CHAPTER 4

HOME VIDEOGAME PLATFORMS

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1. Introduction

What began with a box called Pong that bounced a white dot back-and-forth between two "paddles" on a television screen has now blossomed into a $60B industry worldwide, generating $20B annually in the United States alone.[1] Today, videogames are a serious business, with nearly three-quarters of US households owning an electronic device specifically used for gaming, and many predicting that figure to increase in the coming years.[2] Given the widespread adoption of a new generation of videogame systems introduced in 2006 and the ever growing popularity of online and on-the-go gaming, videogames are also no longer strictly the stuff of child's play: surveys indicate 69 percent of US heads of households engage in computer and videogames, with the average age of a player being 34 years old.[3] As newer devices continue to emerge with even more advanced and immersive technologies, it is likely that videogames will continue to play an ever increasing role in culture, media, and entertainment.

Owing no small part to this success, the videogame industry has been the subject of a growing number of studies and papers. This chapter focuses on research within a particular slice of the entire industry – the home videogame console market – which on its own is a fertile subject for economic research, both in theory and empirics. As a canonical hardware-software market rife with *network effects* (c.f., Katz and Shapiro, (1985); Farrell and Saloner (1986)), videogames are an ideal setting to apply theoretical models of platform competition and "two-sided markets"; and as a vertical market dominated on different sides by a small number of oligopolistic firms, videogames provide an opportunity to study issues related to bilateral oligopoly and vertical contracting. Furthermore, with the development of new empirical methods and tools, data from the videogame market can be used to estimate sophisticated models of dynamic consumer demand, durable goods pricing, and product investment and creation. By focusing solely on videogames, economic research can inform our analysis of other related markets in technology, media, or even more broadly defined platform-intermediated markets.

This chapter is organized as follows. I first provide a brief overview of the industrial organization of videogames, and emphasize the key features that distinguish it from other similar hardware-software markets. Second, I survey economic research on videogames, focusing primarily on models of consumer and firm (both hardware and software) strategic behavior; I also highlight potential avenues for future research, particularly with respect to platform competition. Finally, I conclude by discussing how these economic models can help us better understand vertical and organizational issues within the industry, such as the impact of exclusive contracting and integration between hardware platforms and software developers on industry structure and welfare.

2. The Industrial Organization of Home Videogames

2.1. Hardware

Today firms in a variety of industries produce hardware devices that vary widely in size, portability, and functionality for the purpose of electronic gaming. However, as has been the case for most of the four-decade history of the home videogame industry, these devices are primarily stationary "boxes" that require a monitor or television set for use. Referred to as *consoles* or *platforms*, these devices are standardized computers tailored for gaming and produced by a single firm. Approximately 53 percent of households in the United States are estimated to own a videogame console or handheld system.[4]

For the past decade, the three main *console manufacturers* or *platform providers* have been Nintendo, Sony, and Microsoft. Nintendo, originally a Japanese playing card company founded in the late 19th century, is the most experienced veteran of the three: it has manufactured videogame consoles since the late 1970s, and is the only firm whose primary (and only) business is videogames. Its Nintendo Entertainment System (NES), released first in Japan in 1983 and two years later in the United States, was the first major videogame platform to achieve global success. Nintendo has since released several consoles, including the most recent "Wii" in 2006; the Wii was one of the first to incorporate a novel motion-sensing interface and credited for expanding the appeal of home videogaming to a broader audience.

The other two console manufacturers entered many years after Nintendo's NES system dominated the market. Sony released its first videogame console – the Playstation – in 1995.[5] One of the first consoles to use games produced on CDs as opposed to more expensive cartridges, the Playstation would sell over 100M units in its lifetime and establish Sony as the dominant console manufacturer at the turn of the 21st century. The Playstation has had two successors: the PS2, released in 2000, became the best selling console in history with over 140M units sold;[6] and the PS3, released in 2006, is perhaps most famous for being one of the most expensive videogame consoles ever produced. Finally, Microsoft, as the newest of the three console manufacturers, entered the home videogame market in 2001 with the Xbox console; it later followed it up with the Xbox360 in 2005. Forty-one percent of US households are estimated to own at least one of the three newest consoles.[7]

In general, hardware specifications for a given console remain fixed over its lifetime to ensure compatibility with any games produced for that console; only by releasing a new console could a firm traditionally introduce new hardware with more powerful processing power and graphical capabilities. A new set of consoles has historically been launched approximately every five years – thus heralding a new "generation" within the industry; however, due to the large sunk-cost associated with development of new consoles, the desire of hardware manufacturers to recoup initial investments, and the shift toward upgrading existing consoles via add-on accessories, the length between new generations is likely to increase in the future.[8]

Although this chapter focuses on home videogame consoles, there is still a large market for dedicated portable gaming devices, currently dominated by Sony and Nintendo, and gaming on multifunction devices, such as smartphones and media players (e.g, Apple's iPod and iPhone). In addition, although personal computers (PCs) have always been able to play games, their significance as traditional videogame platforms is small: less than 5 percent of videogame software revenues today derive from PC game sales (though this may change in the future given the rise of online gaming via virtual worlds or social networks).[9]

Finally, just as other devices in other industries have been adding videogaming capabilities, videogame consoles, too, have been adding greater functionality: for example, today's consoles also function as fully independent media hubs with the ability to download and stream movies, music, television, and other forms of digital content over the Internet. Videogame consoles thus sit squarely amidst the convergence battle between personal computers and other consumer electronic devices.

2.2. Software and Games

In addition to console manufacturers, the videogame industry also comprises firms involved in the production of software or games.[10] These firms can be roughly categorized into two types: *developers* or *development studios*, who undertake the programming and creative execution of a game; and *publishers*, who handle advertising, marketing, and distribution efforts. This distinction is not necessarily sharp: most publishers are integrated into software development, often owning at least one studio; and although independent software developers exist, they often have close relationships with a single software publisher for financing in exchange for distribution and publishing rights. Such relationships may appear to be similar to integration insofar they are often exclusive, and have become standard for independent developers as the costs of creating games have dramatically increased over time.[11]

Console manufacturers also historically have been and continue to be integrated into software development and publishing. Any title produced by a console manufacture's own studios or distributed by its own publisher is referred to as a first-party title, and is exclusive to that hardware platform. All other games are third-party titles and are developed and published by other firms.

