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The Relationship Between Transitory Organizational Structures And Non-Linear Environments

Valentin H. Pashtenko, Matthew H. Roy, and Sanjiv S. Dugal

Management Decision 38.2 (2000): 118-129.

Abstract

Examines non-linear adaptation to change in the high-technology environment of the computer industry. These environments are defined, and the efficacy of different organizational adaptations is assessed with respect to these environments. Results from our analyses show that there is a direct and causal relationship between the employment of non-linear organizational archetypes and organizational effectiveness within high-technology industries.

Introduction

The last two decades of the twentieth century are witnessing a rapid growth in the amount of technological development in the USA and abroad. In fact, it is estimated that more unrefined scientific discoveries have been made within this time than in all prior periods combined. Invariably, the pattern of this progress has been unevenly biased toward the development of high-technology sectors. These sectors are readily defined through their high research and development costs as a percentage of total costs. Also, the incremental costs of producing these items are low once a commercially viable design has been developed.

The most prominent example of hightechnology development certainly is that of the computer industry and its supporting businesses. Within these disciplines the rate of development has resulted in computing power doubling every 18 months (Maital, 1994, p. 140). This growth has brought with it the development of technologies and associated business sectors that were all but unknown only a few years prior. Customers of high-technology computer products have thus demanded successive technological changes to keep pace with these new capabilities. These same customers have also rejected investing in new and incompatible formats. The result of this expansion has been atypical rates of failure as many organizations have failed to adapt to these changes. Ultimately, firms within this sector have been forced to adapt to these demands at an unprecedented rate or face the ultimate measure of failure: technological and financial insolvency.

Background and purpose

Rapid technological growth, the sole development and subsequent distribution of continuous product innovations is cost prohibitive for all but a few organizations involved in the field of research and development within high-technology industries (Lamont et al., 1994). The underlying premise in examining this situation thus lies in addressing how organizations adapt to rapid technological change while promoting proprietary technological innovation. More specifically, when organizational knowledge has incrementally advanced in several disciplines, involved firms merge these complementary advances together, thus developing commercially viable products. A review of this process reveals that the manner in which these firms integrate thereby determines the proposed technological industry standard.

First, in addressing the critical question of why specific firms are successful in promoting their inherent proprietary knowledge, researchers in the field have been concerned primarily with the investigation of how the organizations themselves choose potential technological collaborators. In contrast, scant attention has been paid to the manner in which sequential and chance technological innovation itself has regularly determined the subsequent organizational structure. As a rule, strategic technological alliances typically form only after technological advancements in several complementary fields have already occurred. That is to say, technological development precedes the development of collaborative organizational strategies and thus itself is critical in determining the choice of the organizational structures which will promote its distribution (Leavitt and Lipman-Blumen, 1995).

Second, researchers have subsequently been concerned with the maintenance of technologically collaborative strategies. Their empirical efforts have concentrated mainly on the study of why specific organizational collaborative strategies are successful while others fail. However, with technological development regularly preceeding the development of successive organizational structures, firms possessing proprietary technical knowledge routinely form transitory alliances, but only with respect to the technologies in question. With a finite number of organizations involved in the development of computer technology, firms often find themselves collaborating with other organizations with respect to specific technologies while being solid rivals in the development of others (Usher and Evans, 1996; Zammuto and Cameron, 1985).

Third, management researchers have focused their efforts upon empirically determining the firms' collaborative and organizational strategies of products currently under manufacture and their technological succession. However, the transitory nature of these technologically collaborative alliances often involves nothing more than agreements on how to merge each of the proprietary disciplines, how to develop standards, and how to construct licensing agreements to distribute subsequent revenues. This is an incremental process and proprietary knowledge is typically widely distributed to allow industry-wide integration and to generate maximum licensing revenues. The manufacture of these products is of secondary importance and is commonly licensed to other organizations. Consequently, a nation such as Singapore, with no stake in the development of disk drive technology in 1980, became the world's leading producer of these devices within two years (Maital, 1994, pp. 96-7). Notwithstanding, the majority of licensing revenues were repatriated to the

USA, to those firms that were instrumental in developing the technologies and developing them into a commercially viable product (Maital, 1994, pp. 96-7).

