ORGANIZATIONAL CAPABILITY AND ENTRY INTO COMPLEMENTARY MARKETS: EVIDENCE FROM INTEL

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COMMENTS WELCOME

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ABSTRACT

The idea that firms have fundamentally different “capabilities” is a staple of the strategic management literature and has deep roots in the study of organizational behavior, but has not been widely accepted by economists. In this paper we focus on Intel’s behavior in the market for complements to explore this issue. Several recent theoretical papers have suggested that if incumbent firms do not have access to the same “technology of innovation” as entrants, they will refrain from entering some complementary markets, and will attempt to commit to entrants that they will not engage in ex post profit “squeezes” in order to avoid destroying an entrant’s ex ante incentives to enter. We draw on detailed qualitative data to suggest that Intel’s actions are consistent with these models and with the hypothesis that senior management at Intel believes that in many cases they cannot duplicate the innovative capability of new entrants. This paper therefore attempts to build a case both for the existence of heterogeneous capabilities and for the idea that their existence may have significant implications for competitive behavior. This has important implications both for anti trust policy, and for our understanding of competition in general.

I. Introduction

Work in mainstream industrial organization theory has long assumed that all firms have access to the same production function, despite a long and honorable tradition of dissent (Caves, 1980; Nelson and Winter, 1982), and a considerable body of quantitative work suggesting that "firm effects" play a central role in explaining productivity differences across firms (Cockburn, Henderson and Stern, 2000). Within the mainstream tradition, enduring differences in performance across firms are ascribed to factors such as heterogeneous access to inputs, first mover advantage, commitment and the existence of demand and supply side economies of scale (Ghemawat ,1991; Besanko, Dranove and Shanley, 2000), rather than to any intrinsic difference in one firm's ability to do something that others cannot.

In contrast, work within the traditions of organizational sociology and the "resource based view" of strategic management has long maintained that firms differ very significantly in their capabilities, so that one firm may well have access to a production function that is not available to its competitors (Wernerfelt,1984; Hannen and Freeman,1989). More recently significant advances in the theory of organizational economics have begun to lay the groundwork for the development of more theoretically satisfactory models of why this may be the case. For example Stein (2002), Hellman (2002), Gerber, Scharfstein, and Stein (1994) and Stein (2000) suggest that the nature of internal capital markets is such that one might reasonably expect established organizations to be able to fund a significantly different set of projects from the external capital markets, and Van der Stein (2002) and Rotemberg and Saloner (2000) have suggested that it some circumstances it may be rational for senior management to select systematically one kind of project over another. Taken together, this literature is beginning to provide a theoretical rationale for the old idea – most forceably articulated by Schumpeter– that large, established firms may not be able to generate the kinds of innovation that are characteristic of rapidly moving markets full of newly established, smaller firms.

If it is indeed the case that firms do differ significantly in their production functions – particularly in their "technology of innovation" or in the set of new products that they are able to generate given any particular input of R&D resources – then this has

important implications both for anti trust policy and for understanding of the dynamics of competition in general.

In this paper we explore this issue by focusing on the incentives of established monopolists to enter markets for complementary products. In doing so, we attempt to build a case both for the existence of heterogeneous capabilities and for the idea that their existence may have significant implications for competitive behavior. We build on three recent theoretical papers, by Farrell and Katz (2000), by Becchetti and Paganetto (2001), and by Miller (2002). All three papers argue that if firms differ significantly in their "technology of innovation" then classical models of an incumbent's incentive to enter complementary markets will fail to capture an important class of cases in which both social and private welfare is (counter-intuitively, from the perspective of the classical models) increased by the incumbent's ability to commit not to enter such markets.

To explore the usefulness of these ideas, and in doing so to attempt to provide evidence consistent with the idea that heterogeneous capabilities may shape strategic decisions, we draw on qualitative data for the period 1990-2000 collected from senior managers at the Intel Corporation.

We show that Intel behaves in many respects in complete accord with the classical models of investment behavior. It invests heavily in complementary markets, both directly and through venture capital investments in third parties, and it also invests considerable resources in stimulating competition in the markets for complements through the coordination of these markets around open or Intel controlled standards. Moreover Intel has institutionalized the strategic imperative to stimulate intense competition in the market for complements by stressing that the task of expanding demand for the microprocessor (a task referred to as "Job 1" within Intel) may at times be in contradiction to the task of growing profitable businesses based on proprietary IP in complementary markets ("Job 2").

We suggest, however, that not all of Intel's actions can be explained by the classical models. In particular, we suggest that Intel managers talk and act as if they believe that in some markets Intel cannot duplicate the innovative activities of entrants. They are deeply concerned to ensure that potential entrants into complementary markets

believe that entry will earn supra-normal returns, and Intel expends considerable energy trying to commit to these entrants that Intel itself will not compete in these markets.

We argue that these results are consistent with the models of Farrell and Katz, Becchetti and Paganetto and Miller, and that they give some plausibility to the hypothesis that Intel's managers frame their decision to enter or to refrain from entering any particular complementary markets as a function of the degree to which Intel can duplicate the innovative competencies of entrants and as a function of the degree to which their own entry is likely to "shut down" third-party innovation. We show that Intel managers consistently discussed opportunities in terms of whether Intel had appropriate innovative capabilities, and that the firm took a range of measures to reassure potential entrants that they would not enter such markets.

