Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy

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Final version received June 1986

This paper attempts to explain why innovating firms often fail to obtain significant economic returns from an innovation, while customers, imitators and other industry participants benefit. Business strategy – particularly as it relates to the firm's decision to integrate and collaborate – is shown to be an important factor. The paper demonstrates that when imitation is easy, markets don't work well, and the profits from innovation may accrue to the owners of certain complementary assets, rather than to the developers of the intellectual property. This speaks to the need, in certain cases, for the innovating firm to establish a prior position in these complementary assets. The paper also indicates that innovators with new products and processes which provide value to consumers may sometimes be so ill positioned in the market that they necessarily will fail. The analysis provides a theoretical foundation for the proposition that manufacturing often matters, particularly to innovating nations. Innovating firms without the requisite manufacturing and related capacities may die, even though they are the best at innovation. Implications for trade policy and domestic economic policy are examined.

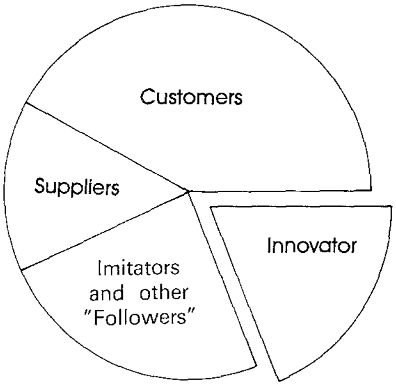
* I thank Raphael Amit, Harvey Brooks, Chris Chapin, Therese Flaherty, Richard Gilbert, Heather Haveman, Mel Horwitch, David Hulbert, Carl Jacobsen, Michael Porter, Gary Pisano, Richard Rumelt, Raymond Vernon and Sidney Winter for helpful discussions relating to the subject matter of this paper. Three anonymous referees also provided valuable criticisms. I gratefully acknowledge the financial support of the National Science Foundation under grant no. SRS-8410556 to the Center for Research in Management, University of California Berkeley. Earlier versions of this paper were presented at a National Academy of Engineering Symposium titled "World Technologies and National Sovereignty," February 1986, and at a conference on innovation at the University of Venice, March 1986.

Research Policy 15 (1986) 285–305
North-Holland

1. Introduction

It is quite common for innovators – those firms which are first to commercialize a new product or process in the market – to lament the fact that competitors/imitators have profited more from the innovation than the firm first to commercialize it! Since it is often held that being first to market is a source of strategic advantage, the clear existence and persistence of this phenomenon may appear perplexing if not troubling. The aim of this article is to explain why a fast second or even a slow third might outperform the innovator. The message is particularly pertinent to those science and engineering driven companies that harbor the mistaken illusion that developing new products which meet customer needs will ensure fabulous success. It may possibly do so for the product, but not for the innovator.

In this paper, a framework is offered which identifies the factors which determine who wins from innovation: the firm which is first to market, follower firms, or firms that have related capabilities that the innovator needs. The follower firms may or may not be imitators in the narrow sense of the term, although they sometimes are. The framework appears to have utility for explaining the share of the profits from innovation accruing to the innovator compared to its followers and suppliers (see fig. 1), as well as for explaining a variety of interfirm activities such as joint ventures, coproduction agreements, cross distribution arrangements, and technology licensing. Implications for strategic management, public policy, and international trade and investment are then discussed.



What determines the share of profits captured by the innovator?

Fig. 1. Explaining the distribution of the profits from innovation.

2. The phenomenon

Figure 2 presents a simplified taxonomy of the possible outcomes from innovation. Quadrant 1 represents positive outcomes for the innovator. A first-to-market advantage is translated into a sustained competitive advantage which either creates a new earnings stream or enhances an existing one. Quadrant 4 and its corollary quadrant 2 are the ones which are the focus of this paper.

The EMI CAT scanner is a classic case of the phenomenon to be investigated. [1] By the early 1970s, the UK firm Electrical Musical Industries (EMI) Ltd. was in a variety of product lines including phonographic records, movies, and advanced electronics. EMI had developed high resolution TVs in the 1930s, pioneered airborne radar during World War II, and developed the UK's first all solid-state computers in 1952.

In the late 1960s Godfrey Houndsfield, an EMI senior research engineer engaged in pattern recognition research which resulted in his displaying a scan of a pig's brain. Subsequent clinical work established that computerized axial tomography (CAT) was viable for generating cross-sectional "views" of the human body, the greatest advance in radiology since the discovery of X rays in 1895.

While EMI was initially successful with its CAT scanner, within 6 years of its introduction into the US in 1973 the company had lost market leadership, and by the eighth year had dropped out of the CT scanner business. Other companies successfully dominated the market, though they were late entrants, and are still profiting in the business today.

Other examples include RC Cola, a small beverage company that was the first to introduce cola in a can, and the first to introduce diet cola. Both Coca Cola and Pepsi followed almost immediately and deprived RC of any significant advantage from its innovation. Bowmar, which introduced the pocket calculator, was not able to withstand competition from Texas Instruments, Hewlett Packard and others, and went out of business. Xerox failed to succeed with its entry into the office computer business, even though Apple succeeded with the MacIntosh which contained many of Xerox's key product ideas, such as the mouse and icons. The de Havilland Comet saga has some of the same features. The Comet I jet was introduced into the commercial airline business 2 years or so before Boeing introduced the 707, but de Havilland failed to capitalize on its substantial early advantage. MITS introduced the first personal computer, the Altair, experienced a burst of sales, then slid quietly into oblivion.

If there are innovators who lose there must be followers/imitators who win. A classic example is IBM with its PC, a great success since the time it was introduced in 1981. Neither the architecture nor components embedded in the IBM PC were considered advanced when introduced; nor was the way the technology was packaged a significant departure from then-current practice. Yet the IBM PC was fabulously successful and established MS-DOS as the leading operating system for 16-bit PCs. By the end of 1984, IBM has shipped over 500 000 PCs, and many considered that it had irreversibly eclipsed Apple in the PC industry.

3. Profiting from innovation: Basic building blocks

In order to develop a coherent framework within which to explain the distribution of outcomes illustrated in fig. 2, three fundamental building blocks must first be put in place: the appropriability regime, complementary assets, and the dominant design paradigm.

[1] The EMI story is summarized in Michael Martin, *Managing Technological Innovation and Entrepreneurship*, (Reston Publishing Company, Reston, VA, 1984).

	Innovator	Follower-Imitator
Win	1 • Pilkington (Float Glass) • G.D. Searle (NutraSweet) • Dupont (Teflon)	2 • IBM (Personal Computer) • Matsushita (VHS video recorders) • Seiko (quartz watch)
Lose	4 • RC Cola (diet cola) • EMI (scanner) • Bowmar (pocket calculator) • Xerox (office computer) • DeHavilland (Comet)	3 • Kodak (instant photography) • Northrup (F20) • DEC (personal computer)

Fig. 2. Taxonomy of outcomes from the innovation process.

3.1. Regimes of appropriability

A regime of appropriability refers to the environmental factors, excluding firm and market structure, that govern an innovator's ability to capture the profits generated by an innovation. The most important dimensions of such a regime are the nature of the technology, and the efficacy of legal mechanisms of protection (fig. 3).

It has long been known that patents do not work in practice as they do in theory. Rarely, if ever, do patents confer perfect appropriability, although they do afford considerable protection on new chemical products and rather simple mechanical inventions. Many patents can be "invented around" at modest costs. They are especially ineffective at protecting process innovations. Often patents provide little protection because the legal requirements for upholding their validity or for proving their infringement are high.

In some industries, particularly where the innovation is embedded in processes, trade secrets are a viable alternative to patents. Trade secret protection is possible, however, only if a firm can put its product before the public and still keep the underlying technology secret. Usually only chemical formulas and industrial-commercial processes (e.g., cosmetics and recipes) can be protected as trade secrets after they're "out".

The degree to which knowledge is tacit or codified also affects ease of imitation. Codified knowledge is easier to transmit and receive, and is more exposed to industrial espionage and the like. Tacit knowledge by definition is difficult to articulate, and so transfer is hard unless those who possess the know how in question can demonstrate it to others (Teece [9]). Survey research indicates that methods of appropriability vary markedly across industries, and probably within industries as well (Levin et al. [5]).

The property rights environment within which a firm operates can thus be classified according to the nature of the technology and the efficacy of the legal system to assign and protect intellectual property. While a gross simplification, a dichotomy can be drawn between environments in which the appropriability regime is "tight" (technology is relatively easy to protect) and "weak" (technology is almost impossible to protect). Examples of the former include the formula for Coca Cola syrup; an example of the latter would be the Simplex algorithm in linear programming.

3.2. The dominant design paradigm

It is commonly recognized that there are two stages in the evolutionary development of a given branch of a science: the preparadigmatic stage when there is no single generally accepted conceptual treatment of the phenomenon in a field of study, and the paradigmatic stage which begins when a body of theory appears to have passed the canons of scientific acceptability. The emergence of a dominant paradigm signals scientific maturity and the acceptance of agreed upon "standards" by which what has been referred to as "normal" scientific research can proceed. These "standards" remain in force unless or until the paradigm is overturned. Revolutionary science is what overturns normal science, as when the Copernicus's theories of astronomy overturned Ptolemy's in the seventeenth century.

