STRATEGIC NETWORKING
IN STANDARD SETTING ORGANIZATIONS:
THE CASE OF JEDEC

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ABSTRACT

This paper examines the strategic impact of networking within a cooperative standard-setting body. The JEDEC JC-42 committee sets standards for memory technologies, and was especially focused on DRAM standards in the early 1990s. I utilize cross-sectional and panel data to analyze whether internal networking helped firms to exert an influence on the development of formal standards for memory technology in general and DRAM technology in particular. Cross-sectional and panel results tentatively suggest that networking within JEDEC, in terms of attendance at different subcommittee meetings, contributed to firm influence on standards development. A somewhat surprising result, given industry-wide concern about DRAM standards, is that non-DRAM-related networking and standard setting activity proved more important for overall standards development success. In addition, coefficients on variables measuring intellectual property holdings suggest that IP portfolio tends to hurt firms in the standard setting process.

Interpretation of results should bear in mind small sample size and limited panel variation, which may yield inconsistent estimators of coefficients. Moreover, although I emphasize results in random effects models because they reflect more observations, fixed effects may be more appropriate given that firm-level characteristics underlie fixed and random effects. In conclusion, cross-sectional and panel analyses tentatively suggest that internal networking contributed to firm influence on standards development within the JEDEC JC-42 committee in the early 1990s. But further study using a richer dataset and accounting for institutional anomalies could improve our understanding of the strategic value of networking, both *within* and *outside* JEDEC, in the effort to develop next-generation DRAM standards.

BIOGRAPHICAL SKETCH

Jonathan David Church graduated from the University of Pennsylvania with a B.A. in economics and philosophy. He completed this master's thesis in fulfillment of part of the requirements for an M.A. in economics at Cornell University.

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I. Introduction

In June 2002, the Federal Trade Commission (FTC) filed an antitrust suit against Rambus, Inc., a firm specializing in the development of memory chip interface technology for digital electronic products.[1] The FTC alleged that Rambus manipulated the rules of a standard-setting organization called the Joint Electron Device Engineering Council (JEDEC) in an attempt to obtain monopoly power in markets for four technologies incorporated in standardized SDRAM and DDR SDRAM memory chips. In February 2004, presiding FTC Administrative Law Judge Stephen McGuire issued an initial decision finding Rambus innocent of anti-competitive conduct.[2] In August 2006, an FTC appeals court ruling reversed the decision and found Rambus guilty of anti-competitive harm.[3]

The case of Rambus has fueled interest in the attempts of members of standard-setting organizations to influence the standards development process. In this case, Rambus was alleged to have participated in JEDEC discussions aimed at defining and adopting specifications for a standardized DRAM memory chip. As a participating member, Rambus allegedly withheld information about its own patents and pending patent applications that pertained to technologies under discussion for incorporation in the standard.

Rambus's silence came in spite of JEDEC rules that, though not devoid of ambiguity about their meaning, required committee members to disclose intellectual property pertaining to technologies under discussion. It was alleged that Rambus participated in committee meetings, observed discussion and decisions made by the committee, withheld information about and revised its patent applications, and waited for adoption of the standard before disclosing that it held patents and patent applications

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[1] Rambus 10-K for the fiscal year ended December 31, 2005.

[2] In the matter of Rambus, Inc., Docket No. 9302, Initial Decision of Stephen J. McGuire, February 23, 2004 ("McGuire decision").

[3] In the matter of Rambus, Inc., Docket No. 9302, Opinion of the Commission, August 2, 2006.

relevant to the standardized technologies. The concern of antitrust authorities was that Rambus ignored disclosure rules and thereby undermined competition in the markets for the standardized technologies.

This case highlights the significance of strategic interaction within standard-setting organizations, particularly with respect to rules requiring disclosure of intellectual property. For example, antitrust concerns arise when a member of a standard-setting body owns intellectual property on aspects of a standard by which everyone has agreed to abide. The concern is that the patent owner decides to license patented technology on grounds deemed anti-competitive; for example, the royalty charged may exceed a competitive benchmark; or the patent owner may demand that the patentee license a patent pool if it is to be granted access to the standalone patent; or the owner may simply request a cross-licensing arrangement as a condition of patent use. The owner may even use its licensing position to restrict access to markets where its interests conflict with use of the standard by competitors in that market, or are otherwise compromised by participation of the competitor in those markets. The basic problem is one of "hold-up" – invoking intellectual property rights to extract concessions from users of the proprietary technology.