Much like videogame hardware, videogame software is predominantly produced by a handful of large firms: the top 10 publishers, which also includes the main three console manufacturers, produce over 70 percent of all games sold, with the largest (Electronic Arts) commanding a 20 percent market share. Furthermore, individual games have been increasingly exhibiting high degrees of sales concentration with the emergence of "killer applications" and "hit games." During the "sixth generation" of the industry between 2000 and 2005, nearly 1,600 unique software titles were released for the three main consoles; however, the top 25 titles on each system comprised 25 percent of total software sales, and the top 100 titles over 50 percent. Since then, a handful of titles have sold millions of copies, with some games even generating over $1B in sales on their own.[12]

Finally, unlike hardware, the lifetime of a particular game is fairly short: typically half of a game's lifetime sales occur within the first 3 months of release, and very rarely do games continue to sell well more than half a year from release.

2.3. Network Effects and Pricing

Since consoles have little if any stand-alone value, consumers typically purchase them only if there are desirable software titles available. At the same time, software publishers release titles for consoles that either have or are expected to have a large installed base of users. These network effects operative on both sides of the market are manifest in most hardware-software industries, and are partly a reason for the complex form of platform pricing exhibited by videogame platforms: most platform providers subsidize the sale of hardware to consumers, selling them close to or below cost, while charging publishers and developers a royalty for every game sold (Hagiu, 2006; Evans, Hagiu, and Schmalensee, 2006). This "razor blade" model was initially used by Atari with the release of its VCS console in 1977 – Atari originally sold its hardware at a very slight margin, but its own videogame cartridges at a 200 percent markup (Kent, 2001) – and Nintendo was the first to charge software royalties with its NES system nearly a decade later.[13] As a result, most platform profits have been and continue to be primarily derived not from hardware sales, but rather from software sales and royalties.[14] Note this stands in contrast to the traditional pricing model in PCs, where the operating system (e.g., Microsoft Windows) is typically sold to the consumer at a positive markup, yet no royalties or charges are levied on third-party software developers.

For the past two generations of videogame consoles, initial losses incurred by platform providers due to this pricing scheme have been substantial: e.g., the original Xbox had estimated production costs of at least $375 yet sold for an introductory price of $249; in the first four years of existence, Microsoft was estimated to have lost $4B on the Xbox division alone.[15] However, as costs for console production typically fall over time faster than the retail price, a console manufacturer's profits on hardware typically increases in the later years of a generation: e.g., Sony in 2010 announced it finally was making a profit on its PS3 console 3.5 years after it launched;[16] a similar path to profitability was followed by Sony's PS2 after its release. There are, however, some exceptions: e.g., Nintendo's current generation Wii console was profitable from day one and was never sold below cost.[17]

2.4. Porting, Multi-homing, and Exclusivity

Typically within a generation, games developed for one console are not compatible with others; in order to be played on another console, the game must explicitly be "ported" by a software developer and another version of the game created.[18] Due to the additional development and programming time and expense to develop additional versions of the game, the porting costs of supporting an additional console can be as high as millions of dollars for the current generation of systems.[19]

During the early years of the videogame industry (pre-1983), any firm who wished to produce a videogame could develop and release a game for any console which utilized cartridges or interchangeable media. However, many console manufacturers recouped console development costs from the sale of their own games, and saw the sale of rival third-party games as a threat; some console manufacturers even sued rival software developers to (unsuccessfully) keep them off their systems (Kent, 2001). The inability to restrict the supply of third-party software led to a subsequent glut of games released in the early 1980s, many of low quality; in turn, this partially caused the videogame market crash of 1983 in which demand for videogame hardware and software suddenly dried up. Whereas there used to be over a hundred software developers in 1982, only a handful remained a year later.

As one of the survivors of the crash, Nintendo deviated from the strategy employed by previous console manufacturers when releasing its NES console in the United States in 1985. First, it actively courted third-party software developers, understanding that a greater variety of software would increase attractiveness of the platform to other consumers; at the same time, it prevented unauthorized games from being released via a security system in which cartridges without Nintendo's proprietary chip could not be played on its console. Nintendo also imposed other restrictions on its third-party software licensees: each developer was limited to publishing only 5 games a year, had to give the NES exclusivity on all games for at least 2 years, and had to pay a 20 percent royalty on software sales (Kent, 2001; Evans, Hagiu, and Schmalensee, 2006).

It was not until 1990 that Nintendo – in the midst of lawsuits levied by competitors and an FTC investigation for anticompetitive behavior – announced that it would no longer restrict the number of games its developers could produce or prohibit them from producing games for other systems.[20] Since then, *forced exclusivity* – the requirement that a videogame be only provided for a given console or not at all – has not been used in the industry.[21] Though many software titles now choose to "multihome" and support multiple consoles, there are still instances in which third-party games are exclusive: some do so voluntarily (perhaps due to high porting costs), some engage in an exclusive publishing agreement with the console provider (typically in exchange for a lump sum payment), and others may essentially integrate with a platform by selling the entire development studio outright.

2.5. Consumers

As mentioned earlier in this chapter, the vast majority of videogame players are no longer children: 75 percent of gamers are 18 years old or older, with two-thirds of those between the ages of 18–49.[22] In addition, there is a wide degree of variance in usage and purchasing behavior across consumers: in 2007, Nielsen estimated the heaviest using 20 percent of videogame players accounted for nearly 75 percent of total videogame console usage (by hours played), averaging 345 minutes per day. Furthermore, although on average 6–9 games were sold per console between 2000–2005, "heavy gamers" reported owning collections of over 50+ games,[23] and on average purchased more than 1 game per month.[24]

3. Economics of the Videogame Industry

Although there exist active markets for PC and portable gaming, most research on videogames has focused on the home videogame market. This is not without reason. First, the home videogame industry is convenient to study since all relevant firms within a generation are known, and there exist data containing a list of all software produced for nearly all of the consoles released in the past three decades. Compare this to the PC industry, where there are thousands of hardware manufacturers and product varieties, and even greater numbers of software developers and products; obtaining detailed price and quantity information, for example, on the universe of PC configurations, accessories, and software products would be impossible. Second, there are relatively few substitutes to a home videogame console, allowing for a convenient market definition. Finally, as videogame consoles have been refreshed over time, there is the potential for testing repeated market interactions across multiple generations.

