Architectural battles in the multimedia market

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by

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Competition in the emerging multimedia market currently focuses on setting standards for storing, retrieving, processing, (de)compressing, and transmitting information. Each multimedia system or architecture combines several standards, some proprietary. This paper uses selected insights from industrial economics to analyze the strengths and weaknesses of the architectural companies by means of some hypotheses. These may guide further research.

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Introduction

This paper develops a case study of the emerging multimedia market. The multimedia market is at the intersection of several information technology industries. The importance of standards (for storing, retrieving and transmitting information) gives rise to architectures (a consistent, complementary set of standards). Business strategies (should) evolve around these architectures. The core concept here is architectural control: if a firm succeeds in owning and controlling an architecture, it has architectural control. The basic premise of the article is that architectural control is the major source of a sustainable competitive advantage in multimedia. The next section describes the multimedia market and demonstrates the importance of architectures. The subsequent four sections explain the strength of firms in the architectural competition. Each section uses an industrial economics theory to highlight one particular aspect of competitive strength. These insights form a cognitive model to explain the viability (and market shares) of architectures. I apply the model to a case study on the multimedia market. Using casual evidence from several journals, I use the model for a preliminary evaluation of the viability of all existing multimedia standards.

Architectural control and multimedia strategies

Business strategies in information technology evolve around architectures (Ferguson and Morris, 1994). A system (*e.g.*, a network) consists of several components that have to work together. An information system consisting of many components requires several standards to govern the intricate flows of information. There are standards about how to store, (de)compress, retrieve, and transmit information. Ferguson and Morris (1994, p. 120) call the complex of standards and rules that governs a system its *architecture*. An important aspect of an architecture is who owns the standards. Some standards are public, and have been selected by joint bodies or governments. Television standards such as PAL in Europe are an example. A privately funded committee, the MPEG, developed VideoCD. Other standards, such as computer operating systems, belong to individual firms. A company that owns and controls a standard has *architectural control*. It sets the conditions and prices by which other companies can access its architecture. For example, software makers pay royalties to video game system owners (such as Nintendo and Sega) for the right to release software for their machines.

Ferguson and Morris make two claims about architectural control. First, it is both more costly but also (potentially) more profitable to have architectural control. Second, since their control is profitable, rivals will launch improved systems. Hence, privately controlled architectures are more dynamic and offer higher quality than publicly controlled standards. They cite the slow advance and low quality of the television and fax standards as examples of public standards.

The operating system of a multimedia system is the key to its architectural control. Within an architecture, however, there can be standards for certain components or links that are controlled by separate companies, or that are world standards. Microsoft owns the Windows operating system, but not the Soundblaster, the *de facto* standard for sound in a Multimedia PC. Most architectures pledge support to world standards such as audio CD, Photo-CD and VideoCD. Because of the complexity of multimedia products, they involve many standards. Innovations keep

adding new functions and thus new standards. Interactive TV is an example where an innovation unleashes a new standard battle. Companies that own one or more standards exert (some) architectural control.

The advantage of proprietary standards induced a spate of systems. Multimedia has become a fragmented market with incompatible systems by Sega, Nintendo, CD-i, 3DO (from Panasonic), Atari, Commodore, as well as Windows and Macintosh multimedia PCs. Tandy used Modular Windows from Microsoft for its system, called the Video Information System. This system appears, however, to have collapsed for lack of sales. Commodore's CDTV failed, but the company bounced back with its CD32.[2] Multimedia PCs secured the largest installed base. None of the other systems can be said to be yet as entrenched. They also target different market segments and types of use. The multimedia computer systems (Macintosh and Windows) and CD-i target all market segments, that is, business, consumers, and education. The systems from Commodore and 3DO, and systems under development from Sega (the Saturn), Sony (PlayStation), Apple (Powerplayer), Atari (Jaguar), and Nintendo (Ultra 64), all target exclusively at videogames.

An Explanatory Model

The next sections piece together a model to explain the evolution of (a) dominant multimedia architecture(s). The dependent variable, so to speak, is the chance that an architecture survives into the next period. Or, alternatively, the market share of architectures. I do not postulate explanatory variables. Instead, I turn to the existing literature in game-theoretical industrial economics. This paradigm contains many useful theories that have already deepened our insight in markets. I identify four theoretical perspectives in particular. Each suggests some explanatory variables for the survival and market share of multimedia architectures. Firms can to some extent manipulate these variables, *i.e.*, use them as instruments in competition. Together, these perspectives provide a model that accounts for the evolution of standards.

