UNITED STATES OF AMERICA

BEFORE FEDERAL TRADE COMMISSION

COMMISSIONERS: **Timothy J. Muris, Chairman**
Mozelle W. Thompson
Orson Swindle
Thomas B. Leary
Pamela Jones Harbour

In the matter of **RAMBUS INCORPORATED,** **a corporation**	**Docket No. 9302**

BRIEF *AMICUS CURIAE* OF ECONOMICS PROFESSORS AND SCHOLARS

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MISCELLANEOUS

1. Interest of *Amici Curiae*

Amici are professors at major universities who have researched and written extensively on the economics of intellectual property, competition policy, and/or compatibility standards.[1] This submission describes what we believe are consensus views on some economic questions that arise in connection with the alleged concealment by Rambus of patents and/or patent applications in the dynamic random access memories (DRAM) industry.

When the intellectual property system works efficiently, it interacts with market mechanisms to ensure that an inventor receives an economically efficient reward. When a standard is adopted without full knowledge of the intellectual property rights associated with it, however, the inventor may be able to "hold up" users of the standard and demand an excessive royalty payment. Economists recognize that economic hold-up can harm competition and consumers. In an important industry such as DRAM, a key input into modern computers, the economic consequences of hold up could be substantial.

Standard-setting organizations (SSOs) sometimes adopt disclosure obligations that might mitigate this hold-up concern, specifying for instance that patents that will be essential to compliance with a proposed standard must be disclosed, and perhaps that the owner must agree to license on reasonable and non-discriminatory terms. However, economic analysis suggests that SSOs' incentives to craft and enforce such rules may be imperfectly aligned with economic efficiency and the protection of end-users against the effects of patent hold-up. While we don't pretend to offer a general solution to this problem, it seems reasonable at a minimum that where an SSO's rules are ambiguous it is sensible for competition authorities to step in to protect end-users by preventing anticompetitive hold-up from "submarine" behavior that falls in a "gray area" of the

[1] *Amici* do not represent and are not being compensated by either party in this action. The primary author was consulted at an early stage by FTC staff; he has been retained by Counsel for Hynix Semiconductor to draft this brief. Other co-signers are not being compensated in any way by Hynix Semiconductor. Appendix A lists all signers.

SSO's rules.[2] Because the SSO may not have the right incentives to design and enforce disclosure and licensing rules, one need not condone hold-up that harms end-users simply because an SSO's rules do not plainly prohibit it.

2. Economics of Intellectual Property Policy

In economic terms, intellectual property policy seeks to improve incentives for innovation and for disclosure, while at the same time seeking to limit the deadweight loss created by protection once the invention is made.

Incentives for innovation are at their best when the inventor can earn economic rents equal to the incremental value of the innovation. The relevant value is incremental in at least two respects. First, it is incremental relative to alternative available technologies, including technologies that are clearly inferior to the innovation (in terms of cost per unit of performance). After an innovation, inferior alternatives may not actually be used and may become commercially non-viable, but nevertheless the *possibility* of using them is economically important in properly constraining the price at which the innovation is licensed.

Second, the relevant value is incremental relative to the possibility of discovery "but for" this particular innovator's discovery. In many cases, another inventor would likely have discovered the invention in due course (and near-simultaneous discovery is far from unknown, as in the case of the telephone).[3] Thus, even in principle, intellectual property should not allow the innovator to exclude others from the use of its invention forever.

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[2] Industry participants often express concern about "submarine patents." A recent FTC Report describes the issue as follows. "The basic scenario is that a patent applicant allows its application to languish in the PTO while watching another company make substantial investments in a technology or product that will infringe the yet-to-be-issued patent. Once the other company's sunk costs are large, the patent applicant obtains the patent, asserts infringement, and 'holds up' the other company, demanding supracompetitive royalties for a license to the 'submarine patent'." Federal Trade Commission (2003), "To Promote Innovation: The Proper Balance of Competition and Patent Law and Policy" at p. 26.

[3] In 1876 Alexander Graham Bell received the telephone patent; he filed his application on the same day that Elisha Gray filed a very similar patent caveat. See Gerald Brock (1981), *The Telecommunications Industry: The Dynamics of Market Structure*, Harvard University Press, p. 89.