This section provides a brief (and thus by no means comprehensive) review of recent economic research on the home videogame industry, and emphasizes both the advances and limitations of the literature in capturing important features and dynamics of the market. As understanding the interactions between the three major types of players in the industry – software firms, hardware firms, and consumers – provide the foundation for any subsequent analysis (e.g., how industry structure or welfare changes following a policy intervention or merger), it is unsurprising that the vast majority of papers have first focused on modeling the strategic decisions of these agents. Only with these models and estimates in hand have researchers have begun addressing more complicated questions including the role and impact of vertical relationships in this industry. Across all of these fronts remain several open questions, and I highlight those areas in which future study would prove useful.

5.2 Consumer Demand and Software Supply

As with many hardware-software industries, videogames exhibit network effects in that the value of purchasing a videogame console as a consumer increases in the number of other consumers who also decide to purchase that console. Although there is a direct effect in that people may prefer owning the same videogame console as their friends or neighbors, the primary means by which this occurs is through an indirect effect: more consumers onboard a particular console attracts more games to be produced for that console, which in turn makes the console an even more desirable product.[25,26] Such indirect network effects also work in the other direction: software developers may benefit from other software developers supporting the same console in that more games attracts more consumers, which further increases the potential returns for developing a game for that console.[27]

Numerous studies have attempted to empirically document or measure the strength, persistence, and asymmetry of these kinds of network effects in a variety of industries. Many of these original empirical papers base their analysis on models in which consumers of competing platforms preferred to purchase the device with a greater *number* of compatible software titles. As long as consumers preferred a greater variety of software products – typically modeled via CES preferences – and certain assumptions on the supply of software held, then a simple log-linear relationship between consumer demand for hardware and the availability of software could be theoretically shown to arise in equilibrium (c.f Chou and Shy (1990); Church and Gandal (1992)). Empirical research based on these types of models include studies on adoption of CD players (Gandal, Kende, and Rob, 2000), DVD players (Dranove and Gandal, 2003), VCRs (Ohashi, 2003), and personal digital assistants (Nair, Chintagunta, and Dubé, 2004).

In the spirit of this literature, Shankar and Bayus (2003) and Clements and Ohashi (2005) are two of the earliest papers to empirically estimate the existence and magnitude of network effects in the videogame industry. Whereas Shankar and Bayus (2003) assume software supply is exogenous and not directly affected by hardware demand, Clements and Ohashi (2005) estimate two simultaneous equations representing the two-sided relationship between a console's installed base of users and its games. This approach, motivated by a static model of consumer demand and software supply, is followed by other papers analyzing the videogame industry (e.g., Corts and Lederman (2009); Prieger and Hu (2010)), and is useful to describe briefly here.

The model assumes a consumer's utility from purchasing console j at time t is given by:

$$u_{j,t} = \underbrace{\beta_0 + \beta_x x_j + \beta_p p_{j,t} + \xi_{j,t}}_{\delta_{j,t}} + \omega N_{j,t} + \varepsilon_{j,t}$$

where x_j are console j's observable characteristics (e.g., speed, processing power), $p_{j,t}$ the price, $N_{j,t}$ the number of available software titles for console j, $\xi_{j,t}$ an error unobservable to the econometrician, and $\varepsilon_{j,t}$ a standard logit error; a consumer purchases console j at time t if it delivers the maximum utility among all alternatives (including an outside option). As in Berry (1994), this can be converted into a linear regression via integrating out the logit errors and using differences in log observed shares for each product to obtain the following estimating equation:

$$\ln(s_{j,t}) - \ln(s_{0,t}) = \delta_{j,t} + \sigma \ln(s_{j,t|j\neq 0}) + \omega N_{j,t} \quad (1)$$

where $s_{j,t}$, $s_{0,t}$, and $s_{j,t|j\neq 0}$ are the share of consumers who purchase platform j, the outside good, and platform j conditional on purchasing a console at time t. Following prior literature, assuming a spot market for single-product software firms, free entry, and CES preferences for software, a reduced form equation relating the equilibrium number of software titles available to a console's installed base of users ($IB_{j,t}$) can be derived:[28]

$$\ln(N_{j,t}) = \alpha_j + \gamma \ln(IB_{j,t}) + \eta_{j,t} \quad (2)$$

where $\eta_{j,t}$ is a mean-zero error. Clements and Ohashi (2005) estimate these two equations across multiple generations of videogame consoles between 1994–2002 using price and quantity information provided by NPD Group, a market research firm (which also is the source for most of the market level data used in the majority of videogame papers discussed in this chapter). They employ console and year dummies in estimation, use the Japanese Yen and US dollar exchange rate and console retail prices in Japan as an instrument for price, and use the average age of software titles onboard each system as an instrument for the installed base.

The main objects of interest are ω and γ in (1) and (2), which represent the responsiveness of consumer demand to the number of software titles, and vice versa. In Clements and Ohashi (2005) and similar studies, these coefficients are found to be significant and positive, which are interpreted as evidence of indirect network effects.[29] Furthermore, these studies often show that such coefficients vary over time: e.g., Clements and Ohashi (2005) include age-interaction effects with installed base in (2), and find that the responsiveness of software to installed base decreases over lifetime of videogame console; similarly, Chintagunta, Nair, and Sukumar (2009) use an alternative hazard rate econometric specification of technology adoption and find that strength of network effects also varies over time, and that the number of software titles and prices have different effects on demand in later versus earlier periods. Both of these studies find price elasticities for a console diminish as consoles get older.

It is worth stressing (as these papers have) that these estimates come from a static model, and care must be used when interpreting estimated parameters. There are several reasons a static model may not be ideal for analyzing this industry. Since consoles and games are durable goods, consumers do not repurchase the same product which typically is implied by a static model without inventory consideration; in addition, forward-looking consumers may delay purchase in anticipation of lower prices or higher utility from consumption in future periods (which may partially explain the strong seasonal spike in sales around the holidays). Failing to account for both the durability of goods and the timing of purchases can bias estimates of price and cross-price elasticities (c.f. Hendel and Nevo (2006)) as well as other parameters – including the strength of network effects.

Most importantly, however, a static model does not allow consumers to anticipate future software releases when deciding when to purchase a console; since consoles are durable, consumers in reality base their hardware purchasing decisions on expectations over *all* software on a platform, including those titles that have not yet been released. Hence, a consumer's utility function for a console for example, should reflect this. Thus, insofar that ω can be estimated, it at best represents the extent to which current software variety reflects a consumer's expectation over the stock of current *and* future games. That estimated coefficients for these static models are shown to vary across time and even across consoles suggest dynamic issues are at play, and the underlying relationship between consumer demand and software availability may be significantly more complex.