The paper begins with a brief discussion of the literature. Section 3 discusses our data and methodology, Section 4 presents our results and Section 5 concludes. We suggest that while our results could clearly be extended in a number of important ways, they nevertheless suggest that the assumption of heterogeneity in innovative competence is well worth taking seriously. We speculate that this may have implications for our understanding of the effect of entry upon social welfare.

2. Literature Review

The literature exploring a monopolist's incentive to enter the market for complements is subtle and complex, and one can draw no quick conclusion as to whether a monopolist will choose to enter complementary markets (Brandenburger and Nalebuff, 1997). However an insight dating to Cournot (1838) and formalized by Tirole (1988) and others (Farrell and Katz, 2000; Nalebuff, 2000; Davis, MacCrisken and Murphy, 2001) suggests that if two products are complements, such that greater sales of one increases demand for the other, both consumer welfare and total profits will be increased if both products are produced by a single firm.

The intuition behind this conclusion is summarized nicely by Davis et. al. in their recent paper:

> *Consider a multi-product firm with downward sloping demand for each product… assume that production costs are unrelated across products.. (and) that all of the*

firm's products are complements, so that greater sales of any one product increase demand for the others.

Under these conditions, complementary demand encourages the multi-product firm to set lower prices than would a collection of independent firms, each selling a single product. The logic is straightforward: a lower price on any one product generates additional sales of that product and all products with complementary demands. A multi-product firm internalizes this demand spillover onto the complementary products, while independent single-product firms do not…

(Davis et al, 2001, p57)

A variety of plausible extensions can strengthen this result. If there are significant economies of scope across markets, such that the monopolist has lower production or distribution costs in the second market, or if physically integrating the two products creates value in itself then, again, the multi-product firm will have more aggressive incentives to enter the market for complements then will independent firms.[2] A related literature explores the incentives that firms have to integrate into complements as a means of offering "closed", or fully proprietary and integrated systems. In a classic paper, for example, Farrell et al (1998) show that in any situation other than duopoly, competing firms have strong incentives to integrate into complements in order to be able to offer "closed" or highly differentiated products. They further show that such integration may be privately optimal but may reduce social welfare.

Of course if the key assumptions on which these models are based are relaxed their results can be reversed. In general they assume that the market for complements exists, that its characteristics are fixed, and that within the market price is constant and above marginal cost. If, for example, the market for complements is already completely competitive, so that price is equal to marginal cost, then an incumbent monopolist in a related market will have no incentive to enter. Similarly, Nalebuff has shown that if there is negotiation over prices in the second market and perfect information then, again, an

[2] Note that this model is significantly different from the extensive literature that explores the monopolists decision to "tie" or "bundle" distinct products. As Whinston has shown, in some circumstances monopolists have incentives to tie products together as means of extracting monopoly rent. When products are complements, however, all the monopoly rent can be extracted in the first market, making tying *for this reason* unnecessary.

incumbent monopolist will not have incentives to enter the second market (Nalebuff, 2002).

More recently, three papers have suggested that heterogeneity in the ability to innovate across an incumbent monopolist and other potential players may also have dramatic effects on an incumbent's incentives to enter complementary markets. Farrell and Katz (2000) expand on the traditionally static model of Tirole (1988) to explore the effect of the monopolist's incentive to price aggressively in complementary markets on the incentives of other firms to innovate. They show that under a number of reasonable assumptions the core intuition of the static models goes through: all other things equal, an established monopolist will have greater incentive to innovate in a market for complements than entrants. More interestingly, perhaps, they show that under a number of conditions the monopolist's *ex post* incentive to engage in "squeezes" (that is to copy the entrant's product and to enter the market, putting pressure on prices, or to reframe interface specifications between the two markets in an attempt to extract rent) in the market for complements is sufficiently strong that entrants may have no *ex ante* incentive to engage in innovation at all.

Of course if the "technology of innovation" is such that the monopolist can cost effectively introduce the complement itself, then the monopolist's incentives remain unchanged from the static case. Farrell and Katz suggest, for example, that if demand is inelastic, and if the technology for developing and producing the complement is freely available to all players, then the monopolist has efficient incentives to innovate, and will simply introduce the complement itself. However if demand is elastic, and if the technology of innovation is more complex, then the situation becomes more complex. As Farrell and Katz suggest "it could… be socially and privately optimal to have multiple innovators, *depending on the technology of innovation* (our emphasis)" (Farrell and Katz, 2000, p424). In particular, if the monopolist cannot duplicate the entrants' innovation at a reasonable cost, then it may have strong incentives to try to commit to entrants that it will not enter the market for complements. The intuition here is straightforward: if the monopolist cannot make such a commitment, potential entrants will refrain from entry, knowing that the monopolist has an ex post incentive to "squeeze" the market for complements. If the monopolist cannot duplicate entrant innovation the market for

complements may not develop, or may be considerably smaller than it might have been otherwise, and the monopolist will be significantly worse off than it would be with free entry into the complementary markets.