Abernathy and Utterback [1] and Dosi [3] have provided a treatment of the technological evolution of an industry which appears to parallel

- Legal instruments
  - Patents
  - Copyrights
  - Trade secrets
- Nature of technology
  - Product
  - Process
  - Tacit
  - Codified

Fig. 3. Appropriability regime: Key dimensions.

Kuhnian notions of scientific evolution. [2] In the early stages of industry development, product designs are fluid, manufacturing processes are loosely and adaptively organized, and generalized capital is used in production. Competition amongst firms manifests itself in competition amongst designs, which are markedly different from each other. This might be called the preparadigmatic stage of an industry.

At some point in time, and after considerable trial and error in the marketplace, one design or a narrow class of designs begins to emerge as the more promising. Such a design must be able to meet a whole set of user needs in a relatively complete fashion. The Model T Ford, the IBM 360, and the Douglas DC-3 are examples of dominant designs in the automobile, computer, and aircraft industry respectively.

Once a dominant design emerges, competition shifts to price and away from design. Competitive success then shifts to a whole new set of variables. Scale and learning become much more important, and specialized capital gets deployed as incumbent's seek to lower unit costs through exploiting economies of scale and learning. Reduced uncertainty over product design provides an opportunity to amortize specialized long-lived investments.

Innovation is not necessarily halted once the dominant design emerges; as Clarke [2] points out, it can occur lower down in the design hierarchy. For instance, a "v" cylinder configuration emerged in automobile engine blocks during the 1930s with the emergence of the Ford V-8 engine. Niches were quickly found for it. Moreover, once the product design stabilizes, there is likely to be a surge of process innovation as producers attempt to lower production costs for the new product (see fig. 4).

The Abernathy–Utterback framework does not characterize all industries. It seems more suited to mass markets where consumer tastes are relatively homogeneous. It would appear to be less characteristic of small niche markets where the absence of scale and learning economies attaches much less of a penalty to multiple designs. In these instances, generalized equipment will be employed in production.

[2] See Kuhn [4].

The existence of a dominant design watershed is of great significance to the distribution of profits between innovator and follower. The innovator may have been responsible for the fundamental scientific breakthroughs as well as the basic design of the new product. However, if imitation is relatively easy, imitators may enter the fray, modifying the product in important ways, yet relying on the fundamental designs pioneered by the innovator. When the game of musical chairs stops, and a dominant design emerges, the innovator might well end up positioned disadvantageously relative to a follower. Hence, when imitation is possible and occurs coupled with design modification before the emergence of a dominant design, followers have a good chance of having their modified product annointed as the industry standard, often to the great disadvantage of the innovator.

3.3. Complementary assets

Let the unit of analysis be an innovation. An innovation consists of certain technical knowledge about how to do things better than the existing state of the art. Assume that the know-how in question is partly codified and partly tacit. In order for such know-how to generate profits, it must be sold or utilized in some fashion in the market.

In almost all cases, the successful commercialization of an innovation requires that the know-how in question be utilized in conjunction with other capabilities or assets. Services such as marketing, competitive manufacturing, and after-sales support are almost always needed. These services are often obtained from complementary assets which are specialized. For example, the commercialization of a new drug is likely to require the dissemination of information over a specialized information channel. In some cases, as when the innovation is systemic, the complementary assets may be other parts of a system. For instance; computer hardware typically requires specialized software, both for the operating system, as well as for applications. Even when an innovation is autonomous, as with plug compatible components, certain complementary capabilities or assets will be needed for successful commercialization. Figure 5 summarizes this schematically.

Whether the assets required for least cost production and distribution are specialized to the

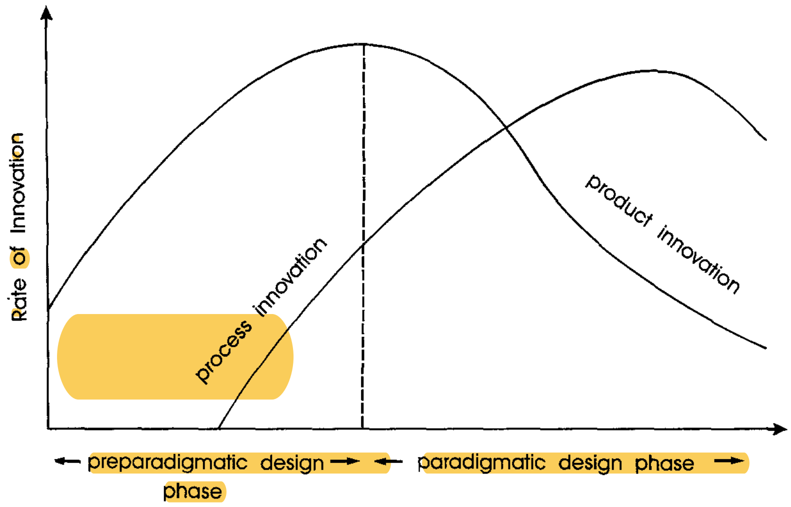


Fig. 4. Innovation over the product/industry life cycle.

innovation turns out to be important in the development presented below. Accordingly, the nature of complementary assets are explained in some detail. Figure 6 differentiates between complementary assets which are generic, specialized, and cospecialized.

Generic assets are general purpose assets which do not need to be tailored to the innovation in question. Specialized assets are those where there is unilateral dependence between the innovation and the complementary asset. Cospecialized assets are those for which there is a bilateral dependence. For instance, specialized repair facilities were needed to support the introduction of the rotary engine by Mazda. These assets are cospecialized because of the mutual dependence of the innovation on the repair facility. Containerization similarly required the deployment of some cospecialized assets in ocean shipping and terminals. However, the dependence of trucking on containerized shipping was less than that of containerized shipping on trucking, as trucks can convert from containers to flat beds at low cost. An example of a generic asset would be the manufacturing facilities needed to make running shoes. Generalized

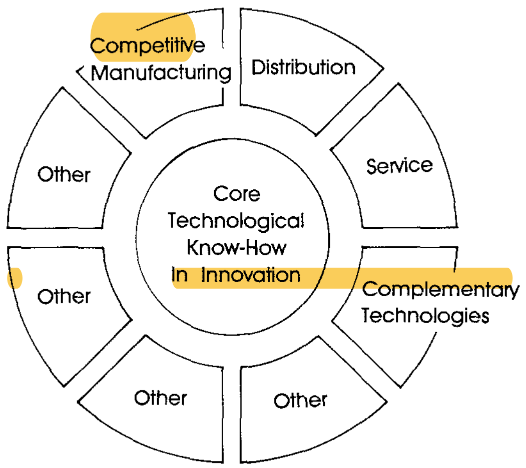


Fig. 5. Complementary assets needed to commercialize an innovation.

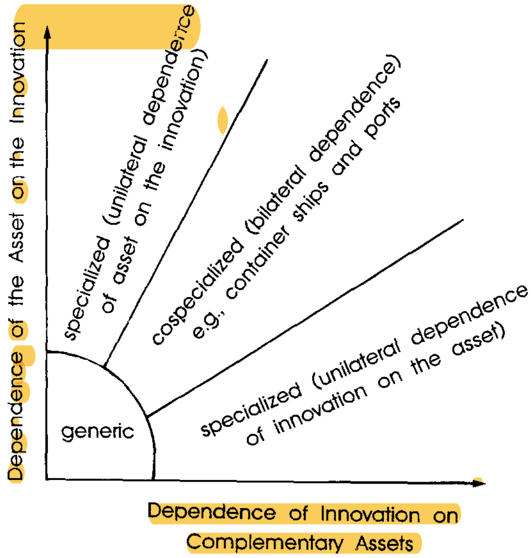


Fig. 6. Complementary assets: Generic, specialized, and cospecialized.

equipment can be employed in the main, exceptions being the molds for the soles.

4. Implications for profitability

These three concepts can now be related in a way which will shed light on the imitation process, and the distribution of profits between innovator and follower. We begin by examining tight appropriability regimes.

4.1. Tight appropriability regimes

In those few instances where the innovator has an iron clad patent or copyright protection, or where the nature of the product is such that trade secrets effectively deny imitators access to the relevant knowledge, the innovator is almost assured of translating its innovation into market value for some period of time. Even if the innovator does not possess the desirable endowment of complementary costs, iron clad protection of intellectual property will afford the innovator the time to access these assets. If these assets are generic, contractual relation may well suffice, and the innovator may simply license its technology. Specialized R&D firms are viable in such an environment. Universal Oil Products, an R&D firm developing refining processes for the petroleum industry was one such case in point. If, however, the complementary assets are specialized or cospecialized, contractual relationships are exposed to hazards, because one or both parties will have to commit capital to certain irreversible investments which will be valueless if the relationship between innovator and licensee breaks down. Accordingly, the innovator may find it prudent to expand its boundaries by integrating into specialized and cospecialized assets. Fortunately, the factors which make for difficult imitation will enable the innovator to build or acquire those complementary assets without competing with innovators for their control.