In addition, intellectual property policy provides a return to innovation in a socially costly currency—the ability to exclude other potential users of the invention. Once the invention is known, disseminating the knowledge embodied in the innovation may cost little. Yet the right to exclude, whether exercised via licensing or literal exclusion, slows or prevents use of the invention and raises prices. Thus an optimal policy should generally sacrifice incentives at least a bit, and give innovators somewhat less return than their incremental contribution.[4]

3. Market Mechanisms

Normally, if a royalty demand exceeds the incremental value of the patented technology, relative to alternative technologies, it will be refused. For instance, consider a patented process that will save a manufacturer $1 per unit of output. The manufacturer will be willing (if necessary) to pay up to $1 per unit, but will not pay more.

Equally, if the patent-holder declines to license but uses its proprietary process itself, this gives it a production-cost advantage over rivals that is commensurate with the incremental value of its invention.

Thus the market mechanism normally and desirably ensures that the patent-holder does not capture (on a flow basis) more than the incremental value it has created relative to alternative technologies. In order for this mechanism to work, however, users must be able to value the innovation and the terms on which it will be available, against its alternatives.

4. Hold-Up

This normal market mechanism for limiting royalty rates breaks down if users commit (fully or partially) to the use of a technology before they know it is (or will be) patented. Then, they cannot smoothly substitute to an alternative if the royalty demanded exceeds

[4] For a general discussion of the economics of patents see, e.g., F.M. Scherer and David Ross (1990), "Market Structure, Patents, and Technological Innovation," in *Industrial Market Structure and Economic Performance*, 3rd edition, Houghton Mifflin, pp. 613-60.

the technology's incremental value—and, as we noted above, that ability to substitute is the basis of a well-functioning market test of an innovation's value.

A user may be committed to a technology through individual switching costs: that is, it may have sunk investments into the patented technology that it would otherwise have held back or invested in an alternative. The result is that the alternative technology is less attractive (relative to the patented technology) than it would have been absent the secrecy; thus the user can be required to pay more for a license because of this hold-up.[5]

For instance, if a patented technology has (*ex ante*) an incremental value of v relative to the next-best alternative (and taking into account any royalties payable on that alternative), and if switching to that alternative would cost s once a user has sunk investments into the patented technology, then the maximum royalty the user would pay is v if negotiations take place before sinking the investments, but would be $v+s$ if negotiations take place after sinking the investments. The component v measures the patented technology's incremental contribution, while s measures the scope for hold-up.[6]

[5] The FTC report states: "If an innovator or producer learns that it has infringed a patent only after it has committed sunk costs to its innovation and production—and thus locked in to the effort—the patentee may be in a position to demand supra-competitive royalty rates. If, before lock-in, the downstream actor had known about the patent and could have designed its product or innovation around it, then the firm might have used the opportunity to adopt alternative designs as leverage for seeking a competitive royalty rate. But after lock-in, the downstream actor no longer has that option. Redesigning a product after significant costs have been sunk may not be economically viable." Federal Trade Commission (2003), "To Promote Innovation: The Proper Balance of Competition and Patent Law and Policy," p. 29.

[6] Because verbal discussion of problems in which costs are "sunk" at an intermediate stage can be confusing (when does it become true that "sunk costs don't count"?), it may be worth sketching a simple formal framework for this discussion. At date 0, a user is aware of two alternative technologies, A and B. A is technically superior, to an extent measured by $v>0$. There is no patent on B, and the user does not know that there is a patent on A. At date 1, the patent on A could be disclosed and a royalty negotiated, or the patent-holder could conceal the patent (or application). At date 2, the user invests s in one technology or the other; this investment is then sunk (not recoverable). At date 3, the patent is revealed (if it was not disclosed at date 1) and licensing negotiations can take place; if the user wants to change to the other technology it must invest another s.