Antitrust concerns arise because these policies threaten to undermine competition, and thus harm consumers by removing competitive forces that protect consumers against the perils of market power concentrated in the hands of too few firms. A firm that "holds up" the standard setting process or the implementation of the standard in order to extract concessions from other firms that result in harm to consumers threatens competition and may stimulate antitrust suits brought by the relevant authorities.

Concern about antitrust liability provides a strong incentive for firms to seek alternative strategies with which to influence the standard setting process. Firms would employ these strategies in their attempt to convince other firms of the merits of their proposals without raising suspicions of anticompetitive intrigue. Leiponen (2006) recommends that firms in network technology industries will find success by forging alliances with other firms through participation in external cooperative organizations (CTOs) such as consortia and private alliances.

Participation in CTOs allows firms to learn about relevant technologies, as well as cultivate relationships with firms in their mutual attempt to develop standards within the relevant standard setting body. In all, firms show a commitment to the standard-setting process that resonates with other firms. Learning, political capital, and the reputation they build for advancing the common cause of a standard facilitate their ability to persuade other firms to follow their lead in the standard setting process. Leiponen (2006) invokes support for this recommendation with a panel data analysis of work item activity in 3GPP, finding that participation in external technical consortia enhances firms' contributions to the development of new specifications in 3GPP committees.

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II. The Economics of Standard-Setting

According to Mark A. Lemley, professor of law at the University of California at Berkeley, a standard is “any set of technical specifications which either does or is intended to provide a common design for a product or process.”[4] Standards are important as a way to ensure product quality and safety, but also to ensure compatibility between parts in a final product. For example, the components of a motherboard in a computer – CPU, DRAM, memory controller, bus lines, etc. – must interoperate with each other if the motherboard, and thus the computer, is to have utility for the consumer. A DRAM chip must operate at certain speeds and process bits of data in such as way as to be recognized by other components on the motherboard. A DRAM standard is an effective way to ensure compatibility between the DRAM and other logic chips on the motherboard.

Network compatibility is also an important goal of standardization activity. Network compatibility implies that products require access to a network for their proper use; for example, the value of fax machines increases in proportion to the number of fax machines with which they can communicate. Network compatibility is distinguished by the positive demand externality generated by increased use of products or technologies compatible with the network. As more people use these products or technologies, the benefit to an individual consumer using a network-compatible product increases.

Thus, standards are an important way by which an industry provides a superior product to consumers. But standard-setting is not without risk of economic harm. Standard-setting gives rise to the possibility of lock-in. The creation of a standard imposes a uniform product design on the market and thereby eliminates or marginalizes competing standards to the extent that an industry commits to the standard.[5] Once the

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[4] Lemley, Mark A., “Intellectual Property Rights and Standard-Setting Organizations,” Draft, p. 6; http://www.ftc.gov/opp/intellect/020418lemley.pdf#search=%22Mark%20Lemley%20standard%20setting%22

[5] Multiple standards can co-exist. The co-existence of the Windows operating system and Apple MacIntosh in the market for computer operating systems is an example.

standard is adopted, manufacturers incur the sunk cost of investments required to develop equipment and expertise necessary to implement the standard. Once investments are made, the manufacturers are effectively locked into implementation of the standard at least in the short run. Lock-in implies that the costs of switching to alternative products or technologies are prohibitive.

Lock-in may also occur as a result of network effects. As mentioned above, network compatibility implies that a product or technology compatible with the network gains value as more people are attracted to the product or technology due to the feedback effects of increased traffic on the network. As more consumers migrate to a particular network, individual consumers are increasingly reluctant to switch away from the network because the value of the product they use depends on its compatibility with the network used by other consumers. The Windows operating system in PC computers is an example of lock-in due to network effects.

Lock-in may not be socially optimal if an economy chooses the wrong standard. As indicated in Section III, Arthur (1989) provides a model showing how lock-in can arise from increasing returns generated by network effects. Arthur models lock-in as a path-dependent process in which a technology becomes predominant in an economy because early events in the adoption process, which may be random, create an environment in which consumers choose the technology over alternative technologies even if the relative long-run potential of the technology, in the absence of network effects, is inferior.

Network effects yield the possibility of multiple equilibriums, where equilibrium is defined as the persistent preference of consumers for one technology over another. This preference may not necessarily be related to the inherent relative benefits of a technology but rather may be related to the relative benefit of using the technology derived solely from increasing returns due to network effects. This implies that an economy can choose a standard that is optimal in the short run, but in the long run is locked into a standard which is suboptimal in the absence of network effects.