Competition from imitators is muted in this type of regime, which sometimes characterizes the petrochemical industry. In this industry, the protection offered by patents is fairly easily enforced. One factor assisting the licensee in this regard is that most petrochemical processes are designed around a specific variety of catalysts which can be kept proprietory. An agreement not to analyze the catalyst can be extracted from licensees, affording extra protection. However, even if such requirements are violated by licensees, the innovator is still well positioned, as the most important properties of a catalyst are related to its physical structure, and the process for generating this structure cannot be deduced from structural analysis alone. Every reaction technology a company acquires is thus accompanied by an ongoing dependence on the innovating company for the catalyst appropriate to the plant design. Failure to comply with various elements of the licensing contract can thus result in a cutoff in the supply of the catalyst, and possibly facility closure.

Similarly, if the innovator comes to market in the preparadigmatic phase with a sound product concept but the wrong design, a tight appropriability regime will afford the innovator the time needed to perform the trials needed to get the design right. As discussed earlier, the best initial design concepts often turn out to be hopelessly wrong, but if the innovator possesses an impenetrable thicket of patents, or has technology which is simply difficult to copy, then the market may well afford the innovator the necessary time to ascertain the right design before being eclipsed by imitators.

4.2. Weak appropriability

Tight appropriability is the exception rather than the rule. Accordingly, innovators must turn to business strategy if they are to keep imitators/followers at bay. The nature of the competitive process will vary according to whether the industry is in the paradigmatic or preparadigmatic phase.

4.2.1. Preparadigmatic phase

In the preparadigmatic phase, the innovator must be careful to let the basic design "float" until sufficient evidence has accumulated that a design has been delivered which is likely to become the industry standard. In some industries there may be little opportunity for product modification. In microelectronics, for example, designs become locked in when the circuitry is chosen. Product modification is limited to "debugging" and software modification. An innovator must begin the design process anew if the product doesn't fit the market well. In some respects, however, selecting designs is dictated by the need to meet certain compatibility standards so that new hardware can interface with existing applications software. In one sense, therefore, the design issue for the microprocessor industry today is relatively straightforward: deliver greater power and speed while meeting the the computer industry standards of the existing software base. However, from time to time windows of opportunity emerge for the introduction of entirely new families of microprocessors which will define a new industry and software standard. In these instances, basic design parameters are less well defined, and can be permitted to "float" until market acceptance is apparent.

The early history of the automobile industry exemplifies exceedingly well the importance for subsequent success of selecting the right design in the preparadigmatic stages. None of the early producers of steam cars survived the early shakeout when the closed body internal combustion engine automobile emerged as the dominant design. The steam car, nevertheless, had numerous early virtues, such as reliability, which the internal combustion engine autos could not deliver.

The British fiasco with the Comet I is also instructive. De Havilland had picked an early design with both technical and commercial flaws. By moving into production, significant irreversibilities and loss of reputation hobbled de Havilland to such a degree that it was unable to convert to the Boeing design which subsequently emerged as dominant. It wasn't even able to occupy second place, which went instead to Douglas.

As a general principle, it appears that innovators in weak appropriability regimes need to be intimately coupled to the market so that user needs can fully impact designs. When multiple parallel and sequential prototyping is feasible, it has clear advantages. Generally such an approach is simply prohibitively costly. When development costs for a large commercial aircraft exceed one billion dollars, variations on a theme are all that is possible.

Hence, the probability that an innovator – defined here as a firm that is first to commercialize a new product design concept – will enter the paradigmatic phase possessing the dominant design is problematic. The probabilities will be higher the lower the relative cost of prototyping, and the more tightly coupled the firm is to the market. The later is a function of organizational design, and can be influenced by managerial choices. The former is embedded in the technology, and cannot be influenced, except in minor ways, by managerial decisions. Hence, in industries with large developmental and prototyping costs – and hence significant irreversibilities – and where innovation of the product concept is easy, then one would expect that the probability that the innovator would emerge as the winner or amongst the winners at the end of the preparadigmatic stage is low.

4.2.2. Paradigmatic stage

In the preparadigmatic phase, complementary assets do not loom large. Rivalry is focused on trying to identify the design which will be dominant. Production volumes are low, and there is little to be gained in deploying specialized assets, as scale economies are unavailable, and price is not a principal competitive factor. However, as the leading design or designs begin to be revealed by the market, volumes increase and opportunities for economies of scale will induce firms to begin gearing up for mass production by acquiring specialized tooling and equipment, and possibly specialized distribution as well. Since these investments involve significant irreversibilities, producers are likely to proceed with caution. Islands of specialized capital will begin to appear in an industry, which otherwise features a sea of general purpose manufacturing equipment.

However, as the terms of competition begin to change, and prices become increasingly unimportant, access to complementary assets becomes absolutely critical. Since the core technology is easy to imitate, by assumption, commercial success swings upon the terms and conditions upon which the required complementary assets can be accessed.

It is at this point that specialized and cospecialized assets become critically important. Generalized equipment and skills, almost by definition, are always available in an industry, and even if they are not, they do not involve significant irreversibilities. Accordingly, firms have easy access to this type of capital, and even if there is insufficient capacity available in the relevant assets, it can easily be put in place as it involves few risks. Specialized assets, on the other hand, involve significant irreversibilities and cannot be easily accessed by contract, as the risks are significant for the party making the dedicated investment. The firms which control the cospecialized assets, such as distribution channels, specialized manufacturing capacity, etc. are clearly advantageously positioned relative to an innovator. Indeed, in rare instances where incumbent firms possess an airtight monopoly over specialized assets, and the innovator is in a regime of weak appropriability, all of the profits to the innovation could conceivably innure to the firms possessing the specialized assets who should be able to get the upper hand.

Even when the innovator is not confronted by situations where competitors or potential competitors control key assets, the innovator may still be disadvantaged. For instance, the technology embedded in cardiac pacemakers was easy to imitate, and so competitive outcomes quickly came to be determined by who had easiest access to the complementary assets, in this case specialized marketing. A similar situation has recently arisen in the United States with respect to personal computers. As an industry participant recently observed: "There are a huge numbers of computer manufacturers, companies that make peripherals (e.g. printers, hard disk drives, floppy disk drives), and software companies. They are all trying to get marketing distributors because they cannot afford to call on all of the US companies directly. They need to go through retail distribution channels, such as Businessland, in order to reach the marketplace. The problem today, however, is that many of these companies are not able to get shelf space and thus are having a very difficult time marketing their products. The point of distribution is where the profit and the power are in the marketplace today". (Norman [8, p.438])

5. Channel strategy issues

The above analysis indicates how access to complementary assets, such as manufacturing and distribution, on competitive teams is critical if the innovator is to avoid handling over the lion's share of the profits to imitators, and/or to the owners of the complementary assets that are specialized or cospecialized to the innovation. It is now necessary to delve deeper into the appropriate control structure that the innovator ideally ought to establish over these critical assets.

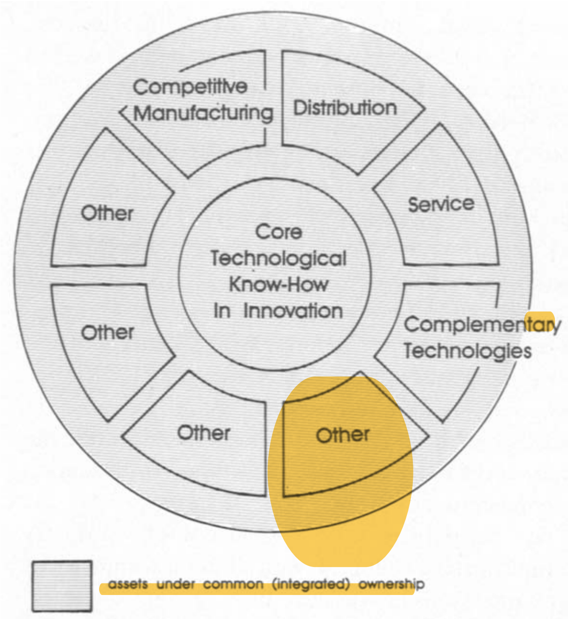


Fig. 7. Complementary assets internalized for innovation: Hypothetical case #1 (innovator integrated into all complementary assets).