Given these considerations, the objectives of this study are:

* to examine the character of transitory organizations that are formed to facilitate the distribution of complementary technological advances;

* to investigate how organizations simultaneously enter into multiple cooperative and competitive agreements with a finite number of organizations based upon the distribution of proprietary knowledge; and

* to understand how and why this collaborative process sustains itself though the stakeholding organizations face continual technological obsolescence.

Characteristics of computer high-technology environments

Non-linearity

In order to define non-linearity, it is better to define its antithesis: linearity, as it is far simpler a concept to understand. Accordingly, linearity is the systematic methodology of proceeding from process to product. Typically, organizations define, plan, integrate, collaborate, and so forth, based upon a converging vision of some result or product. Thus, each incremental attempt, each sequential action, narrows the amount of uncertainty toward the attainment of the stated goal. Each step causes an integral unity of action that in some way contributes toward a predetermined end.

The central theme in linearity is always that of convergence. Consequently, additional knowledge, capabilities, potential, and the like, are considered only with respect to their ability to attain the chosen, stated, limiting goal. The product is fixed, resolute and determined. The result is that the process is systematic and unchanging.

In contrast, non-linearity can best be described as the process of divergence. Under these conditions, the more that an organization knows, the more it realizes how many variables there are and the more uncertain its future becomes. Non-linearity accepts that managerial decisions are made under the premise of bounded rationality. Thus, managers who have more information available to them have the ability to choose from a wider assortment of options. This results in indeterminacy using traditional linear methods of managerial thought.

Non-linearity occurs, for example, when proprietary technological development precedes the formulation of an organizational strategy and the subsequent determination of an organizational structure. This repeatedly occurs in technologically innovative research and development driven environments: conditions that sustain perpetual development. The result is that management faces many different options with respect to developing this proprietary knowledge into a marketable technological product.

What is needed at this time is the development of a non-linear understanding explaining organizational adaptation to rapid change within high-technology environments (Leavitt and Lipman-Blumen, 1995). While many theories have addressed organizational change in response to environmental pressures, none has attempted to explain the dyadic relationship between transitory organizational structures and non-linear environments. It is in these cases that a paradigm shift occurs from functionalism to interpretivism; from malleability to control. With it, assumptions must be changed and organizations must see themselves as not being determined by the context, but as enacting it.

To advance this understanding, the characteristics of the computer industry will be defined. Organizational adaptation to these changes within this environment will subsequently be specified. The result is that a review from a non-linear approach will delineate the factors necessary for effective adaptation within these environments.

Technological succession

An awareness of technological succession is critical in understanding the rapid changes in the computer industry over the last two decades. Prior to this period, only a handful of organizations possessed both the technical ability and the financial capital to solely develop unified computing systems. As such, these organizations were instrumental in the integrated development of hardware, software, and support peripherals. As the discipline progressed and brought technological obsolescence to existing systems, incremental changes occurred. However, the cost of implementing these changes was ordinarily the entire replacement of existing systems and the retraining of support personnel. With technological succession cost prohibitive for the majority of customers, successive change was slow.

Fragmentation of the computer industry came with the advent of the first personal computers. While still being produced by the same handful of organizations, low cost allowed for individual computer ownership. Thus, a new market segment developed. New organizations formed to offer these consumers higher levels of product performance at lower costs as component costs fell. The computer software industry responded by offering operating systems that were able to cope with more memory, faster integrated circuits, and increasingly complex peripherals. The important characteristic for these operating systems was their compatibility with earlier software and peripherals. Each technological development could thus be implemented with only minor incremental changes in software or in hardware. This meant that technology could be successively employed without the prohibitive costs associated with replacing an entire computing system.

Attempts to restrain this pattern of successive change through the introduction of incompatible technologies met with failure. Initial attempts by industry leaders such as IBM to re-acquire the ability to control the development of operating systems from Microsoft were unsuccessful. Similarly, the launch of its own brand of operating system, OS/2, failed.

Integrated circuit manufacturers faced similar problems. Constrained by the requirement that integrated circuit chips must be reverse-compatible with previous software, the company leader, Intel, attempted to invent a seeming revolutionary change in the microchip industry through the introduction of the Pentium name. This attempt then met with failure as the consumer market saw that it was an evolutionary, not revolutionary, change in technology. Further, Intel made an initial attempt to define itself as the industry standard bearer and copyrighted the Pentium name for its admittedly incremental computer chip. This was done to profit from any doubts that consumers still maintained regarding compatibility of their competitors' computer chips with other industry products while indicating that it was the successor to the 80286, 80386, and 80486 legacy; hence the choice of Pentium. This effort to differentiate its product failed as initial examples of its integrated circuit chip contained inherent flaws. The result was competitors such as Cyrix and AMD used Intel's production problems to decrease confidence in the manufacturer and to increase their own market share.

