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Market Dominance and Innovation in Computer Software Markets

by

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ABSTRACT

The ongoing legal battle between Microsoft Corporation and the Department of Justice has prompted a debate concerning competition and innovation in computer software markets and other high technology industries. Economic theory would suggest that by virtue of having monopoly power in the operating system, Microsoft has the ability through tying and predatory product innovation to exclude complementary software producers from software markets. The objective of this thesis is to empirically examine the link between exclusionary strategies such as tying and predatory product innovation and third party software producers' innovation incentives when the hardware component is produced by a monopoly. Using a Poisson model, my estimates suggest that there exists a significant negative relationship between Microsoft's market share in the primary market and innovation in secondary markets. This result provides indirect evidence that a antitrust remedy limiting Microsoft's market power in the operating system market may be warranted.

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To My Clare

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API	Application Program Interface
BWW	Baseman, Warren-Bolton and Woroch
CPU	Central Processing Unit
DOJ	Department of Justice
DOS	Disk Operating System
FTC	Federal Trade Commission
GUI	Graphical User Interface
ICP	Internet Content Provider
IE	Internet Explorer
IP	Intellectual Property
ISP	Internet Service Provider
NDA	Non-Disclosure Agreement
PC	Personal Computer
R&D	Research and Development

CHAPTER ONE: INTRODUCTION

Occasionally, two or more products can be combined together to work as a hardware/software system. Often, the benefits of the system increase with the variety of software produced for the system and the stand-alone value of the hardware component is zero or close to zero. Under these circumstances, it has been theorized that when the hardware (operating system) component is produced by a monopoly, the innovation incentives for third party software suppliers are reduced. The rationale here is that a dominant hardware supplier might profit from incorporating innovative ideas into its own products or exclude rival hardware firms through incompatibility. Bundling complementary software into the hardware component and selling the combined products as a system is a form of tying – selling one product on condition that a second one is purchased from the same supplier. Tying components together results in the foreclosure of rival software producers. Under the market foreclosure theory, a dominant firm's strategy harms competition "by denying competitors access either to one of their suppliers or to one of their buyers." (Perry, 1989, p.244) Similarly, third-party software producers are excluded when the system sponsor, a firm who owns the intellectual property rights over a hardware component, deliberately causes rivals' software products to become incompatible with the hardware (predatory product innovation). In this context, one would expect that software producers would be leery of producing a new product or upgrading the current one (Church and Ware, 1998b, Rubinfeld, 1998b). Ceteris paribus, one would also expect that venture capitalists would not invest in innovative third party software firms. As a result, innovation in software markets is lessened. This thesis addresses the incentives for software producers to innovate when they supply their good to a market characterized by a monopoly hardware producer who has the incentive and ability to tie a software product to its hardware and sell it as a system.

In order to analyze innovation incentives in this context, Microsoft Corporation (Microsoft) will be used as an illustration. This example is topical because on May 18, 1998, the United States federal government together with the attorney-generals of twenty states accused Microsoft of illegally preserving and extending its monopoly in desktop operating systems. This ongoing legal battle has prompted a debate concerning competition and innovation in computer software markets and other high technology industries. Essentially, the United States Department of Justice (DOJ, 1998, p.15) accused Microsoft of maintaining "its monopoly in operating systems and ... achiev(ing) dominance in other markets, not by innovation and other competition on the merits but by tie-ins, exclusive dealing contracts, and other anticompetitive agreements that deter innovation, exclude competition, and rob customers of the right to choose among competing alternatives." Its essential argument was that Microsoft's practice of integrating (tying) its internet browser, Internet Explorer (IE), with its Windows operating system was undertaken not primarily as a part of a vigorous competitive strategy but rather to decrease the likelihood of competitor entry in the browser market so that Microsoft would be able to maintain its operating system monopoly. Furthermore, the DOJ maintained that the operating system market has high barriers to entry due to network effects which result in it being "prohibitively difficult, time consuming and expensive to create an alternative operating system" (p.2).

If Microsoft could prevent this shift to a new standard, the DOJ believes that innovation would be harmed. It listed five specific ways in which tying reduces innovation: it decreases the incentives of competitors to invest in research and development (R&D) because they know that Microsoft will be able to limit the rewards from any resulting innovation; it impairs the ability of Microsoft's competitors to obtain financing for R&D; it inhibits Microsoft's competitors that have succeeded in developing promising innovations from effectively marketing them; it reduces the incentives of original equipment manufacturers (OEMs) to innovate and differentiate their products; and, finally, it reduces competition and thus the spur to innovation that competition provides (Ibid, 1998, p.16).

Many commentators dispute the DOJ conclusions regarding innovation including, not surprisingly, Microsoft Chairman and Chief Executive Officer Bill Gates. In an editorial published in the Wall Street Journal (reprinted in the Globe and Mail), Gates claims that by providing an integrated product, Microsoft is in fact encouraging innovation in the computer industry.[1] He argues that if antitrust authorities impose regulations on Microsoft, innovation would be negatively impacted in the following ways: consumers may never have access to future innovative products; independent software developers would be denied the ability to make use of the latest operating system technology; and consumers would be denied the opportunity to purchase innovative products that would enable them to download data from the internet into other Microsoft programs such as Word. He further alleges that the primary consequence of government intervention would be consumers abandoning Microsoft's products (in favor competitors' products) and, as a result, Microsoft, one of the most innovative software providers, would suffer greatly.

Both sides appear to agree that the primary concern of Microsoft's tactics should be on the effects that they have on innovation. However, as a result of the manner in which the 1998 DOJ Complaint was framed, the focus of the debate has centered around innovation in the operating system market as opposed to complementary software markets. Complementary software markets are important because hardware/software industries such as the computer industry exhibit network effects. In a network industry, there exists a positive relationship between consumers' welfare and the variety of software products that are compatible with the operating system. Consumers gain no utility from consuming the hardware component if no complementary software exists. In other words, by purchasing an operating system a consumer is essentially buying access to the benefits generated by consuming software goods (Church and Gandal, 1998, p.1). Since software variety is positively related to innovation, the manner in which a monopoly's strategy affects innovation in software markets should be of the utmost importance. As a result of the DOJ focus on the internet browser/operating system fight to become the industry standard, the debate has by in large ignored an extremely important facet of the case – the harm caused by tying to innovation in complementary software markets themselves.

[1] See Gates, W. "Microsoft is Defending its Right to Innovate." *Globe and Mail* A21: May 21, 1998. Please note that Gates does not provide specifics regarding the type of government regulation he is referring too.

This thesis focuses on the effects that a system sponsor's strategies have on complementary software producers' innovation incentives. It will be argued that Microsoft's strategies negatively affect innovation incentives in complementary software markets. Vertically splitting Microsoft into two separate companies, one developing and selling only software applications and the other operating systems, would improve innovation incentives in complementary markets.

This thesis is comprised of five chapters. Chapter Two outlines the theoretical tools that will be used throughout the thesis. It will be apparent that a dominant network firm has an incentive to increase the installed base, the total number of consumers of a particular good, for his product or decrease the installed base of his competitors' products. A large installed base may aid a firm in tipping a market in its favor which would lead to its product becoming the industry standard. In Chapter Two it will be shown that once a standard has emerged, a large installed base works as a barrier to entry in that market. In a hardware/software context, a dominant hardware producer has the incentive to extend his monopoly power to complementary software markets. One effective tool that can be used to implement this strategy is tying. It will be argued that if tying increases the concentration of a software market, innovation incentives in that market will be adversely effected.

In Chapter Three, the literature surrounding Microsoft will be outlined using the theoretical framework constructed in the second chapter. With respect to Microsoft, economists have focused on: the welfare implications of the strategies Microsoft used to achieve a dominant market share in the operating system; the welfare implications resulting from the strategies Microsoft employed to extend its monopoly to complementary markets; and finally, the potential remedies that the government could ultimately seek upon resolution of its ongoing legal battle with Microsoft and the resulting welfare effects. Using the economic theory to be developed in Chapter Two, it will be argued that Microsoft's tactics negatively effect innovation both in terms of static and dynamic welfare analysis.

In Chapter Four, the observation is made that in the computer software industry, many products are multi-product systems whereby the manufacturer of the primary hardware producer (system sponsor) can create a technological tie resulting in the exclusion of secondary product developers who produce add-on compatible products. In addition to operating systems, examples of primary software products include spreadsheet, word processing, integrated, personal finance, desktop, accounting and database programs. In each case, the primary product producer has the opportunity to bundle complementary software within its product resulting in the exclusion of complementary software producers. For instance, by bundling a spell checker within its word processor, a dominant word processor manufacturer is able to exclude third party spell checker producers. This observation allows us to test the hypothesis that when it is a dominant player in the primary market, Microsoft harms innovation by deterring entry in secondary software markets. A Poisson Model of per firm counts of new product introductions will test the hypothesis. Microsoft's market share in each primary market as measures for innovation in the secondary market and market dominance in the primary one respectively. The model estimates suggest that there exists a significant negative relationship between Microsoft's market share and innovation. Furthermore, they imply that innovation in secondary markets is all but completely stifled when the dominant firm's market share approaches one hundred percent in the primary market.

The final chapter summarizes the thesis. In addition, the implications of the results relating to the ongoing legal dispute between Microsoft and the DOJ are contemplated. Finally, an outline of the potential areas for further research is included.

CHAPTER TWO: THEORETICAL BACKGROUND

This chapter builds a theoretical framework that will be applied in the following chapters. Broadly speaking, the main theoretical argument outlined here is as follows: 1) operating system (hardware) and complementary software (software) markets are both network markets; 2) because network markets are prone to tipping, firms compete fiercely for the installed base before a standard emerges. At this stage, hardware firms wish to attract a large installed base of software in order to increase the attractiveness of their product to potential consumers; 3) once a dominant hardware firm emerges, that firm has the ability (through tying and predatory product innovation) and the incentive (increased profits) to dominate complementary product markets; 4) one of the most potent methods a dominant firm can use to leverage monopoly power into complementary markets is tying; 5) tying results in foreclosure of software firms and potentially an increasingly concentrated innovation market. In a network market, tying is extremely effective at excluding rivals because it allows the monopoly to tip the software market in her favor; 6) software producers will be leery to enter the market with an innovative new product and investors will be reluctant to provide potential entrants with capital because of the market dominance of the hardware firm.

In order to establish this argument, the theory behind network externalities, tying and innovation markets will be outlined. The theory of networks plays a significant role in hardware/software markets. It will be shown that in a network industry, building up an installed base is an important factor in determining the viability of a technology. Gaining an installed base lead can result in a firm monopolizing a particular network market. As a result, in markets where competing products are incompatible, rival firms battle intensely for the installed base.

After outlining the basic theory of network externalities, firm strategy in a network industry will be explored. Following Church and Ware (1998a, p.86), the abuse of a dominant position can be defined as predatory, exclusionary or anticompetitive behavior if it adversely affects actual or potential competitors and lowers social welfare. Firms use product preannouncements, penetration pricing and predatory product innovation as strategic tools to increase their relative installed base. An installed base lead increases the probability of monopolizing the network good and developing a standard. In a competitive hardware market, one would expect hardware producers to encourage the production of a wide variety of software. When applications software markets are characterized by increasing returns to scale, an increase in demand should induce innovative entry. However, once a firm monopolizes a hardware market, it profits from incorporating (tying) innovative ideas into its own products. Tying complementary products together can be a effective strategy for a hardware monopoly to extend market power to complementary software markets.

At one time, economists felt that tying was not a viable strategy for a profit maximizing firm unless it could be employed in conjunction with a price discrimination strategy. Furthermore, using static welfare analysis it was believed that tying could be welfare enhancing. However, it has recently been theorized that a monopoly hardware producer can increase her profits through foreclosure and this has shown to be an unambiguously welfare decrease in hardware/software markets. (Church and Gandal, 1998) Rather than using static welfare analysis, the concern of this thesis is on a dynamic analysis in an industry where innovation is the key driver to consumer benefits. Federal antitrust agencies such as the DOJ and United States Federal Trade Commission (FTC) use the concept of innovation markets in their antitrust analysis. An innovation market consists of all of the firms likely to enter into the market under consideration, regardless of whether they are currently producing in that market. This analysis requires antitrust authorities enforcement to determine the effect that a firm's actions have on the concentration of the innovation market. It is apparent that if tying deters entry, and thus increases the concentration in the primary hardware market, innovation will be adversely effected.

This chapter is broken down into five sections. The first section is an examination of basic network externality theory. Section Two explores the strategies that a network firm can employ in order to develop and maintain a monopoly in the hardware market. The third section illustrates how a monopoly extends market power to software markets via tying and predatory product innovation. It includes a discussion of the system sponsor's motives for and the static welfare effects of tying hardware with software. In the fourth section, some of the theory behind innovation markets is laid out. The final section summarizes the chapter.

2.1 NETWORK EXTERNALITIES

In a network industry, consumers gain utility as a result of being linked to each other by way of a network.[1] Consequently, consumption benefits depend on the number of people who join a particular network. A *network*, therefore, applies to the underlying economics of an industry rather than with the product itself. *Network effects* refer to the positive relationship that exists between the quality of a network good and the size of that network. Fax machines and word processors are both examples of network goods. The benefits an agent incurs from owning a fax machine are increasing with the installed base of firms and consumers who own compatible fax machines. Similarly, a word-processor increases in value if files can be shared with others.

Five basic concepts of network industries are important: 1) direct network externalities, 2) indirect network externalities, 3) positive feedback 4) tipping and, finally, 5) lock-in. Each of these concepts will be examined in turn. It will be shown that growing an installed base is a crucial element in a firm's quest to become the producer of the standard. Operating systems and software will be used as an example to illustrate the importance of network externalities. The section concludes with a discussion of Liebowitz and Margolis' (1994) influential critique of network externalities.

[1] Information on the basic theory of network externalities was compiled from the following sources: Bensen and Farrell (1994), Church and Gandal (1993), Church and Ware (1998b), Evans and Schmalensee (1996), Farrell and Saloner (1985;1986), Katz and Shapiro (1985;1994), Kristiansen (1995,1996), Lemley and McGowan (1998), Saloner (1990) and Shapiro (1996).

2.1.1 Direct Network Externalities

As mentioned above, increasing the installed base of a network good benefits every agent consuming that good. For a direct network good, an installed base can be defined as the number of people connected to a particular network. An externality arises in this context because agents do not consider the positive effects that they have on others when making the decision to connect to a particular network. Network externalities occur most *directly* when a product allows the consumer to interact or communicate with others who use the same product. Direct network externalities occur most frequently in communication industries - the classic example being a telephone system. Since a telephone is only valuable to an agent if he is able to communicate with others, his utility increases with an enlarging installed base. A direct externality arises in this context because a potential consumer does not consider the network benefits gained by others on the network when the adoption decision is made. Other examples of goods where direct network externalities are important include: fax machines, the internet, electronic mailing networks, modems, and any other communication system where benefits are derived from being connected to a network.

2.1.2 Indirect Networks

Not all networks require communication linkages and therefore, network externalities can also arise *indirectly*. For example, they are often present in goods that have components that work together in a system. Goods used in a system that are not directly linked to a network yet increase in value with the number of additional users are known as *indirect* network goods. The value of an individual component depends on the value of the system for which it is a part. In this case, the value of a durable (hardware) good is increasing in the variety of complementary compatible software (software). Market demand for software increases with the number of adopters of a compatible hardware component. When software production is characterized by increasing returns to scale and monopolistic competition, an increase in demand will induce new entry. The generation of a wider array of software variety creates this indirect network externality.

Given (1994) examines the VHS/Beta race to become the standard. He notes that video cassette recorders (VCRs) illustrate the notion of indirect network effects. As a greater number of people purchase VCRs, there will be an increase in the number of video rental stores that supply rental tapes. Unlike telephone networks, a combined system of a VCR (hardware) and a tape (software) will allow a consumer to gain utility regardless of the installed base. However, ceteris paribus, agents will favor a more popular VCR because the greater demand for tape rentals will lead to a greater variety.

2.1.3 Positive Feedback Effects

An important ramification of network effects springs from the fact that as customers join a network, it becomes more valuable for potential customers to join; all other things being equal, the larger the installed base, the easier the time a network firm has attracting new members. This is known as *positive feedback* - as customers join a particular network, less effort is required to attract additional customers, resulting in a larger installed base.

A potential consumer of a network good will not only base his adoption decision on the size of a network in the present but also on his expectations of its future size. In other words, he may not adopt a network today if he expects that the installed base will shrink in the future or, alternatively, he may join in anticipation of an installed base expansion. As a result of positive feedback effects, a large installed base today may signal potential adopters that the network's installed base will grow.

The combination of positive feedback effects and expectations translates into a self-fulfilling prophesy regarding which product will become a standard in a network industry. A product that is expected to fail (or succeed) will often meet consumer expectations. For example, in the United States in the 1980s, users decided that fax machines would be widely accepted and therefore have value. As a result of expectations, fax machines did gain acceptance. Similarly, a product can fail if it suffers from unfavorable expectations. Once the market was tipped in VHS's favor, for example, Beta may have lost the VCR race because consumers expected it to do so.

2.1.4 Tipping

A direct result of positive feedback effects is that a firm may be able to *tip* a network market in its favor. *Tipping* means that the joint existence of two incompatible products may be an unstable equilibrium and, consequently, a single product will eventually become the *de facto* industry standard. Therefore, if one firm can establish an initial or *first mover's advantage*, it might be able to gain market dominance by building up an initial installed base even in cases where a later-arriving superior technology exists. Since this first mover's advantage means that the first to establish a standard will reap the greatest share of the profits, firms compete aggressively in the initial development of a network good in order to build up an early installed base lead.

2.1.5 Lock-in

After a market is tipped, a monopoly persists for a long period of time because consumers of a network good become *locked into* a particular network. Often, they pay an initial sunk cost to join and, in order to switch to a new network, must forgo the initial sunk cost, pay additional costs of adoption and sacrifice installed based benefits of the original network. There are two important results that spring from lock-in. First, far sighted consumers will anticipate the adverse lock-in effects and realize that the switching costs may translate into market power for the chosen vendor. In other words, once monopolization is accomplished through tipping the market may become impenetrable to new entrants. Second, competing vendors will understand that present sales will lead to future profits and therefore price aggressively in the present.

2.1.6 Installed Base as a Barrier to Entry

All other things equal, being locked into a particular technology means that agents will not substitute a good that they currently use for an incompatible technology with a smaller installed base. As a result, a large installed base is a significant barrier to entry. Furthermore, a competing technology may not be able to displace the current one simply by offering a superior product at a lower price. In order to gain market inroads, an entrant must convince consumers that its product will replace the existing technology and provide comparable network benefits. Hence, fixed and sunk costs increase for potential entrants resulting in a significant barrier to entry for firms unable to produce compatible products. Potential entrants therefore may be extremely reluctant to compete in a network industry against an incumbent. For example, a consumer would likely not replace his fax machine with a fax machine with superior capabilities if the latter could only send faxes to tiny network of people. As a result, firms would be reluctant to produce fax machines which were incompatible with the standard.

2.1.7 Compatibility Between Competing Hardware Components

As mentioned above, a product's installed base and economic value are positively related. The ability of a firm to make its product compatible with rivals' products affects the size of the installed base and consequently the product's desirability. Therefore, in instances where two or more technologies are available, compatibility can affect a good's commercial viability and price. If firms choose to make compatible hardware products, all consumers are better off because: there will exist more software to choose from and it will be available at lower prices; software applications can be used in conjunction with different hardware; and, there will exist a greater amount of available service and support.

2.1.8 Compatibility Between Hardware and Software Components

In addition to deciding whether to make competing hardware products compatible, a system sponsor has the ability to determine which software products will be compatible with the hardware. The value of a hardware good increases with the variety of compatible complementary goods. An increase in the number of users of compatible hardware increases the market demand for compatible applications software. Because the value of a hardware component depends on the installed base of compatible software, compatibility between hardware and complementary software is an important determinant of the degree to which the software will succeed. All other things equal, in order to maximize sales, a software firm will require compatibility with the most popular (largest installed base) hardware component. If a hardware producer has a "closed" system, some software producers will not be able to benefit from the hardware's installed base. Since the success of the software is directly linked to the size of the hardware components' installed base, incompatibility can constitute a stiff entry barrier into the software market.

2.1.9 Network Effects: Operating Systems and Software

An operating system is a textbook case of an indirect network good. Because of increasing returns in software production, as the installed base for an operating system expands, the market will supply a wider variety and greater quantity of application products at lower prices. This springs from the fact that profit maximizing software producers will dedicate more resources to producing complementary software for the operating system with the greatest installed base. Furthermore, as the market size for a particular operating system increases, widespread technical support for the product will be generated. Hence, ceteris paribus, the operating system with the greatest installed base (variety of software applications) will be favored by consumers. For these reasons, an increase in the popularity of an operating system will attract complementary product investment and this will further increase its popularity (positive feedback).

Complementary computer software markets are also network markets. Following Menell (1998), there are three ways in which network effects can be generated in these markets: 1) through protocols, 2) through systems and 3) through computer human-interfaces and other output devices. First, network effects can be generated through protocols or other technical interface specifications which enable computers to communicate with one another and allow application programs to run on the specific operating system of a particular computer. For example communication software such as e-mailing programs would be worthless if computers were not connected.

A second way in which network effects can be generated is through systems such as command menus for structuring the use of an application program. It is important to computer users that software is relatively easy to use when they perform functions such as word processing, communication, playing video games or accessing information via the internet. Consumers internalize particular methods of performing tasks by using certain software. Examples of this include "cut and paste" for spreadsheet and word-processing software and a "search" button on virtually all internet software. Furthermore, common applications allow users to share data files with others across programs.

