# Platform Owner Entry and Innovation in Complementary Markets: Evidence from Intel

Annabelle Gawer
*Imperial College London, Tanaka Business School*
*London, UK*
*a.gawer@imperial.ac.uk*

Rebecca Henderson
*MIT Sloan School and NBER*
*50 Memorial Drive, Cambridge, MA, USA*
*rhenderson@mit.edu*

*This paper explores Intel's strategy with respect to complements. We find that, as the literature predicts, Intel's entry decisions are shaped by the belief that it does not have the capabilities to enter all possible markets, and thus that it must encourage widespread entry despite the fact that potential entrants (rationally) fear Intel's ability to "squeeze" them ex post. We explore the ways in which Intel addresses this issue, highlighting in particular the firm's use of organizational structure and processes as commitment mechanisms. Our results have implications for our understanding of the dynamics of competition in complements and of the role of organizational form in shaping competition.*

## 1. Introduction

Many high-technology industries offer products or services which can be described as systems of interdependent components, built around or on top of "platforms." In these industrial "ecosystems," very large players may have considerable influence over the livelihood of developers of complementary products, and the behavior of platform owners toward the other firms in the ecosystem has been subject to much scrutiny. In particular, the recent landmark Microsoft antitrust trial has sparked considerable interest in the behavior of platform owners with respect

The authors thank Michael Cusumano, Joseph Farrell, David Gann, Barry Nalebuff, Scott Stern, the participants at the Stanford Strategy Conference and two reviewers who provided valuable suggestions. Thanks also go to the many Intel managers who agreed to be interviewed. The usual disclaimers apply.


*Journal of Economics & Management Strategy*, Volume 16, Number 1, Spring 2007, 1–34

to complementary markets, and in the consequences of platform owner entry for innovation.

Despite its importance, this is a surprisingly unexplored question. Existing theoretical models tend to focus quite narrowly on the individual factors that shape entry decisions. Few models have anything to say about how incentives may change in the case of a platform—and its corresponding complementary markets—that are likely to evolve in ways that cannot be predicted. Moreover, although some models suggest that entry in complementary markets is always optimal for a platform owner, others suggest that in some circumstances a platform owner's ability to commit not to enter complementary markets may be important to preserving complementors' incentives to innovate.[1] There is also very scant empirical work in the area. To our knowledge there is almost no research that explores platform owner incentives systematically across a range of complementary markets, or that focuses on how some of the key drivers from the theoretical literature can be identified, on whether they are important, or on how they may trade-off against each other (For an interesting exception see Boudreau, 2006).

For example, while the literature hints at the idea that in those cases in which platform owners do not have the necessary organizational capabilities, they might wish to subsidize entry into complementary markets but to refrain credibly from entry themselves. However, it gives very little insight as to how this might be done. Moreover, it offers no insight as to how platform owners should behave when the platform itself is dynamically evolving. Should they enter complementary markets to maintain control of the platform? Should they refrain? If they do enter, how can they maintain incentives for entrant innovation?

This paper explores these issues through the medium of a detailed study of Intel's experiences with complementary markets in the personal computer industry. Intel offers a particularly favorable setting for an in-depth case study of this question because entry and innovation in complementary markets were a central and recurring problem for the firm: as the provider of an essential element of the personal computer, Intel's decision to enter complementary markets—or not—strongly affected its relationship with external providers of complementary products, and was thus strategically important. Our data cover 14 years of entry decisions in a range of complementary markets, under different

1. We use the term "complementor" in the sense defined by Brandenburger and Nalebuff (1997), as a short-hand for "the developer of a complementary product" where two products are complements if greater sales of one increase demand for the other. Formally, A and B are complements if the valuation by consumers of A and B together is greater than the sum of the valuation of A alone and of B alone. $V_{a+b} = (1 + \delta)\,(V_a + V_b)$, $\delta > 0$.

market conditions and under changing strategic contexts. We use them to analyze Intel's actions and avowed motivations, exploring the degree to which Intel's history confirms the usefulness of current theory and raises new questions for future work.

We find, as predicted, that Intel's behavior with respect to complementary markets is greatly shaped by whether the firm can match the competencies of potential entrants. But we also find that in those cases where the interface between the platform and complementary markets is evolving, Intel is much more likely to enter "connector" markets—markets for those products that embody new platform interfaces. Because this then puts Intel in a particularly strong position to squeeze potential entrants in both the connector markets themselves and in complementary markets that are adjacent to, or "on top," of these markets, Intel experiences the dilemma outlined in the literature in a particularly acute form, and its desire to encourage innovation amongst entrants shapes the firm's behavior in some intriguing ways.

Intel appears to rely on three primary mechanisms to signal that it will not engage in any *ex post* "squeezing" of entrants. First, it uses an internal organizational structure (separate divisions with their own Profit & Loss operations) and a widely publicized rhetorical device (the distinction between "Job 1" and "Job 2"[2]) to signal that it expects both Intel and its competitors to make money in complementary markets–that it will not "suck all the air" out of them. Second, it attempts to subsidize entry into complementary markets not through direct subsidy but by lowering the cost of entry for all potential entrants—largely, but not only, by the development and widespread dissemination of intellectual property. Third, it attempts to commit to the stability and security of these subsidies—and, given its frequent entry into markets for interface technologies—to the promise not to change "the rules of the game" in these markets through the creation of a separate organizational unit (the Intel Architecture Lab or IAL) which is explicitly structured as a cost center and rewarded for its success in "promoting the health of the ecosystem" as a whole, or for stimulating demand for microprocessors.

This combination of activities creates considerable tension inside the firm, because on one hand managers within Intel are encouraged to maximize profit within complementary markets whereas on the other their colleagues are actively subsidizing the entry of competitors and publicly refusing to use Intel's control of the architecture to advantage internal divisions. Intel must make money in complementary markets—but not too much. We believe that these results—and the intriguing

2. "Job 1" refers to the task of expanding demand for the microprocessor, whereas "Job 2" refers to the task of growing profitable businesses in complementary markets.

interplay they suggest between strategic interaction and organizational structure—have potential implications for both theoretical work and further empirical research, and for both business strategy and public policy.

The rest of the paper is structured as follows: Section 2 presents a short literature review, Section 3 the methods and data and Section 4 the results of the study. Section 5 presents a discussion of the results, clarifies the directions in which they extend existing literature, and offers some conclusions.

## 2. Literature Review

We focus our theoretical discussion and empirical research around "platforms." Following Gawer and Cusumano (2002) we define a product as a "platform" when it is one component or subsystem of an evolving technological system, when it is strongly functionally interdependent with most of the other components of this system, and when end-user demand is for the overall system, so that there is no demand for components when they are isolated from the overall system.[3] We define a platform "owner" as a firm that owns a core element of the technological system that defines its forward evolution. Both Intel and Microsoft are platform "owners."

From this perspective, the relationship between a platform owner and other firms which are actual or potential owners of other components of the system is well modeled as that between an incumbent monopolist and actual or potential competitors in other, complementary markets, because demand for the platform is derived from the demand for the overall system.

However, the literature exploring a monopolist's incentive to enter the market for complements is subtle and complex, and whether a monopolist will choose to enter complementary markets or as to whether such entry will enhance or reduce social welfare cannot be answered unequivocally.

Within the vertical integration literature, work focusing on the multiproduct problem and on bundling has examined entry in

3. Our definition therefore differs from the definition of "platform" current in the multisided market literature (e.g., Rochet and Tirole, 2003, 2004) which includes real-estate agencies, or dating bars—as these assume that the complementary markets are predefined, well known, and that the platform scope is static. Our definition is closer to the one of Bresnahan and Greenstein (1999) who define a platform as a bundle of standard components around which buyers and sellers coordinate efforts, or West (2003) who defines it an architecture of related standards, allowing modular substitution of complementary assets such as software and peripheral hardware—but we do not require components to be "standards."

complementary markets, but with the important exception of Farrell and Weiser (2003), has not paid particular attention to platform dynamics or network effects (see for example Schmalensee, 1981; Panzar, 1989; Whinston, 1990; Nalebuff, 2004). These authors suggest that monopolists have several strong reasons for entering complementary markets to offer a bundle or a tie. Cournot (1838) showed that multiproduct firms—that is, those producing both products, in the case of two complementary markets—internalize the demand externality across markets whereas single product firms do not, so that in the simple case both consumer welfare and total profits are increased if both products are produced by a single firm. Firms may also enter multiple markets to weaken rivals through price competition, driving the price of the complement down and raising the price of the essential good to capture the available rent (Ordover et al., 1985). This may or may not be predatory or exclusionary: it depends on how much the monopolist "squeezes" complementors because a price squeeze induces complementors to offer as much surplus as possible in the complementary market (Whinston, 1990; Nalebuff, 2004). These models, however, ignore the effect of entry on complementors' incentives to innovate.