Finally, organizations that have successfully developed non-incremental proprietary knowledge have had their work relegated to specific, technologically appropriate niches. Accordingly, their influence has little effect on the technological succession that dictates industry and consumer standards. Organizations such as Apple, Silicon Graphics, and the like account for less than 3 percent of the overall consumer demand and thus have a negligible effect on industry standards. This is in spite of the fact that they are technologically superior in many respects. The reason for this is that, once proprietary technology has developed integral technical standards that have been accepted by industry and the consumer, incremental development has adhered to this standard as a rule. In short, when consumers demanded a graphical user interface similar to that of the Apple MacIntosh, they waited for Microsoft Windows rather than changing to an incompatible computing platform.

Shared development of standards

As stated earlier, the sole development and distribution of technological innovations is cost prohibitive for most organizations (Lamont et al., 1994). Also, when knowledge has incrementally advanced in several complementary disciplines, technological processes merge collections of these advances together into a commercially viable product. Typically, advancements in the same field parallel each other as rivals compete among one another to develop successive refinements to existing technologies. The result of this process is that at any one time multiple alternative proposals exist that advance their respective disciplines beyond their current state.

Organizations that are instrumental in developing a proprietary ability do not solely attempt to produce a marketable technology. Rather, they seek to develop these standards collaboratively. Parallel development by any number of competitors generates the risk that rival alternatives become accepted as the industry standard. Accordingly, firms seek to diversify risk by dividing their efforts through developing multiple proprietary technologies within their area of specialization (Williamson, 1975). Organizations that fail to adapt to change in this manner expose themselves to further risk any time that a technology advances beyond the proprietary ability of their respective organizations.

The few firms that are successful at solely developing a potentially marketable technology risk it not being accepted without widespread integration into competitors' products and further industry support. Again, it must be remembered that, once a standard has been adopted, technological succession is the accepted means of furthering technical development.

Sharing of technology

With computer power doubling approximately every 18 months, any specific technological development within this industry has a life-cycle of short duration, typically less than two years (Maital, 1994, p. 140). For example, with respect to the development of the floppy disk alone, the respective standards have been: 8", 5.25", 5.25" double-sided, 5.25" high-density, 5.25" doublesided and high-density, 3.5", 3.5" double-sided, 3.5" high-density, and 3.5" double-sided and high-density. In all, these nine standards span a period of less than 20 years. Similarly, integrated circuit chips and virtually all other computer-related products can trace similar developments within their specific fields. Presently, the floppy disk itself is in the process of becoming obsolete as alternative technologies vie to replace magnetic media with recent advances in encoding and decoding optical media.

As a result of these developments, maximum revenue from any specific technological development can only be derived through an industry-wide product distribution.

Inescapably, this distribution must be accompanied with a disclosure of intrinsic product advances to allow integration into the various systems offered by each of the distributors within the industry (Dess et al., 1995). Thus, the distribution of integral technical standards diminishes any advantage in proprietary knowledge that the advancing firm has over its competitors (Dess et al., 1995). Consequently, even firms that are successful in an entirely marketable technological product must make their restrictive knowledge known in order to have their proprietary standard adopted. For this reason, firms must share their technological advances in order to profit from their efforts. In doing so, they advance the aggregate of knowledge of their competitors and thus ultimately commence the processes of obsolescence in the technology that they themselves are promoting.

The compensation for having organizational proprietary knowledge integrated into an industry standard is the realistic expectation of atypical financial rewards during the relatively short life-cycle of product relevance. Once more, the rate of advancement of knowledge has caused incremental advances in technology to occur at an increasing rate. The result has been that, even after a specific technology has been accepted as an industry standard, its relevant life-cycle is being dated at its outset.