Finally, computer-human interfaces (such as screen displays) and other input-output devices (such as a keyboard) which enable the user to operate an application program effectively can also create network externalities in a variety of ways. Interfaces structure the ways in which data is written into a computer program. This effects technical compatibility (interoperability) as well as adoption costs in learning the operation of a program. As well, more popular interfaces benefit users to a greater extent than unpopular ones because they can be used in a larger number of places and across related programs.

The labor market can also be used to illustrate how indirect network externalities in complementary software can be created. Assume that there exists a network of people who are trained to use a particular word processor called *Words*. Firms who adopt *Words* want to employ people who are familiar with its interface and command menus because it reduces training costs. As it becomes known that being able to use *Words* is a marketable skill, an increasing number of employees learn to use it which increases their mobility between firms. As the employee pool of *Words* users increases, an increasing number of firms adopt it, further benefiting each firm on the network because they are able to exchange files with more firms. Indirect network externalities arise in this context as a result of reduced costs to firms and enhanced labor mobility springing from common or compatible software across different working environments as well as increasing effective communication through compatible file formats.

Shapiro (1996, pp.11-12) notes that the (failed) Microsoft/Intuit merger attempt illustrates the strength of network externalities in software markets. Home banking software consists of hardware and software communications services that have enhanced value when combined in a system. Like any network industry, the users of the system benefit from having additional users join - the electronic paying system is no different in that consumers, businesses and banks all benefit from belonging to a larger network. For these reasons, Horvitz (1996) argues that it is a predictable strategy for Microsoft to attempt to merge with a software firm who has proprietary rights over an innovative product with large installed base in the home banking market. Intuit's two main competitors in the Home Banking market, Microsoft and Computer Associates, found it extremely difficult to establish a new product that could successfully compete against Intuit's large installed base for Quicken. Computer Associates offered large numbers of copies of Simply Money at very low prices but was not able to make inroads against Quicken. Even with the natural advantages accrued to it by being the system sponsor, Microsoft felt that it had to merge with Intuit in order to control the market. Shapiro believes that the proposed merger was proof that Microsoft recognizes the benefits of a large installed base and the strength of network effects in the Home Banking software market.

2.1.10 A Critique of Network Externality Theory

Before discussing firm strategy, it is worthwhile to briefly outline Liebowitz and Margolis' (1994) influential critique of the network externality literature. Their claim is that private adoption decisions in network industries do not lead to social inefficiency. An externality, such as pollution, exists only when the realized benefits or costs are imposed outside of the market mechanism. Non-market mechanisms such as property rights, private negotiations or government intervention are needed in order to resolve the externality. They assert that indirect network externalities are simply instances of pecuniary externalities, external effects that work through the price system and therefore are "not an externality in the modern sense." (p.139) Furthermore, they argue that it is difficult to determine the cause of the negative relationship between software prices and network size. This relationship could arise from technological network externalities, cheaper inputs or decreased rents. They maintain that without determining causation, public policy cannot be properly prescribed.

Church, Gandal and Krause (1999) develop a model which refutes the Liebowitz-Margolis critique. Rather than focusing on whether the optimal technology was adopted in the market equilibrium, they demonstrate that network effects are present in hardware/software markets and the size of market networks is sub-optimal. The rationale for their conclusions is derived from the fact that hardware/software markets display increasing returns to scale in the production of software. In this case, the private benefit of the marginal hardware purchaser who sets profits to zero is less than the social benefit because he does not internalize the welfare improving response (more varieties at lower prices) of the software industry on infra-marginal producers who earn positive profits if the last firm does not enter when the market for hardware expands. As a result, network effects present in hardware/software markets are a true externality, with an implied welfare loss, and hence, not merely pecuniary.[2]

2.2 FIRM STRATEGY: COMPETING FOR INSTALLED BASE

As shown in the previous section, installed base considerations are extremely important for network firms. Before a standard is set, firms must convince consumers that the size of their installed base will dominate those of its rivals. Therefore, they engage in strategies which influence expectations of the size of their relative installed base. Some of the installed base altering weapons that a firm has in its arsenal include: product preannouncements, penetration pricing and incompatibility. In an industry with competing products, these

[2] Sheremata (1997, p.957) notes that another problem with the Liebowitz and Margolis critique is that it discounts switching costs, intertemporal and learning effects, and empirical support for network externality theory.

weapons may be implemented in such a way that a firm's product becomes the *de facto* standard. This section outlines strategies that a firm may employ to improve its chances of rising to market dominance.

2.2.1 Product Preannouncements

As noted above, ceteris paribus, consumers prefer a technology with a larger installed base. Farrell and Saloner (1986) argue that one manner in which a firm is able to influence consumers' expectations is by convincing them that their installed base will be larger in the future than their rivals' by using *product preannouncements*. On one level, a product preannouncement informs consumers about the future availability and features of a particular product. On another level, they discourage existing customers from switching to a rival supplier and encourage those intending to adopt the new technology to delay. Product preannouncements therefore encourage consumers to "sit on the fence" until they are able to join the network of the preannounced product. Using Farrell and Saloner's (1986) terminology, when firms adopt a new technology they "jump on the bandwagon" and when they stay with the current technology, they "sit on the fence." In the case of a preannounced product, consumers do not know product quality until it is available. As a result, they are less likely to purchase a rival firm's currently available product, even if a rival firm's product is technology superior to the announced good. Consequently, the timing of the announcement of a new incompatible product can effect the likelihood that a new product will displace the existing technology.

2.2.2 Penetration and Predatory Pricing

Like product preannouncements, *penetration pricing* is a strategy employed in the early stages of a product cycle in order to develop a large relative installed base.[3] Strategically lowering the price increases their respective installed base. In some cases, firms may lower their price below the short run

[3] The section on penetration and predatory pricing in network industries is comprised of information obtained from Church and Ware (1998b), Katz and Shapiro (1986) and Rubinfeld (1998).

profit maximizing level knowing that an increased installed base is the key to tipping the market and gaining market power. Once a firm's product becomes the standard, it can raise prices and use its installed base to deter entry. Examples of penetration pricing to build up an installed base include Microsoft and Netscape's free distribution of their respective web browsers, Internet Explorer and Navigator.

2.2.3 Compatibility

Compatibility may be crucial in determining the viability of a good when products compete to become the standard. Three strategies firms may employ in network industries are: attempting to join existing networks, establishing new networks and enforcing and maintaining incompatibility (Shapiro, 1996, p.5). Dominant firms who have a greater installed base want to make their product incompatible to prevent rivals from building up an installed base. Because network industries can be tipped, a dominant firm will choose incompatibility in an attempt to eliminate competition. Similarly, if there exists two emerging firms and both firms wish to be the standard, they would not choose product compatibility with rivals. Katz and Shapiro (1985) argue that only in cases where firms exhibit similar technologies and neither firm is likely going to develop a monopoly will compatibility be likely.

2.3 COMPETITION FOR COMPLEMENTARY SOFTWARE MARKETS

The focus of this thesis is on hardware/software markets. Hardware markets are the markets in which the original good is sold.[4] With respect to Microsoft, the primary market would be the operating system market. An aftermarket or software market is the market for a good or service used in conjunction with the original equipment, but is sold only after the purchase of the original equipment. The market for software that operates on Microsoft's operating system is an example of an aftermarket. Because an installed base works as a barrier to entry, once a standard is established it is difficult for an

[4] In this thesis, hardware and software products will be referred to as primary and secondary.

alternative technology to displace it. As a result, strategic network considerations become important in software or secondary markets.

A system sponsor has a natural advantage in complementary markets because it controls the hardware (interface or operating system) component. A system sponsor's profit maximizing strategy may be to tie or use predatory product innovation which has the effect of excluding rival software producers from the market. Predatory product innovation occurs when a system sponsor modifies the hardware good in such a way that software products become incompatible. A tying arrangement is one where, as a condition to the sale of one product, the seller requires the buyer to purchase a second product from him.

Antitrust authorities believe that competition in markets for complementary products should be based on the merits of the products themselves and not be diminished by a dominant firm's strategic behavior. As shown above, if a software market is tipped in the favor of a particular firm, it is likely that it will monopolize it. Therefore, as Farrell and Katz (1998, p.2) note, when tipping is likely, predatory practices that disadvantage a rival should be of more concern than usual because the recoupment of costs incurred in a predatory campaign may be easier. Church and Ware (1998b) note that these practices may harm innovation in the complementary product markets. This section outlines tying and predatory product innovation strategies which a system sponsor employs in order to leverage its monopoly into software markets.

2.3.1 Predatory Product Innovation

Predatory product innovation is a strategy that a system sponsor can practice in order to close out producers of complementary products and maintain incompatibility (Church and Ware, 1998b, pp.54-58). Such a strategy can be employed by introducing incompatibility codes into a particular system with the intent to undermine rivals' application programs or peripheral products. For example, Intel has been accused of changing its CPU architecture for the 386 laptop SX chips which effectively excluded third party computer chip producers. Soon after releasing its 386 SX chip (hardware), Intel became the *de facto* industry standard. Makers of support chips and PC boards built sub-systems (software) to be compatible with the SX. Competitors such as Cyrix and AMD came out with clone chips that began to win some of Intel's market share. Makers of laptops were able to install clone chips because they had identical configurations as the SX. When Intel produced its 386 SL for portables the following year the pin configuration changed. As a result of this predatory product innovation, competing chips were no longer compatible with new laptops (Chang, 1994, p.20).

2.3.2 Tying

Tying is a second exclusionary strategy that a system sponsor can employ. There are three ways in which a firm can implement a tie-in: 1) through contracts where tying is made explicit; 2) through a technological tie; 3) or through *de facto* bundling where the standard is not offered as a second product (Church and Ware, 1998b, p.53). The first case transpires when a firm explicitly ties technical support to the initial purchase of a good in the primary market by providing a warranty (or contract) with each purchaser of the firm's good. A warranty essentially ties the initial purchase of a good with the potential aftermarket repairs of that good (Shapiro, 1995, p.488). Examples of *technological tying* include the Nintendo and Sega video game suppliers who, in order to prevent competing firms from producing software for their respective systems, used lock-out technology causing compatibility problems for the video games of non-authorized suppliers. The final type of tying, ***bundling***, occurs when a dominant firm sells its monopoly product together with a version of a complementary product at a single price (that is less than the sum of the products sold individually). When products are bundled together, they can no longer be purchased separately (Rubinfeld, 1998a, p.22-25). Microsoft's bundling of Internet Explorer with Windows 98 is an example where the operating system standard is not offered as a separate product. Internet Explorer is offered as a separate product which can run on non-Windows operating systems but Windows 98 has Internet Explorer bundled within it. A special case of bundling is integration. Two products are integrated when neither product can function as a stand-alone. Examples of integrated products are spark plugs and an automobile engine. An operating system and an internet browser are not integrated products since the operating system can function without have a browser bundled within it.

The classical antitrust concern of a tie-in is that it enables a monopoly to lever his way into a position of dominance in other markets giving it an opportunity to exploit the installed base.[5] One key element of a tie-in is the existence of switching costs due to sunk costs that consumers must incur. In other words, if consumers decide to switch brands, at least some of the expenditures made on the initial component will be lost (Shapiro, 1995, 486). It is therefore possible for a firm to tie two goods together causing rivals to exit and then exploit its installed base by substantially raising prices enabling it to earn abnormally high aftermarket profits.[6]

In the 1970s, Chicago school economists such as Posner (1976), Bork (1978) or Blair and Kaserman (1985) argue against this notion claiming that tying would not exclude firms nor would it be harmful in terms of welfare. In order to illustrate this argument, assume that there exist two complementary goods that are tied together in a system. Following Ordover, Sykes and Willig (1985), a monopoly produces good A_I at a marginal cost of c in the primary market and, in the aftermarket, produces B_I at a minimum cost of a_{BI}. Assume that the complementary good is competitively supplied by N firms including the monopoly and let B_c ($B_c = B_2+B_3+B_4...B_N$) be the total sales of the complementary good excluding B_I. If a consumer's willingness to pay for a system is b then the monopoly could bundle A_I and B_I into a system (A_I/B_I) and earn a maximum profit of b-(c+a_{BI}). Alternately, the monopoly could set p_{AI}, the price of A_I, to (b-a_{BI}) and produce B_I competitively at cost. In this scenario, the monopoly would again earn b-(c+a_{BI}). Hence the monopoly has no incentive to engage in

[5] For the purpose of this thesis, only tying cases where a dominant firm exists in the primary market and ties his product to another in the aftermarket (regardless of the market structure) are considered. However, a large economic literature exists examining the case where both the primary and secondary market are competitive. See Chen et al (1998, pp.136-141) and Shapiro (1995) for a discussion of those theories.

anticompetitive behavior because this "perfect price squeeze" allows it to earn the maximum possible profit per system if it decides to tie or not.[7]

According to the Chicago view, "in the absence of discrimination, a monopoly will obtain no additional profits from monopolizing a complementary product." (Posner, 1976, p.173) In addition to price discrimination however, a system sponsor may find tying to be a profitable strategy if she is able to foreclose on competition in the complementary goods market. Therefore, the theory behind tying with respect to price discrimination and foreclosure will be examined in turn.

Price discrimination is a motive for using tie-ins because it allows a firm to exploit more fully its market power and thus increase profits. In order to illustrate this argument, assume that due to a patent, firm 1 has monopoly power for good A in the primary market. Following Church and Ware (1998b), there are no stand alone benefits of consuming A for any consumer and therefore the monopoly essentially sells access to the benefits gained by consuming good B. Component B is competitively supplied at a marginal cost of c_B. In the complementary goods market, there exists two types of consumers: n_h "high" consumers and n_l "low" consumers and n equals $n_h + n_l$. The high consumers demand a greater quantity of B than the low consumers for any price, p_b. Without tying, the monopoly cannot distinguish between the high and low consumers and therefore has two choices. She can sell component A for $CS_l(c_b)$ where $CS_l(c_b)$ is the consumer surplus that the low consumers realize from optimally consuming component B when its price is c_B. In this case the monopoly earns a profit of $nCS_l(c_b)$. Alternatively, the monopoly could raise the price of A to $CS_h(c_B)$, sell only to high consumers and earn a profit of $n_hCS_h(c_B)$.

However, the monopoly can increase profits if she is able to tie A_l and B_l together. By tying, she will be able price discriminate between low and high consumers in the secondary market based on their intensity of use for component

[6] This is known as the "Surprise Theory." See Shapiro (1995, p.487) or Chen et al. (1998, pp.137-8) for details.

B and thus, increase her profits.[8] Tying A and B together allows the system sponsor to gain monopoly power in market B. The monopoly is now able to raise p_B above MC to p_B^* and set p_A equal to $CS_l(p_B^*)$. By metering sales the monopoly is able to distinguish between the high and low consumers. As a result, she may charge a higher price for a higher quantity of B_l demanded by each consumer. Price discrimination is effective because consumers have no other alternatives but to purchase B_l from the monopoly. In other words, tying "represents a way to charge the high-intensity, higher-value users more." (Chen et al., 1998, p.140)

In the price discrimination case, the welfare implications of a tie-in are ambiguous. If the monopoly was serving both groups prior to the tie, welfare is reduced because the price of B is raised above its marginal cost ($p_B^* > c_B$). Alternatively, the tie increases welfare if the monopoly was only serving the high types before the tie. In this case, welfare increases because consumption of the system is extended to the low types (Church and Ware, 1998b, p.62).

Greenstein (1990) extends the price discrimination theory as an incentive to tie. He considers the incentives for, and effects of, interface alterations by a system sponsor in order to render components supplied by competing suppliers incompatible. If imitation is not instantaneous, a monopoly has an incentive to periodically redesign the interface, which essentially disenfranchises competing suppliers of complementary products. Interface alterations give the system sponsor a temporary monopoly that will last until rivals can regain compatibility through reverse engineering. Using this monopoly, the system sponsor is able to use price discrimination in order to increase her profits. However, the system sponsor may not alter its interface if it benefits from backward compatibility. Backward compatibility means that compatible software for previous interfaces are compatible with the new interface. Reverse engineering in this context means that a firm must create technical compatibility between its software product and a rival's hardware product without the help of the rival. Due to network effects,

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[7] If a competitive firm B produces B_2 at a cost of a_{B2} and firm B is the lowest cost producer of good 2, ($a_{B2}<a_{bi}$ where i = 1 to N) then the monopoly will maximize his profit by bundling A_l with B_2. In this case, the monopoly's maximum profit will be b-(c+a_{B2}).

maintaining compatibility with an installed base of complementary products benefits the system sponsor and therefore may mitigate the incentives of the firm to redesign its interface. If the interface alteration is an improvement over the former system, consumers may nevertheless switch to the new design even if the installed base shrinks. Greenstein argues that, as a result of these improvements it is difficult to distinguish legitimate interface alterations from predatory product innovation.

Whinston (1990) shows that foreclosure is a motive for tying besides price discrimination - complementary goods suppliers exit as a result of the system sponsor's decisions. In order to illustrate this argument, assume that there exists an uniformly inferior competitively supplied component good, denoted as A_2. The existence of A_2 constrains firm 1's equilibrium pricing and profits and therefore, it would be in firm 1's best interest to have firm 2 exit the market. If firm 1 can make a credible commitment to tie A_1 and B_1 into a system (A_1/B_1), it can only gain its profits from A_1 if it also sells B_1. By lowering the price of B_1, sales of A_1 increase and sales of both A_2 and B_c decrease. Tying and aggressive pricing in the secondary market may cause rival firms producing B_c to exit and, as a result, would also lead to firm 2 exiting the primary market. Since A and B are complements, if no B is available for A, firms producing A must exit the market. Once the monopoly forecloses the secondary market, it can raise the price of the formerly competitively supplied good thereby increasing profits.

If firm 1 does exclude firm 2 in this manner, all consumers are made worse off although welfare may rise or fall (Whinston, 1990, p.855). Welfare increases because of the fixed costs savings and consumption by all consumers of the preferred A component. However, it decreases as long as some consumers who prefer B_1 must now consume B_2.

DeGraba (1997) argues that increasing market share rather than changing market structure may be a motive for a firm to tie complementary products; foreclosure will still be the end result. Assume again that firm 1 has monopoly

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[8] See Posner (1976) and Chen et al. (1998, p.139-40) for further details on the 'price discrimination' theory as a rationale to tie.

power in the primary market but now the secondary market is characterized by a zero profit rather than perfectly competitive equilibrium. A direct result of a zero profit equilibrium is that each seller must incur a fixed setup cost F and a constant marginal cost c. Tying does not effect P_s, the price of the complementary good, because total output stays constant; only the distribution of output between the firms changes. In a zero profit equilibrium, since $F > 0$, $P_s > c$ and each unit of B_1 is sold at a positive profit margin. By tying B_1 with A_1, firm 1 increases its sales of B_1 and its competitors exit the market. As a result, firm 1 earns an additional $P_s - c$ on every bundled unit sold, increases its profits and, therefore, has an incentive to tie the complementary products together. In this case, tying results in a reduction in the number of homogeneous goods producers and thus welfare increases.

Church and Gandal (1998) examine the possibility of foreclosure in markets where the final good consists of a system composed of a hardware good and complementary software and the value of the system depends on the availability of software. They find that foreclosure is an effective strategy to monopolize the hardware market. An equilibrium outcome occurs when both the merger and compatibility decisions are part of a multistage game permitting the foreclosed hardware firm to engage in several counter-strategies. To illustrate their argument, assume that a monopoly hardware producer vertically integrates with a software producer. Firm 1, the monopolist, is faced with the choice between making its software, B_1, compatible with both A_1 and A_2 or only with A_1. Foreclosure occurs when an integrated firm makes its software incompatible with the alternative hardware and therefore ties A_1 and B_1 together. Assume that there is no retaliation by the second hardware firm. Firm 2's retaliation strategies, such as merging with a software firm and providing the market with a competing system, could be unprofitable if it expected a bidding war in the hardware market. As a result of the tie-in, the demand for A_1 will increase relative to A_2 because a larger variety of software can be used in conjunction with A_1. Tying is exclusionary since the smaller relative installed base of the foreclosed firm reduces its demand and market size. Firm 1's profitability of foreclosure depends on the trade off between lost software profits (from not supplying the competing system) and increased hardware profits (from the increase in demand). Foreclosure is always profitable and results in monopolization and standardization when the extent of product differentiation is insignificant; the foreclosing firm does not forgo any software profits (since no consumers purchase the competing system) resulting in an increase in hardware market share and in the price of hardware.

Using static welfare analysis, welfare is unambiguously decreased in this case because consumers have fewer software applications to chose from and those who value a greater variety of software may switch to A_1 even if they prefer A_2. The following section will outline some of the dynamic welfare implications.

2.4 INNOVATION AND INNOVATION MARKETS

In the previous section, exclusionary practices that a system sponsor can employ were outlined. This section looks at the dynamic effects resulting from foreclosure due to a system sponsor's decision to tie. Chicago school economists such as Posner (1976) argue that innovation is enhanced as a result of tying. It will be argued here that tying is not an effective method of encouraging innovation in software markets. Rather, using innovation market analysis, it will be shown that if tying excludes innovators of a particular software good, the innovation market can become more concentrated resulting in a reduction of innovation. Exclusion also reduces third-party software producers' innovation incentives and venture capitalists desire to invest in them.

2.4.1 Innovation Markets

On April 6, 1995, the DOJ and FTC issued the Antitrust Guidelines for the Licensing of Intellectual Property (IP Guidelines). These guidelines discuss more than just licensing issues – they consider merger analysis under Section 7 of the Clayton Act, addressing what the agencies called a "separate innovation market." The innovation market consists of

> the research and development directed to a particular new or improved goods or processes, and the close substitutes for that research and development efforts, technologies, and goods that significantly constrain the exercise of market power with respect to the relevant research and development, for example by limiting the ability and incentive of a hypothetical monopoly to retard the pace of research and development (I.P. Guidelines, 1995, p.11).