3.1.1. *Dynamics and Software/Consumer Heterogeneity*

In response to these concerns, researchers have begun incorporating dynamics into their analysis of consumer demand for videogames. For instance, Dubé, Hitsch, and Chintagunta (2010) utilize a dynamic model in which forward looking consumers time their purchases for consoles based on expectations of future prices and software availability; using a two-step estimator, they are also able to simultaneously estimate a console provider's optimal dynamic pricing function. Using estimates from their model, the authors study how indirect network effects can lead to greater platform market concentration, and illustrate how, in spite of strong network effects, multiple incompatible platforms can co-exist in equilibrium. Nonetheless, this dynamic model of hardware demand still maintains the assumption used in the previous empirical network effects literature that consumers respond to software "variety," which can be proxied by the number of available software titles, and that software variety can still be expressed as a reduced form function of each platform's installed base (e.g., as in (2)). This may have been a reasonable assumption for these papers which primarily focused on the period up until and including the 32/64 bit generation of videogames (roughly pre-2000). However, as mentioned previously, the past decade has seen the dominance of hit games where a small subset of software titles captured the majority of software sales onboard a console. Given the increasing variance in software quality and skewed distribution of software sales, a model specifying consumer utility as a function only of the number of software titles as opposed to the identity of individual games – although tractable and analytically convenient – may be of limited value in analyzing the most recent generations of the videogame industry as well as other "hit-driven" hardware-software markets.

Mirroring the necessity to control for software heterogeneity in videogames is the additional need to control carefully for consumer heterogeneity. As has been previously discussed, the variance across consumers in the number of games purchased and hours spent playing games has been well documented, and capturing this rich heterogeneity is important for accurate estimates of product qualities and demand parameters. Although controlling for consumer heterogeneity is also important in a static setting, doing so in a dynamic context adds an additional complexity in that the characteristics of consumers comprising the installed base of a console evolves over time. E.g., since early adopters of videogame consoles are predominantly consumers with high valuations for videogames, software released early in a console's lifetime face a different population of consumers than a game that is released after a console is mature. Failing to correct for this consumer selection across time will bias upwards estimates of early-released games' qualities, and bias downwards estimates of games released later. In turn, the magnitudes of these parameters underly incentives for almost all strategic decisions on the part of firms: e.g., firms may engage in intertemporal price discrimination (initially setting high prices before lowering them) in order to extract profits out of high valuation or impatient consumers first.

In an attempt to control for these issues, Lee (2010a) estimates a dynamic structural model of consumer demand for both videogame hardware and software between 2000–2005 that explicitly incorporates heterogeneity in both consumer preferences and videogame quality. By explicitly modeling and linking hardware and software demand, the analysis is able to extract the marginal impact of a single videogame title on hardware sales, and allow this impact to differ across titles in an internally consistent manner. An overview of the approach follows.

The model first specifies consumer i's lifetime expected utility of purchasing a hardware console j at time t (given she owns other consoles contained within her inventory ι) as:

$$u_{i,j,t,\iota} = \alpha^{x} x_{j,t} - \alpha_i^{p} p_{j,t} + \alpha^{\Gamma} \Gamma_{j,t}(\alpha_i^{p}, \alpha_i^{\gamma}) + D(\iota, \alpha_i^{\gamma}) + \xi_{j,t} + \varepsilon_{i,j,t,\iota}, \qquad (3)$$

where $x_{j,t}$ are observable console characteristics, $p_{j,t}$ the console's price, $\xi_{j,t}$ an unobservable product characteristic, and $\varepsilon_{i,j,t,\iota}$ a logit error. The paper introduces two additional terms to account for inventory concerns and the anticipation of future software: i.e., $D(\cdot)$ captures substitution effects across consoles and allows a consumer to value the console less (or more) if she already owns other consoles contained within ι; and $\Gamma_{j,t}$ reflects a consumer's perception of the utility she would derive from being able to purchase videogames available today *and in the future.* Consumers have different preferences for videogaming, captured by the coefficient α_i^{γ}, and for prices, given by α_i^{p}. Finally, the coefficient on $\Gamma_{j,t}$, α^{Γ}, captures how much hardware utility — and hence hardware demand – is influenced by expected software utility.

Note that this specification of hardware demand does not use a static-period utility function, but rather lifetime expected utilities. Furthermore, the model incorporates dynamics explicitly by assuming consumers solve a dynamic programming problem when determining whether or not to purchase a videogame console in a given period: each consumer compares her expected value from purchasing a given console to the expected value from purchasing another console or none at all; furthermore, consumers can multihome and return the next period to purchase any console they do not already own.

On the software side, the setup is similar: every consumer who owns a console is assumed to solve a similar dynamic programming problem for each game she can play but does not already own. This in turn allows for the derivation of the expected option value of being able to purchase any particular title k onboard console j at time t, which is denoted $EW_{i,j,k,t}$. Finally, to link the hardware and software demand together, the model defines $\Gamma_{j,t}$ as the sum of option values for any software title k available on console j at time t (given by the set $K_{j,t}$) plus an expectation over the (discounted) option values of being able to purchase games to be released in the future, represented by $\Lambda_{j,t}$:

$$\Gamma_{j,t}(\alpha_i^{p}, \alpha_i^{\gamma}; \iota) = \underbrace{\left[\sum_{k \in K_{j,t}} EW_{i,j,k,t} \right]}_{\text{(i) Current Software Utility}} + \underbrace{\Lambda_{j,t}(\alpha_i^{p}, \alpha_i^{\gamma}; \iota)}_{\text{(ii) (Expected) Future Software Utility}}, \qquad (4)$$

Lee (2010a) estimates the underlying structural parameters of the model, which include product fixed effects for every console and game and consumer preferences over price and software availability, utilizing techniques pioneered in Rust (1987), Berry (1994), and Berry, Levinsohn, and Pakes (1995), and later synthesized in a dynamic demand environment by Melnikov (2001) and Gowrisankaran and Rysman (2007).[30] An important extension involves controlling for the selection of consumers onto consoles across time, which requires the simultaneous estimation of both hardware and software demand.