Standardization can occur in two ways. *De jure* standards are developed by consensus as a result of formal meetings convened by members of official organizations like 3GPP or JEDEC. *De facto* standards are developed through competition in the marketplace. *De facto* standards typically emerge when consumers, unguided by any centralized decision-making body, evince their preference for a particular product or technology over existing alternatives, even when the product or technology is not superior. The victory of VHS over Betamax and the omnipresence of the QWERTY keyboard are examples of *de facto* standards. In either case, the standardized product or technology is either superior or not superior to existing alternatives. If superior, formal standard-setting *per se* confers no additional value on the standardized product or technology. It serves as a mere rubber stamp. Formal standard-setting only confers value by eliminating superior substitutes. In either case, however, a standard, once established, can be an important source of value for the firm for as long as the economy is locked into the standard if it incorporates technology promoted or owned by a firm.

The upshot is that if a firm holds intellectual property rights – e.g. a patent – on a product or technology relevant to the standard, it would have *de facto* monopoly power at least in the short run since all manufacturers producing the product that makes use of the product or technology would have to pay royalties to the firm as payment for the use of the technology they seek to implement. In addition, a firm may benefit because adoption of particular technological specifications by the standard setting body increases use of complementary technologies owned by the firm. One can imagine additional instances in which a firm has a clear interest in the direction of the standard-setting process.

A firm participating in the standard-setting process may thus attempt to manipulate the proceedings of the standard-setting organization in an effort to obtain competitive advantage resulting from adoption of an advantageous (e.g. patented) technology by the standard-setting body. Disclosure rules seek to avoid harm to competition that may result from manipulation of the sort Rambus was alleged to have committed. In general, disclosure rules require that members disclose intellectual property – patents, pending patent applications, etc. – relevant to technology under discussion for standards adoption. Disclosure rules, however, are not perfect. The representatives of firms that make up the committee may not be fully knowledgeable about the full range of intellectual property owned by their firm. It may be costly to search the entire patent portfolio of a firm; large firms such as IBM with extensive Byzantine portfolios require much time and effort to search their portfolios. These search costs may be impractical.

Aside from the concerns of individual firms, disclosure rules may not be socially optimal. They may be symptomatic of, or even stimulate, a bias among committee members against royalty-bearing technologies. Even if a technology is superior to existing alternatives, standard-setting bodies may avoid adoption of a royalty-bearing technology in the erroneous belief that this technology bears a higher cost than alternatives, with the cost not justified by its benefits. That is, standard-setting bodies may ignore the performance enhancements to be derived from royalty-bearing technologies, even when the performance enhancements sufficiently offset this cost.

Thus, firms would like to influence the standard setting process without incurring antitrust liability, and standard setting bodies would like to choose a standard which optimizes the tradeoff between cost and performance while respecting the intellectual property of firms. One option is to allow adoption of royalty-bearing technologies but insist that such technologies be licensed on “reasonable and non-discriminatory” terms, however defined. Another option is to promote alternative strategies by which firms may influence the decision-making of standard-setting organizations without incurring antitrust liability. This option is concerned with strategies a firm may employ to persuade a standard setting body of the merits of a particular technology.

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III. Literature Review

The economic literature has witnessed an increased interest in the standard-setting process, perhaps because standard-setting has proved critical to the success of high technology industries such as telecommunications and computing. These are industries in which networks effects are a significant source of value for consumers. Standard-setting has also attracted interest and galvanized discussion in the legal community after the cases of Dell and Rambus alerted attorneys to the lack of consensus on how to treat intellectual property in the standard-setting process in a way that accommodates the concerns of antitrust law. Lemley (2002) has taken the lead among attorneys in attempting to understand the interplay between antitrust and intellectual property in the standard-setting process.

This paper is interested in the literature that addresses strategies firms may use to exert influence in the standard-setting process. As noted above, standards may be set either *de jure* or *de facto*. Strategic interaction can be analyzed separately for each case. Varian and Shapiro (1999) provide an historical overview of well-known standards battles carried out in the marketplace. They consider "standards wars" involving distribution of electricity by alternating current developed by George Westinghouse versus direct current distribution developed by Thomas Edison, VHS videocassette technology developed by Matsushita versus Betamax videocassette technology developed by Sony, the width of railroad gauges built in the second half of the nineteenth century, and color television formats in the mid-twentieth century.