The innovation market is "separate" from the goods market. Although the goods market may appear to be competitive, the market for innovation may in fact be highly concentrated.

The basic premise of innovation market theory is that a less concentrated innovation market will result in greater quantity of innovation - if more than one firm undertakes research and development there is enhanced potential for an innovation that might not otherwise be discovered and produced. In other words, a highly concentrated innovation market is less conducive to innovation than a competitive one. For example, two parties involved in an acquisition (buyer and seller) may be doing R&D aimed at strengthening their competitive position against each other. If the acquisition goes through, the firm may shut down one (or perhaps both) of the pre-merger R&D tracks. The result may be that potential good new products or savings in production costs never reach the market.

The key concern of innovation market analysis is that a reduction in the number of independent R&D paths could lead to a slackening of the efforts to develop new products. If the merged firm has a large share of relevant R&D and faces little threat from new entry, antitrust enforcement may not allow the merger to go through. However, a merged firm will likely lower costs by reducing R&D staff and expenditures on R&D in order to eliminate overlap. Antitrust authorities must examine this trade-off by searching for evidence that the merged firm's R&D goals are intended to provide successful new products or cost savings which will benefit consumers. A firm would likely maintain these goals if the innovation market is competitive.

Rubinfeld (1998a, p.17) argues that an understanding of all of the dimensions of competition in a dynamic network industry is a vital part of sound antitrust policy because it may advance consumer welfare. Innovation market theory was created because traditional methodology ignored the effects that mergers have on technological change in an industry, future competition and market power.[9] In the past, agencies have focused on the price effects of potentially anticompetitive behavior and attempted to identify market power consistent with profit maximizing in a static oligopoly model. However, this methodology ignores the merger's effect on technological change in the industry and hence its effect on future competition and market power. Innovation markets analysis, on the other hand, has expanded the antitrust agencies' ability to examine dynamic industries and make sound policy. It allows them to examine not only the prices that consumers pay for given products but the quality of products in the marketplace and whether dramatically new and better products will come into existence. Higher quality products being offered at lower prices to consumers in the future comes directly from innovation. In order to examine the effects of firm strategy on innovation, agencies (using innovation market theory) are able render their decisions on sound evidentiary evidence.[10]

2.4.2 Critique of Innovation Markets

As mentioned above, the innovation market concept is not without controversy. Hoerner (1995), for example, believes that innovation markets are a method to broaden the ability of the DOJ and FTC to attack nonhorizontal and nonvertical mergers rather than to prevent anticompetitive behavior.[11] His primary criticism is that the innovation "market" is not a market at all because there are no buy/sell transactions. He defines market power as "the ability to raise prices and to sustain that price increase for a meaningful period" (Hoerner, 1995, p.51). Without price data or buy/sell transactions, Hoerner contends that anticompetitive behavior cannot be identified in an innovation market context. A broader criticism of innovation markets is that innovation shares are difficult to

[9] The sections on the rationale and theory of innovation markets were compiled from the following sources: Church and Ware (1999, pp.611-613), Dunlap (1995), Gilbert (1995), Gilbert and Sunshine (1995), Hoerner (1995), Ordover and Willig (1995), Varney (1995) and Weiner (1995).
[10] The antitrust authorities gather evidence on R&D, market shares and concentrations, entry accessibility and the history of firms' behavior with respect to innovation.

assess because information concerning the market is difficult to locate. Finally, Hoerner argues that a decrease in R&D does not necessarily equate to a decrease in innovation. These criticisms will be analyzed in turn.

Hoerner is concerned with the semantics of the term "innovation market." Even though there are no buy/sell transactions in an innovation market, antitrust authorities have a role to play in ensuring that competition among innovators is not reduced. He equates the ability to raise and sustain prices with anticompetitive behavior. Because there exists no price data for an innovation market, there is no ability to ask hypothetical questions regarding the substitutes available to avoid an increase in price. Rather than being concerned solely with price, however, antitrust authorities should concentrate on any tactic used by a dominant firm which effects actual or potential rivals and lowers social welfare (Church and Ware, 1998a, p.86). In this context, the innovation market concept is valid because, unlike Hoerner's definition, consumers may be harmed by firm strategy which increases the concentration of the innovation market.

A criticism of innovation market theory is that information is not available to render sound decisions. However, determining the exact parameters of a relevant product market without hard quantitative information is not a problem unique to innovation markets. Varney (1995, pp.16-17) argues that often in an existing goods market, the data may be limited to qualitative information. However, it has also been argued that qualitative information on innovation markets is difficult to collect. Contrary to this argument, both the FTC and DOJ have found that it is often surprisingly easy for the government to obtain information regarding the nature of specialised research and the availability of close substitutes. Information concerning R&D can be found in a variety of ways. Innovation is often driven by demand - therefore, there may be organised efforts by downstream buyers to press upstream manufacturers to engage in R&D of new products. Also intellectual property (IP) assets such as patents are publicly available. Patents not only disclose who is in the innovation market but can also

[11] **Rapp (1995) and Hay (1995) provide other critiques of innovation market analysis. Gilbert and Sunshine (1995) provide a brief rebuttal of these critiques.**

tell a great deal about the research path that the particular innovator is taking. Finally, firms publicise their research in order to drum up demand for future products. Consumer interest may also assist a firm in generating financial backing for a research project.

Hoerner argues that a reduction in R&D does not necessarily equate to a decrease in innovation because the firms combine their intellectual resources. However, in their example of innovation markets, the IP Guidelines identify a hypothetical monopoly with two traits: the ability to retard the pace of R&D coupled *with the incentive to do so* (IP Guidelines 3.2.3). Therefore, in determining whether a unilateral effect is probable in such an instance, the past behavior of firms may help. If, for example, a researching firm has a history of acquiring competitors who have innovative and seemingly successful research projects and then terminating those projects, it may be likely to do so again.

2.4.3 Tying, Predatory Product Innovation and Innovation

Because a system sponsor has proprietary control over the hardware component, it has the ability to tie a software component with the hardware. Furthermore, it has the ability to use predatory product innovation to exclude software rivals from the market. These strategies have the effect of excluding rivals from software markets.

Shapiro (1996) argues that there may be less incentive on the part of the dominant firm's rivals to expend the R&D funds necessary to win the dynamic competition for the market if they anticipate that the dominant firm may tie, since the likelihood of a successful effort will be small. If the monopoly firm historically expropriates innovations from software firms and then excludes them from the market through tying and predatory product innovation, firms may conclude that the private benefits of the innovation do not exceed the costs and not develop their idea. Furthermore, venture capitalists may be hesitant to provide funding for a project with a limited probability of success. For these reasons, the incentives for innovation are reduced when a system sponsor is able to tie or employ predatory product innovation. Church and Ware (1998b) argue that welfare is harmed under these circumstances if the social benefits exceed the social costs of the production of an innovation and it is not produced either because a private firm is unable to get sufficient venture capital or his private costs exceed his benefits.

Innovation market analysis was designed to examine antitrust concerns with respect to mergers, joint ventures, and acquisitions. However, Kattan (1995, p.15) argues that it is expanding and "courts may well require the antitrust agencies to adhere to the IP Guidelines in analysing tying of goods or services, as they have done in the merger context." We have seen that a system sponsor forecloses on competition in the aftermarket where she implements a tying strategy. Assuming that the innovation market is comprised of the foreclosed firms, tying would increase the concentration of the innovation market leading to a reduction of innovation. Rubinfeld (1998b) argues that a dominant firm may discourage complementary market innovation in order to ensure that it maintains its dominant position in the hardware market.

> The dominant firm can for predatory reasons make the innovations of competitors unprofitable - in a variety of ways. First, it can calculate the maximum price consumers would be willing to pay for a 'system' comprised of its product and that of the newly developed complement and charge consumers enough for its monopolised component that the innovator to earn a reasonable return. Second, the dominant firm can make it clear that its product is or will be designed so as to be incompatible with the innovator's product. Third, it can discourage the innovator by offering or making plans to offer a close substitute for the competitor's innovative product at a 'predatory price.' Finally, by threatening to integrate its dominant product together with its (perhaps somewhat late-to-market) version of the innovator's product, the monopolist may be able to uniquely avail itself of the ubiquity in distribution – making the success of the innovator's product unlikely. (p.867-8)

In other words, the monopoly firm discourages competitor's innovations that might threaten its current market position. Saloner (1990) notes that a system sponsor may be required to provide technical information concerning the interface in order for third party software producers to manufacture compatible products. With this technical information, there exists a risk that rivals may create their own version of the hardware component. In other words, the system sponsor risks losing its installed base advantage and market position in the hardware market. As a result, they may decide to keep the interface closed through predatory product innovation which reduces innovation in software markets.

2.5 SUMMARY

This chapter examined the theory of networks, tying and innovation markets. By examining network externality theory a framework has been constructed in order to examine the economic literature surrounding Microsoft in the following chapter. In this chapter, it was argued that competition in indirect network markets can be broken up into two distinct time periods. In the first period of competition, firms spar for the installed base in the operating system (hardware) market and eventually, a dominant hardware standard emerges. In the second period, the system sponsor leverages its market power in hardware to complementary software markets. Tying and predatory product innovation reduce the likelihood that rivals will be successful in software markets if it chooses not to tie. As a result, (software) innovation markets become more concentrated, third party software producers' innovation incentives are reduced and venture capitalists are less likely to invest in potential software entrants who wish to develop novel products and enter an applications market.

CHAPTER THREE: MICROSOFT

This chapter provides an overview of the issues in the existing literature on Microsoft. The literature can be divided into three general categories: 1) economic analysis of Microsoft's strategies and tactics used when it competed for operating system dominance; 2) strategies used by Microsoft to expand its monopoly power to complementary markets; and finally, 3) antitrust remedies available to the DOJ. The literature examining the strategies employed by Microsoft to achieve dominance in the operating system market grew from analyses of the original DOJ Complaint against Microsoft (DOJ,1994). Examples include Baseman, Warren-Bolton and Woroch (BWW) (1995), Levinson (1995), Levy (1997) and Lopatka and Page (1995). The focus of this category is on the specific strategies employed by Microsoft including: product preannouncements (vaporware), central processing unit (CPU) licensing, non-disclosure agreements (NDAs) and predatory product innovation. These strategies helped Microsoft expand its MS-Windows (Windows) relative installed base which enabled it to tip the operating system market. This first category of literature has three main drawbacks. First, it relies mainly on static welfare analysis to evaluate the effects that Microsoft's tactics have on social welfare and tends to ignore the dynamic nature of the software industry and, thus, the importance of innovation. Second, network externalities are often discounted. Finally, the focus tends to be on the operating system market while complementary markets are generally ignored.

With the advent of the most recent antitrust case against Microsoft, the focus of the literature has shifted away from competition in the market for operating systems to complementary software markets and specifically, the internet browser market. Examples include Fisher (1998), Hall and Hall (1998), Rubinfeld (1998b), Schmalensee (1998), Sibley (1998) and Teece and Coleman (1998) who examine such strategies as predatory pricing, exclusionary agreements, predatory product innovation and tying. By the time the DOJ released its most recent Complaint against Microsoft, the importance of network externalities and innovation in this industry was well recognized. Despite the recognition of the importance of innovation, however, this category of literature is primarily concerned with static rather than dynamic welfare implications of Microsoft's strategy. Both static and dynamic welfare effects of Microsoft's strategies will be outlined here.

The third category of economic literature examines potential remedies the DOJ may pursue if it is successful in its current legal battle with Microsoft. This category includes: Hall and Hall (1998), Lemley and McGowan (1998), Economides (1999), and Rubinfeld (1998). Potential remedies that have been discussed are: conduct restrictions on Microsoft, forcing Microsoft to give away or license its Windows source code, breaking Microsoft into two separate firms and not implementing a remedy at all. It will be argued that the most appropriate remedy is to divide Microsoft into two separate firms – one firm specializing in operating systems and the other on application software.

This chapter is divided into four sections. Section One outlines the strategies that Microsoft employed in its quest to dominate the operating system market and the consequent welfare effects of those strategies. The second section examines the strategies it has used to leverage its monopoly power into complementary software markets. The third section looks at potential remedies that the U.S. government could impose on Microsoft and the final section summarizes the chapter.

3.1 STRATEGIES VIS-A-VIS NEW INTEL SYSTEM

In Chapter Two, it was argued that a firm competing in a network industry has the incentive to increase its relative installed base in order to tip the product market in its favor leading to the acquisition of market power in the market for operating systems. Once a dominant firm emerges, it attempts to prevent rivals in the operating system market from building an installed base. Microsoft's actions will be compared to the tactics one would expect a competitor in a network industry would employ. It will be apparent that Microsoft's primary rationale for using product preannouncements (vaporware), CPU licensing, NDAs and incompatibility was to increase its relative installed base in order to tip the market in its favor. These tactics aided Windows to develop into the industry standard operating system.

3.1.1 Vaporware

Farrell and Saloner (1986) argue that firms making truthful product preannouncements can discourage existing consumers from switching to rival products. However, it is also possible for a firm to make false claims concerning the release date and capabilities of a future product. In terms of computer software, false product preannouncements are known as 'vaporware.' Levy (p.33) defines vaporware as software that is not available to the public at a previously announced date or does not possess certain features or capabilities promised when the software was announced to the public.[1] As a result of vaporware, consumers influenced by the announcement will delay their purchasing decision, rather than obtaining a rival's good. In other words, they alter their buying decisions in favor of the as yet to be released product. Rivals' currently available products therefore gain a smaller market share than they would have otherwise and research efforts by rivals may be discouraged (Menell, 1998, p.25). Hence, in markets characterized by network externalities, firms are able to tip the market in their favor and increase market power through the use of vaporware.

Microsoft has been accused of employing the practice of vaporware for both its MS-DOS and Windows 95. In 1990, DR-DOS 5.0, a competing Intel-based operating system was released on the market and gained ten percent of the operating systems market. Following the introduction of DR-DOS 5.0, Microsoft preannounced an upgrade of MS-DOS, MS-DOS 5.0, that included many of the advantages of DR-DOS 5.0. However, it only began selling MS-DOS 5.0 one full year after its announcement. At the same time it introduced Windows 3.0 and the

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[1] Please note that vaporware has to do with announcements to the public and not to other firms. Lopatka and Page (1995, pp.360-1) argue that Microsoft is in a "damned if you do, damned if you don't" position because it is accused of withholding information to firms such as beta versions of its software and at the same time providing advanced false information to the public. However, no dichotomy exists here due to the different parties to which Microsoft announces.

significantly enhanced Windows 3.1. In 1994, Novell withdrew DR-DOS 5.0 from the market after its sales began to fall (Lopatka and Page, p.323).

Microsoft was also accused of using vaporware when it announced the capabilities and release date for Windows 95. Windows 95 was announced for delivery in mid-1994 but was actually delivered in August 1995. Additionally, it was expected to work well on any PC with a 80386 processor and four megabytes of RAM, but in reality a Pentium processor is required to take full advantage of some of the programs features (Levy, p.35). The practice of vaporware could have therefore theoretically tipped the market irreversibly toward a Microsoft operating system standard.

Some critics of antitrust action against Microsoft believe that vaporware does not merit antitrust scrutiny. Levy models a case where a firm's false announcements negatively effects its reputation. He finds that if "consumers are susceptible to at most one false announcement then making repeated false announcements will have little effect" (p.42) and therefore concludes that it is unlikely that firms have an incentive to issue false product preannouncements. Furthermore, he argues that firms can make honest errors in their forecasts of product availability and therefore it is difficult for antitrust authorities to distinguish between vaporware and honest mistakes. As a result, rather than breaching antitrust law vaporware should be classified as fraud.

Despite reputation effects, a case can be made that vaporware is an antitrust concern when committed in a network industry. Levy ignores network effects in his model. He contends that consumers believe the first false announcement, and as a result of learning effects, will not give any credence to future announcements. However, when network effects are present, one false announcement may be sufficient for a firm to tip the market in its favor. Once monopolization occurs, the firm has little incentive to falsely preannounce upgrades because it has successfully eliminated the competition in that market. Therefore with the inclusion of network effects, Levy's conclusions derived from his multiple step game theory model may be limited and a firm may in fact have incentive to spend its reputation capital in favor of a short term increase in its relative installed base. For example, consumers will purchase Microsoft's operating system upgrades because there exists virtually no competition in that market. However, at the time of the allegedly false preannouncements, vaporware may have prevented consumers from joining another network and thus had negative effects on technology adoption. Since it is the job of antitrust (not anti-fraud) authorities to prevent *competitive* harm from being done, vaporware should be their concern in network markets.[2]

3.1.2 CPU Licensing

The use of the CPU (per-processor) license which typically ran for a two year period is another method in which Microsoft has been accused of illegally furthering its market power in operating systems. Under these contracts, an OEM estimates the number of CPUs (Central Processing Units) it will sell (X) and negotiates a per-unit price (f) with Microsoft. Following BWW (1995), the OEMs would then be required to pay a royalty (of $f \cdot X$) to Microsoft regardless of which operating system is shipped with each computer. OEMs would not receive a refund from Microsoft if they shipped a computer with a non-Microsoft operating system. Consequently, any OEM under license with Microsoft faced a zero marginal price for MS-DOS licenses up to the minimum contract requirement. An OEM who sold a unit with an alternative operating system essentially paid twice – once for MS-DOS and once for the competitor's operating system. As a result, CPU licenses would cause OEMs to favor Microsoft's operating system over its rivals. According to the DOJ, per-processor licenses are therefore exclusionary. (DOJ,1994) As a result of antitrust scrutiny, Microsoft agreed to cease its CPU licensing scheme in August 1995.

Levinson argues that CPU licenses are *not* exclusionary. He believes that the CPU license issue was a red herring because Microsoft did not require all hardware producers to accept per processor terms for MS-DOS or Windows.

[2] There exists substantial anecdotal evidence that reputation effects are relatively unimportant in the operating system market. This is evident in the fact that in a recent Business Week (Feb.22,1999,p.72) article, it is alleged that Microsoft will not likely be able to ship its newest operating system, Windows 2000, by its preannounced April deadline.

Furthermore, he argues that those OEMs who did accept them could adjust the magnitude of their minimum commitments by varying sales expectation information they relay to Microsoft which would take into account the units sold with alternative operating systems. Another argument put forward by Levinson is that operating systems are heterogeneous and therefore, consumers would be willing to pay a greater price for a higher quality operating system. He also claims that per-processor licenses can stop software piracy and, as a result, have positive effects on innovation. Finally, he claims that per-processor licenses are essentially volume discounts - price cuts to buyers of larger quantities of product per unit of time – which reduce OEMs' costs. These arguments will be examined in turn.

Levinson believes that the CPU license scheme was not binding because OEMs could refuse to sign the contract or alternatively, lie to Microsoft about their sales. He argues (p.185) that "since Microsoft is not endowed with the ability to read OEMs' minds, this would suggest that OEMs could adjust the magnitude of its minimum commitments by varying the sales expectations information they relay to Microsoft. If Microsoft disagreed, the likely result would be negotiations." Contrary to Levinson's argument rather than negotiate, Microsoft allegedly penalized OEMs that refused to sign CPU license contracts or shipped competing products by withholding necessary technical service and support or increased the price of Windows by unbundling (Sheremata, 1997, p.944). Moreover, Microsoft only sold DOS licenses to those OEMs who refused the CPU license at a significantly higher price (BWW, p.274). Hence, OEMs had the incentive to accept the CPU license and to give accurate data to Microsoft for fear of losing vital technical support.

Levinson claims that consumers pay more for higher quality operating systems because they are heterogeneous. He notes that "There exists plentiful evidence that consumers are willing to 'pay twice' for operating systems, even when the first operating system is MS-DOS, if the second operating system offers functionality." (p.186) Assuming operating systems were homogeneous, the OEM's would have an incentive only to use MS-DOS because any other operating system would raise their costs and prices. Alternatively, if operating systems are heterogeneous, a competing operating system must be more than marginally superior to MS-DOS in order to be sold. BWW (p.275) argue that "If an operating system competitor offers to sell at a per-unit price *m*, the OEM will only buy if the second operating system has a quality advantage over MS-DOS valued at *m* or more." Therefore, per processor licenses would exclude operating systems that were valued more than MS-DOS but less than *m*.

CPU licenses, Levinson argues, reduces piracy which enhances innovation. Since a Microsoft operating system runs on the majority of computers in the world and operating system software can be inexpensively duplicated, Levinson argues that CPU licenses ensure that OEMs pay for each copy of DOS that is installed. If Microsoft's operating systems were truly in use in all IBM-compatible personal computers, and if somehow Microsoft was, for non-anticompetitive reasons, the only present and future vendor of PC based operating systems, it would naturally follow that Microsoft would be owed a royalty for each PC shipped, present and future. Under such circumstances, per processor licenses, applied to all computers sold by each OEM, would have no exclusionary effects. Because Microsoft would lose any incentive to innovate were it unable to prevent widespread piracy of its products, licensing practices such as these could by viewed as a low cost way of maintaining innovation in desktop operating systems (Levinson, p.187).

On the other side of the argument, BWW believe that CPU licensing is a poor method to reduce illegal copying.[3] They note that in geographical areas where illegal copying is more likely such as Africa and parts of Asia, neither Microsoft nor its competitors have used CPU licensing as a fraud reducing measure. To prevent fraud, other methods such as including the use of serial numbers cross-referenced to end user requests for technical support, the use of holograms, and audits of the OEMs have been employed. Alternatively, Microsoft could impose penalties on OEMs that would dwarf a particular OEM's potential

[3] BWW list seven reasons why CPU licenses are not a good rationale for Microsoft to reduce fraud. However, for the sake of brevity, I have only discussed the main points.

gain from fraud rather than using CPU licenses. In other words, CPU licenses may reduce fraud but there exist more effective methods to do so.