Finally, technology is also shared through the licensing of manufacturing to outside organizations and even to competing firms. These licensed production agreements are also consistent with the understanding that many collaborators to the development of the licensed technology lack the financial ability or the desire to manufacture and distribute the products that their incremental knowledge has helped produce. Even in the presence of such capability, many of these firms elect to engage in further research and development within their specific discipline of expertise. Again, licensing agreements allow these companies to allocate production to other firms and free their respective finances for subsequent research and development (Dugal and Roy, 1996). This preserves the ability of collaborative firms to pursue further advances in their respective disciplines while allowing for earnings to be allocated in proportion to their technological contribution or in proportion to their ability or desire to produce the resultant product.

The final consideration with respect to the sharing of technology is that the existence of a licensing agreement in no way limits the allied firms' abilities to subsequently license their respective proprietary knowledge. Uniformly, firms possessing this knowledge maintain the ability to license their specific disciplinary advances for the development of other products in the same, or in other industries. Likewise, when specific disciplinary advances become dated, technological succession dictates product evolution. Within the floppy disk drive example, the result was that a few initial proprietary advancements spanned several developmental iterations. Others, however, immediately became obsolete with the subsequent development of technology by competitors within the same discipline. Ultimately, the outcome of this behavior is the regular elimination of firms possessing dated proprietary knowledge and their subsequent replacement with the inherent knowledge of competing firms possessing further proprietary advances in those same disciplines.

Attempts to create order in disordered environments

Theoretical literature recognizes that the above-mentioned characteristics of these environments can be restricted through organizational diversification of risk (Williamson, 1975). A brief review of the outcome of these adaptive efforts is consequently in order. Following this is a review of the methods commonly employed by organizations to achieve these outcomes. Admittedly, such an effort is not an exhaustive review of academic literature justifying these adaptations, nor is it meant to be. Regardless, it does provide utility in this analysis by revealing the underlying assumptions inherent in these attempts. The overall suggestion is that certain organizational adaptations are more likely to be successful in high-technology industries while others appear to be inherently less suitable (Dugal and Roy, 1996).

Outcomes

Vertical expansion for risk diversification is generally employed by organizations when larger, typically industry-dominant firms seek to administer a majority of functions, from research and development through the sale and distribution of the finished product. In this manner, environmental change is controlled and order is created through the measured release of proprietary knowledge by these firms. Similarly, this outcome permits firms employing these tactics to impose guidelines upon the industry as well. The problem with this outcome, however, is that it is incompatible with high-technology industries such as the computer industry that have already experienced fragmentation. In these instances, no one specific firm is able to dominate the development and distribution of hardware, software, or peripherals. At present, the only organization even remotely able to demonstrate the fiscal potential for controlling all three facets of the computer industry is Microsoft. Here again, though, organizational dominance is limited only to software and even that capability is being strongly contested in the courts at the present time.

In contrast, the foremost organizational outcome of horizontal expansion, in addition to its inherent diversification of risk, is additional exposure into new markets and alliances. Recently, computer industry firms within concentrated markets have used the need for this outcome to target other firms for technological alliances within incrementally developing areas and within fragmented markets (Chatterjee, 1991). Consequently, these organizations retain their ability to license their proprietary technologies to related products and services or to an expanded market (Porter, 1985). This allows firms to continue to specialize within their respective discipline while licensing proprietary technology for inclusion into a diverse variety of products. Alternately, this outcome is sought when organizations completely dominate their own initial markets and attempt to enter into similar or complementary markets (Porter, 1985). Finally, this result is sought by organizations attempting to create economies of scale (Williamson, 1975). The result is that research and development costs of proprietary knowledge are thus reduced as firms rationalize these costs as being essential for inclusion into a variety of commercially viable products.

Merger and acquisition methods

The method most often used to employ an outcome of horizontal, and to a much lesser extent in the computer industry, vertical expansion, is that of mergers and acquisitions. Alliances of this type involve the outright purchase of another organization to transfer firm-specific skills as well as firm-based knowledge (Pablo, 1994). The actual distinction between merging or acquiring itself matters little since it is based upon whether or not the company targeted for purchase is liquidated as an individual entity or assimilated as a supporting organization. Thus, if liquidation is chosen, firm resources are pooled together and the process is labeled a merger. Conversely, if assimilation is chosen, the target organization is maintained as a subsidiary for financial reporting purposes and the operation is labeled an acquisition.