The next sections discuss four theoretical perspectives within industrial economics. Each presents some explanatory variables. The first is the standards-perspective with its emphasis on the importance of an installed base and compatibility. The next one is the commitment perspective, that focuses on the need to make irreversible decisions in an uncertain environment. Then, a multi-market perspective that focuses on entry by related firms, and finally, a network perspective that compares the pros and cons of alliances and merger. Each perspective suggests one or more hypotheses that indicate the strength of the companies involved in the architectural battles. The final section summarizes the overall strength of these firms. It concludes with ranking the architectural companies in their decreasing strength to sustain their architecture. This entails a prediction about the future viability of these standards.

The Standards Perspective: Installed Base Advantages and Product Compatibility

The cumulative number of machines or systems sold, the installed base, provides an estimate of

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2. The company is now declared bankrupt (*Automatisering Gids*, 16-12-94). The possibility still exists that a buyer sustains the operating system.

the potential market for a software program. Hence, the larger the installed base, the more and better software will be available. This in turn is important for potential consumers' buying decisions. First movers build up an installed base, which is their prime competitive advantage (and entry barrier) to later movers (Farrell and Saloner, 1986; and Matutes and Regibeau, 1988). Table 1 provides estimates of the installed base of some systems. In this respect, multimedia PCs lead, with Windows PCs having by far the largest installed base and largest catalogue of software titles. The Apple Macintosh PC is number two. The installed base of Nintendo and Sega videogame sets is also very large: a third of American homes have a game player, and two-thirds of kids between 6 and 14 are regular players (*Business Week* 22-11-93, p. 54-60). Most of these are not, however, CD-based, and can only serve for games. Sega has already moved up to a CD-version of its videogame set. Nintendo will follow in 1995 with a 64-bit computer that uses cartridges instead of a CD. Both build upon a large catalogue of game titles. Among the newly introduced systems, CD-i appears to have the largest installed base, and the largest catalogue of titles.

Multimedia architectures					
Multimedia standard	Estimated installed base (date of report)		Standards supported		
	Players sold	Consumer titles	Audio CD	Photo-CD	Video CD
CD-i	850-900,000 (end 1994)	200 (Oct. 94)	x	x	x
Multimedia PC windows (MPC)	3.5m (U.S., end 1994)	1,700 (est. end 1994)	x	x	x
Multimedia PC Macintosh			x	x	x
Tandy's VIS			x	?	?
Commodore CDTV			x	-	-
Commodore CD32			x	-	x
3DO	250,000 (24-10-94)	100	x	x	-
Sony PlayStation			?	?	?
Sega Mega CD (cartridges)	(13m., US, 23-5-94)		?	?	?

Table 1

Penetration of multimedia in the home is still small, probably even in the U.S. This suggests that the installed base advantage of early movers may not be sufficiently large to deter all entry. This is, at least, the assumption made by late movers (such as Sony). One strategy to overcome a problem of small installed base is to seek compatibility with an established standard. The three computer systems and the two videogame leaders upgraded their existing operating

system into a multimedia system. The MPC standard for Windows was built on the CD-ROM standard, introduced in 1985. It has, therefore, the oldest roots, which allowed it to build up a large installed base. The new systems introduced by consumer electronics firms seek compatibility with emerging world standards, notably, Photo-CD and VideoCD. If we piece together the available evidence, the result is:

Hypothesis 1 (Strength of installed base and compatibility with standards): The strength of the multimedia systems ranges from High (Microsoft, Apple, Nintendo and Sega), via Medium (Philips and 3DO/Matsushita), and Low (Atari, Commodore, and Tandy) to Absent (Sony).

A Commitment Perspective on the Multimedia Standards Battle

The existence of many incompatible standards leads to uncertainty. Neither consumers nor software suppliers know which standard offers the best future prospects. These questions are important since investments in multimedia are durable and since it is costly to switch from one standard to another one. To attract both consumers and software suppliers, architectural companies must build confidence in their standard. Confidence that the standard will continue to be available worldwide for many years to come, and that it will participate in new developments that consumers consider important. The main instrument to build this confidence is to make irreversible investments in it. These irreversible investments, or *commitments*, display beyond doubt that the firm itself believes in its owns standard. No firm invests massive sums in a standard if it is itself uncertain about the standard's future existence.