Levinson claims that bulk sales result in a reduction in negotiation costs and uncertainty of doing business for OEMs since they can purchase enough inventory to last several years at a lower price than if they purchased one unit at a time. Sheremata (p.944) and BWW question this motive for providing volume discount. Rather than volume discounts, they argue that uniform per unit pricing would have been a more profitable strategy for Microsoft while, at the same time, raising economic welfare. As a result, they conclude that without its effects on excluding competition, CPU licenses would not have been in Microsoft's best interest.

Neither BWW nor Levinson use network externalities in their analysis. It can be concluded that CPU licenses were likely used by Microsoft to exclude other firms from entering the operating system market. However, without including network effects in their analysis, BWW found that CPU licenses will only exclude smaller rivals from the operating system market. BWW crudely define the exclusion of small rival firms from the market "economic infanticide." They argue that Microsoft runs the risk of losing OEMs who are dissatisfied with the conditions of the CPU license. Because selling Microsoft's operating system is essential from a profitability standpoint, smaller OEMs would likely not sacrifice using it in favor of an operating system with a small market share. Furthermore, until a competing operating system achieves a significant market share, the cost of using exclusionary tactics is relatively low for Microsoft.

It should be noted that BWW's exclusion argument could have been strengthened by the inclusion of network effects in their analysis. In the presence of network externalities, CPU licensing could exclude rival firms from the market. Exclusionary tactics combined with network effects could potentially eliminate any size firm from the market. If the presence of CPU licensing was sufficient to tip the market in Microsoft's favor, Microsoft would have gained an installed base lead potentially resulting in the monopolization of the operating system market.

3.1.3 Non-Disclosure Agreements

As well as being concerned with CPU licensing, the DOJ Complaint also challenged Microsoft's use of Non-Disclosure Agreements (NDAs) which it argued discouraged software providers from developing applications for competing operating systems.[4] In order for software producers to write timely software applications for a new operating system, the operating system sponsor must provide them with certain vital information in the form of beta versions. A beta version allows software producers to provide compatible software for new versions of Microsoft's operating system. NDAs are agreements between Microsoft and independent software producers where the software providers agrees not to produce software for competing operating systems for a period of three years. The Consent Decree acknowledged Microsoft's "legitimate interests" in maintaining confidentiality of information it discloses under NDAs, but argued that Microsoft's agreements were overly restrictive and unreasonably long in duration.

3.1.4 Predatory Product Innovation in Operating Systems Market

In Chapter Two, it was argued that a dominant firm in a network industry such as Microsoft would choose a strategy of incompatibility between its product and those of its competitors. Anecdotally, Microsoft has been accused of making it difficult for competitors to achieve compatibility with Windows. For example, it allegedly attempted to create incompatibility between DRI/Novell's DR-DOS and MS-DOS. DRI produces application software as well as operating systems. In order for a software producer to create compatible software for a particular operating system, it needs access to the beta version. In other words, Microsoft must supply a preliminary copy of their operating system software code (beta version) to software companies in order for them to fine tune the interaction between the two programs. In order to create incompatibility between operating systems, Microsoft chose not to give a beta version of Windows 3.1 and Windows

[4] See Lopatka and Page (1995), BWW (1995) and Church and Ware (1998a) for details on NDAs.

for Workgroups to DRI making it more difficult for it to make DRI-DOS and Windows compatible. (BWW,1995)

Through backward engineering, DRI overcame the difficulties that not having a beta version created and DR-DOS did eventually become compatible with Windows 3.1. At this point, however, Microsoft attempted to influence the *expectations* consumers had regarding DR-DOS and Windows compatibility. In cases where DR-DOS and Windows were installed together, an error message appeared on the screen when commencing Windows. The message informed the consumer that a problem was detected and to contact Microsoft's beta support for Windows 3.1. In fact no real error had occurred and if the user continued working past the error message, Windows and DR-DOS worked in conjunction with one another. Furthermore, a "readme" text file accompanied Windows that said "running Microsoft Windows 3.1 with an operating system other than MS-DOS could have unexpected results or poor performance." (BWW, p.278) It is a possibility that due to compatibility concerns, sales of DR-DOS dropped significantly as consumers switched to MS-DOS.

3.1.5 Market Power in the Market for Operating Systems

The strategies laid out above aided Microsoft in gaining a substantial market share of the operating systems market. (Tables 3.1 and 3.2) Despite this, Schmalensee (1999), representing Microsoft in court, argues that Microsoft does not have market power in operating systems despite its high market share for Intel based operating systems. Schmalensee claims that no market power exists because Microsoft faces "long-run competition from its installed base, pirated copies of its operating system, existing vendors of operating systems and a long list of potential entrants." (p.E-32) Proof that Microsoft does not have market power is evident in the fact that it does not charge the "textbook" monopoly price.

TABLE 3.1:
Market Share (%) For Intel-Based
Operating Systems Sold Worldwide

Operating System	1991	1992	1993	1994	1995	1996
Microsoft	93	89	89	91	90	92
IBM OS/2	0	7	7	6	7	6
UNIX	0.2	0.2	0.2	0.1	0.1	0.1
Other Intel	7	4	4	3	3	2

TABLE 3.2:
Market Share (%) For All
Operating Systems Sold Worldwide

Operating System	1991	1992	1993	1994	1995	1996
Microsoft	92	82	82	84	83	86

Notes on Tables 3.1 and 3.2:

- Operating systems used in single user client and PC operating environment.
- Includes Microsoft 16-bit and 32-bit Windows and MS-DOS.
- Market shares may not total 100% due to rounding.
- Even if operating systems for all personal computers, not merely those using Intel chips, are included in the market, Microsoft's share approaches dominant levels (Lopatka and Page, 1995, p.323).
- Source: International Data Corporation (1997), quoted in (Sibley, 1998, pp.14-15).

Schmalensee claims that Microsoft is not a monopoly because it does not charge the monopoly price. His argument is summarized in Reddy, Evans and Nichols (1999, pp.2-4). A true monopolist would charge a profit maximizing price, P, where

$$\frac{P - MC}{P} = \frac{1}{E}.$$

MC is the monopolist's marginal cost and E is the price elasticity of demand. In other words, a monopoly producer sets its price so that the net margin equals the inverse of the price elasticity of demand. With perfect competition among OEMs, the price of personal computers with Windows preinstalled (P_c) will equal the price charged by Microsoft for Windows (P_o) plus the costs of the other components. The price elasticity of demand for the operating system (E_o) will equal the price elasticity of demand for computers (E_c) times the fraction P_o/P_c. Assume that MC of licensing an additional copy of Windows is zero, the average price of a personal computer is \$2000, the average price paid by an OEM for a copy of Windows is \$50 and the elasticity ranges from 1 to 2. Using the equation

$$\frac{P_o - MC_o}{P_o} = \frac{1}{E_c\left[\frac{P_o}{P_c}\right]} = \frac{1}{E_o}$$

and assuming E_c equals two (Brynjolfsson, 1994), the optimal price of an operating system is \$1950 which exceeds the \$50 Microsoft charges OEMs.

Schmalensee reasons that Microsoft cannot charge a monopoly price because it is threatened by competition from its installed base, pirated copies of its operating system, and existing operating systems vendors. If consumers can switch to alternative operating systems, Microsoft may not be able to extract monopoly rents from the operating system/software system. For the purposes of the antitrust case, Schmalensee argues that Linux is a competitor that threatens

Microsoft's operating system monopoly (p.E-26). However, outside of court Microsoft argues the opposite: Linux is not a substitute to Windows. For example, Ed Muth, Microsoft's group product manager claims: "There are fewer applications available for Linux,... there's no long-term development road map, and there is higher technical risk in using it."[5] Furthermore, he claims that Linux is far less user-friendly when compared to Windows. In other words, Linux is unlikely to threaten Microsoft's monopoly power because: the Windows monopoly is protected from the barriers of entry created by its large installed base since operating systems are characterized by network effects; consumers are locked into Windows because they will not likely be willing to incur the learning costs associated with using a new operating system and UNIX software; consumers would not want to switch to a system with less application software; and they will likely not switch because they will have less access to technical support. As Hall and Hall (1998, p.16) note, it is "implausible that the price of Windows to computer makers is held down to $50 by the danger that they would install Linux in growing proportions if Microsoft raised the price of Windows by a small but significant amount."

Hall and Hall (pp.12-18) argue that competition is not an explanation for a low operating system price and outline more plausible explanations. Two arguments they put forward differ from Schmalensee's analysis. First, they argue that a low price "hooks" consumers by making the Windows PC as cheap as possible. "Once hooked, the user becomes a reliable repeat buyer for Microsoft." Second, price discrimination may be an explanation. By setting a low operating system price and higher applications price, Microsoft is able to distinguish between high and low value consumers. For instance, "A desire to purchase Office is a way that Microsoft identifies the high-value consumers." (p.17).

However, Hall and Hall concur with Schmalensee when they argue that Microsoft competes with older and pirated versions of Windows. Microsoft charges a low price in order to encourage upgrades and a high price would "activate the market for illegal copies of software. Computer makers would start

[5] Muth, Ed. quoted in Laver, R. (1999) "Bill Gates Besieged." *Maclean's* March 15:p.31.

selling PCs with no operating systems, knowing that users could obtain copies of Windows from friends or illegal dealers." (Ibid) On the other hand, it could also be argued that Microsoft faces little competition from older versions of its own operating systems because these older versions will be incompatible with a large amount of software due to memory requirements. Consumers can take advantage of a larger installed base of more complex software if they consume the most recent version of Windows. Furthermore, when a consumer purchases a new computer, a recent version of Windows is installed. Therefore, pirated copies are not a serious competitor to current versions of Windows.

Both Schmalensee and Hall and Hall claim that a low operating system price results in Microsoft being unable to exert market power. This argument deserves further scrutiny. In classic "smokestack" industries, charging a monopoly price is the primary fashion in which consumer welfare is diminished. In this operating system/software example however, the value of an operating system on a stand alone basis is zero or close to zero. Consumer benefits are derived from having access to a wide variety of complementary software. *Therefore in dynamic hardware/software markets consumers can be harmed because the monopoly's actions affect complementary markets and innovation in those markets.* In other words, Microsoft's strategies can still harm consumers even if it does not charge a monopoly price in the operating system market. The strategies Microsoft employed in order for it to expand its monopoly to complementary markets and the consequent welfare effects of those strategies will be outlined in the following section.

3.2 STRATEGIES VIS-A-VIS INTEL COMPATIBLE SOFTWARE

Microsoft has been accused of leveraging its operating system monopoly to complementary software markets. This section examines the literature dealing with the strategies used by Microsoft while competing for complementary software market share: predatory pricing, exclusionary contracts, predatory product innovation and tying. In this section, it will be argued that by employing these strategies, Microsoft used its monopoly in an anticompetitive way to expand its market power to complementary market and these practices ultimately harmed consumers. In a static welfare framework, bundling Internet Explorer (IE) with Windows harms consumers because prices increase, quality falls and consumer choice is reduced. In terms of dynamic welfare, future consumer welfare will be harmed as a result of tying because there will be a reduction of innovation in complementary software markets.

3.2.1 Predatory Pricing

In its May 1998 Complaint, the DOJ alleges that Microsoft used predatory pricing with the intent to illegally monopolize complementary software markets. It claims that because Microsoft distributed IE for a zero price, it was committing predatory pricing. According to the Complaint, a Microsoft executive has been quoted as saying, "We are going to cut off their air supply. Everything they [Netscape] are selling, we're going to give away for free." (DOJ, 1998, p.7) The DOJ further claims that Microsoft was able to use the profits generated in the operating system market (deep pockets) to sustain the pricing war that was only profitable once the competition was destroyed. Once the competitors exit the market, Microsoft could raise the price in complementary markets. A higher price would not induce entry because of the barriers to entry created by network effects.

Teece and Coleman (1998, pp.839-840) dispute the DOJ claim and argue that low pricing is not predatory but simply the outcome of competition. Rather than a predatory motive, they argue that more efficient firms exclude competitors by setting prices low and no harm is done because consumers are able to enjoy a low price. One problem with Teece and Coleman's analysis is that they do not consider that the benefits that consumers gain today must be weighed against the harm resulting in future higher prices, decreases in innovation or the harm caused by the strengthening of Microsoft's operating system monopoly.[6] Even though Microsoft has made a public commitment to keep IE's price permanently at zero, it will be difficult in the future to determine if Microsoft keeps its word because

[6] The DOJ argued that Browsers were substitutes for Operating Systems. Thus, by excluding browsers Microsoft strengthens its operating system monopoly.

the browser is bundled within the operating system. Teece and Coleman's view also does not account for the possibility that Microsoft will be able to charge monopoly prices for advertising and other tertiary products on the Web which would negatively effect consumers nor do they consider that the Supreme Court has condemned similar predatory pricing cases in the past (Hall and Hall, p.32-34).

3.2.2 Exclusionary Agreements

Another alleged anticompetitive strategy stems from Microsoft's use of exclusionary agreements with Internet Service Providers (ISPs), Internet Content Providers (ICPs) and OEMs. Microsoft allegedly used these strategies with the intent to exclude competition in the browser market.

> Collectively, Microsoft's contracts with OEMs, ISPs, and ICPs have unreasonably restrained, and, unless enjoined, will continue to unreasonably restrain competition in the market for Internet browsers. They artificially increase the share of the market held by Microsoft's Internet Explorer, and they threaten to "tip" the market permanently to Internet Explorer, not because OEMs or PC customers have freely chosen Microsoft's product in a competitive marketplace, but because of the illegal exercise of monopoly power by Microsoft. (DOJ, 1998, p.15)

The DOJ claims that ISPs and ICPs gave preferential distribution and promotion to IE in return for preferential treatment on the Windows desktop. Favorable placement on the desktop is important to ISPs and ICPs – consumers are likely to choose a service provider that can be reached by clicking on an icon that appears on the desktop. In exchange for the favorable placement, an ISP's provision of Netscape may not exceed 15% and ISPs and ICPs must not promote or receive compensation from a rival browser. "This exclusionary conduct would prevent the development of browser-based applications and highjack the browser to become an aspect of Windows instead" (Hall and Hall, p.18).

Hall and Hall (1998, p.28) argue that an internet browser is not a substitute but rather a complement for an operating system and therefore, Microsoft's motive for exclusion could not be protection of its operating system as the government believes. They note (p.23) that IE is not a substitute for Microsoft's operating system since none of the Java-based desktop applications have achieved any success. They quote Microsoft executive Jim Allchin as arguing that Microsoft did not believe that Netscape's strategy of creating a cross platform approach, the browser functioning both as a browser and as an operating system, would succeed. Finally, Hall and Hall believe that the government has not provided any effective evidence that Netscape would have become a significant rival to Windows had Microsoft not used exclusionary tactics. They argue that "the government has failed in a critical way to build a complete antitrust case because it has not shown that there ever was any real chance that the competition every would have amounted to much." (p.24)

3.2.3 Exclusionary Practices Omitted from the Complaint

Two ways in which Microsoft can exclude complementary software developers are delays in dealing and predatory product innovation. Harz (1997) outlines the delays in dealing argument. Microsoft allegedly discriminates against rival software developers by not providing vital information concerning their operating system in a timely manner. Microsoft software developers are given "the earliest and best access to new or changed programming specifications and testing software as the operating system evolves. That informational advantage means that a Microsoft application software product that exploits a new Operating System feature may reach its downstream market sooner than a rival's competing product." (pp.8-9) This delay means that Microsoft's products will be sold first and likely will have superior interoperability with the operating system. Because of network effects, the delay may result in markets for applications being tipped before competitors have a chance to compete.

Predatory product innovation is a second method in which Microsoft can use its operating system monopoly to exclude rivals in applications markets. Gleick (1996) illustrates the ways in which Microsoft used predatory product innovation to deliberately cause incompatibilities between rivals' internet browser software and Windows. It is alleged that if a consumer installed a Microsoft browser, all competing browsers which were installed prior to the IE installation would be rendered useless. Furthermore, Windows 95 allegedly disabled competing browsers even if IE was never installed. Most Internet dial-up software written for Windows relies on a piece of software called a "Winsock." If Windows 95 recognizes a competing Winsock, "it carefully and explicitly replaces it" (pp.72-81). When competing software is disabled, Microsoft's relative installed base increases aiding it in its quest for operating system dominance.

3.2.4 Tying

Microsoft's operating system has evolved in terms of functionality over time. The first operating system ever produced by Microsoft was the Microsoft Disk Operating System (MS-DOS). Later in the 1980s, a graphical user interface (GUI) was added to MS-DOS which allowed it to evolve into the Windows operating systems that Microsoft sells today. These operating systems are comprised of on-screen icons and menus that allow the user to execute commands with a mouse. Without Windows, a user must manually type commands into the computer. As Gleick (pp.83-84) points out, "The original DOS was little more than a thin (and clumsy) layer of hooks that applications could use for reading and writing data to memory, screen and disks. Windows 95 not only provides a rich environment for controlling many programs at once; it also offers a built in word processor, communications software, a fax program, an assortment of games, screen savers, a telephone dialer, a fax program, a paint program, back-up software and a host of other housekeeping utilities and, of course, internet software." In other words, Microsoft has historically employed the practice of bundling complementary software within its operating system.

Bundling complementary software products within its operating system results in the exclusion of competition in software markets. "One of the things competitors complain about most is Microsoft's practice of adopting others' innovations and integrating them into its own operating system.[7]" Once a

[7] Cortese, A. et al. (1998) "What To Do About Microsoft?" *Business Week* April 20: 112-126.

software product has been bundled within Windows, competing software products typically fail. For example, Gleick (p.89) notes that when Microsoft added a built in backup program to Windows, "it instantly destroyed what had been a modest, competitive market in backup utilities; the only customers left were those with highly specialized backup requirements." Anderson also notes that Microsoft's inclusion of dozen of functions, from back-up utilities to e-mail software, within its operating system has resulted in the bankruptcy of many formally profitable independent software vendors.[8]

Tying is an important part of the most recent DOJ Complaint (DOJ,1998). It hangs on the fact that Microsoft bundled IE into Windows which allegedly excluded rivals such as Netscape from the browser market. Specifically, it argues that tying

> reduces the ability of customers to choose among competing browser products because it forces OEMs and other purchasers to license or acquire the tied combination whether they want Microsoft's Internet browser or not. Microsoft's tying – which it can accomplish because of its monopoly power in Windows – impairs the ability of its browser rivals to compete to have their browsers preinstalled by OEMs on new PCs and thus substantially forecloses those rivals from an important channel of distribution (DOJ, 1998, pp.10-11).

The DOJ believes that Internet browsers and operating systems are separate products and it would be efficient to supply the products separately.

Among the first economists to examine Microsoft and tying were Blair and Esquibel (1995b) who questioned the DOJ motives for not including tying in the initial complaint. They argue that from a legal perspective, the U.S. federal government was not obliged to act even though welfare is harmed.[9] Legally, the U.S. courts only have jurisdiction in cases where a dominant firm uses its monopoly power in one market in order to *monopolize* another.[10] The

[8] Anderson, C. (1996) "Survey: Software." *The Economist* May 25th – 31st: p.58.

[9] Please note that Kattan(1994) supports Lopatka and Page's argument that a leveraging case against Microsoft was highly unlikely to be successful in the antitrust environment at that time.

[10] Harz (1997) argues that British antitrust authorities could have taken legal action against Microsoft regardless of market concentration because Windows is considered a "facility essential to the ability of others to conduct business."

government's contention at the time was that Microsoft used its monopoly power only *to gain a competitive advantage* in a second market. As a result, prior to the browser case, "Microsoft may have slipped through the gap in antitrust coverage." (p.396)

From an economic perspective, Blair and Esquibel believe that welfare is diminished as a result of tying even if Microsoft's sole motive was to gain a competitive advantage in a complementary software market.[11] In order to illustrate their argument, assume a monopoly uses monopoly power in the primary market to gain an advantage in the aftermarket which is competitively structured. Using this advantage, assume the monopoly has gained 40% of the software market and the remaining 60% is shared by a competitive fringe. Initially, demand and supply led to a competitive equilibrium price, P_c with Q_c units of output supplied by the market (Figure 3.1). By using its monopoly power in the primary market, the monopoly is able to enter the second market and increase its profits by restricting output. However, it must take into account the actions of the competitive fringe which will expand their output until their collective marginal cost which is where the competitive fringe supply S_{cf} equals the price selected by the dominant firm.