In this formal framework, if there is disclosure at date 1 and if the patent-holder has all the bargaining power, then technology A will be adopted at a royalty of v, which just extracts the innovation's incremental contribution. If there is no disclosure at date 1 then (unless the user perceives a high probability that A is patented) technology A will still be adopted, but at a higher royalty of $(v+s)$, as in the text. The inferior technology B is not adopted in equilibrium with or without disclosure, but nevertheless plays a real (and beneficial) role, as mentioned in section 2 above.

5. Compatibility Standards and Hold-Up

Another source of hold-up arises if a *compatibility standard* implicates intellectual property. Especially if there are also individual switching costs, it may be hard to *coordinate* any switch to an alternative technology. If users expect that any switch will be unilateral and not coordinated, then each would be willing to pay $v+n$ (or $v + s + n$) rather than switch, where n is the user's value of the network effect.

To be sure, users may have alternatives to sacrificing network effects unilaterally, but those alternatives also tend to be imperfect. For example, they might hope to jumpstart a "bandwagon" movement to another standard by shifting, but doing so in an uncoordinated manner often sacrifices network effects, at least for a while, even if it succeeds in the end. Or, they might use a consensus standards body to agree on a coordinated shift, but such processes can be slow and unwieldy.

Cognizant of these difficulties, courts have recognized that network effects can make it hard for users to substitute away from a standard product, and that this can lead to an excess return to a holder of intellectual property, at an excess cost to users.[7] Thus, for example, several decisions have found that reverse engineering for the purposes of compatibility is legitimate.[8] Reverse engineering potentially reduces *ex post* market power because it effectively functions as an alternative technology, providing potential licensees with additional bargaining power.

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[7] For a discussion of court cases in this area, see Peter S. Menell (2003), "Envisioning Copyright Law's Digital Future," *New York Law School Law Review*, 46:63-109.

[8] For a review of these decisions, see Pamela Samuelson and Suzanne Scotchmer (2002), "The Law & Economics of Reverse Engineering," *Yale Law Journal,* 111:1575-1663.

The Court's decision in *Lotus v. Borland*—holding that the command structure in Lotus 123 was a method of operation and therefore not copyrightable—took a different, but related, route to mitigate problems of hold up arising from intellectual property in an industry with substantial network effects. We note that an Amicus Brief to the Supreme Court, signed by some on this brief, argued that a command menu interface should not be protected by copyright since doing so might allow the exploitation of monopoly power that arises in a situation of network effects and switching costs: "Because of users' reluctance to switch, alternative interfaces that were equally good at the time of initial design do not remain equal and are not equal from the point of view of software designers who must choose an interface specification at a later date. Consequently, a new program attempting to compete with an established program will find that the first one's initially arbitrary interface choices have become economically compelling." Brief Amicus Curiae of Economics Professors and Scholars in Support of Respondent, *Lotus Development Corporation v. Borland International, Inc.*, December 1995, p. 8.

As the discussion above suggests, hold-up is most apt to be important where potential licensees, and/or their customers and complementors, must incur large costs or engage in complex coordination in order to shift *ex post* to an alternative technology.[9] Thus the problem of submarine patents is likely to be greatest in such contexts.

6. Standards Organizations' Rules

Standard-setting organizations sometimes have rules about adopting standards that implicate intellectual property.[10] A reasonable interpretation is that these rules are directed toward avoiding hold-up problems as sketched above. Often such rules require or encourage members to disclose intellectual property and to promise to license it on "reasonable and non-discriminatory" (RAND) terms.

The rules vary across organizations and in some cases are unclear or omit provisions that some might think sensible. For example, controversies have arisen over whether the JEDEC policy applied to patents not yet issued. In particular, the Administrative Law Judge in this proceeding found the policies of the relevant standards body, JEDEC, did not impose a clear duty on Rambus to disclose its intent and expectation to patent key elements of JEDEC's pending standards for SDRAM.[11] On this basis, the judge found in Rambus's favor.