The provocative paper by Becchetti and Paganetto (2001) raises many of the same issues. Becchetti and Paganetto present a model in which a "systems integrator" must trade off the benefits of maintaining full control over a standard with the costs implicit in shutting out third party innovation. Third party innovators are assumed to be more efficient than the monopolist in generating new "components." – i.e., in Farrell and Katz terminology, they have a better "technology of innovation." They suggest that in such cases integration by monopolists into complementary markets may reduce social welfare.

A recent paper by Miller (2002) reaches a similar conclusion. Miller shows that under some circumstances an incumbent's incentive to enter complementary market can deter radical innovation. He suggests that if the costs of innovation are heterogeneous across entrants and incumbents, this ex post incentive may significantly reduce social welfare.

Taken together, these papers do two things. In the first place, they highlight the general point that heterogeneous capabilities across firms cannot be lightly dismissed as a matter of "adjustment costs" in that they may have very concrete implications for investment decisions and for the nature of competition. In the second place, they suggest that such heterogeneous capabilities, if they exist, may have important implications for firm strategy and for our understanding of the welfare implications of such strategies in the particular case of the incumbent's decision to integrate into complementary markets.

II. Data and methods

Our empirical analysis draws on a sequence of 72 in-depth qualitative interviews conducted with key managers at Intel between 1997 and 2000. Intel provides a particularly interesting setting in which to explore our central issue for several reasons. In the first place, between 1990 and 2000, the period covered by the study, Intel was the largest producer of microprocessors in the world, and plausibly had considerable market power in that market for most of the period. Between 1991 and 2000 revenue increased from $4.8 to $33.7 billion, while profits grew from $819 m $10.5 billion over the same

period. Return on assets over the period averaged around 25%. Second, Intel had in place a rich and complex strategy for managing complementary markets that they were willing to discuss with us in depth.

We draw on our data to argue first, that many of Intel's actions with respect to complementary markets are entirely consistent with the classical models and second, that Intel also behaves in ways that suggest that in some markets they believe that they cannot duplicate the innovative capabilities of entrants and that this belief has significant effects upon their strategy and actions. We show that Intel's managers demonstrate a deep understanding of the classical model: that they understand the importance of increasing demand in complementary markets for increasing demand in the core market, and that this sometimes requires entering or subsidizing such markets. We also show that Intel sometimes enters complementary markets in order to control the evolution of standards, and that they sometimes try to structure complementary markets so as to maximize competition in these markets. None of this is surprising from the perspective of the classical model. Much more interesting, in our view, is our finding that many of Intel's actions are quite consistent with the "unorthodox" models of Farrell and Katz, Becchetti and Paganetto, and Miller. Intel's managers talk about their belief that they cannot duplicate entrant's innovative capabilities. More fundamentally, they stress continually their belief that it is vital to persuade potential entrants that entry will be profitable, and that Intel will not act in such a way as to reduce the profitability of complementary markets. They point to concrete actions, and to internal organizational structures, as evidence of their commitment to act on this belief.

Our use of a qualitative approach to exploring this issue warrants more discussion. A qualitative study of this kind inevitably raises important methodological concerns – one might worry, for example, that the respondents to our interviews were carefully coached by the firm's anti-trust lawyers – but we believe that our results are nevertheless potentially important. In the first place, comprehensive studies of firm decision making that focus on economically significant decisions are rare. Given that it is extraordinarily difficult to *measure* the extent to which a given firm's costs of innovation in a particular market would have been more or less than those of potential entrants, systematic qualitative data about organizational process, structure and internal beliefs may provide

an important alternative source of evidence. In the second place, 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 describe reasonably accurately the real beliefs of Intel's senior and middle management, and that these beliefs had important effects on Intel's actions.

Interviews were conducted during three different trips to Intel in which we visited 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", i.e., products whose supply could have a demand-enhancing effect on Intel's main product. The interviews were semi-structured (that is, respondents were provided with a list of interview questions beforehand, but were not held to them as the interview progressed). 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 (the developers of complementary products: Nalebuff and Brandenburger, 1997). 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 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.

In an attempt both to avoid problems of retrospective bias and also in order to avoid being given an "official view", 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. 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 interviewer's own account or who might be able to provide a contrasting perspective.

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 5 different sites. Most interviews lasted about an hour, although some lasted up to two hours and a half and some much longer. Further details can be found in Gawer (2000).

One of the reasons that we believe these interviews to reflect the real beliefs of Intel managers is that we often uncovered real conflict 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 real sense for the basis on which key strategic decisions had been made within the firm.

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 make sure that the quotes are representative in that to the best of our knowledge and belief they catch the sense of a number of interviews and the perspectives of a number of different managers.

III. 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 understands 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. 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. (Our emphasis throughout)

Given this sophistication, it is not surprising that Intel acts in a number of ways that are entirely consistent with the classical models.