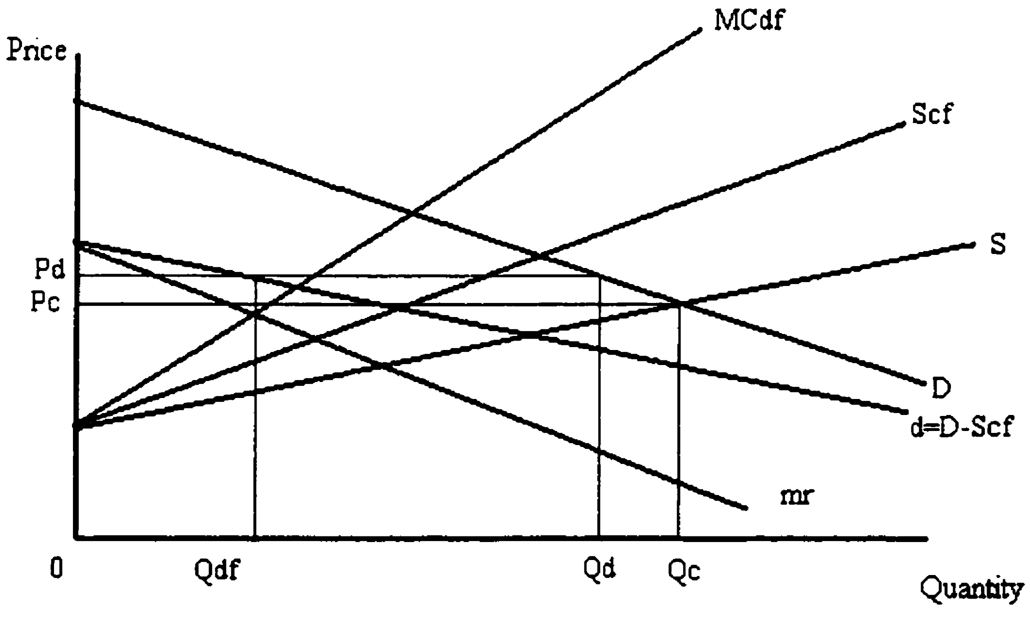
The monopoly would base its profit maximizing calculus on the residual demand which is shown as $d = D\text{-}S_{cf}$. Profit maximization leads the dominant firm to produce that quantity (Q_{df}) where its marginal cost MC_{df} equals the marginal revenue (*mr*) associated with the residual demand at the profit maximizing price, P_d. At this price the competitive fringe firms will produce Q_{cf}. As a result of the emergence of the dominant firm, output is reduced from Q_c to Q_d and price is increased from P_c to P_d. There exists a loss in consumer surplus because consumers value the reduction in output, $Q_c - Q_d$, more than the cost to society of producing that output. Producer surplus decreases because the cost of producing those foregone units is less than their market value. The sum of the reduced consumer and producer surplus is the deadweight social welfare loss. As

[11] Blair and Esquibel extended this argument to include all leveraging techniques and not solely tying.

a result, leveraging leads to a welfare loss even though legally a dominant firm can use its monopoly power in one market to gain a competitive advantage in a secondary market.

There are three fundamental problems with Blair and Esquibel's argument: they do not consider pricing problem of an integrated firm; network externalities are not included in their analysis; and, they do not consider the effects leveraging has on welfare effects from innovation. The first two problems will be discussed presently and the third will be discussed after examining the potential welfare benefits of tying in the Microsoft case.

FIGURE 3.1:
Welfare Analysis of Leveraging



Without considering the consequences of the monopoly's entry decision on the primary market, an argument that welfare is reduced when a monopoly firm attempts to gain a competitive advantage in software markets is incomplete. In Blair and Esquibel's analysis, once the monopoly enters the software market the price of software increases. However, this analysis does not consider the trade-off - an increase in the price of software reduces the sales in the operating system market - that the monopoly faces when making the pricing decision. As a result, the price may not rise when the monopoly enters and welfare may not be harmed.

Blair and Esquibel's argument would have also been strengthened had it included network effects and dynamic considerations into its welfare analysis. It neglects the fact that in a network industry, if a dominant firm's product gains 40% of the software market where the other 60% is competitively supplied it will likely end up becoming the industry standard due to tipping. In other words, the firm will likely monopolize the complementary software market and not merely gain a competitive advantage. Hence, the DOJ did have a legal argument during the period of the licensing Complaint for including tying in the licensing case.

Contrary to Blair and Esquibel, Teece and Coleman (pp.840-841) and Schmalensee (1999) argue that tying *benefits* consumers and therefore should not be disallowed by antitrust authorities. They outline the arguments in favor of tying. Schmalensee claims that tying is not exclusionary because rivals have alternative distribution avenues available to them. He claims that the fact that Microsoft did not foreclose on Netscape is proof that tying is not exclusionary and thus that consumers are not harmed. Rather, Microsoft has a better product which enabled it to gain a leading market share. This was compounded by "Netscape's business, management, and technical mistakes." (Schmalensee, 1999, E-18) As a result, Microsoft should not be prevented from implementing a this strategy. Teece and Coleman argue that tying may allow consumers to use products that they normally would not use on a standalone basis. "Once experience is obtained, the product in question might be viable on a stand-alone basis." (Ibid, 1998, p.841)

Schmalensee asserts that tying is not exclusionary (and therefore not welfare lowering) because rivals have alternative methods of distributing their browsers such as direct mail, retail sales, promotional agreements, mail order sales and internet download. However, as Rubinfeld (1998, p.868) notes, by tying "a monopoly may be able uniquely to avail itself of ubiquity in distribution – making success of the innovator's product unlikely." Bundling its browser within its operating system increases the probability that Internet Explorer will dominate the market. This will occur even if a wide variety of distribution channels are open to software firms. Repeating an argument from above, if Microsoft gives away its browser for free with Windows, the consumer will only buy a the second browser if a quality advantage over IE valued at p or more where p is the price of the competing browser. Therefore any distribution method which requires the consumer to pay for a competing browser will likely fail.

Even when rival browsers are distributed at no cost to consumers, they are at a competitive disadvantage compared to internet download and direct mail, two methods of distribution that Schmalensee believes competes with tying as a distribution method. Rival firms distribute their browsers by allowing consumers to download them over the internet for free. However, these products are disadvantaged because consumers may not know that the browser is available for free whereas they are likely to be aware that IE is installed on Windows at no additional cost. Also, consumers must incur search costs to find the rival browsers. In addition, only those with access to an internet browser can get the free copy of the internet browser. Therefore, first time purchasers of internet browsers are predominantly excluded from this method of distribution. Because of learning and switching costs, there is a strong likelihood that a first time user will continue using their original browser. A second distribution method used by rivals is direct mail. This method increases rivals' costs since they have to produce the CDs and pay for shipping. In other words, as a result of its status as the system sponsor, Microsoft has an important cost advantage over its rivals.

Schmalensee maintains that tying is not implemented to exclude rivals but rather "is part of the dynamic technological competition that takes place in the industry." (p.E-22) He is correct – operating system manufacturers have continually added features - however, just because an action was permitted in the past does not mean that it should necessarily be permitted in the present. Tying is of greater concern today than in the past because Microsoft has an established a monopoly in the operating system market and therefore is able to leverage its monopoly power into software markets.[12] When viable competition existed in the operating system market, Microsoft risked losing its installed base of software for Windows if it employed a tying strategy. All other things equal, this would have the effect of making Windows less attractive than rival operating systems. However, a monopoly supplier of the operating system might profit from incorporating innovative ideas into its own products because consumers are unable to switch to a competing product. Tying in this case is of great concern because the incentives for third parties to design novel software is reduced.

Schmalensee also claims that the current presence of Netscape in the browser market demonstrates that it was not excluded. However, the existence of Netscape in this period does not prove that tying is not exclusionary. Schmalensee argues Netscape has suffered after Microsoft began to tie its browser to Windows but it was due to poor business practices. It is beyond the scope of this thesis to compare and contrast Microsoft and Netscape's business practices to determine whether Netscape's business errors resulted in a loss of sales. However, it can be said that Netscape's decline is consistent with the hypothesis that Microsoft excludes third party software producers by implementing a tying strategy.

Teece and Coleman also argue that tying increases consumer welfare because it provides them with products that they may never have used on a stand-alone basis. Another perspective however is that tying essentially reduces consumer choice - they are *forced* to purchase a second product sold by the hardware producer that they may not wish to consume when they purchase the primary product. In other words, there could be an efficiency loss if some consumers do not want to consume the secondary product or would rather consume a competitor's product.

The primary criticism that can be levied against Blair and Esquibel, Teece and Coleman and Schmalensee is that they only examine static welfare and ignore

[12] Also, using innovation analysis, the fact that a company that has a history of using an anticompetitive practice in the past is taken under consideration when analyzing potential harm of an action today.

the that fact that leveraging can effect innovation incentives in the computer software industry and therefore they do not capture the dynamic nature of the computer industry. They neglect the fact that if the positive effect of lower consumer prices today is outweighed by the negative effects tying has on innovation, then tying may be welfare lowering.

Church and Ware (1998b, p.69) argue that a significant repercussion of tying is that the threat to software producers of being excluded by tying reduces complementary product suppliers incentives for research and development of new products. Furthermore, venture capitalists would not support start-up companies that hope to build a business in any area that Microsoft competes in because it has the ability to foreclose on their firm at any time potentially destroying the profitability of new projects. Also, as a result of exclusion, fewer software firms will participate in the market and according to innovation market analysis, the market will be less innovative. For these reasons, innovation will be reduced due to tying and predatory product innovation. If innovation incentives in complementary software markets are harmed when as a result of Microsoft's decision to tie, antitrust authorities should scrutinize their strategy. As Rubinfeld (1998, p.860) argues, "the antitrust authorities should make every effort to insure that dominant incumbent firm with monopoly power do not use their substantial market power to harm innovation, to retard technological progress and ultimately harm consumers."

Unlike Church and Ware, Hall and Hall have argued that tying *enhances* software developers' innovation incentives. They assume that a firm's innovation incentives are positively related to the expected reward that they will achieve from innovating. Hall and Hall conjecture that "adding functions to the operating system has been beneficial to the consumer. Microsoft's willingness to purchase software companies at high prices is a major incentive to the creation of new software." (p.37) However, this argument depends on the effectiveness of intellectual property rights. If intellectual property rights are weak and a dominant operating system firm has a reputation of expropriating rather than purchasing the innovations of other firms, tying effectively reduces software firms' innovation incentives. In the computer software industry, the anecdotal evidence regarding Microsoft's reputation for purchasing novel software is mixed. On the one hand, it has been accused of using the "look and feel" of Apple's GUI without compensation. On the other hand, "In the past three years, Microsoft has snapped up or taken equity stakes in more than two dozen startups with leading-edge technology.[13]" The dissipation of innovation incentives depends on the extent to which the expected returns to the innovation incentives are reduced due to weak intellectual property rights.

3.3 REMEDIES

In the previous section, it was argued that Microsoft harms welfare by leveraging its monopoly operating system to software markets. This section explores the options available to the DOJ to promote growth and prevent the abuse of market power. With respect to Microsoft, the imposition of a remedy is a contentious issue. The difficulty lies in the fact that the remedy must attempt to achieve various, often conflicting, objectives such as: 1) encourage innovation in software markets, 2) minimize regulatory costs, 3) prevent future antitrust activities, 4) minimize disruption costs to the industry including firms involved, and 5) promote competition in software markets. In this section, potential courses of action that the government could pursue will be explored. Several options have been discussed as a potential remedy in the Microsoft case: vertical and horizontal separation; disclosure of source code or specifications; contractual restrictions; limits on bundling and tying; and, creating an industrial standard. It will be argued here that vertical separation along with placing certain limits on bundling is the best course of action.

3.3.1 Vertical Separation and Limits on Bundling

Vertical separation, dividing Microsoft into separate applications and operating system firms, is one potential remedy available to the government. Economides (1999), Lemley and McGowan (1998) and Hall and Hall (1998) all

[13] Cortese, A. et al. (1998) "What To Do About Microsoft?" *Business Week* April 20: pp.112-126.

argue against vertical separation. Economides asserts without proof that breaking Microsoft up is infeasible, very severe, disproportionate to the crime, and can be accomplished by disclosure of APIs instead and would result in significant upheaval for Microsoft and for the computer industry. Hall and Hall argue that vertical separation would result in a gain for consumers because the applications markets would be free from any anticompetitive threat that Microsoft poses but a loss because of the decreased effectiveness of the two current parts of Microsoft, where the operating systems and applications teams cooperate closely with each other. They also argue that a parallel between Microsoft and AT&T who was vertically divided in 1982 is a weak one. The historical settlement of the AT&T antitrust case resulted in a vertical split of the company into 8 nonrival entities – 7 local phone companies and a long-distance carrier. Hall and Hall argue that the "physical lines drawn to distinguish local from long-distance phone service were arbitrary but decisive. There is no way to draw similar lines between an operating system and an application." (p.35) In opposition to vertical separation, Lemley and McGowan (1998) reason that the outcome of a split would be a relatively stagnant operating system standard. They "would be troubled by holding that Microsoft could never "integrate" its browser into its operating system, regardless of efficiency gains through integration, or changes in technological or market conditions." (pp.739-744) Furthermore, they claim that Internet browsers and operating systems are not separate products and a split would therefore result in a reduction in consumer welfare.

Vertical separation will encourage innovation in software markets. Microsoft concurrently competes in software markets and dominates the market for operating systems. Because of its system sponsor status, Microsoft is able to use tying, predatory product innovation, predatory pricing and delay or withhold essential operating system specifications from competitors. However, if Microsoft was separated vertically into two firms, one specializing in operating systems and the other in applications, then it would no longer be able to use its monopoly power in anticompetitive ways to exclude software rivals. Along with vertical separation, assume that the operating system firm would not be allowed to produce application software. The new firm would have no exclusionary incentives and would encourage independent software development because software variety increases with the value of the operating system. As a result of the operating system firm's incentives, in the long run regulatory costs would be diminished because Microsoft would not exclude software producers and thus vertical separation would result in the prevention of future antitrust activities.

One concern that has been raised is that vertical integration will result in a stagnant operating system standard. However, this need not be the case - the operating system would be able to grow in terms of functionality. For the purposes of this thesis, functionality is defined as the ability of separate components to work together as a system. The government must make a distinction between when it is efficient to add functionality to the operating system even if it excludes complementary software and when it is not. For instance, it could allow an application with a large market share which also *enhances* the operating system through increased functionality to be bundled within the operating system once the market for the application has matured. For example printer drivers bundled within Windows substantially improves the functionality of the computer system. The vast majority of consumers require print drivers and there is little difference between products. On the other hand, video games do not improve the functionality of the operating system itself and therefore would not be allowed to be bundled. Furthermore, video games are heterogeneous products and a particular video game will only be sold to a consumer with particular tastes. Because the operating system firm would not be allowed to produce software, it would have to purchase applications from software developers. Hall and Hall (p.35) argue that the operating system part of Microsoft would face challenges from applications developers including the other half of Microsoft every time it tried to add a feature to the operating system. However, vertical separation would encourage innovation since the innovator could sell its idea to the operating system firm with no fear of expropriation. In this way, the operating system could expand in terms functionality, would not be stagnant as Lemley and McGowan fear and most applications markets would remain competitive.

Economides argues that vertical separation would result in severe disruption to the computer industry. Assume Microsoft was divided into a firm that produces Windows 98 and another which produces only applications.[14] Property rights would not be infringed upon because both firms would remain publicly owned. Like the break-up of AT&T, vertical separation in this way would be arbitrary but decisive. In this way, application developers would be unaffected since the operating system source code would remain intact. Just as the telephone industry prospered after the break-up of AT&T, so would the computer industry prosper from a break up of Microsoft. There would be little long run disruption in the industry because application producers would still produce products for the current version of Windows and their innovation incentives would improve.

Economides argues that forcing Microsoft to disclose APIs that allow IE to be in the operating system will solve all technological bundling problems and is less severe than vertical separation. Hall and Hall argue that there exist several practical problems to disclosure. They note that it would be difficult to prevent Microsoft from providing information to its own software developers before rival ones. Furthermore, an outside developer could hold Microsoft responsible for providing information that later proved erroneous. "The result would be to prevent otherwise efficient communication within Microsoft or to drive it underground." (p.36) Also, contrary to Economides, it is not apparent that disclosure will solve all technological bundling problems. Disclosure limits Microsoft's ability to exclude complementary software developers through predatory product innovation and withholding vital information. Yet, Microsoft will still be able exclude software developers through tying and therefore this remedy does not completely prevent Microsoft's exclusionary behavior.

3.3.2 Horizontal Separation and Source Code Disclosure

Economides (p.1) notes that any government remedy should attempt to encourage innovation in the operating system market. One remedy that would accomplish this objective is dividing Microsoft into two or more operating system firms (horizontal separation). Another is the disclosure of the Window's source code. Horizontal separation, according to Economides, is very severe and consumers' welfare will ultimately be diminished because of lack of compatibility between new operating systems over time. Because of the network benefits generated as a result of having a single operating system are large, any remedy which attempts to promote competition between operating systems should not be administered. Furthermore, due to network effects, in the long run a new standard would emerge in the operating system market. As a result, these remedies would not prevent a future operating system provider from committing similar antitrust actions and as a result would likely not minimize long term regulatory costs.

The disclosure of Microsoft's source code is another method which promotes competition in the operating system market. Economides (p.3) argues that forcing Microsoft to disclose its source code (disclosure) is a severe remedy that takes away the intellectual property of Microsoft and, as a result, the incentives for innovation are decreased. Again, the advantage of vertical separation over the disclosure of the source code is that consumers would not lose the network benefits of having only one operating system.

3.3.3 Contractual Conduct Restrictions

Conduct restrictions on contracts is another remedy which could be applied with the goal of preventing Microsoft from entering exclusive dealing contracts. Under such a regime, firms who sign contacts with Microsoft would also be able to sign contracts with rival firms. Economides (1998, p.2) argues that imposing conduct restrictions on contracts is: easy to tailor according to the violation; prevents Microsoft from repeating the crimes; has minimal effects on

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[14] Of course, since Windows 98 contains IE, this will only help future innovators and not current rivals in the browser market.

the computer industry as a whole; and, prevents vertical effects. Contrary to Economides analysis, contract restrictions will likely not prevent Microsoft from repeating the crimes nor will it prevent vertical effects. Horizontal and vertical effects refer to competition in the operating systems and applications software market respectively. The incentives for Microsoft to continue exclusionary practices, despite conduct restrictions will remain. When the cost of litigation is less that the benefits gained by tipping a market and earning monopoly profits, Microsoft will ignore the restrictions or impose other exclusionary agreements that are not covered by the restrictions. As a result, regulatory and litigation costs will be high for the government.

The operating system market in the 1980s and early 1990s provides a useful illustration. By the time the DOJ passed the consent decree imposing conduct restrictions on contracts, the operating system market was irrevocably tipped. Had the DOJ acted earlier to limit Microsoft's use of CPU licensing and NDAs, they may have allowed the market to decide which product would become the standard. Rubinfeld (1998b) argues that one important implication of this is that antitrust authorities must move quickly to quell predatory behavior in network industries. He notes "With network industries, especially those in which tipping is a real possibility, allegations of anticompetitive behavior need to be treated quickly and seriously. Once the market has been tipped, it may be difficult or even undesirable to undo any anticompetitive effects that have arisen." (p.869) Since the DOJ did not act quickly in the most recent case, anticompetitive contracts may have already resulted in Microsoft gaining market power in browsers and thus contract restrictions would not remedy the situation.

3.3.4 Industrial Standard

A similar remedy to disclosure, is creating an industrial standard, perhaps by expropriating Windows and having a standards-setting organization operate it. Curran (p.777) notes that the central idea behind an industrial standard is that the benevolent standards-setting organization must "as other general antitrust rules dictate, develop standards inclusively, not excluding, but welcoming participants, regardless of credentials, and must *not* allow participants to develop standards that reflect their own narrow economic self interests." Under this regime, an alternative platform to Windows would be run by an amalgamation of firms and would ensure that software suppliers were not excluded from complementary markets. Firms working within the standards-setting organization would work "responsibly and cooperatively" through corporate volunteers and would be "motivated altruistically." (p.775)

Curran reasons that the industrial standard is not an optimal remedy with respect to Microsoft. He believes that "privately developed, and privately owned innovations represent economic self-interests that if jointly protected through standards will dangerously threaten competition, while also jeopardizing expert objectivity and blocking future competitive developments." (p.785) Furthermore, firms can not work altruistically in the development and maintaining of the standard when their primary objective to maximize the benefits of shareholders. Standards will protect dominant product interests at considerable expense to emerging technologies and to consumer interests by restricting market generated alternatives, choices and opportunities.

3.3.5 No Remedy Required

Both Lemley and McGowan and Curran argue that no remedy is required based on a prediction that Microsoft's dominance in operating systems markets will be eventually replaced with a new standard. They note that IBM, Netscape, Novell, Oracle and Sun have joined to achieve platform-independent computing using the Internet and Sun's Java to overcome both the dominance of Microsoft and the limitations of its technology.[15] If an alternative technology replaces Windows in the distant future, antitrust authorities should still deal with anticompetitive behavior today. However, if this shift will take place in the near future, then no remedy is required. Currently, Microsoft resists this shift by producing its own version of Java and envisions a world where Java and

[15] See Sun Microsystems, Inc v. Microsoft Corporation (1998). United States District Court, Northern District of California, San Jose Division, No. C 97-20884.

Windows run together. Because of the strength of network externalities in operating systems, it is doubtful that an alternative platform will replace Windows easily or in the near future and therefore an antitrust remedy is warranted presently.

3.4 SUMMARY

In this chapter, the literature on Microsoft was divided into three categories. The first category dealt with the strategies Microsoft used in order to gain monopoly power in the operating system market. The second category outlined the strategies Microsoft used to expand its monopoly to complementary markets. Analyses of potential remedies which prevent exclusion in complementary software suppliers make up the third category. Microsoft used product preannouncements, CPU Licensing, Non Disclosure Agreements and Predatory Product Innovation in the market for operating systems in order to gain market power in the operating systems market. As a result of its system sponsor status, Microsoft is able to exclude complementary software producers through predatory product innovation, tying, predatory price and withholding essential technical information. These practices diminish innovation in software markets and lower consumer welfare because prices increase, quality declines and choice is limited. Vertical separation in combination with limits on bundling would remove the operating system's incentives to exclude complementary software producers. As a result, consumer welfare would be enhanced and innovation incentives in software markets would be improved.

CHAPTER FOUR: ECONOMETRIC ANALYSIS

The objective of this chapter is to empirically examine the link between exclusionary strategies such as tying and predatory product innovation and third party software producers' innovation incentives when the hardware component is produced by a firm with market power. In the previous chapter, an argument was formulated that Microsoft can use its market power in the operating system market to exclude rivals in application software markets and that a repercussion of exclusion is a reduction in complementary product suppliers' incentives for research and development. Over time, the Microsoft Windows Operating System (Windows) has evolved in functionality and has become a bundled system comprised of many complementary software components. Exclusion negatively affects innovation in two ways. First, when Microsoft bundles a competing product into Windows, one would expect that third party software producers would be hesitant to introduce a new product application or upgrading one that is currently available on the market. Second, one would anticipate that investors would not provide capital for innovative third party software firms who will likely be excluded from the market.