Instruments in making a commitment are irreversible investments in an installed base of multimedia users and software titles (see the previous section). Also, investments in resources: marketing, manufacturing, R&D skills, software, and content (interactive or movie titles). By investing early in multimedia, the firm has time to build up an installed base, to accumulate resources, and to learn about multimedia. Hence, commitments provide first mover advantages. They also, however, tie the firm to decisions that it may later regret. There are, that is, second mover advantages. later comers may integrate new technologies into their systems, and may learn from mistakes made by early movers. For example, Philips's early investments in software for CD-i were largely educational. It later found that most consumer demand was for video-games. CD-i is not, however, primarily designed for video-games. Building a game for CD-i is certainly possible, but required special programming software that was costly to develop (*Multimedia Computing Magazine*, Jan. 1995, p. 39-41). Later movers learned from this by designing their interactive machines with video-games as the primary objective.

If commitments dominate, first movers have an advantage over later movers. If technological uncertainty and imitation dominate, then second movers will win the competition for standards. As a result, firms should strategically over-invest in commitments (if the advantages are most important) or under-invest (if the disadvantages are thought to be the most important). Industrial economists emphasise the importance of these strategic over- or under-investments (Fudenberg and Tirole, 1984; and Bulow, Geanakoplos and Klemperer, 1985). But their approach is not yet sufficiently operational to be able to identify in advance the appropriate strategy for the multimedia market. It comes as no surprise then that firms have made very different choices in

their commitments.

Firm/ Commitment	Entry	Investments in:			OS new (N) or upgraded (U)	Incompatible OS supported	Size of commit-ment
		OS	Hard ware	Applica-tion software			
Microsoft (MPC)	1991	x	-	x	U	0	xxxxxx
Apple (Macintosh)		x	x	-	U	0	xxxxx
Philips (CD-i)	1991	x	x	x	N	1	xxxxx
Commodore (CDTV)	1991	x	x	-	U	1	xxxxx
Tandy (VIS)	1992	-	x	-	U	1	xxx
Sega (Mega CD)	1992	x	x	x	U	0	xxxxxx
3DO (3DO)	1993/4	x	-	-	N	0	xx
Atari (Jaguar)	1994	x	x	-	N	1	xx
Sony (PlayStation)	1994/5	x	x	x	N	3	xx
Nintendo (64-bit)	1996	x	x	x	U	0	xxxxx

Table 2

Table 2 lists firms and the types of commitments they have engaged in. It shows two dimensions of a commitment: in timing and in the investments. A first mover commits himself to certain choices, whereas a later mover by waiting keeps his options open for a while. Hence, an early move represents a greater commitment than a later move. The investment is in turn subdivided in two dimensions: the breadth of activities and the newness. The breadth refers to the objective of developments: an operating system (OS), hardware, application software, or combination thereof (which represents a greater commitment). If a firm upgrades an existing standard (a computer operating system or videogame system), it deepens its commitment to that standard. If it develops a new system from the ground up, it has no prior commitments or does not honour them. Commitments range from low (late entry, develop only one component of a multimedia system, introduce new platfom) to high (early entry, develop all three components of a system, upgrade existing system). Please note that the table is highly tentative. It does not record the absolute size of investments in these standards, nor the quality of resources and policy execution that a firm brings to bear. Introduction of a system in 1991 (in at least one country) is considered an early move; later dates identify later movers.

The size of the firm's overall commitment in the column on the right is added up from the other columns. A first move (in 1991) gives two 'x's, an early move one 'x' (1992 or 1993); later movers get a '0'. A firm can earn at most seven x's by entry in 1991, an 'x' in the OS, hardware, and application software columns, an Upgraded system, and a 0 for no support for incompatible

systems. Some doubts about the table: unknowns leave some cells blank, Nintendo has not yet introduced its 64-bit machine, and it may not be CD-based.

This discussion identifies the breadth of the firm's commitment rather than its size in terms of dollars invested. It ushers in the following hypothesis:

Hypothesis 2 (Upping the ante by increasing one's commitments): In terms of the breadth of the commitment, Microsoft and Sega display the highest commitments, followed by Philips, Apple, and Commodore, and these followed by Tandy, Sony, 3DO, and Atari.

The more commitment is an important instrument in competition, the more the firms that rank high according to this hypothesis derive an advantage from their rank.