Focusing on platform pricing as the main decision variable, related work in multisided markets (Rochet and Tirole, 2003, 2004; Caillaud and Jullien, 2003; Hagiu, 2004) focuses on how platform owners can encourage platform adoption. For example Hagiu (2005) explores the effect of platform pricing on complementors' innovation incentives, but focuses exclusively on the platform owners' choice between charging complementors fixed fees or variable fees (royalties), to find the optimal royalty rate.

Related work has focused on the effects of incumbent entry into complementary markets on complementors' incentives to innovate. Choi and Stefanadis (2001) show that with uncertain investment, a monopolist's entry in complementary market results in a potential price squeeze that may deter innovation by rivals. Heeb (2003) also confirms that price squeezes may deter complementary innovation. Farrell and Katz (2000), Becchetti and Paganetto (2001), and Miller (2005) suggest that when an incumbent monopolist lacks the capabilities of potential third-party complementors it will have an incentive to encourage third-party innovation, but if the entrant monopolist's incentive to engage in *ex post* price "squeezes" is sufficiently strong, complementors may have no *ex ante* incentive to engage in innovation at all. Where the monopolist cannot duplicate the third-party complementors' innovation at a reasonable cost, it may then have strong incentives to try to commit to them that it will not enter the market for complements. The difficulty, of course, is that even if the overall *ex ante* effects of a squeeze are negative for the monopolist, it may be difficult for the firm to commit not to engage in one *ex post*, particularly if it is already integrated into the supply of other complementary products.

Of course there are other—well-known—reasons why a platform owner might not want to enter complementary markets. They might already be fully competitive. They might have too small an impact on platform demand to be worth the effort. A monopolist might be capital constrained or might fear retaliation from powerful competitors.[4]

Intriguingly, none of these models considers the case in which the interface between complementary markets may be evolving. In the few articles that do consider platform evolution, the consequences for the players' incentives to innovate are ambiguous. Farrell et al. (1998) can be interpreted as suggesting that when interfaces are likely to evolve such that a platform owner is likely to lose control of the architecture, the platform owner should integrate into the interface. Similarly Carlton and Waldman (2002) suggest that strategic tie-ins to evolving complementary markets may be a way to extend monopoly power into a newly emerging market. Both models suggest that in these cases innovation in complementary markets is likely to be suppressed. But Davis et al. (2002) suggest that Microsoft's entry into complementary markets, followed by product integration, facilitated the development of new applications.[5] Closest to our own approach, case studies by West and Dedrick (2000) and West (2003) suggest that the treatment of intellectual property (whether the platforms are "open" or "proprietary"), as well as the availability of appropriate development tools, affects the platform owners' ability to control the evolution of the platform architecture, and the likelihood of innovation in complementary markets. These articles suggest that it is generally in the interest of a platform owner to enter complementary markets, but that such entry

4. In 1996 Intel attempted to extend its platform into Microsoft's territory, through the development of "Native Signal Processing," which allowed much of the manipulation of audio and video traditionally carried out on specialized chips on the computer's motherboard to be built into the microprocessor itself. Jackson (1997) reports: "In principle, NSP was in both companies' interest. The problem was that the NSP technology Intel had developed didn't slot into DOS or Windows. It stood alone, and by doing so, it appeared to challenge Microsoft's hegemony over software standards. The reaction from Microsoft was swift and vicious. Without saying anything to Intel, Microsoft warned the PC manufacturers that it had no intention of supporting NSP in future releases of Windows, effectively forcing them to sacrifice 100% compatibility with Microsoft's standards if they went along with Intel's initiative." Intel later halted its NSP investments.

5. Davis et al. (2002) claim that integration in complementary markets reduces the cost of complementors' innovation. They do not however balance this effect with the potential entry-deterrence effect. They point principally to the release of Application Programming Interfaces ("APIs"—software tools that allow complementors to develop complementary applications that will interoperate smoothly with the platform) to facilitate complementary innovation.

must be balanced against the costs of discouraging entry by new firms. In general, however, the existing literature offers no guidance as to how this trade-off should be managed and no evidence as to how—or whether—it is being managed in practice. How do incentives to enter in order to internalize externalities tradeoff against the need to encourage entry when the relevant capabilities are scarce or unavailable? How does a platform owner commit credibly not to enter a market when, once that market is established, it will have a strong incentive to do just that? If the platform owner has strong incentives to enter to control the evolution of a platform, how does this shape action? How does it shape complementors' behavior? Will it be seen as exactly the kind of *ex post* squeeze that other models suggest may be very destructive? How can one distinguish, empirically, between entry to control platform direction and entry to internalize externalities?

Our paper contributes to this debate by allowing us to distinguish between the different drivers of entry into complementary markets, by exploring the degree to which Intel balances it own strong incentives to enter against the risk of discouraging complementors' innovation, and by highlighting the significance of the organizational structure and processes of the firm in enabling Intel to manage these trade-offs.

## 3. Data and Methods

We draw on extensive qualitative data drawn from Intel's recent history to explore these issues. Intel offered a particularly favorable setting for an in-depth case study of our central question for several reasons. First, entry and innovation in complementary markets were a central and recurring strategic problem for the firm. As the provider of an essential element of the personal computer, Intel's approach to complementary markets strongly affected its relationship with external providers of complementary products. Second, as the largest global producer of microprocessors between 1990 and 2004, Intel was clearly a platform owner, and plausibly had considerable market power for most of the period.[6] Intel also changed strategic focus twice between 1990 and 2004. The period thus allows us to explain a wide spectrum of Intel's behaviors vis-à-vis complementors.

6. Between 1991 and 2000, Intel revenue increased from $4.8 billion to $33.7 billion, whereas profits grew from $819 million to $10.5 billion over the same period. Return on assets over the period averaged around 25%. However, like every technology company, Intel was hit hard by the burst of the Internet bubble. Revenues for 2001 were $26.5 billion, whereas net income for 2001 only $1.3 billion. In 2003, however, Intel posted revenue of $30.1 billion and net income of $5.6 billion, followed by annual increases of approximately 15% in 2004 and 2005.

Our data cover the period 1990 to 2004. The empirical analysis draws on a sequence of 72 in-depth qualitative interviews conducted with senior managers at Intel, as well as on primary and secondary literature. We gathered data on 27 complementary markets. In order to explore the determinants of Intel's entry decisions we tried particularly hard to collect information about markets that the firm chose not to enter. Although it is clearly almost impossible to identify the set of all the complementary markets that Intel *could* have entered, the set includes all of those markets that Intel considered important enough to monitor between 1990 and 2004. Of the 27, Intel entered only 17.

We conducted interviews during three visits to Intel to sites in both California and Oregon between November 1997 and April 2000. We explained to our respondents that we were doing a study of the ways in which Intel had attempted to have an effect on innovation in "complementary products," that is, products whose supply could have a demand-enhancing effect on the microprocessor. The interviews were semistructured (that is, respondents were provided with a list of interview questions beforehand, but were not held to them as the interview progressed). Most interviews lasted about an hour, although some lasted much longer. All the interviews were taped and transcribed. The initial interviews covered a broad range of topics, including company history and structure, industry innovation and competition, the relationships between Intel and other firms, customers, suppliers, and complementors. Later interviews focused on the history of the many facets of Intel's involvement in innovation in complementary products, and went deeper into the managerial processes by which Intel attempted to influence innovation. We were also given access to a wide range of internal documents, including organization charts, company brochures, project planning documents, internal presentations documents, and project information, and we were invited to attend several internal company meetings.

The use of a qualitative approach has both advantages and limitations. Comprehensive studies of firm decision making that focus on economically significant decisions are rare. Given that it is difficult to measure the extent to which several variables affect entry decisions in particular markets, systematic qualitative data about organizational processes, structure, and internal beliefs provide an important alternative source of evidence. During the course of our research we took a number of measures to ensure that as far as possible we were not simply hearing the "party line" from our informants. We describe these in more detail below. In consequence, we believe that our results accurately describe the beliefs of Intel's senior and middle management, and that these beliefs had important effects on Intel's actions.