In the computer software industry, many products are multi-product systems whereby the system sponsor, manufacturer of a primary product, can bundle software within his product resulting in the exclusion of third party producers of non-standalone compatible products. In addition to operating systems, examples of such primary software products include spreadsheet, word processing, personal finance, desktop, accounting and database programs (Table 4.1). In each case, the primary product producer makes a decision whether to bundle complementary software within its product. Bundling results in the exclusion of secondary software manufacturers who develop utilities. Utilities are non-standalone software products which work in conjunction with and add functionality to a primary product (Table 4.2). For instance, by bundling a spell-checker within its word processor, a dominant word processor manufacturer is able to exclude third party spell-checker producers.

TABLE 4.1:
Primary Market Description

Market	Description of Primary Product
Accounting	Software that runs on a personal computer and is used to manage and report on an organization's money and/or assets. This type of software includes general ledger, accounts payable/receivable, payroll, and business tax preparation packages.
Desktop Database	This category is comprised of standalone (sold separately from operating system) client database software that provides storage and management functions for data stored in a sequential, hierarchical relational, or object format.
Desktop Publishing	The desktop publishing (DTP) category includes packaged software that provides page layout and design capabilities for print or electronic publishing. DTP software allows the user to manage text and graphics on screen. Text and graphics may be created with the program, but few of them have full-featured text and graphics capability.
Integrated	This category is comprised of software that combines several office/business application functions into one software package. The application functions typically include word processing, database management and spreadsheet capabilities and many include other functions as well. These packages also provide a common user interface for their applications.
Personal Finance	This category is comprised of software that helps an individual manage a household's money and/or assets. Personal finance software can include a wide range of features such as tools that help users balance checkbooks and manage everyday expenses, prepare personal taxes, as well as track investments, plan for retirement and save money to send children to college. Some of the packages can be integrated with online banking services that will let users pay bills at home, transfer money between accounts, and perform other banking chores.
Project Management	Software that supports the ordering of activities across time. This application assists in planning and implementing projects by providing tools for forecasting requirements and projecting costs, as well as other charting and analytical features.
Spreadsheet	Software with the principal function of organizing data into columns and rows to allow the user to perform numerical analysis.
Word Processing	This category includes stand-alone full-feature word processing software with the principal function of allowing the user to create text documents.

TABLE 4.2:
Examples of Utilities

Product	Company	Category	Product Description
Microsoft Comprehensive Spelling	Alki Software Corp.	Word Processing	Adds medical, legal and business spellings to Word's spell-checker.
Zippy Notes	Softline Systems, Inc.	Accounting	ACCPAC add-on. Multi-user electronic sticky notes program. Allows users to attach notes to fields that will pop up whenever field is accessed. Lets user add custom business requirements to general purpose applications.
4D Chart (V.1.0)	ACI US, Inc.	Desktop Database	Add-on module for 4th Dimension that enables users to create graphs from data in database or imported from another application. Allows user to associate graphs with records in database, update graphs when information in database changes and publish graph as hotlink for use with other 4th Dimension modules.
InvoicIt	Survivor Software Ltd.	Personal Finance	Add-on for vendor's MacMoney program. Handles basic AR functions. Includes up to 2,000-name client list with detail, billing item list of up to 300 items, tracking of payments by invoice number, up to 300 lines of items and description per invoice, taxable and non-taxable items on same invoice and printing of statements and standard AR reports.
Project Time for Windows	Selfware, Inc.	Project Management	Enterprise-wide, predictive add-on timesheet application for Microsoft Project 4.0. Designed to collect actual hours from resources across multiple projects.
FW10	BrainChild Software, Inc.	Spreadsheet	Add-on to Financial Wonder. Handles up to 240 monthly periods and 5,000 financial accounts.
Adobe Systems, Inc.	Adobe CheckList (V.2.5)	Desktop Publishing	Add-on utility that allows users of PageMaker to view information including document's fonts and styles without having to open application.

The observation that multi-product bundling and exclusion are not exclusive to operating system/software markets allows us to test the hypothesis that when it is a dominant player in the primary market, Microsoft harms innovation by deterring entry in secondary software markets. The notion underlying this hypothesis is that because it has a reputation for implementing a tying strategy, software producers innovation incentives are diminished in secondary markets where Microsoft is the primary product producer. A per firm count of new products (new product application software releases) is used as a measure for innovation. Microsoft's market share in each primary market is used as a measure of Microsoft's dominance. Poisson estimates suggest that there exists a significant negative relationship between Microsoft's market share and innovation. Furthermore, they imply that innovation in secondary markets would be completely stifled when Microsoft's market share in the primary market approaches one hundred percent.

Six other results emerge from the analysis. First, the existence of a standard in the primary market is important in promoting innovation in the secondary one. In other words, secondary software developers are more likely to enter when a standard has emerged in the primary market. Second, primary market concentration appears to be unrelated to innovation in the secondary market. Third, the model suggests that firm size is unrelated to innovation. Fourth, a firm's age appears to be inversely related to the expected number of compatible products it develops. Fifth, innovation appears to fall in the computer software markets in our sample between 1994 and 1996. Finally, firms who produce new products for the Windows operating system are expected to produce a greater number of innovations than if they developed new products for a non-Windows operating system.

The importance of this work lies in the fact that it is relates to the ongoing legal dispute Microsoft has with the United States Federal Government. A key issue outlined in the 1998 DOJ Complaint is the effect of Microsoft's exclusionary practices on the incentives for innovation by others, in particular the incentives for third party software suppliers, to develop new applications that are complementary with Microsoft's operating systems. However, there has been no systematic empirical evidence on the extent to which Microsoft's exclusionary behavior directed against existing third party suppliers has on their innovation incentives. The result that Microsoft's dominance in the primary market seriously harms innovation in secondary ones is indirect evidence that a remedy limiting Microsoft's market power in primary markets may be warranted.

Chapter Four is divided into four sections. The first addresses the selection and construction of the model. The Poisson Count Model was selected to analyze the data set using a count of per firm new product applications as the dependent variable. The second section focuses on data collection. All of the data was collected from two Gartner Group reports and two Computer Select CD-ROMs which report on the computer software industry. The different market definitions in these two sources allowed me to break the computer software industry into primary and secondary products. The results, diagnostics and limitations of the model are contemplated in the third section. The final section concludes the chapter and considers the implications of the results.

4.1 MODELING INNOVATION

In order to test the hypothesis that Microsoft's dominance in the primary market is inversely related to innovation, a measure of innovation, model specification and choice of regressors must be determined.[1] Although, several potential measures of innovation exist such as patent counts and productivity growth, a per firm new product count is appropriate for the computer software industry because of its availability and applicability. Because a tally of per firm new products is a count, a Poisson Model is used to test the hypothesis. The rationale for using Poisson rather than the Log Regression or Logit Models will also be discussed in this section. Finally, in terms of covariate selection, Microsoft's market share will be used as a measure of its dominance. However, our model must also control for several key factors which also may affect

[1] Microsoft is dominant in the operating systems market. How firms react to Microsoft's dominance has implications for the current antitrust case. Therefore, for the purposes of this thesis, the focus is on *Microsoft's* dominance rather than the firm with the largest market share.

innovation including market structure and maturity, firm characteristics and sector.

4.1.1 Measures of Innovation

Scherer and Ross (1990, p.644) outline various proxies for innovation which have been adopted in the past. Early empirical work focused on the *inputs* to the innovative process such as counts of scientists and engineers employed in a particular industry or firm and expenditures on research and development as their measure of innovation. However, with the advent of new data sources, the focus switched to the *outputs* of the innovative process. These include the number of patents received, tallies of new products and processes introduced by industry members, and the growth in productivity.

The advantages of using a per firm new product count over alternative measures include availability, applicability and appropriateness. Unlike proxies such as productivity measures which are difficult to collect at a firm level, new product counts are readily available. Furthermore, new product counts are applicable because they are a measure of a firm's innovation strategy - in order to enter a market with a new product, a firm must first innovate by developing software. Like new product counts, patent counts also encompass firm strategy; yet, they are not appropriate for the computer software industry because many innovations are not patented and many patented products are not commercialized. Product counts are appropriate because entry and innovation are linked in the computer software industry since new products are often either commercialized upgrades or an original product.

A final advantage of using a product introduction count as a measure for innovation is that it has been applied to the computer industry in the past. For example, Stern and Trajtenberg (1997), examining innovation and rents in the personal computer market of the late 1980s, reason that new product introductions are measures of innovation because of their contribution to economic progress by expanding the range of choices available to consumers and improving the dimensions of existing products. Similarly, using new product counts as a proxy for innovation, Greenstein and Wade (1998) use the Poisson Model to empirically examine the product life cycle of commercial mainframe computer systems between the late 1960s until the early 1980s.

4.1.2 The Poisson Count Model

Like Greenstein and Wade (1998), our data will be analyzed with a Poisson Model. Since the values of a Poisson random variable are non-negative integers, any random phenomenon for which a count of some sort is of interest is a candidate for modeling by assuming a Poisson distribution.[2] This section provides a brief examination of the properties of the Poisson Model and an interpretation of the estimated coefficients that will be used in the following sections.

Let y_i be the number of occurrences of the event of interest and x_i be a vector of linearly independent regressors that are thought to determine y_i. Also assume that $E[y_i|x_i] = \mu(x_i,\beta)$ where $\mu(x_i,\beta)$ is a continuous function and μ is an intensity parameter that depends on the covariates x_i and the unknown parameter vector β. For cross-sectional data and n independent observations, the i^{th} of which is (y_i,x_i), y_i given x_i is Poisson distributed with density

$$f(y_i|x_i) = \frac{e^{-u_i}\mu_i^{y_i}}{y_i!}$$

where $y_i = 0, 1, 2, \ldots, n$. Mood, Graybill and Boes (1974, p.93) provide graphical examples of common Poisson distributions, two of which can be seen in Figure 4.1. This figure demonstrates that the dispersion of the distribution increases with μ. The formulation for μ_i which is used in our analysis is $\ln(\mu_i) = \beta' x_i$. Note that this commonly used formulation ensures that μ exceeds zero ($\mu > 0$). Furthermore, it can be shown that

[2] This section on the theory and application of count models follows Cameron and Trivedi (1998).

$$E[y_i|x_i] = \mu_i = e^{\beta' x_i}$$

which is the basis for our model specification presented in the next section. Although the Poisson is a non-linear regression, the parameters can be estimated with Maximum Likelihood techniques. Given independent observations, the log-likelihood function is

$$\ln(L) = \sum_{i=1}^{n} [y_i x_i' \beta - \exp(x_i' \beta) - \ln y_i!]$$

and the likelihood equations are

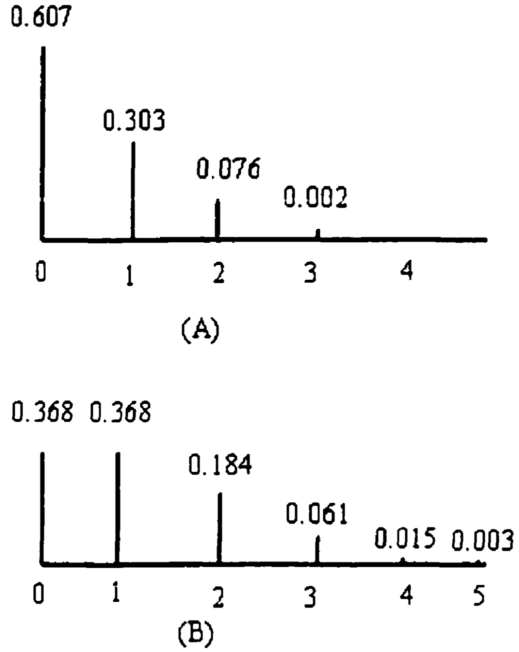
$$\frac{\partial \ln L}{\partial \beta} = \sum_{i=1}^{n} (-\mu_i + y_i) x_i = 0.$$

Finally, the Hessian is

$$\frac{\partial^2 \ln L}{\partial \beta \partial \beta'} = -\sum_{i=1}^{n} \mu_i x_i x_i'$$

which is negative definite for all x and β. Convergence is guaranteed because the log-likelihood function is globally concave.

FIGURE 4.1:
Selected Poisson Distributions



- μ equals 0.5 and 1 for (A) and (B) respectively
- Source: Mood, Graybill and Boes (1974, p.93)

In should be noted that a key assumption of the Poisson Regression Model is *equidispersion*, equality of the mean and variance. In symbols, equidispersion occurs when $V[y_i|x_i] = E[y_i|x_i]$. *Overdispersion* (*underdispersion*) means that the variance exceeds (is less than) the mean. This property is frequently violated in real-life data since count data are often overdispersed. Cameron and Trevedi (p.77) note that the "failure of the Poisson assumption of equidispersion has similar qualitative consequences to failure of the assumption of homoskedasticity in the linear regression model." Specifically, when overdispersion occurs estimated coefficients will be remain unbiased but will be inefficient.

Before proceeding, it is worthwhile to consider the interpretation of the Poisson estimated coefficients. Consider the exponential conditional mean $E[y|x]$

$= \exp(x'\beta)$ where the subscript i has been dropped. Let the scalar j represent the j^{th} covariate. In this case,

$$\frac{\partial E[y|x]}{\partial x_j} = \beta_j \exp(x'\beta).$$

Solving for β_j,

$$\beta_j = \frac{\partial E[y|x]}{\partial x_j} \frac{1}{E[y|x]}.$$

Therefore, the coefficient β_j is a semielasticity which can be interpreted as the proportionate change in the conditional mean if the j^{th} regressor changes by one unit. Since the scalar $\exp(x'\beta)$ is always positive, the sign of the response $\partial E[y|x]/\partial x_j$ is given by β_j. Furthermore, given that

$$\frac{\partial E[y|x]/\partial x_j}{\partial E[y|x]/\partial x_k} = \frac{\beta_j \exp(x'\beta)}{\beta_k \exp(x'\beta)} = \frac{\beta_j}{\beta_k},$$

it follows that if one coefficient is twice as large as another then the effect of a one unit change of the associated regressor is double that of the other.

4.1.3 Model Specification

Since a tally of per firm new product introductions is a count, the Poisson Model can be used to explore the relationship between innovation and the various covariates such as Microsoft's dominance measured by its market share in the primary market. If y_{ijt} equals the count of the new products introduced by firm i in market j in year t then the specification of the Poisson Model is

$$E[y_{ijt}|x_{ijt}] = e^{\beta' x_{ijt}}.$$

The expected number of new products introduced by firm i in market j for year t given the covariates x_{ijt} is $E[y_{ijt} | x_{ijt}]$. Using this model, β can be estimated allowing us to determine the link between the regressors and innovation. Specifically, our regression specification is

$$E[y_{ijt}] = \exp\{\beta_o + \beta_1 MSMS_{ijt} + \beta_2 STANDARD_{ijt} + \beta_3 HHI_{ijt} + \beta_4 AGEFIRM_{ijt} + \beta_5 GRSALES_{ijt} + \beta_6 EMPL_{ijt} + \beta_7 CSYEAR_{ij} + \beta_8 WINDOWS_{ijt} + \beta_9 SPREADSHEET_{it} + \beta_{10} WORDPROCESSING_{it} + \beta_{11} INTEGRATED_{it} + \beta_{12} PERFINANCE_{it} + \beta_{13} DESKTOP_{it} + \beta_{14} ACCOUNTING_{it} + \beta_{15} DATABASE_{it}\}. \quad (1)$$

Definitions and summary statistics of the independent and dependent variables composing (1) can be found in Table 4.3. Market shares refer to a percentage of units sold as opposed to total sales.

TABLE 4.3:
Variable Definitions and Summary Statistics

Variable	Definition	Mean	Standard Deviation
y_{ijt}	Number secondary product introductions by firm *i* in primary market *j* in year *t*.	0.36	0.67
Primary Market Characteristics			
$MSMS_{ijt}$	Microsoft's market share percentage for the primary product it produces in market *j* for which firm *i* produces a secondary product in year *t*.	29.08	22.41
HHI_{ijt}	Herfindahl-Hirschman Index for primary product producers in market *j* for which firm *i* produces a secondary product in year *t*. Sum of the squared percentage market shares.	25.07	9.42
$STANDARD_{ijt}$	Sum of the past four years installed base of leader in primary market divided by the total installed base in market *j* for which firm *i* produces a secondary product in year *t* times 100. A leader is the firm whose calculated $STANDARD_{ijt}$ is the greatest value.	32.48	9.90
Firm Specific Characteristics			
$AGEFIRM_{ijt}$	Age of firm *i* who produces a	12.98	8.61

	secondary product in market j in year t.		
$GRSALES_{it}$	Yearly gross sales for firm i (millions of $US).	500	4460
$EMPL_{it}$	Number of Employees for firm i in year t who produces a secondary product in market j.	1489.57	17245.16
$WINDOWS_{ijt}$	Equals 1 if at least one secondary product for sale by firm i in market j in year t was produced for Windows operating system	0.19	0.392
Time Variable			
$CSYEAR_{ij}$	Year in which firm i sells a secondary product in primary market j. Equals 1 if 1996, 0 if 1994.	0.4	0.49
Markets			
$SPREADSHEET_{it}$	Equals 1 if firm i produces in spreadsheet market in year t	0.07	0.25
$WORDPROCESSING_{it}$	Equals 1 if firm produces in word processing sector	0.12	0.32
$INTEGRATED_{it}$	Equals 1 if firm produces in integrated software market	0.01	0.12
$PERFINANCE_{it}$	Equals 1 if firm produces in personal finance sector	0.04	0.2
$DESKTOP_{it}$	Equals 1 if firm produces in desktop publishing sector	0.05	0.23
$ACCOUNTING_{it}$	Equals 1 if firm produces in accounting market	0.28	0.45
$DATABASE_{it}$	Equals 1 if firm produces in database market	0.31	0.46

4.1.4 Independent Variable

The independent variable y_{ijt} measures the number of secondary product introductions by firm i in market j for year t. The Law of Rare Events states that the total number of events will follow, approximately, the Poisson distribution if an event may occur in any of a large number of trials but the probability of occurrence in any given trial is small. The frequency distribution for y_{ijt} provided in Table 4.4 suggests that a per-firm count of new products satisfies this law since zero event counts are dominant. Furthermore, there exist few large counts, with 98.5% of the sample taking on values of 0,1 or 2. As a result the distribution for y_{ijt} is similar to the Poisson distribution displayed in Figure 4.1 (A). Table 4.5 breaks the distribution into the two years in our sample 1994 and 1996.

TABLE 4.4:
New Product Introductions: Actual Frequency Distribution For Total Sample

y_{ijt}	Frequency	Percent	Cumulative
0	764	71.00	71.00
1	269	25.00	96.00
2	27	2.51	98.51
3	11	1.02	99.54
4	3	0.28	99.81
5	0	0	99.81
6	1	0.09	99.91
7	0	0	99.91
8	1	0.09	100.00
Total	1076	100.00	

TABLE 4.5:
New Product Introductions: Cumulative Frequency Distribution by Year

Year/Total Innovations	0	1	2	3	4	5	6	7	8
1994	84.11	97.77	99.26	99.72	99.81	99.81	99.91	99.91	100
1996	86.9	98.23	99.26	100	100	100	100	100	100

4.1.5 Covariate Selection

Right hand side variables in our regression include primary market, firm and operating system characteristics, year and market (sector) specific control variables. The observation that multi-product bundling and exclusion is not exclusive to operating system/software markets allows us to test the hypothesis that Microsoft harms innovation by deterring entry in secondary software markets when it is a dominant player in the primary one. Primary products, defined in Table 4.1, are ones whereby their producer can create a technological tie resulting in the exclusion of secondary product manufacturers. Secondary software manufacturers develop non-standalone products which work in conjunction with a primary product.

Covariates representing primary market characteristics consist of *MSMS*, *STANDARD* and *HHI*. In terms of testing our hypothesis, the most important variable in our model is *MSMS*, Microsoft's market share in the primary market, because it allows us to examine the link between Microsoft's dominance and innovation. Using market share as a measure of market dominance is consistent with the 1998 Complaint against Microsoft. According to the DOJ (1998, p.1), "Microsoft possesses monopoly power in the market for personal computer operating systems (since) Microsoft's 'Windows' operating systems are used on over 80% of Intel-based PCs." As shown in section 4.1.2, the coefficient β_1 is a semielasticity and can be interpreted as the proportionate change in the expected per firm number of new product introductions in the secondary market if Microsoft's market share in the primary market increases by one percent. If *MSMS* is inversely related to the expected number of per firm new product introductions in the secondary one then β_1 would be negative.

In order to measure market dominance, control variables are required to distinguish between the effect Microsoft has on innovation and a change in innovation opportunities due to market maturity and standardization. It was argued in Chapter Two that in a network industry, a direct result of positive feedback effects is that a firm may be able to tip a network market in its favor. Because of tipping, the joint existence of two incompatible products may be unstable and consequently, a single product will become the *de facto* industry standard. In other words, network externality theory suggests that a standard may emerge as a market matures.