A Multi-market Perspective

The multimedia market is colonized from existing markets whose products or technologies are related. Most participants in the multimedia market are multi-market firms with vested interests in these related markets. Their vested interests provide them with both strengths and constraints. These influence their multi-media strategy and have a large impact on their success. The strengths are based on *shared resources* (Baumol, Panzar and Willig, 1982). A shared resource is an asset that can be utilized in several market simultaneously, without its use in one market impairing its use in another market. That is, it represents a public good in the company's research, production, or marketing process. A brand name, for example, can be used to market different products. Other examples of shared resources are know how and reputation. Once a firm owns a shared resource, it can enter a market at lower costs than a new firm, as the latter still needs to acquire the resource. That is, the shared resource leads to an economy of scope (Bulow *et al.*, 1985). If firms own shared resources, the associated economies of scope induce them to become multi-market in scope. By *related markets* I refer to markets that are linked by economies of scope due to shared resources. *Relatedness* indicates the extent to which a firm that enters the multimedia market can exploit economies of scope with its home market.

The architectural companies in multimedia come from different industries, and are able to bring with them different kinds of resources. Table 3 reviews the architectural companies, their origin, their resources, and possible weaknesses. The entries are evaluative and tentative. The relevance of economies of scale and scope for entry into multimedia suggests the following hypothesis:

Hypothesis 3 (Economies of scale and scope): Size is an important resource for entry into multimedia.

The hypothesis suggests advantages for the standards supported by Apple, Microsoft, Philips, Sega, Nintendo, and Sony. The small size of Atari and Commodore weaken their standards. The standard 3DO is difficult to judge, as 3DO is a small upstart with mounting losses, but some of its backers are powerful companies, notably Panasonic (Matsushita).

Multi-market firms benefit from the relatedness among their markets. Relatedness of a

Firm	Main market	Shared resources used in its multimedia effort	Disadvantages and weaknesses
Apple	Computers	Macintosh OS Installed base (++) Design skills Brand name	
Atari	Computers	Design skills	Small size
Commodore	Computers	Amiga OS Installed base (+) Design skills	Small size
Matsushita	Consumer electronics	Panasonic brand name and manufacturing MCA film library	Focus on hardware may underutilize software (such as its MCA film library)
Microsoft	Computers	Windows OS Installed base (+++) Design skill	
Nintendo	Videogames	OS Installed base (+++) Design skill Brand name	Late entry New machines may not even be CD-based
Philips	Consumer electronics	Brand name Manufacturing Integration in cons. elec. products R&D and design skill Software libraries and skills	Delays from R&D to the market still a problem Unimaginative marketing may mismatch with innovative products
Sega	Videogames	OS Installed base (+++) Design skill Brand name	
Sony	Consumer electronics	R&D, Design skill Brand name Columbia film library Manufacturing skill	Late entry
3DO	[New]	Design skill	Small size

Table 3

home market with the multimedia market is difficult to measure. It is reasonable to argue that relatedness increases if the fim already sells to consumers, if it has experience with user friendly operating systems, and if it already sells some type of content. Given the current demand for multimedia, the relevant content is films and games. Macintosh, Nintendo, and Sega score high on all counts. The Windows system used to be associated with business but is set to reach the home

(with new techniques for easy installation such as Plug-and-play). Consumer electronics firms Matsushita (Panasonic's 3DO), Philips and Sony score less high, as they did not have an operating system before entering into multimedia. Cable companies and media companies (such as Viacom and Time Warner) are also (perhaps even more) distant from multimedia. This suggests that companies in computers, software, and video games, consumer electronics, and cable, media and telecommunication, have decreasing relatedness:

Hypothesis 4 (Market relatedness): In terms of the existence of shared resources, the degree of relatedness with multimedia decreases from computers, software and videogames, via consumer electronics to media, cable and telecommunication markets.

This hypothesis implies advantages for the standards from Apple, Microsoft, Sega, Nintendo, and 3DO. It predicts less relatedness for Philips and Sony. Because of their (nearly complete) exit from the computer industry, Atari and Commodore can not exploit economies of scope resulting from the relatedness between the computer and multimedia markets.

The Networking Perspective

Investments in, for instance, R&D, have direct effects on other firms. They have positive effects as know how leaks to them. There are also indirect effects as the know how generated may improve one's competitive position relative to rivals. These (in)direct effects induce firms to cooperate, which may take the form of a merger or alliance (De Bondt and Veugelers, 1991). Mergers and alliances are both instruments in improving one's competitiveness (market positioning). An alliance allows firms to share costs, and to pool risks. It also allows firms to specialise, to the benefit of the overall quality of the joint project. A firm can enter into numerous alliances (thus creating a network), while it can acquire only so many firms. A merger, on the other hand, allows for tighter coordination and provides more commitment to project or technology.