In the first place, it invests in a wide range of complementary markets. Table (1) summarizes Intel's entry into new markets, 1991-2002. Secondly, the firm has attempted to institutionalize the idea that entry into complementary markets should be at zero, or at least at less than profit maximizing levels, of marginal cost. Since at least 1994, senior management has announced that Intel has two goals: "Job 1", or growing and protecting the profitability of the microprocessor business and "Job 2", growing businesses beyond microprocessors. "Job 1" and "Job 2" are explicitly regarded as potentially direct competitors to each other, since pursuing "job 1" may require giving away intellectual property in adjacent markets or taking other kinds of actions that make it very difficult to pursue "job 2" – making real money in those markets.

For example, Mike Aymar, vice president and general manager, Desktop Products Group, discussed how the tension between these goals 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 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's 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 royalties, but in general, our main purpose is to enable and diffuse this technology broadly.
>
> If it's not Job 1, if it's 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, 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.[3]

Similarly, Jim Pappas, the director of Platform Initiatives at IAL commented that:

> We developed this code[4] and we gave it to our internal groups. In fact, the group in Chandler used that as well to do their chip. And we also made it available to anybody in the industry. And, you know, this is yet another example of knowing what your primary objective is. Because, you know, I can guarantee that there was times where the group in Chandler was-- In fact, they contributed to it as well. They were livid with me for freely distributing this. They have competitors out there who are building products.
>
> So, you know, there came a point where they're out there trying to sell their chips and they would go into an account and they would say, 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 VHDL as you do because they got it off, you know--"
>
> …they would say, you know, "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-- basically Intel circuits are on theirs. And so we want you to stop that." I said, "No, we're not going to stop that."

Andrew Grove, the CEO, summarized the conflict between the two goals in the following way:

> Imagine that somebody inside Intel who is doing videoconferencing wants to keep a given technology proprietary to a videoconferencing product. The people who are responsible for microprocessors want to give those videoconferencing products away for free. The internal terminology for that is microprocessors are Job 1, creating other businesses is Job 2. So it's called a Job 1 vs. a Job 2 conflict. That's our shorthand for it. And depending on the strategic importance of the product, competitive pressures, one thing or other, we decide these, one way or another, that

[3] Interview with Mike Aymar, vice president and general manager, Desktop Products Group, Intel Corporation, Santa Clara, California, November 13, 1997. Emphasis added.

[4] The software code was for USB (Universal Serial Port). USB is an external peripheral interface standard for communication between a computer and external peripherals over an inexpensive cable using biserial transmission. USB replaces existing serial ports, parallel ports, keyboard, and monitor connectors and be used with keyboards, mice, monitors, printers, and possibly some low-speed scanners and removable hard drives. Before March 1996 Intel started to integrate the necessary logic into PC chip sets and encourage other manufacturers to do likewise. It was widely available by 1997.

> almost always we tend to lean towards Job 1, ***because so much more of our business is microprocessors***, a little bit of help to the microprocessor business is so much more important than any additional business that we can create with videoconferencing and chips sets and the like.
> (Emphasis added)

Intel also enters some markets in order to maintain control over key interfaces, as Farrell et al (1998) suggest. Bill Miller (the director of worldwide media relations, in the Sales and Marketing group) recalled:

> 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 move and advance the platform.
>
> Our foray into the motherboard business used to be sort of a manufacturing foray, and now is 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.* (Our emphasis)

In addition to entering markets for complements at below profit maximizing rates and entering in order to control standards, actions clearly consistent with the classical models, Intel also invests heavily in complementors themselves. They do this both through direct financial investments through an internal equity group, Intel Capital, and through heavy investments in projects designed to facilitate the efficient entry of third parties into complementary markets. In the words of one Annual Report:

> Intel Capital, Intel's strategic investment program, focuses on making equity investments and acquisitions to grow the Internet economy in support of Intel's strategic interests. Intel Capital invests in hardware, software and services companies in market segments including computing, networking and wireless communications.

Claude Leglise, the director of the the Software Developers Group suggested that:

> We seldom make investments strictly for money. In other words you come to me with a great idea to sell dog food and you've guaranteed to me

> that it's going to make a lot of money, we're not going to be interested, [as] it doesn't help me sell computers. There's a tight relationship between where we invest the money and how it helps our strategy.

As of September 30, 2002, the Intel Capital strategic equity portfolio included over 475 companies worldwide with an estimated value of $1,314, making it plausibly the largest venture capital fund in the world. Les Vadasz, Intel Capital's director, recalled in our 1998 interview how Intel got into the business of investing in other companies:

> We have invested in various companies over a long period, 20 years. There was nobody in charge of it right from the beginning. But, in the early 1990s, we really started to systematize this and we created an activity. That's when I got in charge of it, and then we started to learn. Initially we only invested in companies directly related to our business, helping us deliver product. Then, we started to venture out a little bit further to the complementors, to the point right now that we're mainly focusing on the complementors.[5]