Adding *STANDARD* to the model allows us to distinguish between the effect that Microsoft has on innovation in secondary markets (competition on a standard) and this natural tendency for software markets to head toward a standard (competition between standards). β_2 is the semielasticity of the expected per firm number of new product introductions in the secondary market with respect to *STANDARD*. The sign of β_2 depends on two factors. First, when a software supplier is making a decision to innovate, a standard in the primary market may reduce uncertainty. When uncertainty exists regarding which primary product will emerge as the standard, a secondary software developer risks producing an innovation for which the hardware product may lose the standards battle thus becoming obsolete. In other words, the expected rewards for the innovation are reduced prior to the emergence of a standard. On the other hand, the dominant supplier in the primary market might profit from incorporating innovative ideas into its own products once it has emerged as the standard. When this occurs, the incentives for third parties to design new ideas are reduced. The addition of *STANDARD* allows us to distinguish the "Microsoft Effect," a reduction in innovation because Microsoft has a reputation for tying and predatory product innovation, and the natural tendency for a standard to emerge in a network market.

It is also important to distinguish between monopolistic structure and innovation effects when examining the effect that Microsoft's dominance has on innovation in secondary software market. Sheremata (1997, p.939) makes the following observation:

> The economics literature often ignores monopolistic structure while analyzing the effects of network externalities on performance, or ignores network externalities while analyzing the effects of monopolistic structure. The *Microsoft* case is revealing as it illustrates the effect of monopoly power *in conjunction with* network externalities on the speed of innovation.

Taking Sheremata's criticism into account, our model distinguishes between market structure and network effects in the primary market. Whereas *STANDARD* takes network effects into account, *HHI* measures market concentration by summing the squares of the individual market shares of all participants in the primary market. β_3 is the semielasticity of the expected per firm number of new product introductions in the secondary market with respect to *HHI.*

As well as providing evidence on the relationship between a standard in the primary market and innovation in the secondary one, our model also sheds some light on the debate regarding firm size and the likelihood that it will innovate. Measures of firm size include its number of employees, *EMPL*, and gross sales, *GRSALES.* Two literature surveys examining the link between firm size and innovation are Freeman and Soete (1997, pp.232-236) and Scherer and Ross (1990, pp.651-654). It has been argued that because small firms are flexible, concentrated and have superior internal communications they have an innovative advantage over larger firms. Furthermore, they may be more adept at risk taking.

Their decisions to proceed with an ambitious project typically are made by a handful of people who know each other well. On the other hand, larger firms have advantages such as the ability to maintain a diversified portfolio of R&D projects which allows them to hedge the risks that any given project will fail. They have greater resources to purchase highly specialized equipment and employ specialists in many disciplines who can work together to solve problems. Moreover, cost reducing innovations benefit large firms to a greater extent than small ones. If β_5 and β_6 are positive (negative), our model would suggest that firm size and innovation were positively (negatively) related.

In addition to examining firm size, our model controls for firm age, *AGEFIRM*. It appears that the literature on the link between firm age and innovation is not nearly as extensive as that of firm size and innovation. One notable paper on this topic however is Hansen (1992) who assesses how the level of innovation for manufacturing firms is influenced by their age. Using a Poisson Model, his results tend to indicate that firm age is inversely related to innovative output. If β_4 is negative, like Hansen, our results would suggest that firm age and innovation are inversely related.

Two variables, *CSYEAR* and *WINDOWS*, provide insight into overall trends in the computer software market. *CSYEAR* tells us if innovation is rising or falling between 1994 and 1996. The reason for the addition of *CSYEAR* into the model is that Windows 95 was introduced in 1995, between the first and second period under investigation in our sample. One possible explanation for a decline in innovation over time may be the influence of the introduction of Windows 95 since newer versions of Microsoft Windows tended to have a greater number of applications bundled within it. *WINDOWS* examines whether at least one of the firm's innovations in the secondary market occurs on the Windows Operating System. One would expect β_8 to be positive because third party software suppliers would desire to create software for the dominant operating system. On the other hand, if it was negative evidence would be provided that the expected number of per firm new product introductions would be less on Windows than all other operating systems.

Finally, sector specific occurrences which are unrelated to Microsoft must be accounted for. As a result, indicator variables have been added to the model. These indicator variables include: *SPREADSHEET, WORDPROCESSING, INTEGRATED, PERFINANCE, DESKTOP, ACCOUNTING* and *DATABASE*.

4.1.6 Alternative Models

Prior to discussing the data collection procedure, it should be noted that two alternative models to the Poisson are the Log Regression and Logit models. In the past, economists such as Orr (1974) and Khemani and Shapiro (1986) have estimated entry models using a log regression on cross-sectional data. Specifically, the entry equation was specified in semi-logarithmic form with the dependent variable measured as the logarithm of the absolute amount of net firm entry into a cross-section of industries. Price (1995) outlines the motivation for using a count model rather than the log regression model. First, he notes that the dependent variable of the model proposed is a count of the total number of new product introductions introduced by a particular firm in a particular sector during a given year. The dependent variable varies from zero to eight in our data set. Since product introductions take on non-negative integer values, a count model is called for. Second, a logarithmic specification requires either the exclusion of zero entry observations or else incorporating *ad hoc* procedures such as the use of dummy variables to account for zero entry observations. On the other hand, zero entry observations are consistent with a econometric specification where product introductions are specified as a discrete random variable. Third, unlike logarithmic specification when the product introduction count is specified as a discrete random variable, maximum likelihood estimation is permissible resulting in more efficient estimators of the parameters. Finally, because many of the observations are small a specification which models the counting properties of the data is appropriate.

The Logit Model is a second alternative to the Poisson model which could have been used to analyze the data. Logit models are used when the dependent variable is qualitative, reflecting binary choices. Rather than using a per firm new product count as a dependent variable, our dependent variable could have been binary reflecting the choice of the firm to innovate or not. However, using a per firm new product count and the Poisson Model is superior for measuring innovation in this case for two reasons. First, by sampling products, a Logit Model estimates the effects covariates have on the rate of or percentage of new products. On the other hand, the Poisson Model provides a more meaningful interpretation. Rather than calculating the likelihood of a product being new, the Poisson Model calculates the expected number of products that each firm will produce. This distinction is important since the focus here is on secondary software developers' innovation incentives when the primary market is dominated by a firm who has a reputation for tying. Second, an implicit assumption of the Logit Model is that each firm produces a single product in only one market. This assumption is limiting because some firms in the sample produce multiple products in several markets.

4.2 DATA COLLECTION AND SAMPLE

This section focuses on the methodology used to assemble the data set. All data was obtained from two separate sources: two Computer Select compact disks (CDs) and two Dataquest reports (reports) on the computer software industry. After describing these sources of data, the sampling procedure will be outlined.

4.2.1 Data Sources

Raw data for this project was obtained from two different sources. The first is two Computer Select compact disks, Computer Select Version 3.5 and 3.7. Computer Select is a collection of information regarding computer hardware, communications and software products; industry trends; companies; technological advances; personalities and newsworthy events. The CDs were released with detailed up-to-date information in January 1995 and December 1996.[3] In other words, Version 3.5 and 3.7 cover the years 1994 and 1996 respectively. All

[3] Attempts were made to obtain version 3.6 with no success.

information on the CDs are collected from DataSources (a product directory used by computer professionals who wish to compare products), contacts made with publishers and manufacturers in the industry, information provided via returned surveys and technical manuals.

Markets and firm information for the secondary market was obtained from the CDs. Computer Select contains a section dedicated to providing in-depth directory information on software products and a glossary of computer company profiles. Each software specification sheet is filled with facts and figures detailing the product and its compatibility with operating systems and other software products. Software specifications feature such information as the manufacturer, product release date, RAM requirements, source language, and customer support options, as well as a summary of the product's functionality. Many of the specifications also offer manufacturer suggested list pricing and installed base information, however for the majority of products, either one or both of these pieces of information is absent. The CDs also provide firm profiles which outlines the year the firm was founded, its gross sales, lists of products it sells, and whether it is publicly or privately owned.

As a result of the lack of complete installed base information on the Computer Select CDs, auxiliary information was required. This information was obtained from Dataquest's 1997 Personal Computing Software Market Share Report and the 1996 Personal Computing Software Vendor Shipment and Revenue Data Report. These documents contain personal computing software shipments and revenue data for the primary vendors within the major categories Dataquest tracks. Dataquest gathers its information from a variety of sources including publications by major software participants, government and trade data, and annual reports.

4.2.2 Sample

The Software Products Specifications section on the CDs includes information on approximately 48,000 and 44,000 products on versions 3.5 and 3.7 respectively. Our sample consists of 758 computer software firms that have produced products available for sale in 1994 and 1996 in 8 different computer software markets (sectors). The manner in which the sample was collected from the CDs, markets were defined and products were divided into primary and secondary and reports will be outlined here.

First, a decision had to be made regarding the markets which would be sampled. Markets are broken down into various categories on both the CDs and the report. For 1994, the CDs break the software industry into 76 markets; however, in the reports, it is only divided into 15 markets. Eight markets described in the reports and CDs overlapped. They are: accounting, personal finance, word processing, spreadsheets, database, desktop publishing, integrated and program management. These markets were selected to be sampled.

Once individual markets were selected, products had to be separated into primary and secondary categories. Primary products are ones where the producer has the option of bundling complementary software within it resulting in the exclusion of complementary software producers. Secondary software are dependent upon a primary product to function. Dividing markets into primary and secondary categories was determined by the data sources used for the creation of the data set. Secondary market product counts were tallied from the information sampled from two Computer Select compact disks (CDs) which include a wide variety of software products in each market. On the other hand, primary markets were defined based on the manner in which Dataquest divided the computer software industry into individual markets in its reports. (Table 4.1) In the reports, only a narrow number of multi-product systems were included and periphery products were excluded. For example, in the word processor markets, word processors such as Microsoft Word are included but, unlike the CDs, unbundled spell-checkers are not. Because many of the software described on the CDs are products that function only in conjunction with products listed in the report, one can consider that the products on the CDs are secondary whereas the ones in the report are primary.[4] Using the installed base information in the reports,

[4] Of course, the strength of this assumption depends on the category. For instance, it appears to hold for word processing but may for integrated software where there are ten primary products and only twenty-one "secondary" products listed on the CDs. It should also be noted that when all

MSMS, *STANDARD* and *HHI* were calculated. Table 4.6 illustrates the differences in the number of products in the primary and secondary market by year and provides a count of firms in the secondary market.

TABLE 4.6:
Primary and Secondary Market Product Count

Sector	Number of Products Listed in Report (Primary Market)		Number of Products Listed on CDs (Secondary Market)		Total Number of Product Producers	
	1994	1996	1994	1996	1994	1996
Accounting	16	21	420	375	221	207
Desktop Database	16	11	1307	1586	461	440
Desktop Publishing	10	11	529	412	167	149
Integrated Software	10	6	46	60	21	33
Personal Finance	8	4	185	169	77	69
Program Management	6	14	281	227	148	136
Spreadsheet	9	7	231	118	120	71
Word Processor	17	13	640	418	262	202

Since the focus of this thesis is on complementary software producers' innovation incentives, our sample is comprised of firm level data in the secondary market and market level data in the primary one. The process of transforming the information on the CDs and reports into our sample involved four steps. First, products were sampled based on whether total number of sales was available. At the time of the sampling procedure, it was believed that sales information would be of importance. However, cross checking the sales data with other data sources on the computer industry suggested that the sales data on the CDs was unreliable – for some products it was a sum of all sales since the product was introduced and for other products, it was yearly. Therefore, in the end, the sales data was not used. Since Microsoft provided no sales data for the categories that have been selected for this thesis, no secondary Microsoft products are included in the data set. Second, the sample was divided into individual markets and the number of per firm new product introductions were tallied for each firm in each market.

observations that belong to the integrated category are removed, the regression results remain the same.

Therefore, a firm with two product applications for sale in two different markets in the sample would result in two observations. Whether at least one of the innovations was compatible with Windows was also recorded. Third, the names of the firms were cross-referenced to a list of computer company profiles available on the CDs. From the profiles, the age, gross sales and number of employees for each firm was recorded. Fourth, *HHI*, *MSMS* and *STANDARD* were calculated for each market and year using the reports and added to the data set. Because our sample consists of eight markets over a two year period, there exist only sixteen values for each of these three variables. For instance, for each firm in a particular year, the market attributes that it faces are coded as well as its own personal characteristics. Also, an assumption had to be made that international market share is a proxy for North American market share since the reports contain international installed base information whereas the CDs supply North American product information.

4.3 REGRESSION ESTIMATION AND TESTING

In the two previous sections, the process of constructing the model and collecting the data have been summarized. In this section, the results, diagnostic tests and limitations of our Poisson regression will be presented. The most important result of the model is that, at a ten percent significance, Microsoft's market share is negatively related to the expected number of per firm new product introductions (innovation). A second important finding is that the emergence of a standard is positively related to innovation suggesting that secondary software developers are more apt to innovate when they are confident that the primary product will not lose a standards' battle. The results also suggest that market structure in the primary market and innovation are not related; a firm's size is unrelated to innovation but inversely related to its age; and, fewer innovations were observed for 1994 than 1996.

4.3.1 Microsoft's Dominance

Our hypothesis is that an inverse relationship between Microsoft's market share in the primary market and innovation in complementary software application markets exists. The Poisson regression's estimated coefficients with their corresponding t-values are displayed in Table 4.7. β_l is the semielasticity of the expected number of per firm new product introductions in the secondary market with respect to Microsoft's market share. Since β_l equals -0.0217, the results suggest that a one percent increase in Microsoft market share results in a 2.17% decline in the expected number of new product introductions. Since the sign of coefficient for *MSMS* is negative and significant at a ten percent level (p-value of 0.092), we cannot reject the hypothesis that Microsoft's market share (dominance) is inversely related to the expected number of per firm new product introductions.

TABLE 4.7:
Poisson Regression Results

Covariate	Corresponding β in Equation 1	Estimated Coefficients (t-statistics)
MSMS	β_1	-0.0217** (-1.68)
STANDARD	β_2	0.1192* (2.70)
HHI	β_3	-0.0034 (-0.17)
AGEFIRM	β_4	-0.20** (1.82)
GRSALES	β_5	-9.46×10^{-4} (-0.95)
EMPL	β_6	1.13×10^{-4} (0.88)
CSYEAR	β_7	-0.56* (-2.65)
WINDOWS	β_8	2.11* (14.67)
SPREADSHEET	β_9	0.95 (0.94)
WORDPROCESSING	β_{10}	2.44* (2.46)
INTEGRATED	β_{11}	-1.02 (-0.91)
PERFINANCE	β_{12}	0.54 (0.86)
DESKTOP	β_{13}	2.02** (1.66)
ACCOUNTING	β_{14}	1.16 (1.47)
DATABASE	β_{15}	2.52* (2.05)
Constant		-6.02* (-3.09)
N		674
Pseudo R^2		0.27
Deviance		377.97
Log Likelihood		-384.62

* Significant at a five percent level.
** Significant at a ten percent level.
*** Per firm product introductions is the independent variable

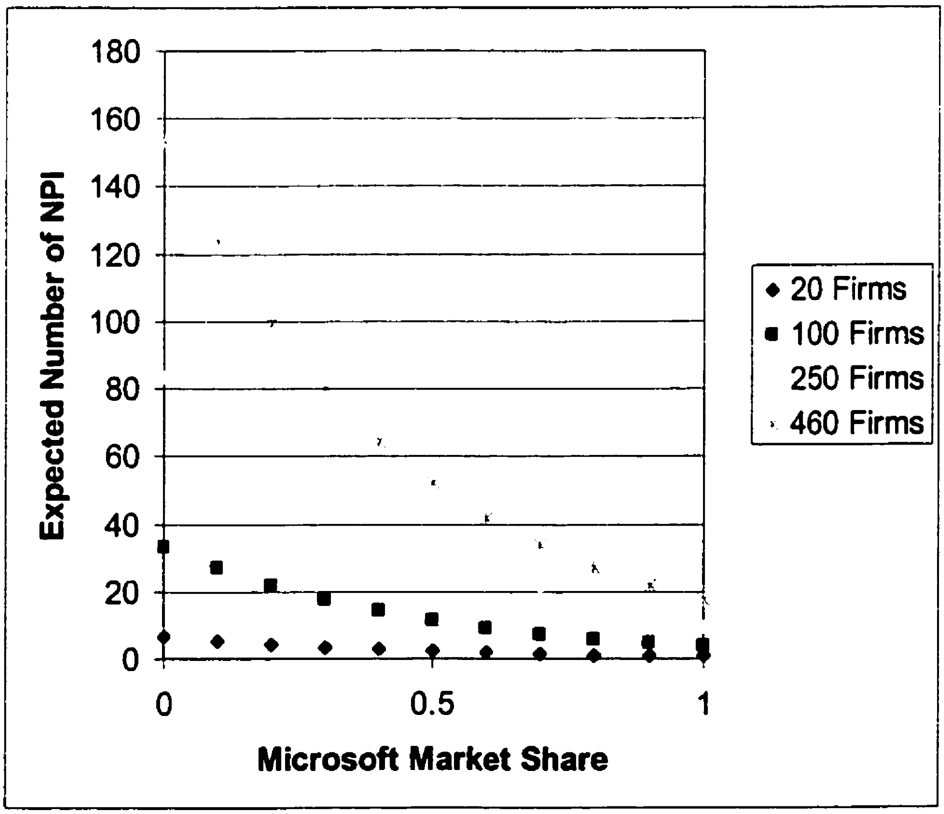
The relationship between Microsoft's market share and the expected number of per firm new product introductions is displayed in Table 4.8. The expected number of per firm new products is calculated by substituting various levels of Microsoft's market share (zero to one hundred percent at ten percent intervals) into Equation 1, outlined in section 4.1.3, while holding all other variables constant at their means. These calculations illustrate that the expected number of new product introductions per firm is 0.33 when Microsoft is not competing in the primary market (has a market share of zero) compared to 0.04 when it completely dominates (has one hundred percent of the market share). In this "Microsoft dominates" case, one would expect one new product to be introduced for every twenty-five firms competing in a secondary market. On the other hand, one would expect that one new product would be introduced for every three firms competing in a secondary market where Microsoft has a zero percent market share in the primary one. In other words, very little innovation occurs when Microsoft dominates the market completely compared to markets where it is absent.

TABLE 4.8:
The Microsoft Effect

MSMS	**Expected Number of Per Firm Product Introductions**
0	0.33
10	0.27
20	0.22
30	0.17
40	0.14
50	0.11
60	0.09
70	0.07
80	0.06
90	0.05
100	0.04

A graphical relationship between the fraction of market share Microsoft has acquired in the primary market and the expected number of per firm product introductions in the secondary market is presented in Figure 4.2. This Figure was created by multiplying different values of firms in the secondary market by the calculated values provided in Table 4.8. The range of the number of firms, 20 to 460, approximates the range of firms found in secondary markets for our sample (Table 4.5). Figure 4.2 demonstrates that the greater number of firms participating in the secondary market, the greater the harm to innovation. It also illustrates that when Microsoft has one hundred percent of the market share in the primary market, innovation in the secondary market is all but stifled.

FIGURE 4.2:
Expected Number of Innovations vs. Microsoft Market Share



4.3.2 Network Effects

Adding *STANDARD* to the model allows us to distinguish between the effect that Microsoft has on innovation and the natural tendency for network markets to head toward a standard. Since β_2 is statistically significant and equals 0.1192, a one percent increase in the value of *STANDARD* results in a corresponding 11.92% increase in the expected number of per firm new product introductions in the secondary market. This result implies secondary software suppliers innovation decisions are based less on the fact that a dominant supplier in the primary market might incorporate their innovative ideas into its own product once it has emerged than the fact that the emergence of a standard increases expected profits because of the improved probability that the primary product's installed base will continue to grow. However, it is possible that since β_1 is negative, secondary software suppliers are concerned when Microsoft is the dominant firm in the primary market since it has a reputation for tying and predatory product innovation.

4.3.3 Market Power

Sheremata's (1997, p.939) argument that the Microsoft case illustrates the effect of monopoly power in conjunction with network externalities harms innovation does not appear to be supported with this data. *HHI* is negative and insignificant. This result in combination with the fact that *STANDARD* is significant and positive and *MSMS* is negative and significant suggests that innovation is harmed by Microsoft's dominance in the primary market and not by the effect of monopoly power in conjunction with network externalities as Sheremata argues.

4.3.4 Firm Size and Age

Our model also sheds light on the debate regarding firm size and the probability of innovation. Measures of firm size include number of employees, *EMPL*, and gross sales, *GRSALES*. If β_5 and β_6 were positive (negative), our model would suggest that firm size and innovation were positively (negatively) related. However, we find that they are both insignificant. Therefore, our results imply that firm size is irrelevant with respect to their innovation decisions.[5]

By examining the manner in which the level of innovation for manufacturing firms is influenced by their age, Hansen (1992) found that a firm's age is inversely related to innovative output. Since β_4 is negative and statistically significant at a ten percent level, like Hansen, our results would suggest that firm age and innovation are inversely related. β_4 equals -0.20, a one year increase in a firm's age leads to a twenty percent decrease in the expected number of new product introductions.

4.3.5 Market Trends

Two covariates, *CSYEAR* and *WINDOWS*, provide insight into overall trends in the computer software market. β_7 is statistically significant and has a value of -0.56 which tells us if innovation is higher or lower in 1994 and than in 1996. Specifically, the expected per firm product introductions are 56 percent higher in 1994 compared to 1996. Possible explanations of the decline are the introduction of Windows 95, higher costs in the computer software industry, and firms switching away from the sectors examined here to other markets. Examining *WINDOWS* rules out the decline in innovation as a result of the introduction of Windows 95. *WINDOWS* examines whether the firm's innovation occurs on the Windows operating system. β_8 equals 2.11 and is statistically significant. This result means that expected number of new product introductions for the Windows Operating System is 211 percent greater than the overall sample. Because third party software suppliers would desire to write software for the dominant operating system this result is expected and suggests that the introduction of Windows 95 did not cause the overall reduction in innovation between 1994 and 1996.