In an attempt both to avoid problems of retrospective bias and also in order to avoid being given "official propaganda," we interviewed managers at several different levels of seniority, including senior officers, team leaders, engineers, and marketers. One set of interviewees was approached through initial contacts with the managers of the Intel Architecture Lab. Another set of interviewees came from an initial contact with a member of the board of directors of Intel, who arranged for interviews with Intel's top management team. The final set of interviewees was derived from recommendations from the first two. The gradual accretion of interviewees allowed the reach of the interviews to move well beyond the initial group of IAL personnel and top managers. Interviews were conducted in 11 different functional groups and at five different sites. Most of the interviewees had a long tenure at Intel and had worked in several groups throughout their career. At the end of each interview, each interviewee was asked to suggest names of other employees who might be able to confirm the interviewee's own account or who might be able to provide a contrasting perspective. One of the reasons that we believe these interviews to reflect the genuine beliefs of Intel managers is that we often uncovered conflicts between different managers, different groups, and different hierarchical levels. This suggested to us that we were not being given a "party line" but were gaining a true sense for the basis on which key strategic decisions had been made within the firm. Further details can be found in Gawer (2000).

In the analysis below, we attempt to summarize the interviews, and the understanding of Intel's strategy and beliefs that we gained as a result of conducting them, through the use of brief quotations. We have endeavored to ensure that the quotes are representative in that they catch the sense of a number of interviews and the perspectives of a number of different managers.

## 4. Results

One of the most striking findings from the interviews is that of Intel's strategic sophistication with respect to the dynamics of the markets for complements. It is clear, first, that Intel understood the importance of generating complements to the success of their microprocessor business. Gerald Holzhammer—the director of the Intel Architecture Lab in 1997 and the director of the Desktop Architecture Lab from 1998 on—described the decision to focus on software in an attempt to stimulate growth in demand for computers in terms that could have come directly from a textbook:

> There was a master plan . . . that said *we need to encourage innovation on software applications*. It all came about fairly

> naturally.... If the end-user doesn't see really immediate added value by buying the next-generation processor, then Intel will not grow. Intel will have a huge problem. We are spending billions of dollars building these new manufacturing plants. If people don't come, don't buy, we will fall off a cliff. That's the reason why we have an Intel Architecture Lab, *whose fundamental mission is to grow the overall market*. We need to amortize our manufacturing capacity in a large number of units. That will happen only if there are new applications. How do you grow a market? Intel has 80, 85, 90 percent market segment share for CPUs.[7] You don't grow by getting another 2 percent. *You grow by growing the entire pie*. How do you grow your pie? By getting new applications, find new users for the PC.[8]

However, understanding Intel's actions in light of the existing literature—even with this promising beginning—is complicated by the fact that the complementary markets Intel faces are both more dynamic and more numerous than can be easily encompassed in a formal model. In the '90s the computing ecosystem was both highly dynamic and "multi-layered." Whereas the standard treatment of the problem considers the case of a monopolist in one market considering integrating into a second, Intel faced something closer to a "stack" of markets whose nature and extent could not be identified *ex ante*. In particular, we identified an intermediate stack of markets, functionally located between the platform and the applications, which we defined as "connector" markets. (Figure 1)

We define connector markets as those in which the products embody one or more interfaces between the platform and end-use

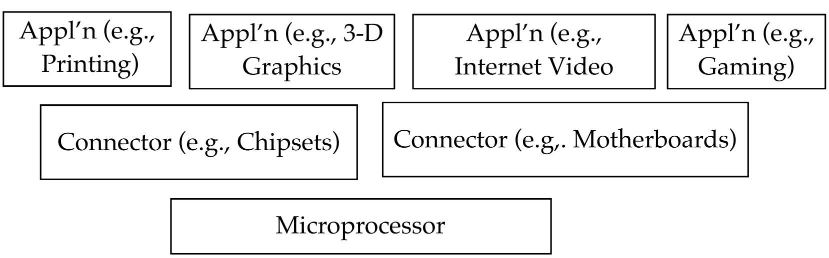


*FIGURE 1. A STACK OF COMPLEMENTARY MARKETS*

7. CPU (Central Processing Unit) is another name for microprocessor.
8. Interview with Gerald Holzhammer, director of the Intel Architecture Lab, Intel Corp., Hillsboro, Oregon, November 11, 1997. Emphasis added.

applications. In the Intel case, the connector markets included both hardware and software, such as chipsets and motherboards, and a range of network connectivity products.[9]

The stack in Figure 1 was dynamic in the sense that both technical progress and the evolution of demand continually expanded the potential set of connector and application markets, and in the sense that the nature of the interfaces between them was unknown *ex ante.*

All of these markets are complements in the classical sense, but some—notably the connector markets—were likely to be significantly more strategic than others. This is both because their creation enabled other markets and thus because they had a disproportionate effect on demand, but also because in many cases they were central to the structure of competition. If Intel could retain architectural control over new connector markets—or at the very least prevent other firms from gaining control—it greatly increased the likelihood that it could preserve Intel's essential role within the overall PC system's architecture over time.

Not surprisingly—and in line with the existing literature—Intel's entry decisions do indeed appear to have been shaped dramatically by whether a complementary market was viewed as a connector market. Of the 17 complementary markets that the firm entered, 12 entries were connector markets whereas the remaining five were the disastrous diversification attempts of the Internet bubble years.[10] However, despite their strategic importance, Intel did *not* enter every connector market. Of the 20 cases that we were told had significant implications for the interface with the microprocessor, Intel entered only 12, or 60%. Connector

9. Chipsets embody the physical and electrical connectors to the platform's new external interfaces, therefore provide an essential function of data transfer into and out of the microprocessor. A motherboard is the main circuit board in a PC, containing the microprocessor, the memory, and other support chips. Network connectivity products embody physical and electrical connections between different components of the PC system when integrated into a network of computers and peripheral devices such as printers.

10. A major strategic shift occurred between 1998 and 2001, the so-called Internet bubble. For the first time in a decade, Intel's profits fell, and the firm was obliged to cut its dividend. Management lost faith in its microprocessor business' ability to grow the firm and meet stockholders' expectations. In 1997, Craig Barrett, then Chief Operating Officer of Intel, noted that "microprocessors by themselves will not be the growth engine that they have been in the past." Meanwhile, the opportunities offered by rapidly emerging Internet-related markets seemed extremely promising. Intel made several attempts to diversify, harnessing internal frustrations that the single-minded focus on Job 1 had prevented the development of other businesses (Burgelman, 2002). Under Barrett's direction, Intel shifted its focus to regenerate growth by entering new markets: Intel entered in five markets during this period, namely Web hosting and online services, toys, audio products, Internet appliances, and wired and wireless handheld PC accessories, in none of which it had previously identified internal organizational capability. Intel exited all of them by the end of 2001.

Table I.
Intel's Decision to Enter

| | Did Intel Have the Necessary Capabilities? | | |
|---|---|---|---|
| | Yes | Partially | No |
| Connector market | 9 entry | 3 entry<br>8 no entry | |
| Not a connector market | | 1 no entry | 1 no entry<br>5 entry (followed by rapid exit) |

markets were clearly important to Intel—but of the 11 connector markets in which the firm lacked the necessary capabilities Intel entered only three times.

Table I summarizes these numbers. (Appendix Table AI provides detailed information about each of the markets Intel entered. Appendix Table AII lists the determinants of the decision to enter (or not) for each of the 27 projects).

These results suggest that (bracketing the "bubble entries") under "normal" conditions, Intel entered only those complementary markets that had implications for control of the platform architecture and only those for which it believed it had the requisite capabilities. The qualitative evidence appears to be consistent with this hypothesis.

Intel entered connector markets, as one would expect, when it was attempting to change the platform/application interface. Interviewees referred to these moves as Intel trying to "advance the platform," or to "accelerate platform transitions."

For example, Intel's first entry into connector markets was in 1994, when Intel invented a new "bus architecture," the Peripheral Component Interface PCI, which increased bus speed by a factor of 5 and provided fast links to other crucial components of the PC, such as the hard disk.[11] Intel first decided to leave the production and commercialization of the PCI to the traditional chipset makers on whom Intel had historically relied, but after being disappointed with their performance decided to enter the market itself.