Intel's second major channel of investments in complementors is the Intel Architecture Lab, "IAL". The IAL is charged with actively facilitating the development of new complements and the entry of new firms. Between 1990 and 2000 the Lab employed between 500 and 700 scientists and engineers – a roughly $600m investment annually -- all doing advanced technology development on technologies that were complementary to microprocessors. None of the IAL engineers and scientists worked directly on improving Intel's microprocessors, yet it was explicitly managed as a cost center and was never required to return any kind of profit. (Table (2) lists IAL's initiatives in 1997/98, as examples of the kinds of work the lab engaged in.) A variety of managers described this mission quite explicitly. For example, Dave Ryan, director of platform marketing at IAL, made it clear that IAL, unlike Intel product groups, is assigned solely to make "components" 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.[6]

[5] Interview with Leslie Vadasz, senior vice president and director of the Corporate Business Development group, Intel Corporation, Santa Clara, California, August 14, 1998.
[6] Interview with Dave Ryan, *op. cit.*

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

> I definitely don't want to compete with 3D editing companies. My job is demand-creation. So, I'm trying to go ahead and 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 3D editing and creation products. There are market segment leaders out there that are doing that; they are well established and have excellent products. [Firms] like Discreet, Light Wave, Interactive, SoftImage are the top-tier players making 3D model authoring products. . . We produce a component that could be included in their product.

Dave Johnson, engineering manager at IAL, explained:

> We want to be a catalyst that just got it started early, that made things happen sooner, that made investments occur — or we may want to make a complementary investment so that the innovators don't have to do all the work. They can focus on a layer of the application where there's lots of innovation and value that they can add, and we take care of the glue and the lower-level infrastructure. That can be a success story.

Of course making heavy investments in complementors is completely consistent with the classical model if the intent is to stimulate entry to such an extent that returns are driven down to the competitive level, and there is some evidence that Intel thought of their investments in these terms. For example, Craig Kinnie, director of the IAL for much of the decade 1991-2000, described the investments that Intel made in structuring peripheral standards for the PC in the following terms:

> 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 and that we can have an effect on. I don't know which company is going to win, but they all will connect to the PC in exactly the same way.
>
> That's not the way it would have happened if we hadn't been around. Every company was figuring out a different way of doing it. Some companies were going to use add-in cards; some were going to use Ethernet cards; some were going to hook to the parallel port — and the software was even worse. We said: Wait a minute. We're Intel, and we

> care about the PC. If you all want to save some money, the best way to hook to a PC is this way. Here's the hardware way; here's the software way.
>
> Coordination here now creates a common connector. *Now they all have to compete*. If they were 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. Because we said there should be one way to hook to a PC and we're going to make it happen, they all now have to compete to deliver to that socket.

However we believe that the explanations for Intel's action are more complex than this, and indeed that the firm's actions are consistent with the hypothesis that Intel believed that in some markets it did not have the innovative capabilities possessed by new entrants, and thus with the models advanced by Farrell and Katz (2000), and Becchetti and Paganetto (2001).

We offer three pieces of evidence. First, several managers discussed Intel's decision to enter complementary markets (or not) in terms of Intel's "capabilities", suggesting that Intel did not have the abilities to enter all of the adjacent markets effectively. Second, they talked continually about the need to maintain adequate margins in those markets in which they were trying to encourage entry, and the need to attempt to commit to potential entrants that they would not squeeze margins in these markets ex post or to build "trust". Third, they discussed the internal organizational structure of Intel – and it's associated internal incentives -- as attempts to signal exactly this commitment.

On the competence front, for example, some managers simply stated that Intel does not have the necessary skills. For example, Claude Leglise, the Director of the Software Developers Group, insisted that his group is not looking to compete with software companies that develop complementary products because Intel does not have, and could not develop, the necessary competence:

> 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.

Similarly, Les Vadasz, an Intel senior vice president and Intel Capital's director, recalled in our 1998 interview that:

> The most important thing is that you develop a philosophy in the company to look at your business in the context of the total market segment, rather than in the context only of your own capabilities… It's all about complementors. When you go into a new area, you have to look at what's going to make up the market segment ecosystem. What are the various buttons I have to push in order to have something happen?

Craig Kinnie, director of IAL during most of the decade 1991-2000, expressed Intel's belief that more innovation happens in the industry when many different companies are allowed to specialize on their areas of competence. Kinnie explained in this context the importance of IAL's specific activity of establishing system interfaces (whose specification would be available freely to all parties interested) which partitioned functional areas on which many firms could specialize based on their own competence. Given this belief, Kinnie explained how this activity of setting and disclosing freely system interface did have an important effect on unleashing industry-wide innovation:

> Look at the "Capability Stack" [see Exhibit 1-1]. What we decide is where in the stack we need to have interfaces such that innovation can occur in these segments independently. If the interfaces aren't there, innovation has to happen on a vertical stack all the way through. That takes a long time to happen, and there are usually big losses. We're breaking down the cost to innovate. A company can innovate in this layer and not worry about what's going on in these other layers because we have interfaces on either side of them. If they weren't there, we'd have to make the entire investment—and not very many people can afford to do that. Our work in the industry enables smaller companies, innovative companies, to make smaller investments and yet potentially win large market share in a segment they can own. And there are more of them that participate, so we get broader innovation. That's why this industry moves so fast: because you know there is still a chance for small innovators to plug in and succeed. You can't do that in the consumer electronics industry. You can't compete with Mitsubishi; it's really hard. In our industry, little companies can thrive. It doesn't matter whether it's software, hardware, or chip sets.