Regardless of the financial reporting methodology employed during mergers and acquisitions, organizational changes precede, and subsequently enable, the flow of skills and knowledge between the firms with this method. These methods are unsuitable in technologically incremental environments where the technology, as a rule, precedes organizational adaptations to the resultant environment. Furthermore, the computer industry's disposition toward fragmentation and technological succession has caused organizations that have used these methods to face anti-trust issues commonly associated with these approaches. Thus, within the computer industry, this method has been relegated to the acquisition of organizations that are financially insolvent rather than organizations that offer additional proprietary knowledge to the acquiring firm.

Strategic alliance methods

Strategic alliances are used to achieve both vertical and horizontal expansion outcomes. These types of affiliations are typically enacted prior to the development of specific technologies within different disciplines (Gulati, 1995). Accordingly, organizations often employ this methodology when attempting to develop marketable products for which technologies have yet to be developed. The procedure typically involves a limited number of organizations entering into an agreement to jointly develop a commercially viable product. As with mergers and acquisitions, the structural process precedes the flow of skills and knowledge. However, the distinction is that the flow of knowledge is something that will optimistically develop as the result of the types of alliances.

To date, the problem with strategic alliances in the computer industry is that they are inherently not technologically incremental. These alliances are adverse to the shared development of standards with firms outside these strategic alliances. In addition, these alliances involve the development of a legal structure that prescribes the further development of technology within each of the organizations' disciplines. As a rule, this incremental development is then limited to the members of the alliance within the inceptive strategic agreement.

For example, IBM, Apple Computers, and Motorola began such a strategic alliance during the early 1990s to develop and produce the Power PC computer. The intent of this alliance was to develop a commercially viable computer that incorporated a RISCbased Motorola microchip, was able to use the Apple Macintosh brand of operating system as well as Windows, and could be manufactured in different forms by IBM as well as Apple. Invariably, consumer response was appropriately cautious, industry support failed to develop, and the attempt was abruptly abandoned by all participants.

The case for a non-linear perspective

Typically, in lower-technology industries, structure precedes the development of technology. However, in high-technology industries, technology repeatedly precedes structure (Usher and Evans, 1996; Zammuto and Cameron, 1985). Accordingly, the linear paradigm is that the more structure an organization has, the more power and control it has. Whereas, under high-technology nonlinear conditions, the more structure it has, the more limited the organization becomes. This is consistent with the understanding that the development of bureaucratic structures slows the ability of an organization to make decisions. This then delays time to market and eliminates any first move advantage that an organization might possess.

Similarly, under linear conditions, the paradigm is that the more an organization knows, the more power and control it has. Whereas, under non-linear conditions the more it knows, the more it realizes how many variables there are, and the more uncertain its future becomes. The result is that hightechnology surroundings are neither determinable nor quantifiable using existing archetypes.

The advantage of a non-linear approach Non-linear technological ventures differ from other alliances in that they are transient organizations that are clearly defined in structure, the distribution of knowledge, and the division of revenues. However, their foremost distinction is that, in all cases, incremental firm-specific skills as well as firm-based knowledge precede entry into these alliances. The rationalization for this is that existence of proprietary knowledge is more important in such alliances than the potential for knowledge. Consequently, a diversity of firms with advances in several complementary disciplines are recognized as having a competitive advantage over larger firms which form structures to develop new technologies.

These endeavors differ from the cited methods of risk diversification in several respects. As stated, the systematic distribution of technical standards through licensing diminishes the technological advantages typically held by larger firms in other industries (Gulati, 1995). Also, firms that are successful in entirely developing a marketable technological product must disclose this intrinsic knowledge to have these proprietary standards incorporated by industry. This has the effect of continually disbursing information among multiple competitors (Lamont et. al., 1994; Meznar and Nigh, 1994). Accordingly, proprietary knowledge typically held by only the largest organizations in lower technology industries does not have the same restrictive influence. Rather, competition is typically centered upon the subsequent, incremental development of technology in which the various standards are known and the manufacturing processes are widely dispersed. It is in this regard that non-linear technological ventures have a distinct competitive advantage over strategic alliances in high-technology industries.