Entry was justified on both classical demand expansion and strategic grounds. On the demand expansion front Will Swope, vice president of the Intel Architecture Business Group, explained:

> The real way you make money is by selling faster processors. And you can't sell a faster processor if you don't have data

11. Yu (1998), 55. A bus is a data pathway that ensures data transfer between different components of the PC.

> to operate on—[data that is brought to the chip through the chipsets.][12]

On the strategic front, Bill Miller, from the Sales and Marketing group, explained:

> We got into the chipset business in a major way *to accelerate platform transitions*. To unleash the power of the Pentium, we had to introduce the new PCI bus. [ . . . ] Our market segment share in the desktop chip set business is equal or greater than processors. This helps our ability to establish platform standards significantly. Having some market segment share in chip sets makes it easier for us to advance the platform.
>
> Our foray into the motherboard business used to be sort of a manufacturing foray, and is now more of a licensing foray. We manufacture some, but mostly we have licensed our designs. This allows us to have influence over other areas of the platform as well. If you are defining how a certain percentage of the motherboards are designed, you then can make a good technical argument and have a good volume argument. Standards follow volume, which seems pretty obvious. The simplest way to get a standard established is to put in a product that sells at a high volume.[13]

By developing chipsets and selling them in large volume, Intel attempted to accelerate the adoption of a bus standard, which the firm saw as crucial both to growing the market for Intel microprocessors and to maintaining Intel's control over the architecture of the overall PC system. Maintaining control also allowed Intel to ensure that the markets for complements that were running "on top of" the connectors were suitably competitive. In the words of Craig Kinnie, director of the Intel Architecture Lab for much of 1991–2000:

> We want to define how these companies will hook their pipe to the PC and how application writers can take advantage of that pipe that we control [ . . . ]. They all will connect to the PC in exactly the same way. [ . . . ] Coordination here now creates a common connector. [ . . . ] Because we said there should be one way to hook to a PC and we are going to make it happen, they all now have to compete to deliver to

12. Interview with Will Swope, vice president, Intel Architecture Business Group, and director, Platform Planning, Intel Corp., Hillsboro, Oregon, August 6, 1998.

13. Interview with Bill Miller, director of Worldwide Media Relations, Sales and Marketing Group, Intel Corp., Santa Clara, California, August 13, 1998. Emphasis added.

> that socket,—whereas if they had been all allowed to have a different connector and one of them won, there wouldn't even be competition: it would be one guy or two.[14]

This concern with stimulating demand and maintaining control was tempered, as the raw numbers suggest, by the recognition that Intel did not have the organizational capabilities required to enter all possible complementary markets. For example, Claude Leglise, director of the Developer Relations Group, insisted:

> I have no intention whatsoever of getting into the software business. Intel has no corporate competence in entertainment software. We don't know how to do video games, so forget it. We're not trying to go into their space. We're trying to get them on the same strategic road map so that the overall ecosystem will benefit.[15]

In chipsets, entry was justified on the basis of a good match between the requirements of the market and Intel's capabilities. Said Bill Miller from the Sales and Marketing Group:

> We did start by giving specifications [to the chipset manufacturers]. [ . . . ] But we realized that they weren't fast enough, and one of the most troublesome things was that *it was really hard getting the other chipset vendors to do PCI "right."* It was *so close to the processor that we wanted them to do it right*, because our product ramp on Pentium was gated by the fact that you needed a PCI bus to do it. The [previous industry] bus [standards] were at the time were too stinking slow to show the benefit [of our platform]. We had to "put our own skin in the game." We got impatient and we said, "This is not fast enough." So, our PCI Components Division [ . . . ] entered the chipset business. We now provide chipsets,—and, as *we happen to execute really well in chipsets*, we are now in the chipset business in a significant way: our market segment share in the desktop chipset business is equal or greater than in processors.[16]

This strategy, however, presented Intel with exactly the dilemma identified in the literature. Given that Intel had a history of entering complementary markets—and that this entry put it in a particularly

14. Interview with Craig Kinnie, director of the Intel Architecture Lab, Intel Corp., Hillsboro, Oregon, November 11, 1997.
15. Interview with Claude Leglise, director of the Developer Relations Group, Intel Corp., Santa Clara, November 13, 1997.
16. Interview with Bill Miller, *op. cit.* Emphasis added.

advantageous position with respect to other adjacent markets—in both connector *and* nonconnector markets in which the firm wished to encourage entry because it believed it lacked the requisite capabilities it faced the difficult task of committing to potential entrants that it would not engage in precisely the kind of *ex post* squeeze identified by the literature.

Our respondents appeared to have deeply internalized this issue. As Dave Johnson, engineering manager at IAL, explained:

> The market segment gets hurt if third parties think: "Intel, the big guys, are there, so I don't want to be there. They're going to crush me." That's not good, and it's not what we want, because we're trying to encourage people to do these complementary things.[17]

Similarly, in the context of the firm's experience with videoconferencing, Dave Johnson recalled:

> You [as a platform owner] *need to be careful not to come in so hard that you don't undermine the conditions in the market you enter.* In some ways, what we did with ProShare[18] was to enter the market segment with a product and expect the market to respond. *But then you have to be careful because you can undermine the whole market segment and not end up fostering innovation.* Some people claim we did just that. We wanted to deliver an affordable product that would make videoconferencing a desktop PC add-on. We were so intent on videoconferencing as a method for selling CPUs that our own products drove the prices down to where the channel [that is, the existing players] wasn't making money, we weren't making money, competitors couldn't make money—and, therefore, we didn't help the overall marketplace. Major players are still there, but they are weak. A number of the more peripheral players have left.[19]

Notice that the "layered" nature of the technical system in which Intel was embedded—and the continuous evolution of the boundaries between components—made this problem particularly acute. Once Intel had entered an interface layer, for example, the problem of encouraging entry into related markets did not disappear—rather it became significantly more acute because the interface was only likely to be

17. Interview with David B. Johnson, director of the Media and Interconnect Technology Lab, Intel Architecture Lab, Intel Corp., Hillsboro, Oregon, August 4, 1998.
18. ProShare was Intel's $750 million failed videoconferencing effort (1992–1998). See Burgelman (2002), 269.
19. Interview with David B. Johnson, *op. cit.* Emphasis added.

valuable if there was entry into the markets that ran "on top" of it. As the platform continuously evolved, Les Vadasz, director of Intel Capital—the venture capital branch of Intel—acknowledged that evolving platform boundaries created "skirmishes" with complementors:

> In our business, the boundary has always moved because the interfaces between our customers and us have always changed as a result of the way the technology has evolved. While I recognize that it's moving and that it has always moved, it's very important that we don't get carried away with our own delusions of grandeur, and that we stay in businesses that we know we can succeed in . . . We have looked at our business more as a supplier of building blocks that others can build their business on, and that continues to be the majority of our business. But even there, we have skirmishes sometimes because the interface changes. When we first started to sell motherboards, there was a lot of paranoia amongst our OEMs.[20] What's our intent? Why are we doing this? I think now it's more of a positive to the business than a negative. But anytime you do that, there are a lot of issues. *Also, it's important that your complementors trust you because you need them, they need you, and you cannot just trample all over everybody's business willy-nilly.*[21]

Dr. Grove, CEO of Intel at the time of the interview summed this perspective up:

> We are in a certain business and we are defining a platform upon which other people are going plug in peripherals or other products. And we want competition in those areas. And yet we want to supply there, also.
>
> [Isn't there a tension there?] Yes, precisely: we are defining the platform and we want to be a participant to build on the platform. It's a pretty common situation. It is almost inconceivable that you can have the expertise, the momentum, and the market credibility to define a platform unless you are participating both above and below that platform. Microprocessors are below. You can't come and define buses if you don't know enough about chipsets and microprocessors.

20. OEMs = Original Equipment Manufacturers. PC makers such as Compaq, IBM, Gateway, and Dell are OEMs.

21. Interview with Les Vadasz, senior vice president and director of the Corporate Business Development group (renamed Intel Capital in 2000), Intel Corporation, Santa Clara, California, August 14, 1998. Emphasis added.

> On the other hand, if you are in it, you obviously have a business interest for yourself. *The resolution of these tensions is crucial for repeated success*. You get to fool some of the people some of the time, but you can't make that an ongoing practice.[22]

Intel's actions, and the dilemma that it faced, are broadly consistent with the existing literature. It is in the analysis of the actions that Intel took to resolve it that we begin to enter new ground.

Intel's first response was to attempt to develop a reputation for "treating complementors well" and to that end the company developed a rhetoric that presented Intel as a benevolent industry coordinator, or "honest broker," careful to protect incentives for external complementors. In the words of Claude Leglise:

> You have to manage the future of the ecosystem. It's really a complete system with lots of people. So the role that we're trying to play is one of leadership—which is very different from wanting to own everything. Our future wealth is completely tied to the wealth of the ecosystem and the well-being of the ecosystem. Therefore, it is to our advantage to make sure that this whole thing evolves positively.[23]

It may be that Intel did indeed develop a reputation for behaving this way—we did not have the opportunity to interview any actual or potential complementors and are thus unable to gauge whether this was a successful strategy. Here we focus on the degree to which Intel used its organizational structure and processes to commit to complementors that it would not engage in exactly the kinds of "*ex-post* squeezes" identified in the literature. Intel's approach to this issue is complex, and highlights a number of important issues. The key to understanding the firm's actions, we believe, is first, to unpack the concept of "*ex-post* squeeze" and second, to understand the ways in which Intel attempted to use organizational structure and processes as commitment mechanisms.