They analyze the strategies that were crucial to the success of the winners. They advise a general set of strategies that includes building alliances, exploiting first-mover advantage, and managing consumer expectations. In particular, they emphasize the importance of cultivating an installed consumer base, exploiting intellectual property rights, commitment to innovation, pushing development of complementary products, and investing in brand name development and recognition. Building alliances was a key strategy in the gradual emergence and market victory of the RCA color television standard.

Stango (2004) provides an overview of the literature on standards wars, which he defines as a market-mediated competition between alternative standards where the goal is to become the official "winner-take-all" standard. Stango distinguishes between *de jure* and *de facto* standards, as well as between sponsored and un-sponsored standards. In the latter case, Stango emphasizes the dependence of standards wars outcomes on the strategic behavior of firms that sponsor a particular standard for adoption. This is in contrast to the dependence of standards wars outcomes on demand-side decisions when competing standards are un-sponsored.

Stango reviews the academic literature primarily with respect to *de facto* standards, but also directs our attention to areas of interest where more research would be useful, such as the advantages of *de jure* standard-setting in comparison to *de facto* standard setting. Among the more specific issues addressed by Stango is the importance of network effects in determining the outcome of standards wars. Network effects can be direct or indirect, with the former relating to the positive externality of increased adoption of a particular standard, and the latter relating to spillover effects in complementary markets. Stango also reviews the literature that studies conditions under which excess inertia occurs.

Standards wars relate to competition *between* standards to become the dominant standard. But standards-based competition also may be carried out *within* a standard. Besen and Farrell (1994) study three cases involving either competition *between* standards or competition *within* a standard. A firm can choose to embrace inter-technology (*between* standards) competition or intra-technology (*within* standards) competition. They analyze and advise strategies that firms should employ in each case. These cases are: 1) a firm settles on a standard even if it is not the one it originally endorsed or developed, or 2) a firm goes it alone and commits resources to participating in a full-fledged war to establish the standard it endorsed or developed, or 3) a firm yields to a dominant firm and attempts to join the network of firms and consumers committed to the standard sponsored by the dominant firm.

Besen and Farrell distinguish between horizontally and vertically related firms, and concentrate their study on horizontal competition, i.e. competition between producers of the same commodity product, rather than interaction between vertically-related firms, i.e. firms that produce complementary products. They outline the strategies appropriate to each form of competition, and identify the determinants of success. For example, in the "Pesky Little Brother" case in which there is a dominant firm which has proprietary control over a standard to which a "Pesky Little Brother" firm would like to commit, Besen and Farrell describe strategies used by the dominant firm to prevent access to the standard by other firms – such as enforcement of intellectual property rights and continually dedicating resources to developing new technologies, thus making it difficult for other firms to catch up.

Farrell and Saloner address *de jure* standard-setting, which precedes horizontal competition *within* a standard. Farrell and Saloner (1988) attempt to fill a gap in the literature by showing conditions under which cooperative standard-setting – i.e. *de jure* standard setting – outperforms marketplace competition. Nevertheless, in the case of *de jure* standard-setting, a primary concern still remains that a firm may attempt to "hold up" the implementation of an approved standard by asserting intellectual property rights. "Hold up" can most easily occur when firms fail to disclose intellectual property during the standard-setting process, betting the SSO will adopt a standard that incorporates their intellectual property. Once the standard is set, firms make the necessary investments to implement the standard, or network effects become sufficiently entrenched, so that firms and consumers are effectively locked into the standard at least in the short run.

The theoretical literature makes more precise the ways in which lock-in results from prohibitive switching costs or network effects, thus shedding additional light on the incentive for firms to influence the direction of the standard setting process.[6] As a standard becomes more entrenched, the costs of switching to alternative standards may become increasingly prohibitive. Beggs and Klemperer (1992) present a model showing that switching costs explain why firms may be more concerned about long-term market share than short-run profit maximization. In markets where switching costs are present, prices and profits are higher than in markets where they are not present. The long-term benefits of increased market share resulting from lock-in may thus outweigh the benefits of short-run profit maximization. In the context of standard setting, Beggs and Klemperer thereby help to clarify why firms are interested in standard setting outcomes.