Our second piece of evidence that the problem of heterogeneous capability is a very real one for Intel is the fact that for Intel's managers, Farrell and Katz's speculation as to the probable effects of ex post incumbent entry into the market for complements on ex ante incentives for innovation appear to be a very real – and dangerous -- possibility.

They talked continually about the need to reassure third parties that Intel was not going to compete "too aggressively" in the market for complements. As Dave Johnson 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.

In the case of video conferencing, a market that Intel did choose to enter, Dave Johnson suggested that in retrospect entry had been a mistake, precisely because it destroyed third-party innovation:

> 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 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. Being a catalyst is very hard because, if you don't do enough, you don't really change the balance. You don't accelerate things. Likewise, you 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 was 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.* (Our emphasis) Some people claim we did just that.[7]

Claude Leglise, the director of the the Software Developers Group, indicated that:

> You have think of sort of managing 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. We believe that 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. (Leglise 1997)

Vadasz acknowledges that Intel Capital sometimes walks a fine line:

> 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's always moved, it's very important that we don't get carried away with

[7] Of course Intel's failure in the videoconferencing market may also be attributable to very significant problems in generating demand for the service.

> our own delusions of grandeur, 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. 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.*

Our third piece of evidence is Intel's apparent attempt to use their internal organizational structure, and its associated local incentives, to commit to potential entrants that it will not "squeeze" ex post profits. The first element of this strategy is to place some key responsibilities with the IAL, a non profit group that third parties know has no <u>local</u> incentive to attempt to exploit them. For example, Grove, the CEO, framed entry into complementary markets as sometimes driven by the need to develop the credibility to define a platform by having expertise both "below" (i.e., the microprocessor) and "above" (i.e., complementary products) the interface, but he was careful to frame this by reference to IAL's "credibility":

> 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 chip sets and microprocessors. 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.
>
> [Do you think there are ways to organize the work inside Intel so that these tensions can be dealt with efficiently?] 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 to proselytize platform design and architecture was much more difficult than for IAL, because CEG would be a supplier to that platform.*
>
> *Wherever possible, it is much better that the standards be done by a group that is not a profit and loss center.*[8]

On the importance of creating trust Andy Grove further suggested:

> So this... (conflict between job 1 and job 2) is not all good because the consequence of this over a long period of time is that we have managed to build a very strong microprocessor business but nothing else. Not a good environment in which you can build new businesses, because everything that the new business wants to create will get sucked away by the microprocessors and given to the new business competitors. Not everything, but almost everything, which is why, on the flip side, that's why the world trusts us when we do that. But they trust us because we have not created an additional business that was that successful.

Jim Pappas, the director of Platform Initiatives, attempted to persuade us that the internal separation of his unit — which was part of the Intel Architecture Lab — from Intel's profit-oriented product groups was crucial to maintaining good relationships with external parties from which he was seeking support for the USB. He suggested that the separation created an institutional commitment to "openness" (ie to Intel not engaging in an ex post squeeze through changing the standard.) He then went on to assert that the role played by the Computing Enhancement Group (the business group charged with making money from this technology) demonstrated Intel's "faith in the future," indicating to other firms that there was, indeed, a profit to be made in the peripheral business. Here, forcing Intel's own entry to make money, or distinguishing and separately rewarding "Job 2", is framed as something that helps to persuade third parties that innovation will be profitable – as if Intel's own entry in fact <u>increased</u> ex ante incentives:

> 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*

[8] Interview with Dr. Andrew S. Grove, *op. cit.* Emphasis added.

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.

[Why?] First of all, in [IAL], I think we did a pretty good job of understanding that our primary motivation was to advance the PC platform: if the PC platform is stronger, then PCs are easier to use or can have more functions; we'll get more PC users; and the industry wins. Of course, Intel also wins if that happens. Selling more microprocessors is what we call Job 1.

What I do is definitely part of Job 1. Selling processors is Job 1, and this [USB effort] was all done for Job 1 purpose: advance the platform so we sell more PCs. Job 2 might be something that we do for revenue, like another product, or like building a network chip. They're not going to get measured on how many more processors they sell; they get measured on how profitable their division is. For us, we're all Job 1. It's advancing the platform.

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 — *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. That product group was a whole division, called PCD [now the Computing Enhancement Group]. This is the group that builds the chip sets, and they were integrating this functionality into their chip sets.[9]

[9] Interview with Jim Pappas, Milpitas, California, August 7, 1998. Emphasis added.

VI. Discussion and Conclusions

We have attempted to use detailed qualitative data to suggest that heterogeneous capability – or Intel's belief that in some markets it cannot duplicate the innovative activities of potential entrants – plays a significant role in shaping Intel's actions with regard to complementary markets in the microprocessor industry.