An alliance usually has an objective which is focused and specified *ex ante*. It may, for example, entail a project with given time schedule, budget, and partners' contributions. A merger or acquisition instead allows firms to coordinate a wide variety of decisions, without specifying them *ex ante*. A merger tends to coordinate both R&D and other investment decisions, as well as product market decisions. The latter allows the merged firm to exploit market power. Mergers are more costly to realise than alliances, as a merger or takeover may have far going implications for shareholders and the equity markets. This suggests that a large firm has better access to this instrument than a small firm. Thus large firms may be more 'acquisition-active' than smaller firms. Some firms are involved in a large number of mergers and alliances in multimedia.

Table 4 and journal reports suggest that the following firms are very active: the computer companies Apple and Microsoft, the telecommunication, media and cable companies Time Warner, Tele-Communications (TCI) and Viacom, the consumer electronics companies Matsushita, Philips and Sony, the video-game makers Nintendo and Sega, and the telecommunication firm AT&T. The firm 3DO appears to have created a network with numerous hardware and software firms. Since the number of mergers and alliances recorded in this paper is but a small part of the total number, the following hypothesis is a mere speculation about the centrality of firms in the networks in and

Standard	Open*	Acquirer (Acquired firm)	Alliances
Audio CD	Yes		Philips/ Sony
CD-i	Yes	Polygram's film acquisitions (Propaganda Films; Working Title Films; A&M films; Island Pictures) Philips (Superclub videorentals)	MPDC (Philips/ Motorola) PCD-i (Philips/ IBM) Interactive TV (Philips/ Compression Labs)
CD32	No		
Jaguar			Atari/IBM
Macintosh	Yes		Apple/IBM (Kaleida)
Nintendo (NES)	No		
Nintendo (Project Reality)	No?		Nintendo/Silicon Graphics
Photo-CD	Yes		Kodak/ Philips
PlayStation	No	Sony (Columbia Pictures; Guber-Peters Productions)	
Powerplayer	Yes		Apple/Bandai
Sega	No		Sega Channel (TCI, Time Warner)
Sega Saturn			Hitachi
VideoCD	Yes		MPEG; JVC, Matsushita, Philips, Sony
VIS	No		Tandy / Microsoft
Windows	Yes	Microsoft (Dorling Kindersley, 26%, 1991)	1991 Multimedia PC Marketing Council (AT&T Computer Systems, CompuAdd Corp, Creative Labs Inc., Media Vision, NEC Technologies, Olivetti, Philips, Tandy Corp., Video Seven, Zenith Data Systems, and Microsoft)
3DO	Yes	Matsushita (MCA Universal)	3DO (alliance of Time Warner, Matsushita, AT&T, Electronic Arts)

* for a license

Table 4

around multimedia:

Hypothesis 5 (Centrality in networks): The firms Apple, Microsoft, Time Warner, TeleCommunications (TCI), Viacom, Matsushita, Philips, Sony, Nintendo, Sega, AT&T, and 3DO are involved in large numbers of (5.1) alliances and (5.2) mergers.

The network literature suggests that network centrality is an important asset, although no conclusive evidence seems to exist (Duysters, 1995).

The overall strength of multimedia firms

In the multimedia industry, firms face several interconnected choices. They must chose whether to introduce their own standard. If not, they must choose which (existing or announced) standard to support, when to do so, and at which level of commitment. They also face the choice of partners. The latter raises difficult questions about the (technological) quality and creativity of potential partners, and about their motives and hidden agendas. Each firm's strategy is unique in the precise mix of decisions undertaken. Consumers face a bewildering choice among standards, whose characteristics they are not yet familiar with. Demand is therefore uncertain, while commitments are large.