A natural question for an economist is whether SSOs, generally, and JEDEC, in particular, have the right incentives to craft, clarify, and enforce these rules. In other words, would one expect the members collectively to favor rules that encourage overall economic efficiency, including appropriate returns to innovation? There seems no clear

[9] Another form of hold-up may arise if inventors other than the original innovator might develop what turn out to be follow-on innovations. If the original innovation is disclosed only belatedly, these later innovators may be unable to practice (or license) their innovations without permission from the first innovator, raising the possibility of hold-up of follow-on innovators. Similarly, the prospect of hold-up may discourage effort and participation in SSOs by those who will not gain from hold-up.

[10] For a survey of approaches to intellectual property and standards used by a variety of standard-setting organizations, see Mark A. Lemley (2002), "Intellectual Property Rights and Standard-Setting Organizations," *California Law Review*, 90: 1889-1980.

[11] "In sum, the record shows that JEDEC did not require disclosure of patent applications or intentions to file patent applications by anyone other than possibly presenters, although the voluntary, early disclosure of intellectual property was encouraged." Initial Decision, *In the Matter of Rambus Inc., a Corporation*, February 23, 2004, p. 270.

reason to expect such a result, and indeed, at least one obvious economic analysis suggests otherwise. This result follows from the fact that direct purchasers of a technology can often pass through royalty costs to their customers downstream, as described below. In this section we make three simple points about a standards organization's incentives to choose and enforce rules on including intellectual property in a standard and on disclosure and licensing of such intellectual property.

A. Standards organizations are a collection of interests

Standards organizations such as JEDEC often include both potential sellers and buyers of intellectual property rights that might be included in a standard. The interests of these two groups may well diverge, but the same members may play different roles in different instances. With respect to the technologies at issue in the present case, for example, Rambus is a seller and the DRAM manufacturers are buyers. However, a number of the manufacturers also sell other technologies used in the production of DRAMs. To some degree, therefore, one might expect the group collectively to choose policies that reflect their joint or aggregate interests, and those interests may well be maximized by higher royalties than an innovation warrants, and by a higher final price than would result from competition with lower or no royalties.

B. Manufacturers may be partly immunized against uniform cost shocks

Even if the policies adopted by the SSO largely serve the interests of technology buyers (here, manufacturers of DRAMs), these buyers may have only weak incentives to resist supra-competitive royalty demands *that apply uniformly to all of them*. Depending on market demand and supply elasticities, such royalties can be largely passed through to buyers downstream. When excessive royalties are passed through, downstream buyers pay higher prices and the manufacturers are to a degree immunized and lose relatively little profits.

It is well understood in economics that an increase in marginal costs, applying equally to all firms in a competitive market, is passed through in a proportion that depends on the

relative slopes of the supply and demand curves.[12] In particular, if supply is much more elastic than demand, then the increase is largely passed through, as we now explain.

> Consider a commodity industry characterized by fierce competition and by constant marginal costs up to capacity.[13] The analysis of economic incidence of an increase in each firm's marginal costs depends on whether we consider the short run or the long run, and (in the short run) depends on the state of the industry.
>
> (*1*) In the short run, if *c* denotes short-run production marginal cost, and *r* denotes marginal royalties, then short-run marginal cost becomes (*c*+*r*).[14] If the industry is operating competitively with excess capacity, the marginal cost (*c*+*r*) will also be the price. Downstream consumers thus pay the royalty, in the economic sense that the final price they pay is higher by *r*; producers lose only from the resulting reduction in the scale of output (and when price is equal to marginal cost, a modest change in output has little or no profit impact).[15]
>
> (*2*) In the short run, if the industry is capacity-constrained, the final price to downstream consumers must make their demand equal to industry capacity, so *r* does not affect that price, and its incidence is on the manufacturers.
>
> (*3*) In a "boom and bust" industry that alternates between excess capacity and capacity constraints, the manufacturers will thus bear the cost of *r* some, but not all, of the time. In the medium run (a period of time during which demand may vary, but that is too short for capacity to equilibrate), one would therefore expect them on average to bear some, but not all, of the cost of increases in *r*.
>
> (*4*) In the long run (in which capacity can smoothly be brought into or taken out of producing this product), and if there are constant returns in building capacity, the analysis is like the case of short-run excess capacity except that instead of

[12] For a discussion of this result in the context of pass-through of taxes, see Michael L. Katz and Harvey S. Rosen, *Microeconomics*, 3rd edition, Irwin/McGraw-Hill, 1998, pp. 349-54.