Many of Intel's actions, including their own investment in complementary markets, their explicit acknowledgement that such entry may be less than profit maximizing ("Job 1" versus "Job 2") and their heavy subsidization of entry by third parties, are clearly consistent with classical models of entry, and thus with the hypothesis that in many markets Intel's innovative capabilities are no different from those of potential entrants.

However Intel's aggressive attempts to persuade entrants that entry into some complementary markets will be profitable, the firm's concern that entrants "trust" them not to squeeze such markets ex post and their creation of the IAL as a separate entity from the profit maximizing parts of the firm are consistent with the models of Farrell and Katz (2000), and Becchetti and Paganetto (2001) --- or with the hypothesis that the ex ante deterrence of entry into complementary markets would have significantly negative consequences for the firm. As these models suggest, this is entirely consistent with the belief that Intel cannot duplicate the activities of entrants. For if it could, why would there be any cost to deterring entry? If Intel believed that its own innovative capabilities were the match of any entrant – that it could, in essence, duplicate the creativity of an entrepreneurial market place inside the firm – then there would be no cost to deterring entry.

Of course this type of limited qualitative analysis opens up more questions than it can answer. A purely cynical interpretation of our results is that Intel's managers have been very well coached: that their apparent concern with maintaining the profitability of potential entrants is nothing more than an elaborate script. We have described above our attempts to control for this issue, and we do not believe that it explains our results. However without empirical evidence that Intel's innovative capabilities would have been less effective than those of the universe of entrants, we cannot prove that heterogeneous

innovative capability exists. Our hope is merely that the evidence presented here does at least suggest that the problem is worth pursuing.

Our results suggest that Farrell and Katz's conjecture – and Becchetti and Paganetto's assumption -- that not all firms share a common "technology of innovation" may be worth exploring in considerably more depth. It appears to be entirely consistent with Intel's actions and beliefs, and, if true, may have significant implications for our understanding of when integration into complementary markets may be privately optimal but socially destructive. If aggressive monopolist entry destroys incentives for third party innovation, and if monopolists have substantial private incentives to enter complementary markets to maintain control over standards, (in addition to their incentive to merely subsidize the production of complements), then there may plausibly be circumstances under which consumers might prefer lively entry into complements but monopolists might not!

Our results may also have implications for the increasingly interesting question of the degree to which advances in our understanding of organizational economics have implications for problems in industrial organization. If it is indeed the case that newly created firms have innovative options that are not available to established monopolists, for example, this may have implications beyond the question of whether monopolists are likely to integrate into the production of complements. Along this line, several recent papers have suggested that under some circumstances the internal organization of the firm may have significant implications for the way in which it competes (See, for example, work by Fershtman and Judd, 1987 and Zitzewitz, 2001). We look forward to exploring these issues in further work.

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*, Vol.19, Issue 9, pp. 1407-1421.

Besanko, David, David Dranove and Mark Shanley (2000): Economics of Strategy, 2nd Edition, New York: Wiley.

Brandenburger, Adam and Barry Nalebuff (1997), Co-opetition, A Revolutionary Mindset that Combines Competition and Cooperation, New York: Currency Doubleday.

Caves, Richard E. "Industrial Organization, Corporate Strategy and Structure." Journal of Economics Literature, Vol. XVIII, March 1980, pp 64-92.

Cockburn, Iain, Henderson, Rebecca and Scott Stern "Untangling the Origins of Competitive Advantage" Strategic Management Journal, Fall 2000, Volume 21, 1123-1145.

Davis S. J., J. MacCrisken, and K. M. Murphy (2001), "Economic Perspectives on Software Design: PC Operating Systems and Platforms", NBER Working Paper 8411, http://www.nber.org/papers/8411

Farrell J., Monroe, H. K., and G. Saloner (1998), "The Vertical Organization of Industry: Systems Competition versus Component Competition", *Journal of Economics and Management Strategy*, Fall, Vol. 7, No. 2, pp. 143-182.

Fershtman, C. and Judd, K.L. (1987), "Equilibrium Incentives in Oligopoly", *American Economic Review*, Vol. 77, Issue 5, pp.927-940.

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.

Ghemawat, Pankaj (1991): Commitment: the Dynamics of Strategy, New York: the Free Press.

Hannen, Michael T. and John H. Freeman (1989). Organizational Ecology, Cambridge MA: Harvard University Press.

Miller, David A. (2003) "Invention under uncertainty and the threat of ex post entry". Stanford University Graduate School of Business Working Paper.

Nalebuff, B. (2000),"Competing against bundles", Yale School of Management, Mimeo, November, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=239684

Nalebuff, B (2002). “Bundling and the GE-Honeywell Merger” Yale SOM, Working paper No. ES-22

Nelson, Richard and Sidney Winter (1982): An Evolutionary Theory of Economic Change, Cambridge MA: Harvard University Press.

Rotemberg, J.J. and G. Saloner (2000): “Visionaries, Managers, Strategic Direction”, Rand Journal of Economics, 31(4), pp 693-716.

Scharfstein, David and Jeremy Stein (2000): “The dark side of internal capital markets: divisional rent seeking and inefficient investment.” Journal of Finance, December, pp 2537-2564.