There are a myriad of possible channels which could be employed. At one extreme the innovator could integrate into all of the necessary comple-

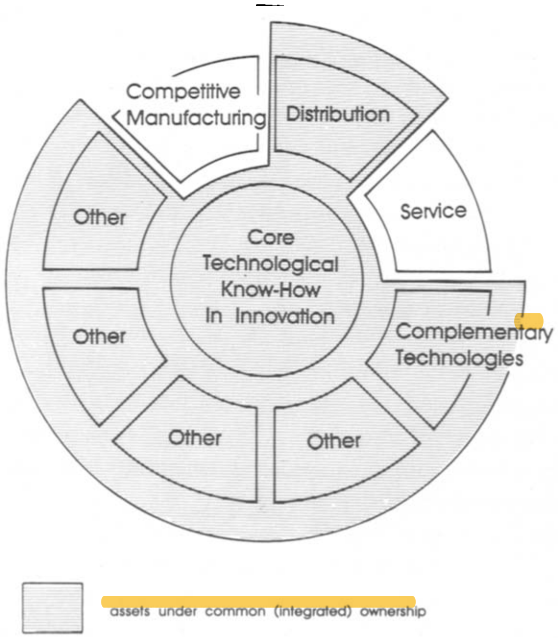


Fig. 8. Complementary assets internalized for innovation: Hypothetical case #2 (innovator subcontracts for manufacturing and service).

mentary assets, as illustrated in fig. 7, or just a few of them, as illustrated in fig. 8. Complete integration (fig. 7) is likely to be unnecessary as well as prohibitively expensive. It is well to recognize that the variety of assets and competences which need to be accessed is likely to be quite large, even for only modestly complex technologies. To produce a personal computer, for instance, a company needs access to expertise in semiconductor technology, display technology, disk drive technology, networking technology, keyboard technology, and several others. No company can keep pace in all of these areas by itself.

At the other extreme, the innovator could attempt to access these assets through straightforward contractual relationships (e.g. component supply contracts, fabrication contracts, service contracts, etc.). In many instances such contracts may suffice, although it sometimes exposes the innovator to various hazards and dependencies that it may well wish to avoid. In between the fully integrated and full contractual extremes, there are a myriad of intermediate forms and channels available. An analysis of the properties of the two extreme forms is presented below. A brief synopsis of mixed modes then follows.

5.1. Contractual modes

The advantages of a contractual solution – whereby the innovator signs a contract, such as a license, with independent suppliers, manufacturers or distributors – are obvious. The innovator will not have to make the upfront capital expenditures needed to build or buy the assets in question. This reduces risks as well as cash requirements.

Contracting rather than integrating is likely to be the optimal strategy when the innovators appropriability regime is tight and the complementary assets are available in competitive supply (i.e. there is adequate capacity and a choice of sources).

Both conditions apply in petrochemicals for instance, so an innovator doesn't need to be integrated to be a successful. Consider, first, the appropriability regime. As discussed earlier, the protection offered by patents is fairly easily enforced, particularly for process technology, in the petrochemical industry. Given the advantageous feedstock prices available in hydrocarbon rich petrochemical exporters, and the appropriability regime characteristic of this industry, there is no incentive or advantage in owning the complementary assets (production facilities) as they are not typically highly specialized to the innovation. Union Carbide appears to realize this, and has recently adjusted its strategy accordingly. Essentially, Carbide is placing its existing technology into a new subsidiary, Engineering and Hydrocarbons Service. The company is engaging in licensing and offers engineering, construction, and management services to customers who want to take their feedstocks and integrate them forward into petrochemicals. But Carbide itself appears to be backing away from an integration strategy.

Chemical and petrochemical product innovations are not quite so easy to protect, which should raise new challenges to innovating firms in the developed nations as they attempt to shift out of commodity petrochemicals. There are already numerous examples of new products that made it to the marketplace, filled a customer need, but never generated competitive returns to the innovator because of imitation. For example, in the 1960s Dow decided to start manufacturing rigid polyurethene foam. However, it was imitated very quickly by numerous small firms which had lower costs.[3] The absence of low cost manufacturing capability left Dow vulnerable.

Contractual relationships can bring added credibility to the innovator, especially if the innovator is relatively unknown when the contractual partner is established and viable. Indeed, arms-length contracting which embodies more than a simple buy-sell agreement is becoming so common, and is so multifaceted, that the term strategic partnering has been devised to describe it. Even large companies such as IBM are now engaging in it. For IBM, partnering buys access to new technologies enabling the company to "learn things we couldn't have learned without many years of trial and error."[4] IBM's arrangement with Microsoft to use the latter's MS-DOS operating system software on the IBM PC facilitated the timely introduction of IBM's personal computer into the market.

[3] Executive V.P. Union Carbide, Robert D. Kennedy, quoted in *Chemical Week*, Nov. 16, 1983, p. 48.

[4] Comment attributed to Peter Olson III, IBM's director of business development, as reported in The Strategy Behind IBM's Strategic Alliances, *Electronic Business*, October 1 (1985) 126.

Smaller less integrated companies are often eager to sign on with established companies because of the name recognition and reputation spillovers. For instance Cipher Data Products, Inc. contracted with IBM to develop a low-priced version of IBM's 3480 0.5 inch streaming cartridge drive, which is likely to become the industry standard. As Cipher management points out, "one of the biggest advantages to dealing with IBM is that, once you've created a product that meets the high quality standards necessary to sell into the IBM world, you can sell into any arena." [5] Similarly, IBM's contract with Microsoft "meant instant credibility" to Microsoft (McKenna, 1985, p. 94).

It is most important to recognize, however, that strategic (contractual) partnering, which is currently very fashionable, is exposed to certain hazards, particularly for the innovator, when the innovator is trying to use contracts to access specialized capabilities. First, it may be difficult to induce suppliers to make costly irreversible commitments which depend for their success on the success of the innovation. To expect suppliers, manufacturers, and distributors to do so is to invite them to take risks along with the innovator. The problem which this poses for the innovator is similar to the problems associated with attracting venture capital. The innovator must persuade its prospective partner that the risk is a good one. The situation is one open to opportunistic abuses on both sides. The innovator has incentives to overstate the value of the innovation, while the supplier has incentives to "run with the technology" should the innovation be a success.

Instances of both parties making irreversible capital commitments nevertheless exist. Apple's Laserwriter – a high resolution laser printer which allows PC users to produce near typeset quality text and art department graphics – is a case in point. Apple persuaded Canon to participate in the development of the Laserwriter by providing subsystems from its copiers – but only after Apple contracted to pay for a certain number of copier engines and cases. In short, Apple accepted a good deal of the financial risk in order to induce Canon to assist in the development and production of the Laserwriter. The arrangement appears to have been prudent, yet there were clearly hazards for both sides. It is difficult to write, execute, and enforce complex development contracts, particularly when the design of the new product is still "floating." Apple was exposed to the risk that its co-innovator Canon would fail to deliver, and Canon was exposed to the risk that the Apple design and marketing effort would not succeed. Still, Apple's alternatives may have been rather limited, inasmuch as it didn't command the requisite technology to "go it alone."

In short, the current euphoria over "strategic partnering" may be partially misplaced. The advantages are being stressed (for example, McKenna [6]) without a balanced presentation of costs and risks. Briefly, there is the risk that the partner won't perform according to the innovator's perception of what the contract requires; there is the added danger that the partner may imitate the innovator's technology and attempt to compete with the innovator. This latter possibility is particularly acute if the provider of the complementary asset is uniquely situated with respect to the complementary asset in question and has the capacity to imitate the technology, which the innovator is unable to protect. The innovator will then find that it has created a competitor who is better positioned than the innovator to take advantage of the market opportunity at hand. *Business Week* has expressed concerns along these lines in its discussion of the "Hollow Corporation." [6]

It is important to bear in mind, however, that contractual or partnering strategies in certain cases are ideal. If the innovator's technology is well protected, and if what the partner has to provide is a "generic" capacity available from many potential partners, then the innovator will be able to maintain the upper hand while avoiding the costs of duplicating downstream capacity. Even if the partner fails to perform, adequate alternatives exist (by assumption, the partners' capacities are commonly available) so the innovator's efforts to successfully commercialize its technology ought to proceed profitably.

[5] Comment attributed to Norman Farquhar, Cipher's vice president for strategic development, as reported in *Electronic Business*, October 1 (1985) 128.

[6] See *Business Week*, March 3 (1986) 57–59. *Business Week* uses the term to describe a corporation which lacks in-house manufacturing capability.

5.2. Integration modes

Integration, which by definition involves ownership, is distinguished from pure contractual modes in that it typically facilitates incentive alignment and control. If an innovator owns rather than rents the complementary assets needed to commercialize, then it is in a position to capture spillover benefits stemming from increased demand for the complementary assets caused by the innovation.

Indeed, an innovator might be in the position, at least before its innovation is announced, to buy up capacity in the complementary assets, possibly to its great subsequent advantage. If futures markets exist, simply taking forward positions in the complementary assets may suffice to capture much of the spillovers.

Even after the innovation is announced, the innovator might still be able to build or buy complementary capacities at competitive prices if the innovation has iron clad legal protection (i.e. if the innovation is in a tight appropriability regime). However, if the innovation is not tightly protected and once "out" is easy to imitate, then securing control of complementary capacities is likely to be the key success factor, particularly if those capacities are in fixed supply – so called "bottlenecks." Distribution and specialized manufacturing competences often become bottlenecks.