Estimates indicate that although the vast majority of titles had a marginal impact on hardware demand, the availability of certain software titles could shift hardware installed bases by as much as 5 percent; furthermore, only a handful of such "hit" titles are shown to have been able to shift hardware demand by more than one percent over the lifetime of any given console. A model which assumed consumers valued all titles equally would thus lead to drastically different predictions on the impact and magnitudes of software on hardware demand. Lee (2010a) also demonstrates that by failing to account for dynamics, consumer heterogeneity, and the ability for consumers to purchase multiple hardware devices, predicted consumer elasticities with respect to price and software availability would be substantially biased.

As is often the case, however, several strong assumptions are required for this more complicated analysis. First, for tractability, consumers perceive each software title onboard a system as an independent product.[31] Second, consumers have rational expectations over a small set of state variables which are sufficient statistics for predicting future expected utilities. Although the consistency of beliefs with realized outcomes may have been a reasonable assumption for the period examined, there may be other instances for which it may not be well suited: e.g., Adams and Yin (2010) study the eBay resale of the newest generation of videogames consoles released in 2006, and find that prices for pre-sale consoles rapidly adjust after they are released.[32]

3.1.2. *Software Supply and Pricing*

Accompanying the development of more realistic models for consumer demand have been richer models for software supply which treat software firms as dynamic and strategic competitors. One strain of literature focused on the optimal pricing of videogame software, itself a general durable goods market with forward looking consumers. Nair (2007) combines a model of dynamic consumer demand for videogame software with a model of dynamic pricing, and finds that the optimal pricing strategy for a software firm is consistent with a model of "skimming": charging high prices early to extract rents from high value (or impatient) consumers before dropping prices over time to reach a broader market. This corresponds to the pricing patterns observed in the data: the vast majority of games on a console are released at a single price point (e.g., $49.99), and prices fall in subsequent periods.[33]

Inevitably, studies on pricing can only be conducted on games which have been already released for a particular platform; moving one step earlier in a software developer's decision process is the choice of which console to join. A first-party game has historically only been released exclusively on the integrated platform;

However, a third-party software developer has a strategic choice: it can release a title on multiple platforms in order to reach a larger audience but pay additional porting costs, or it can develop exclusively for one console and forgo selling its game to consumers on other platforms.

Lee (2010b) models what can be considered software's "demand" for a platform. As in consumer demand, dynamics are important in this decision as well: since each software publisher makes this choice months before a game's release and since a game remains on the market for at least several months, a software developer anticipates changes in future installed bases of each console as well as the subsequent choices of other software developers when comparing expected profits of different actions. Using both the consumer demand estimates and similar assumptions used in Lee (2010a), the model computes a dynamic rational expectations equilibrium in which every software title chooses the optimal set of platforms to develop for while anticipating the future actions (and re-actions) of other agents.

A key input into the model, however, are porting costs for supporting different sets of consoles. These are typically unobserved. Lee (2010b) estimates these costs for games released between 2000 and 2005 under the revealed preference assumption that games released in the data were released on the subset of platforms which maximized their expected discounted profits.[34] Via an inequalities estimator developed in Pakes, Porter, Ho, and Ishii (2006), relative differences in porting costs can be estimated. Estimates show significant variance in costs depending on the genre or type of game being ported, and that some consoles are cheaper (e.g., Xbox) than others (e.g., PS2) to develop for. On average, costs for this generation are approximately $1M per additional console, which are roughly in line with industry estimates.

The final step back in the software production sequence involves the creation and development of new games. This represents the least developed area of research on software supply, and is the remaining key step in completely unpacking the mechanism which generates the reduced form relationship shown to exist between installed base of a console and software availability. On this front are issues related to an investment-quality tradeoff for game development, a product positioning decision of what genre or type of game to produce, timing games with release dates as with motion pictures (Einav (2007)), and the make-or-buy decision faced by a software publisher who can either engage in an arms-length contract with an independent developer or integrate into software development. Although some papers have studied whether integration with a console provider improves game quality,[35] there remains much to be done.

3.2 Platform Competition

Most of the analysis discussed so far has held fixed the actions of each platform, including choices of royalty rates charged to third-party software providers, development or porting costs, and integration or exclusive contracting decisions.

Understanding these decisions from a theoretical perspective is complicated; the ability to analyze these strategic choices is further confounded by the absence of detailed data on these objects of interest (i.e., royalties, costs, and contracts). Even so, understanding how videogame platforms compete with one another for consumers and software firms is not only perhaps the most important aspect of this industry, but also the one that is the most relevant and generalizable to other hardware-software markets and platform industries. Thus overcoming these challenges should be the focus of future efforts.

3.2.1. *Pricing*

The most developed area of research on platform strategy has been on the pricing of hardware consoles: both Dubé, Hitsch, and Chintagunta (2010) and Liu (2010) estimate dynamic models of hardware pricing to consumers, and highlight the importance of indirect network effects in explaining observed pricing patterns and rationalizing console "penetration pricing" – that is, consoles are typically priced below marginal costs, but as marginal costs fall faster than prices, margins tend to increase over time. Dubé, Hitsch, and Chintagunta (2010) further note that the presence of network effects are not sufficient on their own to make penetration pricing optimal, and rather that these effects need be sufficiently strong.

Nonetheless, these analyses hold fixed prices charged by platforms to the "other side" of the market in that the supply of software is only dependent on the installed base of consumers onboard a console, and not the royalty rates levied by the console. Of course, in reality these royalties are as much a strategic decision as the price charged to consumers, and in many ways are just as important to a platform's success. For example, Sony charged a much lower royalty than Nintendo when it introduced its Playstation console ($9 as opposed to $18), which helped it attract a greater number of third-party software developers (Coughlan, 2001).

To determine the optimal royalty, it's useful to understand why they need be positive at all. The theoretical two-sided market literature (c.f. Armstrong (2006); Rochet and Tirole (2006); Weyl (2010)) has focused on precisely this question in related networked industries, and emphasized how changing the division of pricing between sides of a platform market can affect platform demand and utilization; Hagiu (2006) focused on the videogame industry in particular, and analyzed the relationship between a console's optimal royalty rate and optimal hardware price. As noted before, the videogame industry differs from most other hardware-software markets such as the PC industry in that the majority of platform profits derive not from the end user or consumer, but rather from the software developers in the form of royalty payments. However, providing a single explanation of why this occurs within the videogame industry proves difficult, as many theory models indicate which side can multihome, how much one side responds and values the participation of the other, and the heterogeneity in such preferences can drastically influence the optimal division of prices.[36] Thus, there may be many forces at work. Hagiu (2009) provides another explanation, in which the more that consumers prefer a variety of software products, the greater a platform's profits derive from software in equilibrium.

