, October 6, 1997, p. 1; Zschau, 1997). There has been no compensating increase in R&D spending in storage technology by other US firms (who focus on ‘D’, not ‘R’), nor by the US government or universities. Without adjustments in the system, the stream of future research breakthroughs may be diminished. This may create an opportunity for Japanese firms, particularly Fujitsu and Hitachi, that have not cut back their research spending to the same extent (Nagai, 1998; Sugihara et al, 1998).

The Japanese configuration of attributes poses different challenges for the sustainability of its system. While the system provides strong incentives for diffusion and imitation, it lacks some of the elements needed for pioneering new breakthroughs, such as greater individual incentives for risk-taking. Now that the Japanese system has in many industries reached the frontier of technology, its own internal logic needs to shift to address these issues. As Odagiri and Goto (1993, p. 111) concluded, ‘. . . further changes are inevitable and necessary to the Japanese innovation system . . . (I)nnovation to create a leader’s innovation system out of a follower’s innovation system, however successful it may have been in the past, is very much in need.’ The complementarities between the institutional factors noted here suggest that realizing such changes will be extremely difficult, because each factor must change in order to build such a system. Moreover, such changes will create losers as well as winners, and those who perceive that their interests are not served by institutional changes may be able to frustrate those changes.

5. The Strategy Implications of Differences in National Institutional Characteristics

The distinct differences between the institutional environments in the USA and Japan also imply differences in the way firms approach strategy. The US environment supports first mover strategies, for example, since it allows firms to rapidly assemble and deploy experienced engineering talent. Newly entering firms can not only provide attractive financial incentives to lure experienced people away from incumbents, they also can move quickly to commercialize even rather advanced technology, which provides a time-to-market advantage. Environmental characteristics that support strategies for
being a first mover, though, create challenges in retaining and upgrading staff. Firms that seek to sustain their positions must build strong market positions and strong complementary asset positions if they are to retain their early lead.

Firms in the Japanese environments may find it difficult to pursue such strategies in a rapidly evolving technology where individual skills are paramount, since it takes time to build the internal expertise necessary to exploit a new opportunity. They may instead prefer a strategy of following into a market if and when demand becomes significant (Odagiri and Goto, 1993, p. 111). Once into the market, they can improve over time to catch up and overtake the early entrants. In the case of HDDs, Japanese firms watched IBM's product and technology announcements quite closely, and seldom committed to significant technology deployments until after they perceived that IBM had done so. This approach is quite consistent with their environment, since these firms can invest in research, retraining and technical development with little fear of having other firms appropriate their investments in key personnel.

The importance of these characteristics varies with the rate of technical change. In industries where technology changes quite slowly, these features may carry little value, because time to market is not very important to overall success, and later entrant firms can ‘catch up’. Similarly, in industries where organizational coordination is much more critical than individual skills, firms that can train and retain their staff may be able to achieve technological leadership. In rapidly evolving technologies where individual skills are vital, however, these advantages could prove quite disruptive to incumbent firms. Firms that wait too long may find that, just as they enter, the technological game has altered. In industries with strong demand side externalities, first movers may be able to secure overwhelming advantages and effectively lock out late entrants.29

A related strategic effect is whether a firm should acquire its capabilities or build them from within. The US environment poses hazards to firms that strive to build strong internal capabilities, because many of these reside in people, who cannot be indentured to the firm and potentially are available (given sufficient stock options) to competitors. Companies that surmount such obstacles and manage to succeed, in turn, become human resource pools for a later generation of entering firms (and their VC backers). This may explain some recent organizational experiments of certain US high technology

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29 An example here might be the Internet access software market, where Mosaic initially established itself, followed by Netscape and then Microsoft. It seems unlikely that an incumbent firm from Japan will be able to catch up and penetrate this market (Cottrell, 1996).
firms, which have established corporate VC programs. These programs attempt to harness the high powered incentives of VC to promote corporate technological and strategic objectives. In a sense, these incumbent firms have concluded, 'If you can't beat them, fund them'. Other companies have accelerated their acquisition activities, increasingly buying technology, capabilities and the people associated with them, instead of relying chiefly on internal growth. While these experiments are too recent to judge their efficacy, they do reflect the internal logic of the US institutional factors of fluid labor and capital markets, and available customers.