Another distinct advantage of these alliances is that they are intrinsically able to adapt to uncertainty and disordered environmental situations. Again, in mergers, acquisitions, and strategic alliances, structure predates the development of knowledge. As these firms spend time merging their distinct organizational cultures, they lose their first move advantage. This in turn makes for dissynergies. Also, these alliances produce situations in which firms are legally entwined with their technological collaborators. The result is a lack of malleability through these obligations. The result is that a change in industry's acceptance of developments in any one associated discipline means a failure of the alliance, merger, acquisition, or sole development itself. In contrast, non-linear technological ventures repeatedly form different technological solutions from the aggregate of advances in the different disciplines. The result is that these alliances are able to excel against the above-mentioned organizational adaptations and change from the viewpoint of the number of potentially marketable technologies that they offer to industry. Furthermore, these alliances are able to bring about these technologies at the moment that a suitable solution becomes viable. This solidly contrasts with the limited ability of mergers, acquisitions, or strategic alliances that are repeatedly constrained by the terms established in their inceptive agreements.

Hypothesis

The focus of existing empirical studies has been to determine whether firms which are successful at licensing their incremental proprietary knowledge demonstrate more managerial commitment at developing organizational structures which promote these technologically cooperative endeavors. To date, the results of these empirical studies have been mixed. From the contrary standpoint proposed within this article, proprietary technological development has repeatedly been shown to precede the formulation of organizational strategies and thus be the determinant of the organizational structures that follow. Further, existing empirical findings reveal that, lineartechnological and sole-developmental methods offer specific disadvantages such as being contractually bound to a single technological innovator in a divergent field or in not having a viable technological product accepted by industry.

Referring specifically to non-linear behavior, it might be suggested that risk diversification and the ability to enter into multiple coalitions enables management not only to seek attractive technological cooperative opportunities, but to effectively market their proprietary abilities to the aggregate of complementary firms. Through this divergent approach, organizational uncertainty must thus be offset through a paradigm shift from convergence to divergence. With it, assumptions must be changed and organizations must see themselves as not being determined by the context, but as enacting it. Thus, managers must transform their organizations from strict (product) functionalism to (process) interpretivism. They must understand that organizational relationships are integral to firm success. In non-linear environments: The Process is the Product.

The following two hypotheses are presented, and are consistent with, this nonlinear perspective. In each, organizational change is justified from this conceptual bias. It is the specific intention of these hypotheses to illustrate the objectives outlined at the beginning of the article: that a non-linear model offers a theoretical justification for delineating effective organizational behaviors within these transitory environments.

H1. If a firm is involved in a merger, acquisition, or a strategic alliance, then it is less likely to earn licensing revenues from that respective technology than a firm involved in non-linear technological ventures.

As previously submitted, the prerequisite for entry into mergers, acquisitions, or strategic alliances is participation in a legal structure prescribing the development of technology by each respective member and while limiting incremental development to the same.

Accepting these restrictions ultimately increases the limitations that firms have rather than decreasing them. Further, the involved organizations are able to produce fewer potentially marketable technologies for industry than their rivals. Consequently, it is offered that these firms are less likely to actually earn licensing revenues than organizations retaining their ability to enter into non-linear technological ventures with the aggregate of firms with advances in the different disciplines.

H2. If a firm develops a proprietary ability and attempts to solely develop or produce a marketable product, then it is less likely to earn revenue than a firm entering into a non-linear technological venture to secure collaborative disciplinary knowledge.

Organizations should weigh the benefits of solely developing products against those of entering into several non-linear technological ventures. It is suggested that, in rapidly changing environments that share technology through licensing and resist sole development by withholding industry support, sole development is inappropriate. Therefore, it is proposed that single-- technology joint ventures will yield more revenue than sole development of a product.

Methodology

The research methodology that was used in this study consisted of time series analysis of data published in the various organizational journals, industry trade publications, and online journals[1]. Within these publications were exhaustive listings of each of the organizations involved in specific technological fields. Also, industry consumption rates were charted for each of the various commercially available products. Past and present product life-cycles were depicted in these journals and papers and indicated specific product launch dates, growth rates, maximum sales, and intersections (equivalent sales volumes and revenues) between older and incrementally newer technologies.

With respect to the two hypotheses, this comprehensive listing of specific products was used to generate a list of final product manufacturers. This was then used to generate licensing information and this information was subsequently used to determine the extent of participation by the various principals as well as determine their respective revenue. Specifically, revenue information from these licensees was gathered from their respective 10-K and 10-Q forms via the Internet from the Securities and Exchange Commission's Web pages. Further, detailed information about these licensing agreements was found through the documentation contained in each of the organization's footnotes on these same forms.