In principle there are two ways in which Intel could "squeeze" complementors. It could drive returns in a complementary market to zero by entering the market and depressing prices—effectively subsidizing entry using profits derived from the primary component—or it could enter and capture all the returns for itself by manipulating the boundary between the market and the core of the platform in order

22. Interview with Dr. Andrew S. Grove, CEO, Intel Corp., Santa Clara, August 18, 1998. Emphasis added.

23. Interview with Claude Leglise, *op. cit*.

to advantage Intel-owned products. Intel could thus either attempt to commit never to enter complementary markets—a difficult task, particularly in connector markets, given its history and its obvious economic incentives—or it could commit to enter and "play nicely"—by making money *but not too much*. In our view it is this second strategy that Intel pursued, and they did so by attempting to leverage both their intellectual property and their internal structures and processes.

Intel committed to making money in those complementary markets that it did enter—and thus not to drive returns down in those markets—by committing to "Job 2"—by organizing entry into these markets using organizationally distinct units with their own "P&Ls." It then committed not to making "too much" money in these markets by aggressively subsidizing third-party entry, and by broadly sharing the Intel-owned IP that might otherwise give the Intel-owned business unit undue advantage. This balancing act created very significant tensions within the firm that were managed by institutionalizing the strategic imperative to stimulate entry in the market for complements while simultaneously entering those markets and making money—but not too much—by stressing that the task of expanding demand for the microprocessor (a task referred to as "Job 1" within Intel) might at times be in contradiction to the task of growing profitable businesses based on proprietary IP in complementary markets ("Job 2"), and by structuring the organizational unit responsible for the development of the majority of the IP—the Intel Architectural Labs, or IAL, as a stand alone, not-for-profit unit.

Mike Aymar, vice president and general manager of the Desktop Products Group, discussed how this tension affected the treatment of Intellectual Property in the context of digital video disk (DVD) technology:

> We worked with the suppliers and came up with some software technology for doing the [DVD] copyright encryption. We also worked with some participants to come up with an MPEG2[24] player that works on a PC with no additional hardware—so once you buy a certain level of PC, this is "free." Now, what do we do with that technology? If it is Job 1, we probably broadly diffuse it. We make it available to as many participants as we can, so that as many PCs in the world from any supplier, any hardware supplier, any software supplier, all have this capability. And we just broadly diffuse it. We may license some things, we may charge small

24. MPEG2 is a standard specification for audio and video from the MPEG (Moving Picture Export Group) standardization body.

> royalties, but in general, our main purpose is to enable and diffuse this technology broadly.
>
> If it is not Job 1, if it is its own business unit, they don't want to diffuse it broadly. They want to take that cool software we developed and go sell it one-on-one to Compaq, Hewlett-Packard, and NEC in Japan. And they want to do that in competition with the other people who might be selling similar software. They don't want to enable the other people. They want to go win the business on their own. They want to charge money for it. They want to make a profit. So, you have two very different ways of acting.[25]

Notice that Mike Aymar's comment highlights the fact that the units created to exploit complementary markets are explicitly designed to encourage their managers seek profits, but that at the same time the firm creates an expectation that the unit may need to compete "on level ground."

Jim Pappas, the director of Platform Initiatives at IAL, also commented on the ways in which this policy created tensions between Intel's chipset business group and IAL.

> We developed the [USB] code[26] and we gave it to our internal chipset business group in Chandler, Arizona, who used it to do their chip. And we also made it available to anybody in the industry. I can guarantee that there were times where the group in Chandler was livid with me for freely distributing this. They have competitors out there who are building products.[27]

Thus one key element of the strategy was the creation of independent units charged to do nothing but execute on "Job 2"—who were "livid" when other elements of the organization (in this case IAL) took actions that would plausible reduce their profitability.

The second element was the active subsidization of entry into complementary markets. Intel subsidized entry extensively, but, intriguingly, believed that direct financial subsidies to complementors were usually counterproductive. Claude Leglise explained that he had a

25. Interview with Mike Aymar, vice president and general manager, Desktop Products Group, Intel Corp., Santa Clara, California, November 13, 1997.

26. USB = Universal Serial Bus: an external peripheral interface standard for communication between a computer and external peripherals such as keyboards, mice, monitors, printers, and scanners.

27. Interview with Jim Pappas, director of Platform Initiatives, Desktop Products Group, Intel Corporation., Hillsboro, Oregon, August 4, 1998. Emphasis added.

policy of refusing to subsidize entry fully—insisting that complementors "put their skin in the game."

> The one thing that I have consistently refused to do (although we may have done it once or twice by accident) is to pay people [external complementors] to do a job. Tell them "I want this kind of software, build it." I don't want to do that because again, back to my premise, we don't know software, they do. I'm much more interested in saying "this project is very exciting. Our strategy and your strategy are very consistent, we both agree it's risky: *I will help you mitigate the risk, I'll pay half of it*. But you pay the other half. I want you to have some skin in it. So you are interested in making it successful." *I want them to be successful, on their own with their business model.*
>
> . . . If you look at history . . . rumor has it that IBM spent a billion dollars on applications for [their operating system] OS2 but they bought people, they said "here, do this for me." And at the end, the companies turned around and said "here, it's done"—and IBM said "well, aren't you going to sell it, market it? They said "well no, our deal was to develop it: you've got it, now good luck." The same with Philips and the CD-Rom Interactive (technology): Philips did CDI and they sprinkled money over the entire industry. It did terribly. And they had all these developers developing stuff but there was no business model—the business model was "I'll pay you."[28]

Instead of direct financial subsidies Intel used a wide variety of mechanisms to facilitate complementors' innovation, including sharing emerging technology and IP, the loan of engineers, the facilitation of access to market by making marketing and commercialization resources available, industry coordination initiatives via Compliance and Developers Forums, and the diffusion of development tools such as Software Development Kits. Appendix Table AIII presents detailed examples of these kinds of mechanisms.

For example, the Intel Developer Relations Group's resources[29] were devoted to help external software developers innovate in ways that were complementary to Intel's latest microprocessors. It provided a range of assistance, including grants to external software developers, sharing market information, facilitating entry into new markets, and

28. Interview with Claude Leglise, *op. cit.* Emphasis added.
29. The Intel Develop Relations Group counted approximately 200 persons in 1998.

sharing with them Intel technology before it appeared on the market—which gave them an edge over their competitors. As Leglise explained:

> The first thing we'll tell [external software developers] is to share with them our strategy. "Here is our best understanding of what's going to happen. We are sharing with you our plan, our best view of the market, and you have the opportunity to plan." [...] For example, last year, my organization took something like 20 software companies to China. We organized meetings with the government, the retailers, the hardware and software distributors, and we introduced them to the minister of technology, the minister of telecommunications, 20 different retailers, 30 different computer companies, and in the matter of a month they were up and running. Now, every one of them has at least one deal cooking, where they're exporting their software into China.
>
> The second thing I do I give them early access to technology, i.e., to our latest generation of microprocessors six to 12 months before the market, which means six to 12 months before their competitors. [...] We give them tools to get started. Just on the hardware side it's a five to seven million dollar effort.[30]

The Software Developer Relations group also allied with the Intel Marketing and Sales group to facilitate external software developers' commercialization of their software. Sometimes, Intel took charge of selling the software directly to original equipment manufacturers (OEMs), and paid the external complementors in royalties.

> We also help them with sales and marketing. We have done a decent job on selling the software that is bundled with computer systems by the OEMs. We sell it to the OEMs, [with whom we have privileged relationships], and the software companies get a royalty.[31]

Table II summarizes the extent to which Intel licensed the IP associated with the complementary markets that it explored.

At one level these subsidies can be viewed as analytically equivalent to direct entry by Intel itself, and our reading of the literature is that this has been the tacit assumption of many who have studied this issue. But our study of Intel leads us to believe that this may be a misleading simplification. The widespread diffusion of Intel's IP simultaneously

30. Interview with Claude Leglise, *op. cit.*
31. Interview with Claude Leglise, *op. cit.*

Table II.
Intel's Decision to Share IP

| | Did Intel Have the Necessary Capabilities? | | |
|---|---|---|---|
| | Yes | Partially | No |
| Connector market | 9 entry | 3 entry<br>2 IP share, 1 not | |
| | 9 share IP | 8 no entry<br>7 IP share, 1 not | |
| Not a connector market | | 1 no entry<br>No IP share | 1 no entry<br>IP Share<br>5 entry (followed by rapid exit)<br>No IP share |

reduced the costs of *all* potential entrants *and* made it harder for Intel to engage in any *ex post* squeeze, and was a particularly elegant way to solve Intel's dilemma. It encouraged the entry of a wide range of firms with a wide range of skills, thus driving demand for the microprocessor. But it also made it difficult for Intel to make "too much" money in those markets that it did choose to enter—hence Jim Pappas' description of his colleague as "livid."