There are difficulties testing these alternative explanations in the data. First, although obtaining measurements of elasticities of consumers with respect to software (and vice versa) is possible, estimating how software supply would change in response to a change in royalty rates is difficult; not only is data on royalty rates difficult to come by, but typically they do not change for a particular console during its lifetime and hence there is little identifying variation.[37] Second, given that certain hit software titles dominate the market and games are supplied increasingly by publishers with market power, it is an open question whether the theoretical results still apply when one side of the market no longer are price-takers but rather strategic oligopolists.

3.2.2 *Porting Costs and Compatibility*

Another decision on the part of console manufacturers that has not widely been studied is the ability of a platform provider to affect the costs of developing or "porting" to its console. The theoretical literature has studied the role of switching costs in influencing market share and power in general networked industries (c.f. Farrell and Klemperer (2007)), and these issues are central in the videogame market as well. For example, anecdotal evidence suggests that one of the main reasons for Sony's success in entering the videogame market was that it was easier and cheaper to develop for the Sony Playstation than rival consoles at the time: in addition to having lower royalty rates, Sony actively provided development tools and software libraries to third party developers, and it utilized CDs as opposed to more costly cartridges (the format used by Nintendo consoles at the time). Incidentally, Microsoft also leveraged lower development costs as a selling point of its first console: as essentially a modified Microsoft Windows PC with an Intel CPU, the Xbox was extremely easy for existing PC developers to adjust to and develop games for (Takahasi, 2002).

Relatedly, platform providers can also decide whether or not to make games compatible across consoles, as opposed to forcing developers to make different versions. Although cross-platform compatibility across competing consoles has not been witnessed (instead, requiring software developers to port and create multiple versions of a game), a platform provider could allow for backwards compatibility – that is, a new console being able to play games released for the previous generation console. One widely cited advantage of Sony's PS2 over its competitors at the time was its compatibility with original Playstation games; this gave it an accessible library of over a thousand games upon release, easily surpassing the number of playable titles on any of its competitors.[38] Interestingly, the PS3 initially could play PS2 games, but newer versions of the console eliminated this ability; this suggests that the benefits to backward compatibility are most substantial early in a console's life before current-generation games are widely available, and later may not be worth the cost.[39]

3.2.3. *Exclusivity and Integration*

Although there is some degree of hardware differentiation across consoles, the primary means by which consoles compete with one another for consumers (in addition to price) is through the availability of exclusive games.[40] Before Sony entered the videogame business in 1993 with its Playstation console, it purchased a major software developer in addition to securing agreements for several exclusive titles (Kent, 2001). Similarly, before launching the Xbox in 2001, Microsoft bought several software developers to produce exclusive games; many attribute the (relative) success of Microsoft's Xbox console to its exclusive game *Halo*, acquired in 2000. In both instances, having high-quality games available with the release of a console that were not available on competitors contributed to greater sales.

A platform typically obtains an exclusive game in one of two ways: via internal development by a integrated developer, or via payment to a third party developer. In recent years as development costs for games have been increasing and porting costs have fallen as a percentage of total costs, most third-party titles have chosen to multihome and support multiple consoles in order to maximize their number of potential buyers. Thus, even though exclusive arrangements still occur for third-party titles, they are now increasingly used for only a temporary period of time (e.g., six months), and console providers have become even more reliant on their own first-party titles to differentiate themselves.

In general, understanding how platforms obtain exclusive content – either via integration or exclusive contracting – requires a model of bilateral contracting with externalities between console manufacturers and software developers (c.f. Segal (1999); Segal and Whinston (2003); de Fontenay and Gans (2007)). For example, the price Sony would need to pay a software developer for exclusivity depends crucially on how much Sony would benefit, as well as how much Sony would lose if Microsoft obtained exclusivity over the title instead. Unfortunately, the applicability of theory to settings with multiple agents on both sides of the market is limited (there are at least three major console manufacturers and multiple software publishers and developers), and is even further confounded by the presence of dynamics.[41] Although static models of bargaining for exclusivity have been analyzed,[42] a general model that can be taken to the data and inform our ability to predict which games or developers would be exclusive, and the determinants of the negotiated price, would be extremely useful.[43]

3.2.4. *Other Concerns*

Ultimately, one of the biggest hurdles in bringing the theory to the data may very well be identifying the incentives each major platform provider faces. Both Sony and Microsoft have multiple other platform businesses which are affected by decisions made within their videogame divisions. For example, Sony faced a much higher marginal cost than its competitors as a result of including its proprietary Blu-ray player in its PS3 console; such a decision was a response to its desire to win the standards battle for a next-gen DVD format over consumer electronics rival Toshiba.

In addition, Microsoft viewed the Xbox as partly a means of protecting and expanding its Windows and PC software business during an era of digital convergence (Takahasi, 2002). In both cases, each company sustained large initial losses in their videogame divisions ($4B in the first four years of the Xbox for Microsoft, $3B for Sony in the first two years of its PS3),[44] but focusing on these numbers alone would understate the total benefits each company received.[45] Furthermore, there is again a dynamic aspect: had Microsoft not entered in 2000 with a viable platform, it would have had a more difficult time releasing its Xbox360 device in 2005. Determining the appropriate scope across industries and time horizon each company faces when making strategic decisions is an open challenge.

3.3. Vertical Issues

3.3.1. *Exclusive Software for Consoles*

The forced exclusivity contracts employed by Nintendo in the 1980's – whereby developers could only develop exclusively for Nintendo or not at all – were dropped under legal and regulatory pressure in 1990. Since then, many have argued that these were anticompetitive not only in videogames (e.g., Shapiro (1999)), but in other industries (e.g., *U.S. v. Visa*) as well. Nonetheless, exclusive games persist. A natural question, thus, is whether the continued presence of exclusive first-party games developed internally by platforms, or the use of lump-sum payments by platforms in exchange for exclusivity from third-party software developers, can be anticompetitive.