[5] Running our regression while excluding either *AGEFIRM* or *GRSALES* yields the same results – firm size is unrelated to innovation.

4.3.6 Model Evaluation and Testing

In order to ensure the reliability of a Poisson Count Model, Cameron and Trivedi (1998) argue that three diagnostic examinations must be performed – overdispersion tests, residual analysis and tests for goodness of fit. A key assumption of the Poisson model is that the conditional variance equals the conditional mean (equidispersion). As noted in section 4.1.2, the primary consequence of the failure of equidispersion is inefficient standard errors. One indication of overdispersion can be obtained simply by comparing the sample mean and variance of the dependent count variable. For our sample, the mean number of product introductions is 0.36 with a variance of 0.67 implying that the raw data are overdispersed. However, as Cameron and Trivedi (p.77) note,

> Subsequent Poisson regression decreases the conditional variance of the dependent variable somewhat. The average of the conditional mean will be unchanged, however, as the average of the fitted means equals the sample mean. This follows because Poisson residuals sum to zero if a constant term is included. If the sample variance is less than the sample mean, the data necessarily are even more underdispersed once regressors are included. If the sample variance is more than twice the sample mean, then data are likely to remain overdispersed after the inclusion of the regressors.

Since our variance is less than twice the sample mean, it is possible for the overdispersion to disappear once the regressors are added. Since underdispersion is uncommon; it occurs most often when events are not independent (i.e. y_i is related to y_{i+1}) and since the mean number of product introductions for our sample (0.36) is lower than the variance (0.67), underdisperson is not a concern here.

An overdispersion test comparing the suitability of the Negative Binomial Maximum Likelihood Model (Negative Binomial), the standard model used in the event that count data is overdispersed, to Poisson will be used here. (Cameron and Trivedi, pp.70-71) In order to formulate the standard overdispersion test, recall that in the Poisson Model, y_i has a mean $\mu_i = \exp(x_i'\beta)$ and variance μ_i. Now, suppose that the assumption of equidispersion does not hold - the count variable is believed to be generated by a Poisson-like process, only the variation is greater than that of a true Poisson. In this case,

$\omega_i = V[y_i|x_i]$

where $\omega_i = \omega(\mu_i,\alpha)$ for some function $\omega(\bullet)$ and α is a scalar parameter. If ω_i takes the form

$\omega_i = \mu_i + \alpha\mu_i^2$

then we have described what is known as the Negative Binomial Model.

In order to test for departures from equidispersion, a hypothesis test comparing the Negative Binomial and Poisson Models is performed. The null hypothesis that we wish to test is

H_o: $\text{var}\{y_i\} = \mu_i$ (Poisson)

against the alternative

H_1: $\text{var}\{y_i\} = \mu_i + \alpha g(u_i)$ (Negative Binomial)

where $g(u_i) = u_i^2$. When α equals zero, the null hypothesis that the data is Poisson cannot be rejected. On the other hand, if α exceeds zero, data is overdispersed and the Negative Binomial is an improvement over Poisson. The extent of overdispersion increases with α.

A Likelihood Ratio Test was performed at a one percent significance level to test whether α, the overdispersion parameter, equals zero (indicating that no overdispersion exists). By performing this test, it was found that the probability that we would observe this data conditional on $\alpha = 0$, the process being Poisson, is insignificant. A χ^2 value of 0.0000222 ($p = 0.9962$) was calculated and the Stata Statistical Software estimated α to equal 3.85×10^{-09}. Therefore, the hypothesis of equidispersion is not rejected – the data is Poisson and the Binomial Model is not an improvement over Poisson Model.

After testing for overdispersion, residual analysis was performed. Residuals measure the departure of fitted values from actual values of the dependent variable. Residual analysis can be used to detect model misspecification, outliers and influential observations. For count data, no residual exists that has zero mean, constant variance and a symmetric distribution. As a result, the raw residual

$$r_i = (y_i - \hat{\mu}_i)$$

is not appropriate for a Poisson Model. Deviance residuals are recommended by McCullagh and Nelder (1989) as having the best properties for examining the goodness of fit of a Generalized Linear Model such as Poisson. The deviance residual is defined by Cameron and Trivedi (p.14) as

$$d_i = sign(y_i - \hat{\mu})\sqrt{2\{l(y_i) - l(\hat{\mu}_i)\}}$$

where

$$2\{l(y_i) - l(\hat{\mu}_i)\}$$

is the Deviance Statistic, the difference between the log density of y evaluated at μ = û and the log-density of μ = y. Cameron and Trivedi (p.152) define the Deviance Statistic as "twice the difference between the maximum log-likelihood achievable and the log-likelihood of the fitted model." For Poisson, the deviance residual equals

$$d_i = sign(y_i - \hat{\mu}_i)\sqrt{2\left\{y_i \ln\left(\frac{y_i}{\hat{\mu}_i}\right) - (y_i - \hat{\mu}_i)\right\}}$$

Figures 4.3 and 4.4 show the deviance residuals plotted against the actual and predicted count of product introductions. Because Cov[y-μ,y]=V[y] which equals

μ for Poisson data, there is a positive relationship between $y-\mu$ and y. This positive relationship can be seen in Figure 4.3. In Figure 4.4 no pattern is visually detected. However, three residuals appear to be outliers in Figure 4.4.

FIGURE 4.3:
Residual vs. Actual y

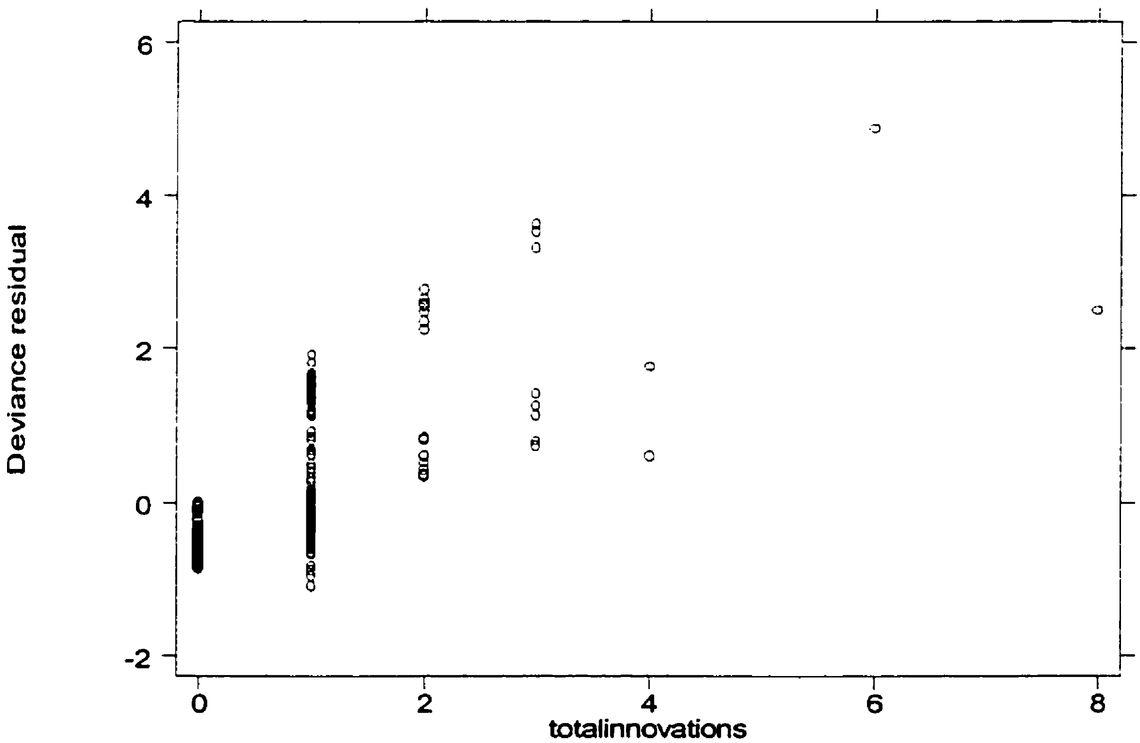
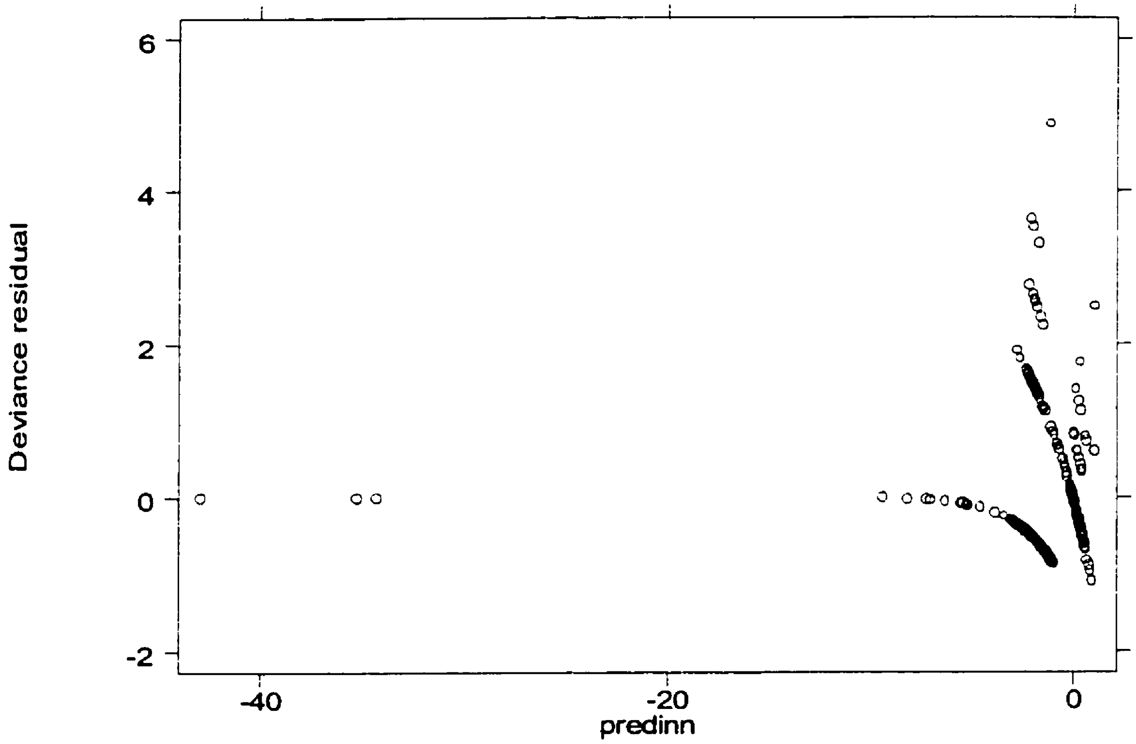


FIGURE 4.4:
Residual vs. Predicted y



Outliers are less important in cases where the large data sets exist or the relative importance of the individual observations are small. Considering the size of the data set, it is likely that the outliers are not influential. In order to be confident that this is the case however, the outliers were identified and removed from the data set. A Poisson regression was then run and it was found that the results are virtually identical to the ones presented in Table 4.6. Most importantly, the coefficient and t-statistic for *MSMS* do not change at all.

After examining residuals, goodness of fit should also be examined by examining the Pseudo R^2 and the Deviance Statistic reported in Table 4.6. The Pseudo R^2 is the log-likelihood value on a scale where zero corresponds to the "constant-only" model and 1 corresponds to a perfect prediction (log-likelihood value of zero). A Pseudo R^2 can be interpreted in a similar manner to the commonly reported R^2 measure for linear regression analysis. The Deviance

Statistic, known as the G^2 statistic for Poisson Models, is a second goodness of fit measure. It calculates the difference between the maximum log-likelihood achievable and the log-likelihood of the fitted model. Although Cameron and Trevedi report the Deviance Statistic, they provide little insight into interpretation. Similarly, in the May-June, 1997 issue of the Journal of Applied Econometrics (a special issue on econometric models of event counts), of the seven articles presented only one provides an R^2 measure and the Deviance Statistic is never reported.

4.3.7 Limitations

Before discussing the implications and conclusions drawn from our results, it is important to briefly discuss four limitations of the model and data. First, by choosing a new product count as a measure for innovation, each innovation is weighted equally. Because of the difficulty in discerning the importance of each innovation, innovations which a greater impact on society have equal weights to those that are less important.

A second limitation of the model is the lack of data availability. The data covers only 8 markets over two years. Ideally, following Greenstein and Wade, ten or more markets should be examined over a five year time frame. Furthermore, because of the lack or high cost of data, several factors that may influence innovation incentives are not included here such as: access each firm has to venture capital; software development costs; and labor costs. The lack of data also meant that the assumption that the international market share equaled its market share in the United States had to be made. Had national data been available, confidence in the results would have increased.

Finally, it should be the case that the analogy between operating systems/software markets and primary/secondary software markets is not a perfect one. Perhaps, in primary/secondary software markets firms are able to avoid Microsoft more easily by producing software in non-Microsoft sectors. It could be the case that, because Microsoft is the system sponsor, it is more difficult for software producers to avoid Microsoft and therefore they .enter regardless of Microsoft's dominance in the operating system market.

4.4 IMPLICATIONS AND CONCLUSIONS

It has been argued that Microsoft can use its market power in the operating system market to exclude rivals in secondary software markets and that a repercussion of exclusion is a reduction in complementary product suppliers' incentives for research and development. Because multi-product bundling and exclusion is not exclusive to operating system/software markets, the hypothesis that when it is a dominant player in the primary market, Microsoft harms innovation by deterring entry in secondary software markets because it has a reputation for implementing a tying strategy was tested. A Poisson Model using a per firm count of new products as the dependent variable and Microsoft's market share in each primary market as measures for innovation in the secondary market and market dominance in the primary one, we found that there exists a significant negative relationship between Microsoft's market share and innovation. Furthermore, the results imply that innovation in secondary markets is all but completely stifled when Microsoft's market share in the primary market approaches one hundred percent. At the same time, innovation incentives are improved when a single product in the primary market exists

These results have implications for the ongoing legal dispute Microsoft has with the United States Federal Government. A key issue outlined in the 1998 DOJ Complaint is the effect of Microsoft's exclusionary practices on the incentives for innovation by others, in particular the incentives for third party software suppliers, to develop new applications that are complementary with Microsoft's operating systems. According to the DOJ (1998,p.2), in order "to extend its operating system monopoly into other software markets, Microsoft has engaged in a series of anticompetitive activities. Microsoft's conduct includes agreements tying other Microsoft software products to Microsoft's Windows operating system."

The empirical work done here examined the relationship between primary products such as Microsoft Word and utility producer's innovation incentives where a utility performs small tasks or chores designed to aid the primary product. The DOJ complaint on the other hand, is concerned with effect on innovation incentives in application markets by Microsoft strategies since it is the monopoly operating system producer. Assuming that the analogy between operating systems/software and primary/secondary software markets holds, our result provide indirect evidence that that a repercussion of Microsoft's tying strategy is a reduction in innovation in applications software markets. If this is the case, a indirect evidence has been provided that remedy such as vertical separation with limits on bundling which was outlined in Chapter Three would result in an improvement in third party software suppliers' innovation incentives.

CHAPTER FIVE: SUMMARY AND CONCLUSIONS

The ongoing legal battle between Microsoft and the DOJ has prompted a debate concerning competition and innovation in computer software markets and other high technology industries. Economic theory would suggest that by virtue of having monopoly power in the operating system, Microsoft has the ability through tying and predatory product innovation to exclude complementary software producers. However, the economic literature surrounding Microsoft has tended to ignore the dynamic welfare effects occurring in complementary markets as a result of Microsoft's exclusionary strategy. Furthermore, there has been no systematic empirical evidence on the extent to which Microsoft's exclusionary behavior directed against existing third party suppliers has on their innovation incentives. As a result, this thesis empirically examined the link between exclusionary strategies such as tying and predatory product innovation and third party software producers' innovation incentives when the hardware component is produced by a monopoly and provided indirect evidence that a remedy limiting Microsoft's market power in the operating system market is necessary.

On May 18, 1998, the United States federal government together with the attorney-generals of twenty states accused Microsoft Corporation (Microsoft) of illegally preserving and extending its monopoly in desktop operating systems. One of the essential arguments put forward by the DOJ was that by using exclusionary strategies such as tying applications to Windows, the likelihood of competitor entry in the browser market is reduced which results in a reduction in innovation. It listed five specific ways in which tying reduces innovation: it decreases the incentives of competitors to invest in R&D because they know that Microsoft will be able to limit the rewards from any resulting innovation; it impairs the ability of Microsoft's competitors to obtain financing for R&D; it inhibits Microsoft's competitors that have succeeded in developing promising innovations from effectively marketing them; it reduces the incentives of OEMs (original equipment manufacturers) to innovate and differentiate their products;

and, finally, it reduces competition and thus the spur to innovation that competition provides (DOJ, 1998, p.16).

On the other side of the debate, Microsoft argues that by providing an integrated product, it revitalizes innovation in both operating system and complementary software markets. Furthermore, if antitrust authorities impose regulations, innovation would be negatively impacted in the following ways: consumers may never have access to future innovative products; independent software developers would be denied the ability to make use of the latest operating system technology; and consumers would be denied the opportunity to purchase innovative products that would enable them to download data from the internet into other Microsoft programs such as Word.

Despite Microsoft's argument, economic theory suggests that the DOJ should be concerned that Microsoft's tying strategy harms innovation in complementary markets. The main theoretical argument provided in Chapter Two and repeated here was that: 1) the operating system (hardware) and complementary software (software) markets are both network markets; 2) because network markets are prone to tipping, before a standard emerges, firms compete fiercely for the installed base. At this stage, firms wish to attract a large installed base of software in order to increase the attractiveness of their product to potential consumers; 3) once a dominant hardware firm emerges, it has the ability (tying and predatory product innovation) and incentive (increased profits) to dominate complementary product markets; 4) one of the most potent methods a dominant firm can use to leverage her monopoly power into complementary markets is tying; 5) tying results in foreclosure of software firms and potentially an increasingly concentrated innovation market. In a network market, tying is extremely effective at excluding rivals because it allows the monopoly to tip the software market in her favor; 6) software producers will be leery to enter the market with an innovative new product and venture capitalist will be reluctant to provide those that wish to with capital because the system sponsor can exclude rivals through tying thus limiting the rewards of innovation.

In spite of the existence of economic theory supporting the hypothesis that market power in the primary product reduces innovation in secondary software markets, there has been no systematic empirical evidence on the extent to which Microsoft's exclusionary behavior directed against existing third party suppliers has on their innovation incentives. The objective of Chapter Four was to empirically examine the link between exclusionary strategies such as tying and predatory product innovation and third party software producers' innovation incentives when the hardware component is produced by a monopoly. The observation that multi-product bundling and exclusion are not exclusive to operating system/software markets allows us to test the hypothesis that when it is a dominant player in the primary market, Microsoft harms innovation by deterring entry in secondary software markets. The notion underlying this hypothesis is that because it has a reputation for implementing a tying strategy, secondary software producers innovation incentives are diminished in markets where Microsoft is the primary product producer. Constructing a Poisson Model and using a per firm count of new products (new product application software releases) and Microsoft's market share in each primary market as measures for innovation in the secondary market and market dominance in the primary one respectively, the results suggest that there exists a significant negative relationship between Microsoft's market share and innovation. Furthermore, the results imply that innovation in secondary markets is all but completely stifled when Microsoft's market share in the primary market approaches one hundred percent.

Returning to the debate, the finding that Microsoft harms innovation in secondary markets provides indirect evidence that antitrust scrutiny is warranted in the Microsoft case. Of course, an important difference exists between the empirical work done here and the argument put forth in DOJ Complaint - the Complaint is concerned with the effect on innovation incentives in application markets (and competition in the operating system market) by Microsoft strategies since it is the monopoly operating system producer and the empirical work done here examines the relationship between primary products such as Microsoft Word and utility producer's innovation incentives. Assuming that the analogy between operating systems/software and primary/secondary software markets holds, our results provide indirect evidence that that a repercussion of Microsoft's tying strategy is a reduction in innovation in applications software markets.

If this is the case, indirect evidence is also provided that a remedy may be warranted in the Microsoft Case. In Chapter Three, it was argued vertical separation, splitting Microsoft into two or more firm, would encourage innovation in software markets. Microsoft concurrently competes in software markets and dominates the market for operating systems. Because of its system sponsor status, Microsoft is able to use tying, predatory product innovation, predatory pricing and delay or withhold essential operating system specifications from competitors. However, if Microsoft was separated vertically into two firms, one specializing in operating systems and the other in applications, then it would no longer be able to use its monopoly power in anticompetitive ways to exclude software rivals. Along with vertical separation, regulations must be imposed on the operating system firm disallowing it from producing application software. Because software variety increases with the value of the operating system, the new operating system firm would have no exclusionary incentives and would promote independent software development.

5.1.1 Areas For Future Research

There are three potential areas of future research which would be of interest. In this thesis, innovation incentives in secondary markets were examined when the primary market was characterized by a dominant producer. It was argued that new product introductions characterized innovation strategy well because they are often upgrades of existing products or new products themselves.

Therefore, one obvious extension to this work would be to net out these two types of innovation and examine the manner in which market structure in the primary market affects a firm's upgrading and product development strategies in the secondary market. To my knowledge, there exists no empirical work on upgrade strategy and therefore, examining innovation in this way would be of particular interest. Second, assuming that a richer data set could be assembled, examining secondary software producers innovation over a greater span of time and across a larger number of markets would be desirable. With a greater number of markets, the likelihood that a relationship exists between any of the primary market variables outlined in Chapter Four would be reduced. Furthermore, more care will be taken to ensure that a new product introduction is an innovation. Finally, in this thesis it was argued that Microsoft should be vertically separated and its tying decisions should be regulated. Further work examining the rationale for regulation of the operating system market is also of interest.

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