As a practical matter, however, an innovator may not have the time to acquire or build the complementary assets that ideally it would like to control. This is particularly true when imitation is easy, so that timing becomes critical. Additionally, the innovator may simply not have the financial resources to proceed. The implications of timing and cash constraints are summarized in fig. 9.

Accordingly, in weak appropriability regimes innovators need to rank complementary assets as to their importance. If the complementary assets are critical, ownership is warranted, although if the firm is cash constrained a minority position may well represent a sensible tradeoff.

Needless to say, when imitation is easy, strategic moves to build or buy complementary assets which are specialized must occur with due reference to the moves of competitors. There is no point moving to build a specialized asset, for instance, if one's imitators can do it faster and cheaper.

It is hopefully self evident that if the innovator is already a large enterprise with many of the relevant complementary assets under its control, integration is not likely to be the issue that it might otherwise be, as the innovating firm will already control many of the relevant specialized and cospecialized assets. However, in industries experiencing rapid technological change, technologies advance so rapidly that it is unlikely that a single company has the full range of expertise needed to bring advanced products to market in a timely and cost effective fashion. Hence, the integration issue is not just a small firm issue.

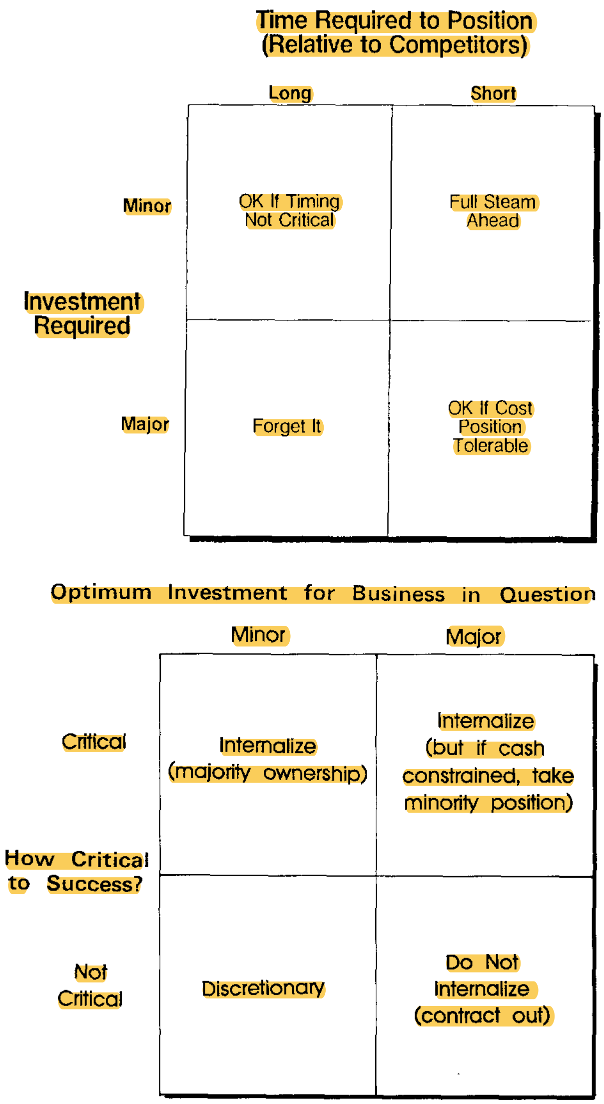


Fig. 9. Specialized complementary assets and weak appropriability: Integration calculus.

5.3. Integration versus contract strategies: An analytic summary

Figure 10 summarizes some of the relevant considerations in the form of a decision flow chart. It indicates that a profit seeking innovator, confronted by weak intellectual property protection and the need to access specialized complementary assets and/or capabilities, is forced to expand its activities through integration if it is to prevail over imitators. Put differently, innovators who develop new products that possess poor intellectual property protection but which requires specialized complementary capacities are more likely to parlay their technology into a commercial advantage, rather than see it prevail in the hands of imitators.

Figure 10 makes it apparent that the difficult strategic decisions arise in situations where the appropriability regime is weak and where specialized assets are critical to profitable commercialization. These situations, which in reality are very common, require that a fine-grained competitor analysis be part of the innovator's strategic assessment of its opportunities and threats. This is carried a step further in fig. 11, which looks only at situations where commercialization requires certain specialized capabilities. It indicates the appropriate strategies for the innovators and predicts the outcomes to be expected for the various players.

Three classes of players are of interst: innovators, imitators, and the owners of cospecialized assets (e.g. distributors). All three can potentially benefit or lose from the innovation process. The latter can potentially benefit from the additional business which the innovation may direct in the asset owners direction. Should the asset turn out

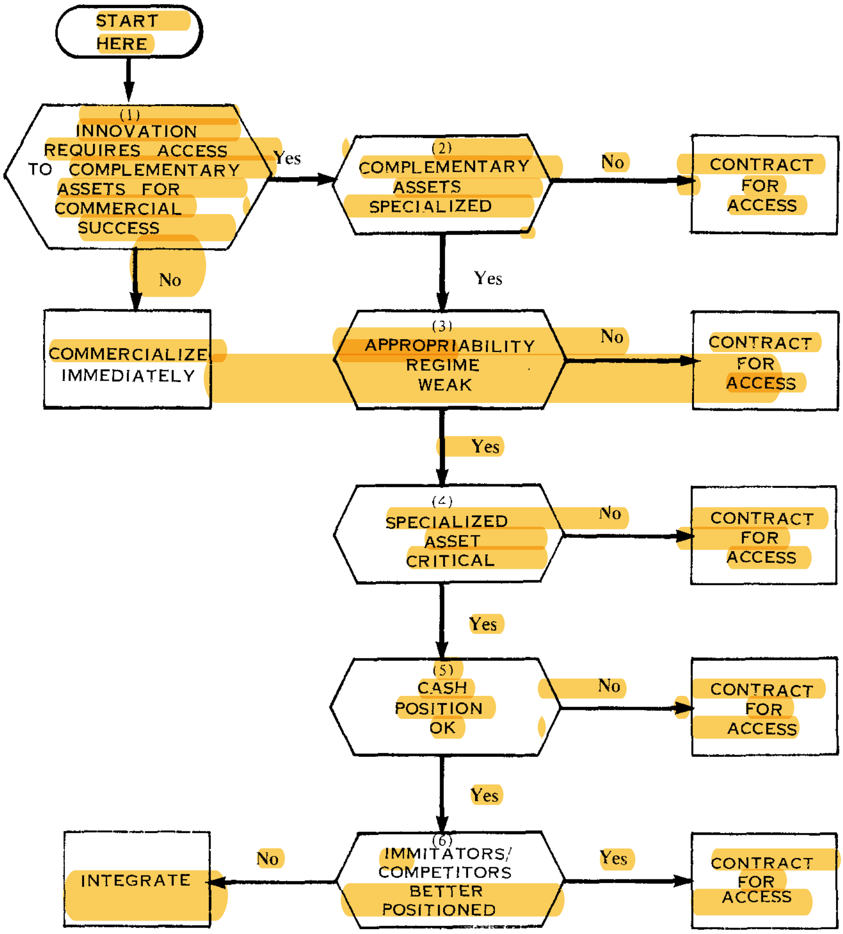


Fig. 10. Flow chart for integration versus contract decision.

to be a bottleneck with respect to commercializing the innovation, the owner of the bottleneck facilities is obviously in a position to extract profits from the innovator and/or imitators.

The vertical axis in fig. 11 measures how those who possess the technology (the innovator or possibly its imitators) are positioned vis à vis those firms that possess required specialized assets. The horizontal axis measures the "tightness" of the appropriability regime, tight regimes being evidence by iron clad legal protection coupled with technology that is simply difficult to copy; weak regimes offer little in the way of legal protection and the essence of the technology, once released, is transparent to the imitator. Weak regimes are further subdivided according to how the innovator and imitators are positioned vis à vis each other. This is likely to be a function of factors such as lead time and prior positioning in the requisite complementary assets.