Beggs and Klemperer explore the effects of lock-in resulting from switching costs, but lock-in can be the result of, or further reinforced by, network effects. Arthur (1989) provides a model showing how lock-in can arise from increasing returns generated by network effects. He models lock-in as a path-dependent process in which a technology becomes predominant in an economy because early events in the adoption process, which may be random, create an environment in which consumers choose the technology over alternative technologies even if the relative long-run potential of the technology is inferior. These consumers, as well as additional consumers, continue to prefer the technology because of positive feedback from increased use of the technology.

The upshot of these models is to imply that lock-in yields a significant strategic advantage for a firm that holds intellectual property rights on some aspect of a standard,

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[6] As pointed out by Farrell and Saloner (1988), Dixit and Shapiro (1985) have studied the case of coordination in which sunk costs are small, while Crawford and Haller (1987) have studied the case of coordination in which there are no sunk costs. In such cases, the presence of relatively costless design-around alternatives can be expected to loosen the grip of lock-in, though network effects may still persist.

produces a product in complementary markets, or gains value in some other way from implementation of the standard. As more firms and consumers commit to the standard, firms with a vested interest in the standardized product or technology can profit from an increase in the size of the market that may follow standardization of the product or technology.

It is worth noting that lock-in, and thus the strategic advantage, need not be long-lived. Farrell and Saloner (1985) develop a model to show that under complete information firms are willing to switch to a new standard assuming others are also willing to do so. Thus, they provide conditions under which it is optimal for a firm to jump ship and commit to another standard. Nevertheless, lock-in confers a strategic advantage to incumbent claims on the standardized product or technology for as long as lock-in persists. In principle, therefore, it is easy to understand why firms have an interest in pushing the directions of standards development.

In addition to the theoretical literature, there is a well-developed empirical literature that includes case studies of the standard-setting process. Greenstein and Rysman (2004) analyze the historical development of the 56K modem standard and find that standardization turned out to be a hybrid of *de jure* and *de facto* standardization processes. In their analysis, Greenstein and Rysman emphasize the role of coordination costs in the standard setting process. In particular, they emphasize the ways in which coordination depended on the circumstances specific to 56K modem standards development.

Rysman and Simcoe (2006) have considered the role of patents and market power as factors influencing the standards development process. The intellectual property holdings of a firm may indicate its relative technical sophistication; the firm is able to refine its proposals to appeal to the expertise of well-qualified engineers, and this could have a positive effect on the firm’s ability to influence standards development. One caveat is that other members may have a predilection against proprietary standards, thus raising suspicions that the firm will assert intellectual property rights and “hold up” implementation of the standard. This could adversely affect the ability of a firm to influence standards development. Another caveat is that the technical expertise arising out of a firm’s intellectual property portfolio may be muted by its irrelevance to the technology under consideration by a standard setting body.

Rysman and Simcoe not only study the factors that influence standards development, but also study the impact of standard setting *per se*. They analyze the flow of citations of patents disclosed to four standard setting bodies and find that citations increase following patent disclosure. They argue that their results suggest that standard setting bodies identify and select appropriate technologies, as well as help promote adoption of these technologies as industry standards.

Bekkers, Duysters, and Verspagen (2000) consider the role of essential intellectual property (i.e., intellectual property essential to implementation of the standard) in the standard-setting process. They examine the development of the GSM standard, and describe how Motorola attempted to “hold up” implementation of the standard by asserting intellectual property rights after the standard was set. Among the policies imposed by Motorola was to demand cross-licensing agreements in exchange for the right to use the intellectual property owned by Motorola and essential to the implementation of the standard. Thus a firm with intellectual property relevant to a standard may create entry barriers in the form of patent pools or cross-licensing agreements.

Other empirical literature studies the case of a firm finding strategic value in the number of concessions offered to the standard setting organization. For example, a firm may agree to license intellectual property on reasonable and non-discriminatory terms. Chiao, Lerner, and Tirole (2004) have modeled the extent to which a technology sponsor considering whether to join a standard setting organization is willing to offer concessions, and find empirical evidence to suggest a positive correlation between sponsor-friendliness of the SSO and the number of concessions offered by the sponsor. Chiao, Lerner, and Tirole (2005) also attempt to build disclosure as a strategy into their model of the standard-setting process.

Leiponen (2006) argues that a firm may exert influence on the standards development process by participating in external consortia and private alliances dealing with the technology or industry of interest. A firm may have an easier time convincing members of the organization that they should "push" the standard in a direction that would ultimately benefit the firm if it has cultivated a reputation for integrity in the perception of other members of the organization.