Of course a reduction in entry costs is only likely to be effective in inducing entry if potential entrants believe that the *next* release of IP is likely to be as open and as widely disseminated as the current one, and that Intel will not use its unique knowledge of the system architecture to advantage its own participants.

Intel appeared to be very aware of this danger, and to have structured the Intel Architectural Lab (IAL) as a not-for-profit unit for precisely this reason. Andy Grove was quite explicit in his belief that the structuring of IAL as a not-for-profit unit significantly increased Intel's credibility in the market place:

> *Wherever possible, it is much better that the standards be done by a group that is not a Profit-and-Loss center.* That's where IAL came in. IAL, by and large, was created as an architecture lab, as its name implies. IAL has no profit-and-loss responsibility, and no products. Most of this work was done by IAL. *And IAL has achieved an extra measure of credibility. It comes, first, from the fact that they are very good, and second, that they are not in a business. For the CEG organization*[32] *to proselytize platform design and*

32. CEG was the Computer Enhancement Group, which was the business group based in Chandler, Arizona, that made and sold chipsets and motherboards.

> *architecture was much more difficult than for IAL, because CEG would be a supplier to that platform.*[33]

Jim Pappas's extended remarks convey his apparent internalization of this imperative:

> We developed the [USB] code and we gave it to our internal chipset business group in Chandler, Arizona, who used it to do their chip. And we also made it available to anybody in the industry. I can guarantee that there were times where the group in Chandler was livid with me for freely distributing this. They have competitors out there who are building products. So, there came a point where they were out there trying to sell their chips and they would go into an account and they would explain why they should buy the Intel chips. And the people would say, "Well, I'm trying to decide between you and this other guy, and this other guy uses the same [technology] as you do."
>
> They would tell us at IAL, "Jim, you have to stop distributing this thing because I want to sell my product and you're basically adding credibility to these other people because they're using the same Intel circuits that we are using. And so we want you to stop that." I said, "No, we're not going to stop that." *This is yet another example of knowing what your primary objective is.*[34]

Many of the managers to whom we spoke at IAL were quite explicit about their view of themselves as enablers of *entrant* success. Dave Ryan, director of Technology Marketing at IAL, made it clear that IAL was assigned solely to make basic technological components (as opposed to finished products) and to "enable" innovation in the industry:

> We don't make products at IAL. We make product components. The core—the conferencing standards, the engines for processing the standards-based data streams, and the engines to encode and decode video and audio—all those basic components were developed by IAL. They're pieces, component parts of a product.[35]

33. Interview with Dr. Andrew S. Grove, *op. cit.* Emphasis added.
34. Interview with Jim Pappas, *op. cit.* Emphasis added.
35. Interview with Dave Ryan, director of Technology Marketing, Intel Architecture Lab, Intel Corp., Hillsboro, Oregon, August 4, 1998.

Similarly Carol Barrett, an IAL marketing manager in multimedia software, saw her job at IAL as helping sell more Intel microprocessors, by partnering, not competing, with external developers of multimedia solutions:

> *I definitely don't want to compete with 3-D editing companies. My job is demand-creation,* so I'm trying to help sell our next-generation microprocessors. I'm not trying to sell 3-D engines. *My basic mechanism for diffusion is all about partnering* to provide solutions to the market. We build media components. We don't build products that are full solutions, but components that really need to be incorporated into full 3-D editing and creation products, for which there are market segment leaders out there that are well established and have excellent products. [ . . . ]. We produce a component that could be included in their product.[36]

Herman D'Hooge, manager in the IAL Media Interconnect Technology group, described IAL's "neutrality":

> IAL has this neutrality [ . . . ]. Neutrality means that we really try to do this to the betterment of the whole PC industry and not just to the betterment of Intel. [ . . . ] We are just doing this for the goodness of the whole industry but we are privy to a lot of inside information that these people [external firms] have and we must be careful not to broker that information to potential Intel product groups that might be able to use it. They [external firm] are willing to open up and tell you their secrets about their road map, what they see happening, and where they want to go with PCs,—but they don't want to make the information readily available to a competing product group in Intel. So, we receive information that we will not share with product groups within Intel, simply because it would be a breach of our neutrality in the industry. It is in our best interest for the Lab neutrality *not* to go straight over to here and say, 'Oh, guess what they just told me, under nondisclosure.'[37]

36. Interview with Carol Barrett, Marketing Manager, Intel Architecture Lab, Intel Corp., Hillsboro, Oregon, August 5, 1998. Emphasis added.

37. Interview with Herman D'Hooge, Manager, Media Interconnect Technologies, Intel Architecture Lab, Intel Corp., Santa Clara, California, November 12, 1997. Emphasis added.

Jim Pappas summarized the overall strategy particularly coherently—Intel attempted to "show faith in the future" (by competing in, and attempting to profit from, a complementary market) while simultaneously attempting to persuade potential entrants that Intel's operations would not have access to preferential information. Intel would make money, signaling that there was money to be made, although not making too much:

> Once we decided we were going to put this in our chip set products, all of a sudden there were many people working on the design. But *we had a very clear separation*. We had a group that was defining the specification, and we had other groups implementing products. They would take our specification and implement the products, but *we kept a sort of wall between the two.*
>
> For USB to be successful, it needs to be available to the industry, and the industry needs to believe and understand that they have a good shot at going off and implementing it and being successful with it. The best way to do that is to do it for real, and just to say that *this group over here* is defining the [specification]—*and this group over there* will get the specification. They're going to design a product—and we make it very clear that Intel is going to design products for this. We plan to sell a lot of products for these things. By doing so, we are showing faith in the future. So, even though we would develop products, *at the same time, we would lose our credibility if we were saying that this is something we're only going to do for our internal products and we're not going to enable any competition here*.
>
> Other firms that would compete with the Intel product might worry that we would be giving preferential information to our product group. So, we took great pains not to do that. Our product group was running fast and hard with this technology, and that's good.[38]

## 5. Conclusion

Our examination of Intel's history with respect to complementary markets and to potential complementors confirms the usefulness of much of the existing literature while highlighting a number of areas in which it could be usefully extended.

38. Interview with Jim Pappas, *op. cit*. Emphasis added.

We found that Intel did indeed experience incentives to enter and/or subsidize the market for complements to its core asset—the microprocessor. Both entry and subsidy, however, were conditioned by the firm's belief that because it could not match the capabilities of potential entrants, sustaining a credible commitment not to engage in the *ex post* squeeze of entrants was critical to its success.

Sustaining such a commitment was greatly complicated by the fact that when the interfaces between the platform and complementary markets were evolving rapidly Intel had acute incentives to enter—and that such entry put the firm in a particularly strong position to control the evolution of complementary markets because it gave the firm control over the IP that defined each market.

Intel's solution to this dilemma highlights a tension that to our knowledge has not been noted before. On one hand, Intel committed to making money in complementary markets—signaling that it would not drive returns down—by structuring entry into complementary markets as separate organizational units with Profit & Loss responsibility ("Job 2"). But at the same time it committed that it would not make "too much" money in these markets by actively giving away IP and subsidizing competitive entry. This "commitment" was sustained both by formal and informal statements of the firm and by maintaining the organizational unit responsible for the development of key IP as an independent cost center whose mission was to extend the size and power of the entire ecosystem ("Job 1"). Further, the careful choice of which complementary market to enter (the connectors) while giving away the corresponding IP not only helped Intel to solve the dilemma, but also allowed the firm to push forward the platform/applications interface—thereby retaining control of the architecture—while renewing incentives for complementors to innovate "on top of" the new extended platform.

These results have implications for both the literature focused on the evolution and adoption of standards and for the literature that has explored the relationship between organizational structure and competition. With reference to the literature on complements and standards evolution, Intel's history underlines the complexity of the task of managing the evolution of a platform and the difficulty of making unambiguous welfare predictions in such cases. Although it seems possible to conclude provisionally from the Intel case that foreclosing entry by third parties to the system almost certainly reduces consumer welfare, it also suggests that some entry by monopolists is almost certainly beneficial. More broadly, Intel's history suggests the utility of further work that is explicitly dynamic and multilevel, and that incorporates a heterogeneous distribution of capabilities as a fundamental assumption.

Within the organizational context, our results belong to the small stream of literature suggesting that organizational structure can have real competitive consequences. The decision to vertically integrate into adjacent markets, for example, is almost certainly shaped by similar concerns and may be susceptible to similar solutions, as Farrell and Weiser (2003) suggest. Given that a growing body of work in organizational economics suggests that organizational structure and practice may be difficult to change, understanding how organizational mechanisms may enable firms to commit to actions in the market place may be a particularly fruitful area for further exploration.