Figure 11 makes it apparent that even when firms pursue the optimal strategy, other industry participants may take the jackpot. This possibility is unlikely when the intellectual property in question is tightly protected. The only serious threat to the innovator is where a specialized complementary asset is completely "locked up," a possibility recognized in cell 4. This can rarely be done without the cooperation of government. But it frequently occurs, as when a foreign government closes off access to a foreign market, forcing the innovators to license to foreign firms, but with the government effectively cartelizing the potential licensees. With weak intellectual property protection, however, it is quite clear that the innovator will often loose out to imitators and/or asset holders, even when the innovator is pursuing the appropriate strategy (cell 6). Clearly, incorrect strategies can compound problems. For instance, if innovators integrate when they should contract,

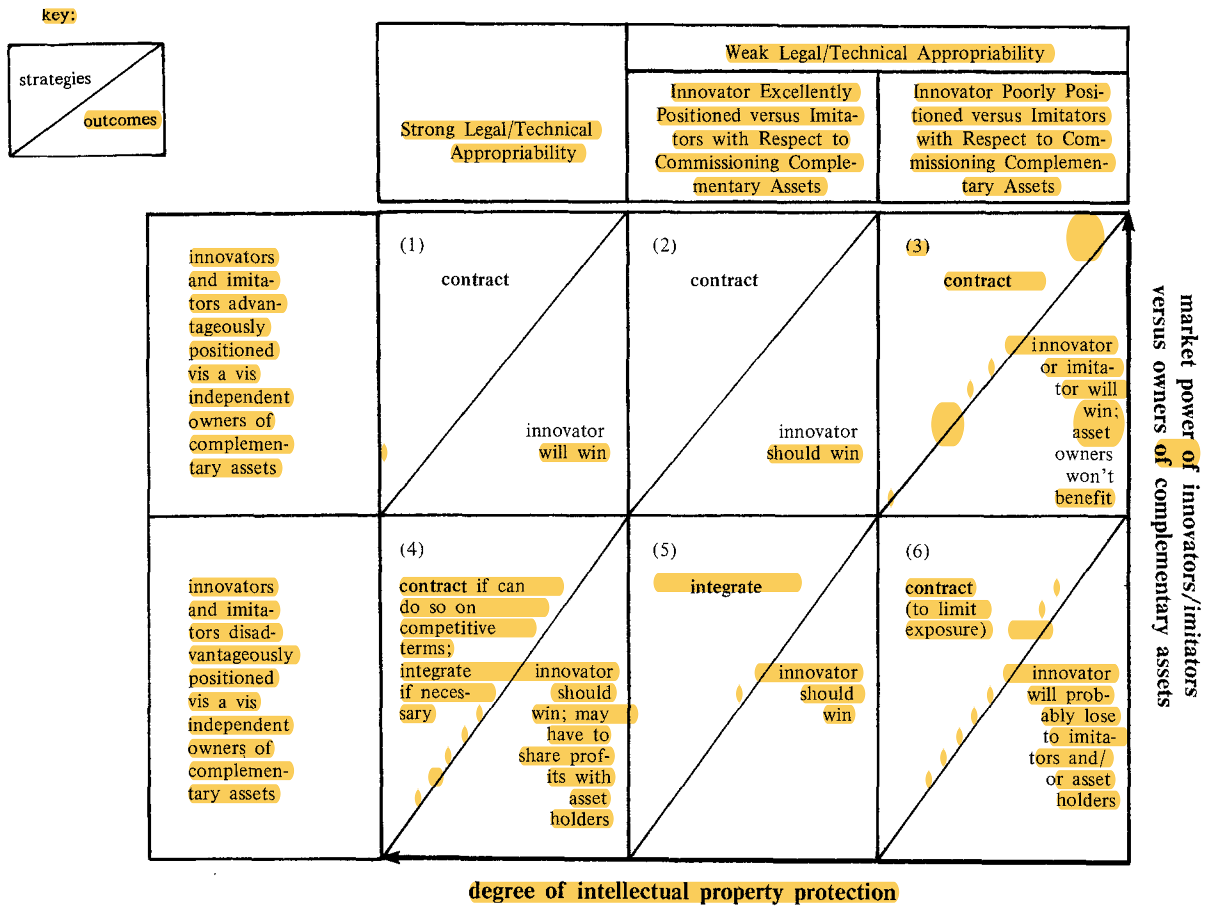


Fig. 11. Contract and integration strategies and outcomes for innovators: Specialized asset case.

a heavy commitment of resources will be incurred for little if any strategic benefit, thereby exposing the innovator to even greater losses than would otherwise be the case. On the other hand, if an innovator tries to contract for the supply of a critical capability when it should build the capability itself, it may well find it has nutured an imitator better able to serve the market than the innovator itself.

5.4. Mixed modes

The real world rarely provides extreme or pure cases. Decisions to integrate or license involve tradeoffs, compromises, and mixed approaches. It is not surprising therefore that the real world is characterized by mixed modes of organization, involving judicious blends of integration and contracting. Sometimes mixed modes represent transitional phases. For instance, because of the convergence of computer and telecommunication technology, firms in each industry are discovering that they often lack the requisite technical capabilities in the other. Since the technological interdependence of the two requires collaboration amongst those who design different parts of the system, intense cross-boundary coordination and information flows are required. When separate enterprises are involved, agreement must be reached on complex protocol issues amongst parties who see their interests differently. Contractual difficulties can be anticipated since the selection of common technical protocols amongst the parties will often be followed by transaction-specific investments in hardware and software. There is little doubt that this was the motivation behind IBM's purchase of 15 percent of PBX manufacturer Rolm in 1983, a position that was expanded to 100 percent in 1984. IBM's stake in Intel, which began with a 12 percent purchase in 1982, is most probably not a transitional phase leading to 100 percent purchase, because both companies realized that the two corporate cultures are not very compatible, and IBM may not be as impressed with Intel's technology as it once was.

5.5. The CAT scanner, the IBM PC, and NutraSweet: Insights from the framework

EMI's failure to reap significant returns from the CAT scanner can be explained in large measure by reference to the concepts developed above. The scanner which EMI developed was of a technical sophistication much higher than would normally be found in a hospital, requiring a high level of training, support, and servicing. EMI had none of these capabilities, could not easily contract for them, and was slow to realize their importance. It most probably could have formed a partnership with a company like Siemens to access the requisite capabilities. Its failure to do so was a strategic error compounded by the very limited intellectual property protection which the law afforded the scanner. Although subsequent court decisions have upheld some of EMI's patent claims, once the product was in the market it could be reverse engineered and its essential features copied. Two competitors, GE and Technicare, already possessed the complementary capabilities that the scanner required, and they were also technologically capable. In addition, both were experienced marketers of medical equipment, and had reputations for quality, reliability and service. GE and Technicare were thus able to commit their R&D resources to developing a competitive scanner, borrowing ideas from EMI's scanner, which they undoubtedly had access to through cooperative hospitals, and improving on it where they could while they rushed to market. GE began taking orders in 1976 and soon after made inroads on EMI. In 1977 concern for rising health care costs caused the Carter Administration to introduce "certificate of need' regulation, which required HEW's approval on expenditures on big ticket items like CAT scanners. This severely cut the size of the available market.

By 1978 EMI had lost market share leadership to Technicare, which was in turn quickly overtaken by GE. In October 1979, Godfrey Hounsfield of EMI shared the Nobel prize for invention of the CT scanner. Despite this honor, and the public recognition of its role in bringing this medical breathrough to the world, the collapse of its scanner business forced EMI in the same year into the arms of a rescuer, Thorn Electrical Industries, Ltd. GE subsequently acquired what was EMI's scanner business from Thorn for what amounted to a pittance. [7] Though royalties continued to flow to EMI, the company had failed to capture the

[7] See GE Gobbles a Rival in CT Scanners, *Business Week*, May 19, 1980, issue no. 2637.

lion's share of the profits generated by the innovation it had pioneered and successfully commercialized.

If EMI illustrates how a company with outstanding technology and an excellent product can fail to profit from innovation while the imitators succeeded, the story of the IBM PC indicates how a new product representing a very modest technological advance can yield remarkable returns to the developer.

The IBM PC, introduced in 1981, was a success despite the fact that the architecture was ordinary and the components standard. Philip Estridge's design team in Boca Raton, Florida, decided to use existing technology to produce a solid, reliable micro rather than state of the art. With a one-year mandate to develop a PC, Estridge's team could do little else.

However, the IBM PC did use what at the time was a new 16-bit microprocessor (the Intel 8088) and a new disk operating system (DOS) adapted for IBM by Microsoft. Other than the microprocessor and the operating system, the IBM PC incorporated existing micro "standards" and used off-the-shelf parts from outside vendors. IBM did write its own BIOS (Basic Input/Output System) which is embedded in ROM, but this was a relatively straightforward programming exercise.

The key to the PC's success was not the technology. It was the set of complementary assets which IBM either had or quickly assembled around the PC. In order to expand the market for PCs, there was a clear need for an expandable, flexible microcomputer system with extensive applications software. IBM could have based its PC system on its own patented hardware and copyrighted software. Such an approach would cause complementary products to be cospecialized, forcing IBM to develop peripherals and a comprehensive library of software in a very short time. Instead, IBM adopted what might be called an "induced contractual" approach. By adopting an open system architecture, as Apple had done, and by making the operating system information publicly available, a spectacular output of third part software was induced. IBM estimated that by mid-1983, at least 3000 hardware and software products were available for the PC. [8] Put differently, IBM pulled together the complementary assets, particularly software, which success required, without even using contracts, let alone integration. This was despite the fact that the software developers were creating assets that were in part cospecialized with the IBM PC, at least in the first instance.