Participation in external cooperative technical organizations (CTOs) may also provide opportunities for firms to learn about existing and developing technologies and thus refine their proposals to make them more likely to meet with the approval of other members. Thus it is worthwhile for firms to focus their efforts on exploiting the learning opportunities or the political and social capital gained from participation in external organizations. Leiponen (2006) provides empirical support by analyzing data on the worldwide standard setting body (3GPP) responsible for developing standards for third generation (3G) wireless technology.

In general, the literature suggests that intellectual property portfolio, firm size, and networking are three firm-specific variables likely to have an impact on the standard setting process. In this paper, I also distinguish between intra- and inter-organizational networking as factors that have an influence on the standard setting process. In addition to these variables, I consider the impact of a firm's previous standard setting experience and success in JEDEC standard setting. Finally, I provide a way to isolate the impact of a firm's technical capabilities which are directly relevant to the standard, thus addressing the shortcoming of considering overall IP portfolio, a fraction of which may not be relevant to the technologies considered for standardization.

I conduct this analysis in the context of standard setting efforts by the JC-42 committee of the JEDEC standard setting body, which set out to define a next-generation DRAM standard in the early 1990s. The JC-42 committee has responsibility for the development of standards for memory products, including DRAM chip interface technology. The JC-42.3 subcommittee was responsible for developing the SDRAM standard published in 1993; this standard was designed to address performance concerns which plagued the industry during the late 1980s and early 1990s. This focus on performance concerns created a new standard setting climate within which to understand the impact of networking and other strategies on the standard setting process.

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IV. The Structure of JEDEC[7]

The JEDEC Solid State Technology Association, formerly known as the Joint Electron Device Engineering Council, is the semiconductor engineering standardization body and a founding sector of the Electronic Industries Alliance (EIA).[8] In 1999, JEDEC became an independently incorporated association governed by its own Board of Directors.[9] Prior to 1999, JEDEC was governed by the JEDEC Council, and prior to 1998 the JEDEC Council was unable to set or change policies without approval from the EIA Engineering Department Executive Council.[10] According to its website:

> JEDEC is the leading developer of standards for the solid-state industry. Almost 2700 participants, appointed by some 270 companies work together in 50 JEDEC committees to meet the needs of every segment of the industry, manufacturers and consumers alike. In particular, one of its primary responsibilities is to convene meetings between firms and manufacturers in the computer industry to develop standards for technologies relevant to the industry. In the early 1990s, the committee convened to discuss development and adoption of specifications for a standardized DRAM memory chip.[11]

Today, JEDEC consists of 282 members and 48 committees/subcommittees which answer to the Board of Directors.[12] The Board of Directors determines the responsibilities of committees and the scope of their activities. JEDEC is organized into committees and

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[7] In this section, I rely on information from the JEDEC Manual of Organization and Procedure ("JEDEC Manual") to summarize the general aspects of JEDEC standard setting procedure. See JEDEC Manual at: http://www.jedec.org/Home/manuals/JM21L.pdf

[8] The EIA is a trade association representing the electronics industry; it consists of 5 sector members. See JEDEC Manual at: http://www.jedec.org/Home/about_jedec.cfm, and http://www.eia.org/new_about/sectors.phtml.

[9] http://www.jedec.org/Home/manuals/JM21L.pdf, http://www.jedec.org/Home/about_jedec.cfm

[10] McGuire decision, ¶¶ 237, 238

[11] http://www.jedec.org/

[12] http://www.jedec.org/service_members/New_Members/memberco.cfm; http://www.jedec.org/Home/about_jedec.cfm

subcommittees. The work of a committee may be compartmentalized into subcommittees in order to nurture specific items within the overall committee agenda. For example, the JC-42 committee consists of four subcommittees: JC-42.1, JC-42.3, JC-42.4, and JC-42.5.[13] The JC-42.3 subcommittee is responsible for guiding the development of standards pertaining to DRAM technology. The JC-42.5 subcommittee guides development of standards pertaining to memory modules.[14] JEDEC committees report to the Board of Directors. In the early 1990s, each subcommittee typically, though not always, met four times per year.

Committees are led by a chairperson, and often a vice chairperson, who must be members or alternates of the committee they serve. They are elected for two-year terms either by secret vote of committee members during a regular meeting, or by regular ballot. Each committee considers all matters within the scope of its approved activity pertaining to (among other things):

- Development of proposed standards, guidelines, registrations, and related technical publications to be presented for committee ballot

- Authorization of committee ballots on all such matters

- Initiation of proposals to have committee-approved ballots presented for ballot on the Board of Directors

- Evaluation of the results of all committee ballots, as well as comments on related ballots by the Board of Directors

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[13] There is also a JC-42.2 subcommittee for which I have not received meeting minutes. Thus, I focus on the four subcommittees identified in the text.