[13] This is sometimes taken as a reasonable description of the market for a specific DRAM design.

[14] For convenience this discussion assumes that the royalty is a fixed sum *r* per unit of output. If royalties are a percentage of revenue, a more notation-intensive but substantively very similar analysis will apply.

[15] In addition, if industry demand is inelastic, even the quantity effect will be small compared to the royalty.

> short-run marginal cost *c* we would use long-run marginal cost *m* (including capacity cost). Thus, again, royalties—and the effect of hold-up on royalties—are passed through to downstream buyers and have little effect on manufacturers' profits.

Thus competitive firms individually and collectively tend to have only weak incentives to minimize the risk of excessive marginal costs that would apply uniformly to all of them. Such common cost shocks have relatively little impact on profits—especially when the firms compete fiercely on price, the marginal costs of all relevant rivals are affected alike, supply is highly elastic, and demand is inelastic. Downstream consumers, however, are strongly affected by such cost shocks in these cases. It would therefore be wrong for competition authorities or courts to presume that the direct buyers of a technology such as Rambus's can be left fully in charge of protecting the market against such costs, including the possibility that those costs are excessive.[16]

Thus, while manufacturers do have some incentives to craft rules to resist or limit hold-up, those incentives are likely to be quite limited relative to the full incidence of hold-up: there is thus potentially scope for public policy (such as competition policy) to go further in protecting downstream customers. This conclusion is strengthened when standards organizations include not only manufacturer/licensees but also holders of actual or potential patents who might *gain* from intellectual property hold-up: then, one might expect the organization's rules to be even more lenient on the possibility of such hold-up. Of course, the conclusion would be weakened if standards organizations included effective representation from *final* consumers. As noted above, we do not offer any grand solution to this problem here.

C. Manufacturers are not immunized against idiosyncratic cost shocks

The pass-through argument above does not imply that firms generally do not care about their costs: most things that a firm can do to affect its costs do not simultaneously affect the costs of its rivals. A firm bears the burden of "idiosyncratic" increases in its own

[16] For an application of similar reasoning to antitrust issues including merger investigations, see Joseph Farrell, "Listening to Interested Parties in Antitrust Investigations: Competitors, Customers, Complementors, and Relativity," *Antitrust*, 18:2, Spring 2004.

costs, whether or not it passes through such cost increases to customers. If it does so, its downstream customers are also harmed, but at least the firm is not immunized by pass-through, so it has a strong incentive to resist cost increases.

Specifically, the analysis above assumed that the boost in royalties due to hold-up—which raises manufacturers' costs—is uniform across competing manufacturers. This might be particularly relevant in the consensus standards context because standards organizations' rules on intellectual property often require non-discriminatory royalties. Moreover, the analysis also assumed that the boost in royalties applied to all relevant competitors; in an industry where compatibility is important, competition from any rivals using a different technology (departing from the standard, and thereby perhaps avoiding the intellectual property) is presumably more differentiated and thus more distant than it would be if compatibility were less important.

The analysis is different if the cost increase in question applies non-uniformly: in the extreme, if it affects only one firm (an "idiosyncratic" cost increase). In that case, as we now explain, consumers downstream may still be affected, but so is the firm: it is not immunized.

The economic "envelope theorem" implies that the impact of a small cost change on a firm's profits can be calculated as if the firm did not adjust its (presumed to be profit-maximizing) price and output decisions, even though in general it will do so. To illustrate, consider a firm whose marginal cost is $5 per unit and that sets a profit-maximizing price of $6. Now let its costs increase to $5.50. If the firm did not change its price or output, its profits would fall by 50 cents per unit of output. The firm may (and in general will) choose to revise its price, say to $6.75, so consumers are not insulated from the effect of the cost increase.[17] Nevertheless, the price increase cannot fully restore the firm's profits: in fact, a simple calculation establishes that its profits fall by *at least* the 50 cents times its new (lower) output (and at most by the 50 cents times the old, higher