Theory has shown the effects of such exclusive vertical relationships can be ambiguous. Such relationships can be used to deter entry or foreclose rivals (Mathewson and Winter (1987), Rasmusen, Ramseyer, and Wiley (1991), Bernheim and Whinston (1998)), which may be exacerbated by the presence of network externalities (e.g., Armstrong and Wright (2007)).[46] Furthermore, exclusivity can limit consumer choice and hence welfare by preventing consumers on competing platforms from accessing content, products, or services available only elsewhere. On the other hand, exclusive arrangements may have pro-competitive benefits, such as encouraging investment and effort provision by contracting partners ((Marvel 1982), Klein (1988), Besanko and Perry (1993), Segal and Whinston (2000)). In networked industries, integration by a platform provider may be effective in solving the "chicken-and-egg" coordination problem, one of the fundamental barriers to entry discussed in the two-sided market literature. Furthermore, exclusivity may be an integral tool used by entrant platforms to break into established markets: by preventing contracting partners from supporting the incumbent, an entrant can gain a competitive advantage, spur adoption of its own platform, and thereby spark greater platform competition.

Both Prieger and Hu (2010) and Lee (2010b) attempt to shed light on this question in the context of the sixth generation of the videogame industry (2000–2005).

Prieger and Hu (2010) use a demand model similar to Clements and Ohashi (2005) to show that the marginal exclusive game does not affect console demand; consequently, the paper suggests that a dominant platform cannot rely on exclusive titles to dominate the market. However, as already discussed in this chapter, controlling for heterogeneity in game quality is crucial, and cannot be captured in a model where consumers only value the number of software products: estimates from Lee (2010a) show that games that actually could drastically affect hardware market shares were primarily integrated or exclusively provided to only one console. Thus, insofar the few hit games onboard the largest platform of the time period studied could have contributed to its dominant position, exclusive vertical arrangements may have led to increased market concentration.

To explore this possibility, Lee (2010b) conducts a counterfactual environment in which exclusive vertical arrangements were prohibited in the industry during the time period studied: that is, all hardware providers both could not write exclusive software or write exclusive contracts with software providers. Using the techniques described in the previous chapter and demand estimates from Lee (2010a), Lee (2010b) simulates forward the market structure if all consumers *and* games (including those that previously had been integrated) could freely choose which platforms to purchase or join, and solves for the dynamic equilibrium of this game. The main finding, focusing on the platform adoption decisions of consumers and software, is that banning exclusive arrangements between hardware platforms and software publishers would have actually benefited Sony, the dominant "incumbent" platform (with the one-year head start and larger installed base), and harmed the two smaller platforms (Microsoft and Nintendo) during the time period studied.

The intuition for this result is straightforward: without exclusive arrangements, the developers of high quality software would typically multihome and support all three consoles; lower quality titles, constrained by the costs of porting, would likely develop first for the incumbent due to its larger installed base, and only later, if at all, developed a version for either entrant platform. As a result, neither entrant platform would have been able to offer consumers any differentiation or benefit over the incumbent. With exclusivity, however, entrants could create a competitive advantage, and was hence leveraged by them to gain traction in this networked industry.[47]

The paper still notes that even though banning exclusive vertical arrangements may have increased industry concentration, consumers may have benefited from access to a greater selection of software titles onboard any given platform: consumer welfare would have increased during the five-year period without exclusivity since a consumer could access a greater number of software titles while needing to only purchase one console. Nonetheless, the analysis abstracts away from many potential responses to such a counterfactual policy change: for example, platform providers are assumed to offer the same non-discriminatory contracts to all firms, investment and product qualities do not change, and prices, entry, and exit of all products are held fixed. Indeed, the paper notes that if Sony's prices increased as as a result of its increased market share (or if either Nintendo or Microsoft exited in that generation or the subsequent one, or software supply was adversely affected by the efficiency benefits of integration and exclusivity) the change to consumer welfare could easily have been significantly negative.

Thus, although it does appear that both Microsoft and Nintendo benefited from the ability to engage in exclusive dealing in this period, the effects on consumer welfare are ambiguous; furthermore, in order to paint a complete story of the effects of integration or exclusivity, one might also wish to examine an environment in which only certain platforms (e.g., the incumbent or dominant player) could not engage in exclusive contracting, but others could. Such extensions would require developing additional tools to analyze the broader set of strategic decisions facing software and hardware firms discussed previously.

4. Concluding Remarks

The home videogame market is but a portion of the entire videogame industry, yet has proven to be a rich testing ground for models of strategic interaction and theories of platform competition. The literature that has developed, though still nascent, has shown the potential for tackling and addressing myriad issues simply by studying an industry which once was considered just a curiosity and fad.

Looking forward, the continued growth of the videogame industry has the potential for being both a curse and a boon for research. On one hand, as videogames become even more pervasive and intertwined with other industries, it becomes – to a certain degree – less suited for "clean" and tractable analysis. Indeed, one of the advantages of studying the home videogame market was precisely the relative ease in which the relevant agents and parties could be identified; going forward, this no longer may be the case. Furthermore, as this chapter discussed, even retrospective analysis of the videogame market when all the players were known required sophisticated modeling techniques to handle the industry's complexities, which include controlling for dynamic issues and accounting for consumer and software heterogeneity. Accounting for even more complicated strategic interactions poses a daunting challenge.

On the other hand, the success and proliferation of videogames will continue to spawn broader questions and improve our understanding of general networked industries. At the heart of digital convergence is the story of dominant platforms in once separated markets suddenly finding themselves to be competitors: much as videogame consoles encroach upon adjacent markets such as content distribution, so to have firms in other markets – for example, smartphone manufacturers, social networking platforms – ventured into the gaming business. How this cross-industry platform competition will play out and adapt to changing environments remains a fascinating topic for exploration.