A sample of 364 agreements were codified and assigned to merger, acquisition, strategic alliance or non-linear technological venture categories from the information contained in these publications. Remaining licensing agreements were subsequently used to determine which of the leftover arrangements were the result of sole organizational attempts to produce a marketable product or to manufacture these product themselves. In this manner, the revenues generated from mergers, acquisitions, strategic alliances, and attempts to solely produce marketable technologies were statistically compared to the revenues generated from non-linear technological ventures to see if significant differences exist. Both hypotheses were subjected to ANOVA to test for significant mean differences in the dependent variable between non-linear technological ventures and other approaches.

Findings

The result of the first hypothesis (see Table I) indicates that there are significant differences between the dependent variables at the $p < 0.01$ level of significance. Accordingly, we reject the null hypothesis H1 and accept that there is a significant difference in licensing revenue between firms involved in mergers, acquisitions, or strategic alliances, and firms involved in non-linear technological ventures. In addition, the difference between the dependent variables yields a statistically significant result in the manner predicted. Correspondingly, we accept that non-linear technological ventures yield significantly higher licensing revenues than mergers, acquisitions, or strategic alliances.

The result of the second hypothesis (see Table II) also reveals a significant difference between the dependent variables at the $p < 0.01$ level of significance. Here we also reject the null hypothesis H2 and accept that there is a significant difference in revenue between firms that solely attempt to develop or produce a marketable product and those that enter into non-linear technological ventures. Again, the difference between the dependent variables yields a result in the manner predicted. Thus, we accept that nonlinear technological ventures yield significantly higher revenues than attempts to solely produce marketable technologies.

Respectively, the basis of comparison for both hypotheses is the non-linear technological venture. The ultimate result thus becomes that non-linearity and interpretivism are preferable methods of forming alliances in these environments.

Implications for managers and industry

Decision-makers in high technology firms should pay attention to the effect which rapid organizational restructuring may have on the level of licensing revenues. Although essentially uncontrollable in nature, the impact of fragmentation within these industries can be circumvented, to a large extent, through the implementation of nonlinear organizational forms. High technology firms, particularly those highly engaged in research and development activities, may find it prudent to immediately license the production of emergent technologies to other firms focused on manufacture rather than to tie up capital needed for the subsequent technological development within these markets. Clearly, the study implies that these elements play a critical role in the attainment and sustenance of technological proficiency over competing firms which do not employ this methodology within the computer industry.

Managers within these industries must appreciate the importance of maintaining the ability to choose among many technological relationships. Issues such as flexibility in adapting to alternative technological specifications, increasing organizational ability to communicate across technical disciplines, the ability to cooperatively arrive at a set of technological standards, and intangible issues such as fairness, reliability, and reputation all must be emphasized within these organizations' technological venture strategies. While proprietary technological knowledge in a specific area or discipline might be a condition of entry into these technological ventures, these strengths may alone be insufficient to remaining essential to an industry where there are often many suppliers offering viable alternative proprietary technologies focused at the same end result. The results cited here indicate that, within the technologically turbulent environment of the computer peripheral industry, it is critical to maintain a competitive equilibrium between the ability to continuously develop proprietary technological knowledge and innovations and the ability to maintain and further develop potential cooperative relationships with a variety of potential technological collaborators.

This study empirically demonstrates that the difference between cooperative ventures and the sole development of high-technology peripherals underscores the forces driving the development of high-technology peripheral devices. Smaller developers of technological developments may find advantage in the pursuit of business relationships within specific niche markets. To this end, the results imply that these developers have a competitive advantage in developing proprietary knowledge focused upon integrating successive technological developments toward specific industries. Thus, with respect to knowledge of specific industry characteristics, inherent knowledge and the ability to maintain cooperative relationships might lead to regular technological involvement. This would then further positively influence the firm's cooperative venture abilities, hightechnology involvement, and organizational performance.

This study also demonstrates that, within these industries, success is measured by the ability to be perpetually innovative at developing knowledge. Accordingly, developers of proprietary technical knowledge may find advantage in discontinuing remaining policies of attempting to physically manufacture their successive technological innovations. The results of this study imply that to survive in a technologically turbulent environment characterized by perpetual innovation, firms must first generate sufficient capital for continual research and development. In addition, it has been shown that proprietary knowledge alone is insufficient; thus still more capital is necessary to develop many alternative relationships, each with unique technological specifications.