The Japanese environment, by contrast, increases the ability of firms to develop strong internal capabilities (Teece et al., 1997), because they are better able to protect those capabilities from rival firms. Even in a period of prolonged recession in the Japanese economy, many individual firms remain extremely effective in their industries, even as these firms strive to maintain long term employment policies and promote close relations with their affiliated customers. Sako (1997) among others argues that the commitments of Japanese firms to their workers will shift from long term employment within the firm to long term employment within the group of affiliated companies. This suggests an increasingly important role for new subsidiary companies within large Japanese groups. Western governments are advising Japanese policymakers to adopt more Western approaches to a wide variety of practices. Frequently, this advice ignores much of the logic of Japanese institutional factors. While it is unclear what measures will help the Japanese economy regain its growth and success of recent decades, piecemeal interventions that prescribe 'institution free' policies are unlikely to contribute to the solution.

6. Conclusion: Beyond ‘Best Practice’

Incumbents and start-ups differ in their incentives to respond to technical change, due in part to differences in the level of organizational constraints they face. Incumbent firms face incentive constraints as they strive to adapt to innovation challenges, while start-up firms face appropriability constraints in exploiting their innovations. National institutional factors, in turn, affect the levels of these organizational constraints. As a result, there may be no single best way to organize for all innovation opportunities, and the efficacy of any organizational structure will depend in part upon the environment in which the organization functions. Institutional factors therefore condition the impact of technological change upon incumbent and start-up firms.

This theory suggests that analysts of comparative economic institutions
would profit from paying greater attention to processes that limit the intensity of internal incentives at the firm level, as well as processes that promote or retard new business formation. While the potential list of important institutional factors is lengthy, the parsimonious approach offered here has focused on three factors to explain these differences: the technical labor market, the venture formation capital market and the structure of buyer–supplier ties. These three factors work as a system, exhibiting complementarities among them. Indeed, one of the virtues of a parsimonious list of institutional factors is that these complementarities can be identified and analyzed explicitly. The internal logic of each system, in turn, poses issues in being able to sustain itself over time. Sustaining investments in training and R&D are important problems for the US system, while stimulating risk-taking and entrepreneurship are emerging as issues for the Japanese system.

This theory also suggests that detailed studies of the impact of innovation in individual industries would do well to develop their theories in cross-national samples of firms. When firms manage innovation challenges in one institutional context, their experience may differ from that of competing firms in the same industry managing these challenges in another institutional context. Firms pursuing competitive advantage will have to assess competitive threats and opportunities by considering the logic of the institutional environment they confront, and the environment(s) their competitors confront. First-mover strategies and follower strategies may be more or less advisable, depending on the regime firms find themselves in relative to competitors. Building capabilities, instead of buying them, may similarly fit better in one institutional setting vs. another. Firms should work to exploit the logic of their institutional environment, rather than attempt to copy individual ‘best practices’ that may have developed in quite different contexts.

There are also important policy implications of this approach. The theory offered here suggests that policy makers must disabuse themselves of the notion that there is one best way to stimulate innovation in an economy. Emulating the ‘best practices’ of different countries’ innovation systems ignores the internal logic and the complementarities that knit these practices into a coherent system. Piecemeal adaptations at the margin that result from copying individual country policies fail to account for such complementarities, and therefore are likely to produce disappointing results. US policy makers who seek to promote extensive training of workers within US firms, for example, need to account for the realities of the US institutional environment. US employers face negative externalities in many industries, due to the fluid labor market in those industries, which is sometimes fueled by large amounts
of VC. This diminishes the incentive of US firms to invest in training for its workers when firms risk losing the benefits of that training to rival firms. Japanese policy makers who seek to increase the amount of VC available in Japan to spur new business formation must consider that this VC requires a supportive institutional environment—access to experienced workers, available customers willing to buy products and services from newly formed businesses, and available paths to eventual financial liquidity—in order for that VC to realize a financial return.

This comparative analysis has been confined to firms in two particular countries, the USA and Japan. It would benefit greatly from studying how firms respond to innovation opportunities in additional environments, such as advanced industrial settings like Western Europe, as well as emerging industrial settings in the Far East, the former Soviet Union and Latin America. In each of these regions, the above institutional factors are found in different configurations, posing different levels of organizational constraints. This analysis has also been grounded in a single industry. Additional comparative industry studies will likely identify additional institutional factors of critical importance. I suspect, though, that in every study of an industry lacking a tight appropriability regime, the institutional factors noted here will prove to be important. These contributions would broaden further our understanding of the organizational impact of innovation, and move us beyond institution-free descriptions (and concomitant prescriptions) of best practices in managing innovation.

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