## Appendix

Table AI.

Intel's Entry in New Markets 1990–2004

| Product | Year of Entry/Year of Exit (When Applicable) |
|---|---|
| Chipsets | • Date of entry: 1991<br>• Perceived by Intel a complementary market mostly aimed at enhancing demand for Intel PC microprocessors, by facilitating the industry transition to next versions of Intel processors<br>• Intel had the requisite capabilities<br>• Still thriving as of 2006 |
| Motherboards | • Date of entry: 1995<br>• Perceived by Intel as a complementary market mostly aimed at enhancing demand for Intel PC microprocessors, by facilitating the industry transition to next versions of Intel processors<br>• Intel had the requisite capabilities<br>• Still thriving as of 2006 |
| Videoconferencing (equipped with ProShare software)<br>• Digital PC cameras<br>• Audio and video enhancement cards | • Date of entry: 1994<br>• Perceived by Intel as a market with high profit potential, as well as a complementary market to microprocessors<br>• New capabilities required<br>• Date of exit: 1999 |

Continued

**Table AI.**
**CONTINUED**

| Product | Year of Entry/Year of Exit (When Applicable) |
|---|---|
| Networking (Network Connectivity) | • Date of entry: 1991 with LAN[1] network adapter cards |
| • Network adapters | • From 1991 to 1997: At first not considered strategic (no strong complementarities perceived to microprocessors) |
| • "AnyPoint" networking solutions to share IT access, music, printers, etc. | • From 1998, change of Intel's internal perception: As part of diversification effort, perceived as a market with profit potential, as well as a complementary market to microprocessors<br>• Intel had the requisite capabilities |
| • "Bluetooth" products, to create wireless connections around the mobile computer with mobile phones, Personal Digital Assistants, etc. | • Still operating as of 2006, with desktop adapters, mobile handheld adapters, server adapters, wireless networking, and modem chipsets |
| Web Hosting, Intel Online Services | • Date of entry: 1999<br>• Perceived by Intel as mostly a new arena to diversify in and compete, rather than a complementary to microprocessors<br>• New capabilities required<br>• Date of exit: June 2002 |
| PC Toys, Intel Play products<br>• QX3 Plus computer microscope<br>• Sound Morpher, Me2Cam virtual game system | • Date of entry: 1999<br>• New capabilities required<br>• Date of exit: 2001 |
| Consumer Audio products<br>• Personal audio player<br>• Music system software | • Date of entry: Jan 2001<br>• New capabilities required<br>• Date of exit: Oct 2001 |
| Consumer Internet (wireless and handheld) Appliances<br>• ChatPad<br>• WebPad | • Date of entry: Jan 2001<br>• New capabilities required<br>• Date of exit: late 2001 |
| Consumer Wired and Wireless PC Accessories<br>• Wired series: keyboard, mouse<br>• Wireless series: keyboard, mouse and game-pad | • Date of entry: June 2000<br>• New capabilities required<br>• Date of exit: late 2001 |

[1]LAN = Local Area Network: A computer network that spans a relatively small area.

Table AII.
## Drivers of Intel's Entry in Complementary Markets 1990–2004

| | Projects | Type of Project | Was It a Complementary Market?[1] | Was It a Connector Market? | Did Intel Enter the Market? | Did Intel Exit Later? | Did Intel Have the Technological and Commercial Capabilities to Succeed in This Market? | Did Intel Share Intellectual Property for Low Royalties? | Did Intel Engage in Ecosystem Innovation Coordination or Facilitation? |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Networked Multimedia | Initiative | Y | Y | Y[2] | Y | Y/N[3] | N/Y[4] | Y |
| 2 | Manageability | Initiative | Y | Y | Y[5] | N | Y/Y | Y | Y |
| 3 | Big pipes (broadband) | Initiative | Y | Y | Y[6] | Y | Y/N | Y | Y |
| 4 | Security | Initiative | Y | Y | N | N/A | Y/N | Y | Y |
| 5 | Anywhere-in-the-home | Initiative | Y | Y | N | N/A | Y/N | Y | Y |
| 6 | Advance-the-platform | Initiative | Y | Y | Y[7] | N | Y/Y | Y | Y |
| 7 | PCI (peripheral component interface) | Interface | Y | Y | Y | N | Y/Y | Y | Y |
| 8 | AGP (advanced graphics port) | Interface | Y | Y | Y | N | Y/Y | Y | Y |
| 9 | USB (universal serial bus) | Interface | Y | Y | Y | N | Y/Y | Y | Y |
| 10 | 1394 (also called FireWire) | Interface | Y | Y | Y | N | Y/Y | Y | Y |
| 11 | TAPI (Telephony application programming interface) | Interface | Y | Y | N | N/A | Y/N | Y | Y[8] |
| 12 | H.323 (interface for computer telephony) | Interface | Y | Y | N | N/A | Y/N | Y | Y[8] |
| 13 | Home radio-frequency | Interface | Y | Y | N | N/A | Y/N | Y | Y |
| 14 | DVD (digital video disk) | Interface | Y | Y | N | N/A | Y/N | Y | Y |
| 15 | CDSA (security) | Interface | Y | Y | N | N/A | Y/N | Y | Y |
| 16 | Indeo (Intel Video) | Interface | Y | Y | N | N/A | Y/N | Y[8] | Y[8] |
| 17 | Intel ProShare (videoconferencing) | Product | Y | Y | Y | Y | Y/N | N/Y[9] | N/Y[9] |
| 18 | Hood River (PC in the family room) | Product | Y | N | N | N/A | Y/N | N | N |

Continued

**Table AII.**
**CONTINUED**

| | Projects | Type of Project | Was It a Complementary Market?[10] | Was This a Connector Market? | Did Intel Enter the Market? | Did Intel Exit Later? | Did Intel Have the Technological and Commercial Capabilities to Succeed in This Market? | Did Intel Share Intellectual Property for Low Royalties? | Did Intel Engage in Ecosystem Innovation Facilitation or Coordination? |
|---|---|---|---|---|---|---|---|---|---|
| 19 | Networking | Product | N/Y[11] | Y | Y | N | Y | Y | Y |
| 20 | Chipsets (for PCI, USB, AGP, etc.) | Product | Y | Y | Y | N | Y | Y | Y |
| 21 | Motherboards (for PCI, USB, AGP, etc.) | Product | Y | Y | Y | N | Y | Y | Y |
| 22 | Software | Product | Y | N | N[12] | N/A | N | Y | Y |
| 23 | Web hosting and online services | Consumer service | N | N | Y | Y | N | N | N |
| 24 | Toys | Consumer product | N | Y/N[13] | Y | Y | N | N | Y/N[13] |
| 25 | Audio products | Consumer product | N | N | Y | Y | N | N | N |
| 26 | Internet appliances | Consumer product | N | N | Y | Y | N | N | N |
| 27 | Wired and Wireless handheld PC accessories | Consumer product | N | N | Y | Y | N | N | N |

[1] I.e., did Intel managers believe that this project will help Job 1?
[2] Intel entered with Videoconferencing products. See Appendix Table AI.
[3] In this column: Y/N means Y for technological capabilities and N for commercial capabilities; Y/Y means Y for both technological and commercial capabilities.
[4] N at first, Y later. See Appendix Table AIII.
[5] Intel entered with a few Networking products. See Appendix Table AIII.
[6] Intel entered with a few Networking products. See Burgelman (2002), 279.
[7] Intel entered with Chipsets and Motherboards. See Appendix Table AI and Appendix Table AIII.
[8] See Appendix Table AIII.
[9] N at first, Y later. See Burgelman (2002), 262–270, and Appendix Table AIII.
[10] I.e., did Intel managers believe that this project will help Job 1?
[11] N at first, Y later (after 1998). See Burgelman (2002), 279–281.
[12] N for software applications, and N with Native Signal Processing. See supra note 5.
[13] Y at first, N later (D'Hooge et al., 2001).