Notes

1. DFC Intelligence, 2009. 2010 Essential Facts, Entertainment Software Association.
2. Ibid.
3. Ibid.
4. 2010 Media Industry Fact Sheet, Nielsen Media Research.
5. Sony also released a general purpose computer system called the MSX in 1983 that could be used for gaming.
6. http://www.scei.co.jp/corporate/release/100118e.html.
7. 2010 Media Industry Fact Sheet, Nielsen Media Research.
8. "Natal vs. Sony Motion Controller: is the console cycle over?" *guardian.co.uk*, February 26, 2010.
9. ESA 2010 Essential Facts.
10. Originally, the first videogame consoles were essentially integrated hardware and software devices provided by a single firm; not until after 1976, with the release of the Fairchild System F and the Atari VCS, were other firms able to produce software for videogame consoles via the use of interchangeable cartridges.
11. Average costs reached $6M during the late 1990s (Coughlan, 2001), and today can range between $20 - 30M for the PS3 and Xbox360 ("The Next Generation of Gaming Consoles," *CNBC.com*, June 12, 2009).
12. E.g., "Call of Duty: Modern Warfare 2 tops $1 billion in sales," *Los Angeles Times*, January 14, 2010.
13. 3DO was a console manufacturer who tried a different pricing scheme by significantly marking up its hardware console, but charging no software royalties. 3DO survived for 3 years before filing for bankruptcy in 2003 (Brandenburger, 1995).
14. See Hagiu, "Software Platforms," chapter 3 in this Handbook for more discussion.
15. "Will Xbox drain Microsoft?," CNET News, March 6, 2001. "Microsoft's Midlife Crisis," Forbes, September 13, 2005.
16. "Sony Eyes Return to Profit," Wall Street Journal, May 14, 2010.
17. "Nintendo takes on PlayStation, Xbox," *Reuters*, September 14, 2006.
18. A notable exception is "backwards compatibility," which refers to the ability of a new console to use software developed for the previous version of that particular console. E.g., the first version of the PS3 could play PS2 games, and the PS2 could play PS1 games; the Xbox360 can play Xbox games.
19. Industry sources; Eisenmann and Wong (2005) cite $1M as the porting cost for an additional console for the sixth generation of platforms.
20. "Nintendo to ease restrictions on U.S. game designers," *The Wall Street Journal*, October 22, 1990. Kent (2001).
21. This may also partially be a result of the fact that no console has since matched Nintendo's 80–90 percent market share achieved in the late 1980s.
22. ESA Essential Facts, 2010.
23. "Video Game Culture: Leisure and Play Preferences of B.C. Teens," *Media Awareness Network*, 2005.
24. "Digital Gaming in America Survey' Results," *Gaming Age*, August 12, 2002.
25. This follows since games are high fixed cost, low marginal cost products: the larger the potential market for a game (i.e., a console's installed base), the more likely an additional game will be produced.

26. On the other hand, direct network effects are generally stronger for individual software titles, particularly given the rise of online play.
27. Whether the negative competition effect between two substitutable games dominates this positive network effect depends on the relative elasticities for adoption, which in turn typically depends on how early it is in a console's lifecycle.
28. See also Dubé, Hitsch, and Chintagunta (2010) for the derivation of a similar estimating equation.
29. Corts and Lederman (2009) also find evidence of "cross-platform" network effects from 1995 to 2005: i.e., given the ability of software to multihome, software supply for one console was shown to be responsive to the installed bases across all platforms; as a result, users on one console could benefit from users on another incompatible console in that their presence would increase software supply for all consoles.
30. Estimation of the model follows by matching predicted market shares for each hardware and software product over time from the model with those observed in the data (obtained from the NPD Group), and minimizing a GMM criterion based on a set of conditional moments. The main identifying assumption is that every product's one dimensional unobservable characteristic (for hardware, represented by ξ in (3)) evolves according to an AR(1) process, and innovations in these unobservables are uncorrelated with a vector of instruments.
31. Since videogames are durable goods, keeping track of each consumers' inventory and subsequent choice sets for over 1500 games was computationally infeasible. However, both Nair (2007) and Lee (2010a) provide evidence which suggests independence may not be unreasonable for videogames.
32. Whether or not consumer beliefs can be estimated or elicited without imposing an assumption such as rational expectations is an important area of research for dynamic demand estimation in general.
33. Nair (2007) provides anecdotal evidence that managers follow rules-of-thumb pricing strategies in which prices are revised downward if sales are low for a game, and keep prices high if sales are high. There is also evidence that consumers prefer newer games over older ones (e.g., Nair (2007) and Lee (2010a) both find significant decay effects in the quality of a game over time).
34. The analysis ignores games that are contractually exclusive, which are discussed later in this chapter; it furthermore assumes publishers maximize profits individually for each game.
35. E.g., Gil and Warzynski (2009) study videogames released between 2000 and 2007 and find reduced form evidence that indicates once release timing and marketing strategies are controlled for, vertically integrated games are not of higher quality than non-integrated games. However, regressions on the software fixed effects recovered in Lee (2010a) for a similar time period show first-party games are generally of higher quality.
36. See also Evans, Hagiu, and Schmalensee (2006) for discussion.
37. Appealing to cross-platform variation in royalty rates would require considerable faith that other console specific factors affecting software supply can be adequately controlled for.
38. Nintendo and Microsoft followed suit with their seventh generation consoles.
39. The original PS3 console included the PS2 graphic chip, which was eliminated in subsequent versions.
40. Clearly, any game that multihomes and is available on multiple systems yields no comparative advantage across consoles.

41. For instance, the gains to exclusivity depend on the age of the console (among other things), and platforms may choose to divest integrated developers later. E.g., Microsoft acquired the developer Bungie prior to launch of original Xbox in 2000; in 2007, it was spun off as Microsoft reasoned Bungie would be more profitable if it could publish for other consoles ("Microsoft, 'Halo' maker Bungie split," *The Seattle Times*, October 6, 2007).
42. For example, Hagiu and Lee (2011) apply the framework of Bernheim and Whinston (1998) to analyze exclusive contracting in platform industries; see also Stennek (2007).
43. See Lee and Fong (2012) for progress along these lines.
44. "Microsoft's Midlife Crisis," *Forbes*, September 13, 2005; "PlayStation Poorhouse," *Forbes*, June 23, 2008.
45. Further confounding matters are each console manufacturer's online gaming businesses; Microsoft's online service generates over $1B a year ("Microsoft's Online Xbox Sales Probably Topped $1 Billion," *Bloomberg*, July 7, 2010), and all 3 current-generation platforms have downloadable gaming stores as well.
46. Whinston (2006), Rey and Tirole (2007), and Riordan (2008) overview the theoretical literature on vertical foreclosure and the competitive effects of exclusive vertical arrangements.
47. Note that had Sony's exclusive titles been significantly higher quality than those onboard Microsoft's or Nintendo's consoles, this result may have been different: i.e., even though the two entrant platforms would have lost their exclusive titles, they would have gained access (albeit non-exclusively) to Sony's hit exclusive titles. Nevertheless, demand estimates clearly indicate this was not the case. The question of how Nintendo and Microsoft were able to get access to higher quality software in the first place is beyond the scope of the paper, as it requires addressing questions raised in the previous section regarding software supply and hardware-software negotiations.

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