[14] These are the subcommittees of which I am aware from my review of the JEDEC JC-42 meeting minutes. The McGuire decision briefly mentions the JC-42.2 subcommittee responsible for SRAM standards development, but I have not received meeting minutes for this subcommittee and conduct my analysis as if there are four subcommittees.

- Request to the Board of Directors for approval to convert standards or publications into ANSI or IEC standards

JEDEC committees hold at least one meeting per year to maintain active status. They may also approve meetings to address limited topics of discussion. The chairperson of any committee may authorize a task group to explore a particular topic or achieve a specific objective. The chairperson appoints a task group chairperson from among the members or alternates of the overseeing committee. Membership within a task group is open to any member or alternate of the committee which appoints the task group. In addition, members of the task group may be appointed by the task group chairperson from nonmember JEDEC companies with approval of the chairperson overseeing the full committee. A task group does not hold formal votes or establish final results pertaining to standards, publications, or ballots. Task groups present reports of their activities to the full committee for review, modification, and approval. A task group is dissolved upon completion of its objectives.

Two JEDEC committees, or a JEDEC committee and a non-JEDEC organization, may form a joint task group. In the case of joint task groups between two or more JEDEC committees, the chairpersons of the two committees agree to authorize the joint task group and also agree on the selection of the task group chairperson drawn from one or more committees involved in the task group.

JEDEC documents are developed according to the following procedure:

- Presentation – initial showing or distribution of material proposed for publication. A presentation may occur at any regular meeting or special meeting if related to the limited scope and agenda of the meeting.

- Motion for ballot – may occur at any time after a presentation. The motion must have a “second” before being considered for vote. The company agreeing to second the motion for ballot accepts responsibility for sponsoring the material if the original sponsor is unable or unwilling to do so.

- Editorial process – ballots are subject to the editorial process prior to posting on the JEDEC voting machine.

- Committee ballot – if approved, material is sent to ballot through the JEDEC voting machine.

- Motion for Board of Directors ballot – if a ballot passes and all comments are addressed then a motion may be made to send the material to the Board of Directors for further consideration. The motion for Board of Directors ballot may be skipped if the ballot passes by acclamation.

- Board of Directors ballot – when approved, the committee material is put up for ballot through the JEDEC voting machine.

- Publication – after approval through the appropriate balloting processes, a proposed document is approved for publication.

JEDEC policy assigns one vote to each company. Vote counts are deemed legitimate only if two-thirds of the possible votes are cast. Possible votes do not include abstaining votes. JEDEC committee ballots are processed through the JEDEC electronic voting machine. Member companies are encouraged not to lobby or coerce other member companies to approve or disapprove ballots.

A "regular ballot" is one in which the entire standard, publication, registration, guideline, or specification is open for comment. A "limited ballot" proposes a limited number of revisions to an existing document. For example, after a committee ballot has been approved, the committee may wish to propose minor technical changes to the ballot before forwarding the approved material to the Board of Directors for final consideration. If the limited ballot is passed, these changes are incorporated into the original material. If it fails, the originally approved material remains unchanged. In the JEDEC Meeting Minutes, item logs that record balloting results of items put up for ballot show that in several cases an item may "pass" but with a hold on a component of the balloted item for which there remains debate.

All ballots that pass committee deliberation and relate to proposed JEDEC standards, guidelines, or specifications must be reviewed and approved by the JEDEC Board of Directors before they become official JEDEC publications. The Board of Directors may only make editorial modifications to material proposed by a committee.

JEDEC committees are discouraged from considering standards proposals that incorporate a patented technology unless all relevant technical information covered by the patent or pending patent is known to the committee. Moreover, the patent must be made available license-free to any applicant desiring to implement the standard, or the patent must be made available for licensing on reasonable and non-discriminatory grounds.