Table 5 lists the overall conclusions in this paper about the strength of the architectural companies in supporting their architectures. Note that M&A stands for merger and alliances. It

Firm	Installed base/ Compatibility	Commitment	Relatedness	M&A activity	Total strength
Source (Table)	1	2	3	5	
Apple	Medium	xxxxx	High	High	High
Atari	Low	xx	Low	Low	Low
Commodore	Low	xxxxx	Low	Low	Low
Matsushita	Medium	xx	Medium	High	Medium
Microsoft	High	xxxxxx	High	High	Very high
Nintendo	High	xxxxx	High	Low	High
Philips	Medium	xxxxx	Medium	High	Medium/high
Sega	High	xxxxxx	High	Medium	Very high
Sony	-	xx	High	High	Low/medium
Tandy	Low	xxx	?	Medium	Low
3DO	Medium	xx	-	High	Medium

Table 5

suggests that the best prospects as architectural companies exist for Microsoft and Sega ('Very

high'). They are followed by Apple and Nintendo ('High'). The rest (in decreasing strength) are Philips ('Medium/High'), Matsushita and 3DO ('Medium'), Sony ('Low/Medium'), and Atari, Commodore and Tandy ('Low'). This result indicates the strength of these firms as architectural leaders. It does not reflect their strength and profitability in other markets within multimedia (hardware and components, software programming). Moreover, the limitations of the underlying data must be stressed. A higher quality database is required for more systematic work along these lines. Some firms, for example, are not reflected above although they may have architectural significance as well (such as computer makers Compaq, IBM, and Packard Bell, the telecommunication giant AT&T, and other telecom and cable manufacturers involved in interactive television). New developments in multimedia, such as interactive television and virtual reality, may have considerable effect on the rang order of leading architectural companies.

Given these caveats, the table does give a picture of the strengths and weaknesses of the architectural companies. It will not come as a surprise that Microsoft and Sega are able to support their architectures with considerable resources. Nintendo, although a bigger company than Sega, scores less than Sega. Their difference is small, however. The reason is that Sega seems to have been more alert than Nintendo in discovering the potential of multimedia. It had a CD-based videogames console since 1992, unlike Nintendo, which still has none. Sega also appears more involved in alliances than Nintendo is. Another closely tied pair is Sony and Matsushita. Matsushita leads Sony by its earlier entry (through 3DO in 1993/4 versus 1995, expected). In 1991, Sony also supported too many incompatible systems. But Sony seems to try harder in achieving synergies between its film division and its consumer electronics division. Surprisingly, Philips ranks higher than both Sony and Matsushita. This is due to its early entry, large commitment, and many alliances. The small installed base of CD-i, Philips's lack of experience in software (a lack of relatedness), and its initial support for CD-ROM are drawbacks. Apple scores lower than Microsoft for well known reasons (smaller installed base, little activity on multimedia content software). Small size is a problem with 3DO, Atari and Commodore. 3DO's networking, however, it being an alliance, may be its major strength.

I emphasize that these results are extremely tentative. They are based on data which are extremely limited and qualitative (subjective). Many relevant data are absent, for example, about product quality. And the paper is silent on the weights one should give to the determinants of the explanatory variables (such as the size of the installed base). The results are to be considered as a conjecture whose foundations are but little better than a layman's judgement. They can also be seen as a prediction that can be tested on future data. Data on the growth or decline of these standards may be helpful to identify the weights of the explanatory variables: How important is market relatedness for successful entry into an architectural battle? Or company size? How many alliances should a firm engage in, and how to select useful partners?

REFERENCES

Baumol, W.J., J.C. Panzar and R.D. Willig (1982) *Contestable Markets and The Theory of Industry Structure*, New York: Harcourt Brace Jovanovich.

Bondt, R. de, and R. Veugelers (1991) Strategic Investment with Spillovers, *European Journal of Political Economy*, 7: 345-366.

Bulow, J.I., J.D. Geanakoplos and P.D. Klemperer (1985) Multimarket Oligopoly: Strategic Substitutes and Complements, *Journal of Political Economy*, 93(3): 488-511.

Duysters, G. (1995) *The Evolution of Complex Industrial systems: The Dynamics of Major IT Sectors*, Maastricht: Datawyse.

Farrell, J. and G. Saloner (1986) Installed Base and Compatibility: Innovation, Product Preannouncements, and Predation, *American Economic Review*, 76(5), Dec. 1986: 940-955.

Ferguson, Ch. H. And Ch. R. Morris (1994) *Computer Wars: the Fall of IBM and the Future of Global Technology*, New York: Times Books.

Fudenberg, D. and J. Tirole (1984) The Fat-Cat Effect, The Puppy-Dog Ploy, and the Lean and Hungry Look, *American Economic Review*, Papers and Proceedings 74(2), May 1984: 361-366.

Matutes, C. and P. Regibeau (1989) Standardization across Markets and Entry, *Journal of Industrial Economics*, 37(4), June 1989: 359-371.