Stein, Jeremy (2002) “Agency, Information and Corporate Investment” in Handbook of the Economics of Finance edited by Costantinides, Milt Harris and Renè Stultz.

Wernerfelt, B. (1984), “A Resource-based View of the Firm”, *Strategic Management Journal*, Vol. 5, Issue 2, pp. 171-180.

Zitzewitz, Eric (2001), “A Strategic Rationale for Imperfect Profit Measures”, Mimeo, Stanford University, and Chapter 3 in his MIT PhD dissertation.

Table 1: Summary of Intel's entry in new markets 1991-2002

PRODUCT	Year Launched / Year Dropped (when applicable)
Chipsets	• Date of entry: 1991 • Seen as mostly a complementary market to PC microprocessors – profits not seen as the priority (rather, to facilitate the industry transition to next versions of Intel processors) • Competencies required: close to existing competencies • Date of exit: no exit. Still thriving
Motherboards	• Date of entry: 1995 • Seen as mostly a complementary market to PC microprocessors – profits not seen as the priority (rather, to facilitate the industry transition to next versions of Intel processors) • Competencies required: close to existing competencies • Date of exit: no exit. Still thriving
VideoConferencing - digital PC cameras (5 products) which can also be used for video phone calls	• Date of entry: 1994 • Seen as a both a complementary market and as a market in which big profits were expected • New competencies required • Resources spent: $750 million • Date of exit: 1999
Networking & communications: - adapters for WLAN, WWAN, PAN - networking solutions to share IT access, music, printers … "AnyPoint" products - wireless Bluebooth technology based products, to create personal connections around the mobile computer (with mobile phone, PDA, …)	• Early 1990s: network adapter cards • Launch (AnyPoint): Winter 2000 (AnyPoint)
Web Hosting (Intel Online Services)	• Date of entry: 1999 • Seen mostly as a new arena to compete (not as a complementary product/service) • Third party innovation: not critical • New competency critical • Date of Exit: 06/2002
Consumer Wireless Products	• Date of entry: June 2000

- wireless series: base station + keyboard, mouse and game-pad	
Consumer Audio Products - personal audio player - music system software	• Entry with a big push in Jan 2001 • Intel's $299 digital music player (launched Feb 01) • Exit: Divison of Connected Products was shuttered in Oct. 2001
Consumer Internet Appliances (wireless handheld): - ChatPad - WebPad	• Entry with a big push in Jan 2001 • Exit: late 2001
PC Toys (Intel Play products) - QX3 Plus computer microscope - Sound Morpher - Me2Cam virtual game system	• Entry in 1999 • Exit in Oct 2001

Table (2): IAL's Initiatives in 1997 and 1998:

Networked Multimedia:
Mission: Make multimedia pervasive on the Net and provide the best experience on the high-performance Connected PC
Key programs: Scalable, MMX Technology optimized media engines; Efficient media network transports and services: tools and services;
Diffusion: H.323 stack in Microsoft's Internet Explorer 4.0; supported by firewall vendors; but also products Indeo Video 5.0; and also building blocks WDE ships as part of Microsoft's Internet Explorer 4.0; RSVP and RTP ship in Windows 98 and Windows NT 5.0.

Manageability:
Mission:Enable platform and network infrastructure to make IA systems the most easily manageable and the best managed
Key programs: Industry specifications and industry groups; software development kits;
Diffusion: Specifications, SDKs (i.e., non products); but also products: Intel NIC and LanDesk Software products; Also, diffused through Microsoft, as ingredients: Wake-on-LAN and Wake-on-Ring NICs and Modems in NT%, Win 98.

Big Pipes:
Mission: Increase content delivery capacity of the connected PC to allow home and business customers to easily receive compelling new broadband digital content
Key programs: common software architecture for PC broadband transport; reference designs.

Security:
Mission: Make PC interaction trustworthy for communications, commerce, and content
Key programs: Industry specifications and industry groups (drives the CDSA standardization effort); software development kits;
Diffusion: Open specifications and industry groups (CDSA R2.0) in OpenGroup; OpenGroup standard, IBM licensed – others to follow. But products also: IBM and Intel shipping product based on CDSA standard. And also, licenses: DVD copy protection licensed to Zoran.

Anywhere in the home:
Mission: 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.
Key programs: PC-friendly protocols and standards; concepts demos and prototypes.
Diffusion: Standards (Control-IR – with Hewlett Packard, Microsoft, and Sharp; Home-RF (Radio-Frequency – with Compaq, IBM, and HP; and Home Device Control).

Emerging opportunities:
Personal and group info management: relevance technology; rich media knowledge exchange
Advanced human input/output: speech, gestures, image recognition, new input forms

Advance the platform:
Mission: Establish the media, communications, and interconnect building blocks for the next generation high performance Intel Architecture platforms
Key programs: interconnects USB, AGP, 1394 A/B; future processor optimizations, visual PC 2000;
Diffusion: AGP drivers, USB compliance workshops, PC-friendly 1394A specifications. No commercialized products. Ingredients in Microsoft's products: Real-time services in WDM in Windows 98 and Windows NT 5.0.