[17] Pass-through in excess of 100%, as here, is by no means anomalous economically: for instance, it arises whenever the firm's demand curve has constant elasticity in the relevant range.

output).[18] In other words, the firm's profits fall roughly by the full amount of the cost increase. Perhaps surprisingly, this is so even if the cost increase is fully or, as here, more than fully passed through to consumers.[19]

Even though a firm subjected to an idiosyncratic cost shock is not immunized by pass-through—its profits fall by the full extent—consumers can also suffer (in this example, from the 75-cent price increase). However, at least the firm has strong incentives to minimize its costs. And if the firm operates in a competitive market, an idiosyncratic increase in its own costs (not paralleled by increases in its rivals') will not affect consumers. Thus firms have strong incentives to avoid letting their costs rise, given what is happening to rivals' costs.

7. What should competition policy do?

We have explained how (a) submarine patents can create market power that is not justified by the economics of intellectual property protection, and that is caused by secrecy, e.g., in the standard-setting process, rather than by the innovation; (b) although direct purchasers of a technology normally have an incentive to guard against submarine patents, that incentive is weakened if they expect the technology to be licensed on nondiscriminatory terms; and (c) the incentive is most weakened where the direct purchasers compete strongly against one another in a market segment with inelastic demand that faces only limited competition from other products that do not use the patented technology.

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[18] Write V(p,c) for the firm's profit when price is p and cost is c. In the example above, the firm chooses p=$6.00 when cost is c=$5.00, and its profits are V(6.00,5.00). Now, suppose cost increases to $5.50 and the profit maximizing price is $6.75. In general, the firm must reduce its output to sell at this higher price, and the firm's maximum profits are V(6.75, 5.50). The difference between the firm's profit before and after the cost increase is V(6.00,5.00) – V(6.75, 5.50). But, using Q(p) to indicate the quantity sold at p, we can express profits after the cost increase as the sum of two components: V(6.75, 5.50) = V(6.75, 5.00) – ($5.50 – $5.00)Q($6.75). Thus we can write the profit differential as: V(6.00,5.00) – V(6.75, 5.50) = V(6.00,5.00) – V(6.75, 5.00) + ($5.50 – $5.00)Q($6.75). Since by revealed preference V(6.00,5.00) $\geq$ V(6.75, 5.00), the profit differential is at least equal to the cost differential times the new quantity, Q($6.75). This establishes the claim in the text.

[19] The firm has then maintained or even increased its margin, but is now selling less. The calculation given links the impact of that loss of sales (when the firm chooses rationally) to the cost increase.

The intellectual property system is unlikely to function well when potential infringers/licensees cannot evaluate a patented technology and its associated license terms before they are committed to using it. In such cases hold-up can create market (even monopoly) power that exceeds the innovator's incremental contribution, even on a flow basis.

Although direct buyers of a technology embodied in a compatibility standard may try to protect themselves through rules of a standards organization, those direct buyers (even if they alone chose the organization's rules) are unlikely to bear the full costs of a royalty rate inflated by hold-up: much of the cost will be passed through to downstream buyers, especially if supply is highly elastic.

Competition authorities should be aware of these dangers and cannot in general assume that direct purchasers (e.g., of technology as an input to manufacturing) will always adequately act as agents of final consumers in respect of choices that will affect most or all rivals alike. In particular, reasonable competition policy could include watching for egregious submarine patent behavior generally, and/or strengthening and filling loopholes in standards organizations' disclosure policies.

Respectfully submitted,

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Dated April 15, 2004

APPENDIX A

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1. Joseph Farrell

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   University of California, Berkeley

   Joseph Farrell is Professor of Economics, Affiliate Professor of Business, and Chair of the Competition Policy Center at the University of California, Berkeley. He is a Fellow of the Econometric Society, past President of the Industrial Organization Society, and former Editor of the Journal of Industrial Economics. Much of his research has focused on the economics of compatibility standards and lock-in, on which he has published numerous professional articles. In 2000-2001 he was chief economist and Deputy Assistant Attorney General in the Antitrust Division of the US Department of Justice. In 1996-1997 he was Chief Economist at the Federal Communications Commission. He testified by invitation three times at the FTC/DOJ hearings in 2002 that led to the report cited in footnote 2 above.