A number of special factors made this seem a reasonable risk to the software writers. A critical one was IBM's name and commitment to the project. The reputation behind the letters I.B.M. is perhaps the greatest cospecialized asset the company possesses. The name implied that the product would be marketed and serviced in the IBM tradition. It guaranteed that PC-DOS would become an industry standard, so that the software business would not be solely dependent on IBM, because emulators were sure to enter. It guaranteed access to retail distribution outlets on competitive terms. The consequences was that IBM was able to take a product which represented at best a modest technological accomplishment, and turn into a fabulous commercial success. The case demonstrates the role that complementary assets play in determining outcomes.

The spectacular success and profitability of G.D. Searle's NutraSweet is an uncommon story which is also consistent with the above framework. In 1982, Searle reported combined sales of $74 million for NutraSweet and its table top version, Equal. In 1983, this surged to $336 million. In 1985, NutraSweet sales exceeded $700 million [9] and Equal had captured 50 percent of the U.S. sugar substitute market and was number one in five other countries.

NutraSweet, which is Searle's tradename for aspartame, has achieved rapid acceptance in each of its FDA approved categories because of its good taste and ability to substitute directly for sugar in many applications. However, Searle's earnings from NutraSweet and the absence of a strategic challenge can be traced in part to Searle's clever strategy.

It appears that Searle has managed to establish an exceptionally tight appropriability regime around NutraSweet – one that may well continue for some time after the patent has expired. No competitor appears to have successfully "invented around" the Searle patent and commercialized an alternative, no doubt in part because the FDA

[8] F. Gens and C. Christiansen, Could 1,000,000 IBM PC Users Be Wrong, *Byte*, November 1983, 88.

[9] See *Monsanto Annual Report, 1985*.

approval process would have to begin anew for an imitator who was not violating Searle's patents. A competitor who tried to replicate the aspartame molecule with minor modification to circumvent the patent would probably be forced to replicate the hundreds of tests and experiments which proved aspartame's safety. Without patent protection, FDA approval would provide no shield against imitators coming to market with an identical chemical and who could establish to the FDA that it is the same compound that had already been approved. Without FDA approval on the other hand, the patent protection would be worthless for the product would not be sold for human consumption.

Searle has aggressively pushed to strengthen its patent protection. The company was granted U.S. patent protection in 1970. It has also obtained patent protection in Japan, Canada, Australia, U.K., France, Germany, and a number of other countries. However, most of these patents carry a 17-year life. Since the product was only approved for human consumption in 1982, the 17-year patent life was effectively reduced to five. Recognizing the obvious importance of its patent, Searle pressed for and obtained special legislation in November 1984 extending the patent protection on aspartame for another 5 years. The U.K. provided a similar extension. In almost every other nation, however, 1987 will mark the expiration of the patent.

When the patent expires, however, Searle will still have several valuable assets to help keep imitators at bay. Searle has gone to great lengths to create and promulgate the use of its NutraSweet name and a distinctive "Swirl" logo on all goods licensed to use the ingredient. The company has also developed the "Equal" tradename for a table top version of the sweetener. Trademark law in the U.S. provides protection against "unfair" competition in branded products for as long as the owner of the mark continues to use it. Both the NutraSweet and Equal trademarks will become essential assets when the patents on aspartame expire. Searle may well have convinced consumers that the only real form of sweetener is NutraSweet/Equal. Consumers know most other artificial sweeteners by their generic names – saccharin and cyclamates.

Clearly, Searle is trying to build a position in complementary assets to prepare for the competition which will surely arise. Searle's joint venture with Ajinomoto ensures them access to that company's many years of experience in the production of biochemical agents. Much of this knowledge is associated with techniques for distillation and synthesis of the delicate hydrocarbon compounds that are the ingredients of NutraSweet, and is therefore more tacit than codified. Searle has begun to put these techniques to use in its own $160 million Georgia production facility. It can be expected that Searle will use trade secrets to the maximum to keep this know-how proprietary.

By the time its patent expires, Searle's extensive research into production techniques for L-phenylalanine, and its 8 years of experience in the Georgia plant, should give it a significant cost advantage over potential aspartame competitors. Trade secret protection, unlike patents, has no fixed lifetime and may well sustain Searle's position for years to come.

Moreover, Searle has wisely avoided renewing contracts with suppliers when they have expired. [10] Had Searle subcontracted manufacturing for NutraSweet, it would have created a manufacturer who would then be in a position to enter the aspartame market itself, or to team up with a marketer of artificial sweeteners. But keeping manufacturing inhouse, and by developing a valuable tradename, Searle has a good chance of protecting its market position from dramatic inroads once patents expire. Clearly, Searle seems to be astutely aware of the importance of maintaining a "tight appropriability regime" and using cospecialized assets strategically.

6. Implications for R&D strategy, industry structure, and trade policy

6.1. Allocating R&D resources

The analysis so far assumes that the firm has developed an innovation for which a market exists. It indicates the strategies which the firm must

[10] Purification Engineering, which had spent $5 million to build a phenylalanine production facility, was told in January 1985 that their contract would not be renewed. In May, Genex, which claimed to have invested $25 million, was given the same message, A Bad Aftertaste, *Business Week*, July 15, 1985, issue 2903.

follow to maximize its share of industry profits relative to imitators and other competitors. There is no guarantee of success even if optimal strategies are followed.

The innovator can improve its total return to R&D, however, by adjusting its R&D investment portfolio to maximize the probability that technological discoveries will emerge that are either easy to protect with existing intellectual property law, or which require for commercialization cospecialized assets already within the firm's repertoire of capabilities. Put differently, if an innovating firm does not target its R&D resources towards new products and processes which it can commercialize advantageously relative to potential imitators and/or followers, then it is unlikely to profit from its investment in R&D. In this sense, a firm's history – and the assets it already has in place – ought to condition its R&D investment decisions. Clearly, an innovating firm with considerable assets already in place is free to strike out in new directions, so long as in doing so it is cognizant of the kinds of capabilities required to successfully commercialize the innovation. It is therefore rather clear that the R&D investment decision cannot be divorced from the strategic analysis of markets and industries, and the firm's position within them.

6.2. Small firm versus large firm comparisons

Business commentators often remark that many small entrepreneurial firms which generate new, commercially valuable technology fail while large multinational firms, often with a less meritorious record with respect to innovation, survive and prosper. One set of reasons for this phenomenon is now clear. Large firms are more likely to possess the relevant specialized and cospecialized assets within their boundaries at the time of new product introduction. They can therefore do a better job of milking their technology, however meager, to maximum advantage. Small domestic firms are less likely to have the relevant specialized and cospecialized assets within their boundaries and so will either have to incur the expense of trying to build them, or of trying to develop coalitions with competitors/owners of the specialized assets.

6.3. Regimes of appropriability and industry structure

In industries where legal methods of protection are effective, or where new products are just hard to copy, the strategic necessity for innovating firms to integrate into cospecialized assets would appear to be less compelling than in industries where legal protection is weak. In cases where legal protection is weak or nonexistent, the control of cospecialized assets will be needed for long-run survival.

In this regard, it is instructive to examine the U.S. drug industry (Temin [10]). Beginning in the 1940s, the U.S. Patent Office began, for the first time, to grant patents on certain natural substances that involved difficult extraction procedures. Thus, in 1948 Merck received a patent on streptomycin, which was a natural substance. However, it was not the extraction process but the drug itself which received the patent. Hence, patents were important to the drug industry in terms of what could be patented (drugs), but they did not prevent imitation [10, p.436]. Sometimes just changing one molecule will enable a company to come up with a different substance which does not violate the patent. Had patents been more all-inclusive – and I am not suggesting they should – licensing would have been an effective mechanism for Merck to extract profits from its innovation. As it turns out, the emergence of close substitutes, coupled with FDA regulation which had the de facto effect of reducing the elasticity of demand for drugs, placed high rewards on a product differentiation strategy. This required extensive marketing, including a sales force that could directly contact doctors, who were the purchasers of drugs through their ability to create prescriptions. [11] The result was exclusive production (i.e., the earlier industry practice of licensing was dropped) and forward integration into marketing (the relevant cospecialized asset).

Generally, if legal protection of the innovator's profits is secure, innovating firms can select their

[11] In the period before FDA regulation, all drugs other than narcotics were available over-the-counter. Since the end user could purchase drugs directly, sales were price sensitive. Once prescriptions were required, this price sensitivity collapsed; the doctors not only did not have to pay for the drugs, but in most cases they were unaware of the prices of the drugs they were prescribing.

boundaries based simply on their ability to identify user needs and respond to those through research and development. The weaker the legal methods of protection, the greater the incentive to integrate into the relevant cospecialized assets. Hence, as industries in which legal protection is weak begin to mature, integration into innovation-specific cospecialized assets will occur. Often this will take the form of backward, forward and lateral integration. (Conglomerate integration is not part of this phenomenon.) For example, IBM's purchase of Rolm can be seen as a response to the impact of technological change on the identity of the cospecialized assets relevant to IBM's future growth.