TABLE AIII.
ECOSYSTEM INNOVATION COORDINATION MECHANISMS[1]

| IAL Initiative | Mission | Key Programs | Diffusion |
|---|---|---|---|
| Networked multimedia | Make multimedia pervasive on the Net and provide the best experience on the high-performance Connected PC. | Scalable, MMX Technology optimized media engines; Efficient media network transports and services: tools and services. | • Standards: specification of H.323[2] stack in Microsoft's Internet Explorer 4.0; supported by firewall vendors<br>• Products: Indeo Video 5.0.<br>• Building blocks shipped as part of Microsoft's Internet Explorer 4.0®; other building blocks shipped in Windows 98® and Windows NT 5.0®. |
| Manageability | Enable platform and network infrastructure to make Intel Architecture systems the most easily manageable and the best managed. | Industry specifications and industry groups; software development kits. | • Specifications, Software Development Kits.<br>• Products: Intel NIC[3] and LanDesk Software products.<br>• Ingredients diffused through Microsoft: Wake-on-LAN,[4] Wake-on-Ring NICs and modems in Windows NT®, Windows 98®. |
| Big pipes | Increase content delivery capacity of the connected PC to allow home and business customers to easily receive new broadband digital content. | Common software architecture for PC broadband transport; reference designs. | • Networking connectivity products. |

Continued

**TABLE AIII.**
**CONTINUED**

| IAL Initiative | Mission | Key Programs | Diffusion |
|---|---|---|---|
| Security | Make PC interaction trustworthy for communications, commerce, and content. | Industry specifications and industry groups, driving the CDSA[5] standardization effort; software development kits. | • Open standards specifications and industry groups, CDSA R2.0, in OpenGroup; OpenGroup standard, IBM licensed.<br>• Products: IBM and Intel shipping products based on CDSA standard.<br>• Licenses to Zoran: DVD copy protection |
| Anywhere-in-the-home | Unleash the potential of home PCs with new uses that deliver computing power and content when, where, and how it's is needed in the home. | PC-friendly protocols and standards; concepts demos and prototypes. | • Standards, Control-InfraRed—with Hewlett Packard, Microsoft, and Sharp; Home-Radio-Frequency—with Compaq, IBM, and HP; and Home Device Control. |
| Advance-the-platform | Establish the media, communications, and interconnect building blocks for the next generation high performance Intel Architecture platforms. | Interconnects USB, AGP, IEEE 1394 A/B;[6] future processor optimizations, visual PC 2000. | • Standards: AGP drivers, USB compliance workshops, PC-friendly IEEE 1394A specifications.<br>• No commercialized products.<br>• Ingredients in Microsoft's products: Real-time services in Windows 98® and Windows NT 5.0®. |

[1] Source: Intel Coordination Initiatives (1997–1998).
[2] H.323 is a standard for Internet telephony.
[3] NIC = Network Interface Card, an expansion board (i.e., a printed circuit board) that can be inserted into a computer so the computer can be connected to a network. Most NICs are designed for a particular type of network, protocol, and media, although some can serve multiple networks. (Source: www.webopedia.com)
[4] LAN = Local Area Network: a computer network that spans a relatively small area.
[5] CDSA = Common Data Security Architecture: a security standard and cryptographic framework that provides an infrastructure for creating security-enabled applications.
[6] AGP = Accelerated Graphic Port, an interface specification designed especially for the high demand of 3-D graphics; IEEE 1394 = A very fast external bus standard that supports data transfer rates of up to 400 Mbps (in 1394a) and 800 Mbps (in 1394b). Trademarks for 1394 include FireWire (Apple) and i.link (Sony).

## References

Becchetti, L. and L. Paganetto, 2001, "The Determinants of Suboptimal Technological Development in the System Company-Component Producers Relationship," *International Journal of Industrial Organization*, 19(9), 1407–1421.

Boudreau, K., 2006, *How Open Should an Open System Be? Empirical Essays on Mobile Computing*, MIT PhD Thesis.

Brandenburger, A. and B. Nalebuff, 1997, *Co-opetition: A Revolutionary Mindset that Combines Competition and Cooperation*, New York: Currency Doubleday.

Bresnahan, T.F. and S. Greenstein, 1999, "Technological Competition and the Structure of the Computer Industry," *Journal of Industrial Economics*, 47(1), 1–40.

Burgelman, R.A., 2002, *Strategy is Destiny: How Strategy-Making Shapes a Company's Future*, New York: Free Press.

Caillaud, B. and B. Jullien, 2003, "Chicken and Egg: Competition among Intermediation Service Providers," *RAND Journal of Economics*, 34(2), 309–328.

Carlton, D.W. and M. Waldman, 2002, "The Strategic Use of Tying to Preserve and Create Market Power in Evolving Industries," *RAND Journal of Economics*, 33(2), 194–220.

Choi, J.P. and C. Stefanadis, 2001, "Tying Investment and the Dynamic Leverage Theory," *RAND Journal of Economics*, 32(1), 52–71.

Cournot, A.A., 1838, *Researches into the Mathematical Principles of the Theory of Wealth*, N.T. Bacon trans., Macmillan 1897. A.M. Kelley, New York, 1871. Reprint of the 1927 edition.

Davis, S.J., J. MacCrisken, and K.M. Murphy, 2002, "Economic Perspectives on Software Design: PC Operating Systems and Platforms," in D.S. Evans, ed., *Microsoft, Antitrust and the New Economy: Selected Essays*, Springer, 361–419. Previous version available at http://gsbwww.uchicago.edu/fac/steven.davis/research/

Farrell, J., H.K. Monroe, and G. Saloner, 1998, "The Vertical Organization of Industry: Systems Competition versus Component Competition," *Journal of Economics and Management Strategy*, 7(2) Fall, 143–182.

——, and M.L. Katz, 2000, "Innovation, Rent Extraction, and Integration in Systems Markets," *Journal of Industrial Economics*, 97(4) December, 413–432.

——, and P.J. Weiser, 2003, "Modularity, Vertical Integration, and Open Access Policies: Towards a Convergence of Antitrust and Regulation in the Internet Age," *Harvard Journal of Law and Technology*, 17(1), 85–134.

Gawer, A., 2000, *The Organization of Platform Leadership: An Empirical Investigation of Intel's Management Processes Aimed at Fostering Complementary Innovation by Third Parties*, MIT PhD Thesis.

——, and M.A. Cusumano, 2002, *Platform Leadership: How Intel, Microsoft, and Cisco Drive Industry Innovation*, Boston: Harvard Business School Press.

Hagiu, A., 2004, "Optimal Pricing and Commitment in Two-Sided Markets," Mimeo, presented at "The Economics of Two-Sided Markets" conference held in January 2004 at the University of Toulouse.

——, 2005, "Two-Sided Platforms: Pricing and Social Efficiency," Mimeo, Research Institute of Economy Trade and Industry and Princeton University. http://www.princeton.edu/%7Eahagiu/job%20market%20paper%204%202.pdf

Heeb, R., 2003, "Innovation and Vertical Integration in Complementary Markets," *Journal of Economics and Management Strategy*, 12(3), Fall, 387–417.

D'Hooge, H. and M. Goldstein, 2001, "History of the Smart Toy Lab and Intel® Play™ Toys," *Intel Technology Journal*, Q4, 1–7. Available at http://developer.intel.com

Jackson, T., 1997, *Inside Intel: How Andy Grove Built the World's Most Successful Chip Company*, New York: Free Press.

Miller, D.A., 2005, "Invention under Uncertainty and the Threat of Ex-Post Entry," February 25, Mimeo. Available at http://ssrn.com/abstract=319180

Nalebuff, B., 2004, "Bundling as an Entry Barrier," *Quarterly Journal of Economics*, 119(1) February, 159–187.

Ordover, J., A. Sykes, and R. Willig, 1985, "Nonprice Anticompetitive Behavior by Dominant Firms towards the Producers of Complementary Products," in F. Fisher, ed., *Antitrust and Regulation Essays in Memory of John J. McGowan*, Cambridge, MA: MIT Press.

Panzar, J.C., 1989, "Technological Determinants of Firms and Industry Structure," in R. Schmalensee and R.D. Willig, eds., *Handbook of Industrial Organization*, 13.

Rochet, J.-C. and J. Tirole, 2003, "Platform Competition in Two-Sided Markets," *Journal of the European Economic Association*, 1(4), 990–1029.

——, and ——, 2004, "Two-Sided Markets: An Overview," Mimeo, IDEI, University of Toulouse, presented at "The Economics of Two-Sided Markets" conference held in January 2004 at the University of Toulouse.

Schmalensee, R., 1981, "Monopolistic Two-Part Pricing Arrangements," *Bell Journal of Economics*, 11, 445.

Whinston, M.D., 1990, "Tying, Foreclosure, and Exclusion," *American Economic Review*, September, 837–859.

West, J. and J. Dedrick, 2000, "Innovation and Control in Standards Architectures: The Rise and Fall of Japan's PC-98," *Information Systems Research*, 11(2), June, 197–216.

——, 2003, "How Open is Open Enough? Melding Proprietary and Open Source Platform Strategies," *Research Policy*, 32, 1259–1285.

Yu, A., 1998, *Creating the Digital Future: The Secrets of Consistent Innovation at Intel*, New York, NY: The Free Press.