[Additional signatories, in alphabetical order]

2. Jay Pil Choi

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   Michigan State University

   Jay Pil Choi is Professor of Economics at Michigan State University. He was previously Associate Professor of Economics at Columbia University and Seoul National University. He received his Ph.D. at Harvard in 1990 and was a Post-Doctoral Fellow at Tilburg University, the Netherlands. He was also a recipient of the Abe Fellowship. He is currently Associate Editor of the European Economic Review and has published numerous articles on intellectual property rights and R&D competition.

3. Aaron S. Edlin

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   University of California, Berkeley

   At 30, Aaron Edlin held a Ph.D. in economics and J.D. in law from Stanford; tenured professorships in both the economics department and law school at UC Berkeley; and served as Senior Economist at the Council of Economic Advisers in the Clinton White House covering industrial organization, regulation and antitrust. He is co-author with P. Areeda & L. Kaplow of the leading casebook on Antitrust as well as many articles on industrial organization, competition policy, antitrust law, and a variety of other issues in economics, law, and public policy. He received his AB Summa Cum Laude from Princeton.

4. Shane Greenstein
   Kellogg Graduate School of Management
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   Shane Greenstein is the Elinor and Wendell Hobbs Professor and Department Head of the Management & Strategy Department at the Kellogg School of Management, Northwestern University. He teaches courses in Technology Strategy and Statistical Methods. He is also a Research Associate of the National Bureau of Economic Research in the productivity and the industrial economics groups, as well as regular columnist for *IEEE Micro*, a publication for electronics engineers. His research covers many economic and strategic topics in computing, communications and electronics. He has published over five dozen articles in refereed journals and academic books. He is editor and author of three books, including "Diamonds are Forever, Computers are Not: The Economics and Strategy of Computer Markets," forthcoming in June, 2004, published by Imperial College Press. He holds a B.A. from the University of California, Berkeley, and a Ph.D. from Stanford University, both in economics.

5. Bronwyn H. Hall

   Department of Economics
   University of California, Berkeley

   Bronwyn Hall is a Professor of Economics at the University of California, Berkeley. She is also a Research Associate at the National Bureau of Economic Research and a member of the National Bureau of Economic Research Programs on Productivity and Technical Change, and Industrial Organization. Professor Hall conducts research and has published numerous articles in the areas of technology and innovation, research and development incentives and expenditures, and patents. She earned her B.A. at Wellesley College, her M.A. at Oxford University, and her Ph.D. at Stanford University.

6. Garth Saloner

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   Stanford University

   Garth Saloner is the Jeffrey S. Skoll Professor of Electronic Commerce, Strategic Management and Economics and Co-Director of the Center for Electronic Business and Commerce at the Graduate School of Business at Stanford University. He is a member of the Steering Committee of the National Bureau of Economic Research Program in Industrial Organization. Professor Saloner earned a B.Com. and an MBA (with distinction) from the University of the Witwatersrand, and an MS in Statistics, an AM in Economics, and a Ph.D. in Economics, Business, and Public Policy from Stanford. He has taught courses in electronic commerce, strategic management, industry analysis, and competitive strategy, and was one of the founders of the Stanford Computer Industry Project, a major study of the worldwide computer industry, funded by the Sloan Foundation. Professor Saloner has published numerous papers in refereed journals and books and is the author of the books Strategic Management (co-authored with Joel Podolny and Andrea Shepard) and Creating and Capturing Value: Perspective and Cases on Electronic Commerce (co-authored with A. Michael Spence). Renowned for his seminal work on “network effects,” his research has focused mainly on issues of electronic commerce, strategic management, competitive strategy, industrial economics, and antitrust economics.

CERTIFICATE OF SERVICE

I hereby certify that on April 16, 2004, I served a true and correct copy of the MOTION FOR LEAVE TO FILE *AMICUS CURIAE* BRIEF and the accompanying BRIEF OF *AMICUS CURIAE* of the Economics Professors and Scholars, as set forth below:

_____
David T. Beddow, Esq.

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