The final implication for decision-makers is that the sole development of proprietary technological innovations has several distinct disadvantages. The first is that shared development of standards and technological incrementalism have limited technological peripheral development to be reverse-compatible with existing technologies and thus evolutionary rather than revolutionary in nature. Second, sole development of any product risks the potential for industry indifference without some integrative means of support. Lastly, attempting to form coalitions through purchasing organizations possessing proprietary knowledge requires a certain period of time and then an additional period of time to integrate management and to transfer knowledge. Thus, organizations which employ these tactics lose the first move advantage and are regularly beaten to market by alternative, incremental technologies. The findings of this study suggest that the emphasis be placed on maintaining the ability to continually choose among a variety of relationships for an organization's proprietary technological knowledge. Such tactics could offer benefits to each of the organizational structures studied as well as limiting total capital expenditures on methods which limit future research and development potential while increasing risk.

Limitations and future research

The evidence reported in this paper should be interpreted with the understanding of certain limitations. First, caution may be exercised in generalizing the present findings too broadly. The study focused upon specific segments of the computer peripheral industry, namely, those segments within the computer industry that are characterized with rapid technological development and product change. The supposition behind this limitation is that it is these segments of the computer industry that are the most profitable and consequently are the most fundamental in shaping the industry as a whole. Testing the external validity of these findings would likely require replication of this study within other industries that are not characterized by the sharing of technology and the shared development of standards. Realistically, however, generalization of our research findings may be applicable to those industries with similar characteristics such as consumer products that demand annual or sequential improvements and whose technologies are easily reverse engineered. Of these types of products, there are many.

Second, the cross-sectional character of the data allows us to conclude on the basis only of associations between research and development organizations which are limited in establishing industry standards through technological succession and shared technological development. Any further speculation should be made with caution, as it is widely acknowledged that larger organizations have the collusive ability to forestall technological advances by competitors through a variety of means other than through enactment. Undoubtedly, this latter issue is an important and challenging task for future researchers in the field. Regardless, it must be conceded that the collusive ability of larger organizations has the potential for altering the results achieved by this study within the computer industry at this time.

Third, the present study provides only limited insight into the effect of shared sequential technological development within the peripheral spectrum of the personal computer industry. Attributable in part to the focus on this specific area of technological development, the evidence provided here indicates the presence of a significant correlation between the methods with which research and development firms alternatively compete and jointly develop their respective proprietary technologies. The question which might be raised is to what extent has prior competition and consensual agreement within the industry limited technological development to the incremental forms seen within this study?

Fourth, a natural extension of this research would be to include other hightechnology industries into the study of transitory organizational structures. An immediate industry which comes to mind is that of pharmaceuticals. Drawing upon the recent findings that show incremental product development and the full disclosure of proprietary knowledge within industries, future researchers can contribute to existing knowledge by investigating possible differences in high-technology product development. Thus, distinct groups of firms such as: those which develop sequential proprietary knowledge as a by-product of divergent areas of development; those which develop proprietary knowledge sporadically; and those which regularly produce this knowledge because of a continual, directed focus, can be compared for possible differences in how they form these transitory structures among firms.

Finally, it would be of interest to determine if other variables such as differences in organizational size, and similar firm and managerial characteristics are considered in determining the level and extent of shared technological development through transitory organizational structures. To this end, future research studies may pursue the identification of those factors that discriminate between the groups of regular and sporadic developers of technological innovation as well as those firms which have existing infrastructures for collaborative development of technologies versus those which must develop these abilities. Such an investigation would be insightful for technology management practice and the sequential development of high-technology products and would positively impact upon the development of managerial practices within these environments.

Footnote

1 Mergers and Acquisitions, Wall Street Journal, Computer Currents, Computer Life, Computer Retail Week, Computer Shopper, Computer Talk, Computing, Computing Connection, and Configurations.

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Application questions

1 Does the old adage that "structure should follow strategy" still hold up in all organizational environments, or does structure sometimes dictate strategy?

2 What in practice might a "transitory organization" look like? What would it be like to work in one?

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