6.4. Industry maturity, new entry, and history

As technologically progressive industries mature, and a greater proportion of the relevant cospecialized assets are brought in under the corporate umbrellas of incumbents, new entry becomes more difficult. Moreover, when it does occur it is more likely to involve coalition formation very early on. Incumbents will for sure own the cospecialized assets, and new entrants will find it necessary to forge links with them. Here lies the explanation for the sudden surge in "strategic partnering" now occurring internationally, and particularly in the computer and telecommunications industry. Note that it should not be interpreted in anti-competitive terms. Given existing industry structure, coalitions ought to be seen not as attempts to stifle competition, but as mechanisms for lowering entry requirements for innovators.

In industries in which technological change of a particular kind has occurred, which required deployment of specialized and/or cospecialized assets at the time, a configuration of firm boundaries may well have arisen which no longer has compelling efficiencies. Considerations which once dictated integration may no longer hold, yet there may not be strong forces leading to divestiture. Hence existing firm boundaries may in some industries – especially those where the technological trajectory and attendent specialized asset requirements has changed – be rather fragile. In short, history matters in terms of understanding the structure of the modern business enterprise. Existing firm boundaries cannot always be assumed to have obvious rationales in terms of today's requirements.

6.5. The importance of manufacturing to international competitiveness

Practically all forms of technological know-how must be embedded in goods and services to yield value to the consumer. An important policy for the innovating nation is whether the identity of the firms and nations performing this function matter.

In a world of tight appropriability and zero transactions cost – the world of neoclassical trade theory – it is a matter of indifference whether an innovating firm has an in-house manufacturing capability, domestic or foreign. It can simply engage in arms-length contracting (patent licensing, know-how licensing, co-production, etc.) for the sale of the output of the activity in which it has a comparative advantage (in this case R&D) and will maximize returns by specializing in what it does best.

However, in a regime of weak appropriability, and especially where the requisite manufacturing assets are specialized to the innovation, which is often the case, participation in manufacturing may be necessary if an innovator is to appropriate the rents from its innovation. Hence, if an innovator's manufacturing costs are higher than those of its imitators, the innovator may well end up ceding the lion's share of profits to the imitator.

In a weak appropriability regime, low cost imitator-manufacturers may end up capturing all of the profits from innovation. In a weak appropriability regime where specialized manufacturing capabilities are required to produce new products, an innovator with a manufacturing disadvantage may find that its advantage at early stage research and development will have no commercial value. This will eventually cripple the innovator, unless it is assisted by governmental processes. For example, it appears that one of the reasons why U.S. color TV manufacturers did not capture the lion's share of the profits from the innovation, for which RCA was primarily responsible, was that RCA and its American licenses were not competitive at manufacturing. In this context, concerns that the decline of manufacturing threatens the entire economy appear to be well founded.

A related implication is that as the technology gap closes, the basis of competition in an industry will shift to the cospecialized assets. This appears to be what is happening in microprocessors. Intel is no longer out ahead technologically. As Gordon Moore, CEO of Intel points out, "Take the top 10 [semiconductor] companies in the world... and it is hard to tell at any time who is ahead of whom.... It is clear that we have to be pretty damn close to the Japanese from a manufacturing standpoint to compete."[12] It is not just that strength in one area is necessary to compensate for weakness in another. As technology becomes more public and less proprietary through easier imitation, then strength in manufacturing and other capabilities is necessary to derive advantage from whatever technological advantages an innovator may possess.

Put differently, the notion that the United States can adopt a "designer role" in international commerce, while letting independent firms in other countries such as Japan, Korea, Taiwan, or Mexico do the manufacturing, is unlikely to be viable as a long-run strategy. This is because profits will accrue primarily to the low cost manufacturers (by providing a larger sales base over which they can exploit their special skills). Where imitation is easy, and even where it is not, there are obvious problems in transacting in the market for know-how, problems which are described in more detail elsewhere [9]. In particular, there are difficulties in pricing an intangible asset whose true performance features are difficult to ascertain ex ante.

The trend in international business towards what Miles and Snow [7] call "dynamic networks" – characterized by vertical disintegration and contracting – ought thus be viewed with concern. (*Business Week*, March 3, 1986, has referred to the same phenomenon as the Hollow Corporation.) "Dynamic networks" may not so much reflect innovative organizational forms, but the disassembly of the modern corporation because of deterioration in national capacities, manufacturing in particular, which are complementary to technological innovation. Dynamic networks may therefore signal not so much the rejuvenation of American enterprise, but its piecemeal demise.

6.6. How trade and investment barriers can impact innovators' profits

In regimes of weak appropriability, governments can move to shift the distribution of the gains from innovation away from foreign innovators and towards domestic firms by denying innovators ownership of specialized assets. The foreign firm, which by assumption is an innovator, will be left with the option of selling its intangible assets in the market for know how if both trade and investment are foreclosed by government policy. This option may appear better than the alternative (no renumeration at all from the market in question). Licensing may then appear profitable, but only because access to the complementary assets is blocked by government.

Thus when an innovating firm generating profits needs to access complementary assets abroad, host governments, by limiting access, can sometimes milk the innovators for a share of the profits, particularly that portion which originates from sales in the host country. However, the ability of host governments to do so depends importantly on the criticality of the host country's assets to the innovator. If the cost and infrastructure characteristics of the host country are such that it is the world's lowest cost manufacturing site, and if domestic industry is competitive, then by acting as a de facto monopsonist the host country government ought to be able to adjust the terms of access to the complementary assets so as to appropriate a greater share of the profits generated by the innovation.[13]

If, on the other hand, the host country offers no unique complementary assets, except access to its own market, restrictive practices by the government will only redistribute profits with respect to domestic rather than worldwide sales.

6.7. Implications for the international distribution of the benefits from innovation

The above analysis makes transparent that innovators who do not have access to the relevant specialized and cospecialized assets may end up ceding profits to imitators and other competitors, or simply to the owners of the specialized or cospecialized assets.

Even when the specialized assets are possessed by the innovating firm, they may be located abroad. Foreign factors of production are thus

[12] Institutionalizing the Revolution, *Forbes*, June 16, 1986, 35.

[13] If the host country market structure is monopolistic in the first instance, private actors might be able to achieve the same benefit. What government can do is to force collusion of domestic enterprises to their mutual benefit.

likely to benefit from research and development activities occurring across borders. There is little doubt, for instance, that the inability of many American multinationals to sustain competitive manufacturing in the U.S. is resulting in declining returns to U.S. labor. Stockholders and top management probably do as well if not better when a multinational accesses cospecialized assets in the firm's foreign subsidiaries; however, if there is unemployment in the factors of production supporting the specialized and cospecialized assets in question, then the foreign factors of production will benefit from innovation originating beyond national borders. This speaks to the importance to innovating nations of maintaining competence and competitiveness in the assets which complement technological innovation, manufacturing being a case in point. It also speaks to the importance to innovating nations of enhancing the protection afforded worldwide to intellectual property.

However, it must be recognized that there are inherent limits to the legal protection of intellectual property, and that business and national strategy are therefore likely to the critical factors in determining how the gains from innovation are shared worldwide. By making the correct strategic decision, innovating firms can move to protect the interests of stockholders; however, to ensure that domestic rather than foreign cospecialized assets capture the lion's share of the externalities spilling over to complementary assets, the supporting infrastructure for those complementary assets must not be allowed to decay. In short, if a nation has prowess at innovation, then in the absence of iron clad protection for intellectual property, it must maintain well-developed complementary assets if it is to capture the spillover benefits from innovation

7. Conclusion

The above analysis has attempted to synthesize from recent research in industrial organization and strategic management a framework within which to analyze the distribution of the profits from innovation. The framework indicates that the boundaries of the firm are an important strategic variable for innovating firms. The ownership of complementary assets, particularly when they are specialized and/or cospecialized, help establish who wins and who loses from innovation. Imitators can often outperform innovators if they are better positioned with respect to critical complementary assets. Hence, public policy aimed at promoting innovation must focus not only on R&D, but also on complementary assets, as well as the underlying infrastructure. If government decides to stimulate innovation, it would seem important to clear away barriers which impede the development of complementary assets which tend to be specialized or cospecialized to innovation. To fail to do so will cause an unnecessary large portion of the profits from innovation to flow to imitators and other competitors. If these firms lie beyond one's national borders, there are obvious implications for the internal distribution of income.

When applied to world markets, results similar to those obtained from the "new trade theory" are suggested by the framework. In particular, tariffs and other restrictions on trade can in some cases injure innovating firms while simultaneously benefiting protected firms when they are imitators. However, the propositions suggested by the framework are particularized to appropriability regimes, suggesting that economy-wide conclusions will be illusive. The policy conclusions derivable for commodity petrochemicals, for instance, are likely to be different than those that would be arrived at for semiconductors.

The approach also suggests that the product life cycle model of international trade will play itself out very differently in different industries and markets, in part according to appropriability regimes and the nature of the assets which need to be employed to convert a technological success into a commercial one. Whatever its limitations, the approach establishes that it is not so much the structure of markets but the structure of firms, particularly the scope of their boundaries, coupled with national policies with respect to the development of complementary assets, which determines the distribution of the profits amongst innovators and imitator/followers.

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