The discussion above relates to JEDEC structure and procedure as it is practiced today, but there has been little, if any, substantive difference in the structure and procedure of standard setting by JEDEC between now and the early 1990s, except that committee ballots now go to the JEDEC Board of Directors rather than the JEDEC Council. The standards development process in the early 1990s, as now, began with discussions among participants at a JEDEC meeting concerning subjects that members believed should be considered as possible standards. JEDEC entertained a number of proposals by members when working toward a standard for a new device. JEDEC members would make a first showing or first presentation, during which proposals received an item number. In some cases, discussions of possible features generated a survey ballot requesting members to express their views concerning different solutions. Following the conclusion of the second or subsequent presentations, the sponsor of the item, or another member, could make a motion to have the item balloted by the committee, which then decided if it wanted to create a ballot to vote on the substance of a proposed standard.

Thus, in the early 1990s the standards development process would have begun with a standards proposal, or work item, sponsored by a particular member. The work item would be discussed on a particular subcommittee, and if the item had potential as a new standard, the sponsor would make a motion for the item to be balloted. In order to make to advance the motion, the original sponsor of the item was required to convince another member to "second" its motion.

This requirement for a "second" provides us with a possible context in which to test the hypothesis that firms exert influence on the standard-setting process via network connections. Since a motion for ballot requires a "second," we may assume that two members have a network connection if one member proposes a motion and another supports the motion. However, it is not explicitly clear from JEDEC procedure whether a company making a motion and a company that "seconds" the motion must work together to develop the item in preparation for ballot. Thus, it is unclear if this "connection" represents a network connection in a strict sense. Future work could explore the nature of the relationship between the motioning company and the "second" to determine whether it is possible to analyze the extent of correlation between the "motion for ballot" and standard setting influence. Thus, future work could possibly study the effect of internal network centrality in addition to the effect of internal network participation.

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V. The “Bottleneck” Problem[15]

In the late 1980s, the computing industry encountered a problem. For many years, the performance of DRAM chips had been comparable, if not superior, to the performance of microprocessors. But during the 1980s, the speed of microprocessors improved dramatically. In accordance with Moore’s law, CPU speeds were increasing by a factor of four every three years. The evolution of DRAM chip speeds failed to keep pace. Bandwidth requirements were increasing at such a significant rate that Dr. Michael Farmwald, one of two founding members of Rambus, Inc., “projected that the number of DRAMs needed to support future microprocessors would become extremely large over time.”[16] The increasing number of DRAM chips required to support the bandwidth requirements of microprocessors would be costly for an economy itching to exploit the latest improvements in computing technology.

This performance gap became a widely recognized concern within the computer hardware industry, and was identified as the “bottleneck” problem. In response, the JC-42.3 subcommittee began to standardize certain aspects of DRAM performance and design relationships in the early 1990s. In previous years, JC-42.3 had focused almost exclusively on interoperability issues, such as standardizing the location of pins on the DRAM chip. The JC-42.3 subcommittee subsequently began standardizing certain technologies to address performance concerns in addition to interoperability concerns. JC-42.3 was responding to industry recognition that a new generation of memory was needed if memory speeds were to keep pace with increasing microprocessor and computer speeds.

At this time, DRAM chips were based on “asynchronous” technology – i.e., technology according to which row address strobe ("RAS") and column address strobe

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[15] I rely on the McGuire decision for much of the information in this section. The decision provides a helpful discussion of the institutional history of DRAM standard setting in the early 1990s.

[16] McGuire decision, ¶ 31

("CAS") signals control the operation of the DRAM rather than a system clock. Thus, the timing of DRAM chips was not necessarily synchronized with the timing of system operation. Examples of asynchronous DRAM technology commonly used in the industry in the late 1980s were page mode and extended data out (EDO) DRAM, both standardized by JEDEC. The JC 42.3 subcommittee continued to develop a new generation of EDO DRAM, eventually standardizing "Burst EDO" in 1995, but this technology ultimately gave way to synchronous DRAM, or SDRAM. JEDEC also considered an additional asynchronous option developed by IBM called High Speed Toggle (HST).

At the JEDEC JC 42.3 meeting in May 1991, NEC Corp. presented the first proposal to JEDEC for a fully synchronous DRAM. SDRAM is based on technology that uses a system clock to synchronize the timing of chip operation with the timing of system operation.[17] For example, one feature of the SDRAM chip is programmable CAS ("column address strobe") latency, whereby a register on the chip regulates the latency, or number of cycles, it takes for the chip to respond to a read request from the memory controller by accessing the relevant column data in the memory array of the chip; the register is "programmable" in the sense that the device is "programmed" at system startup to adjust to system timing needs.[18] At the JC-42.3 meeting on September 18, 1991, NEC made a second presentation of its SDRAM proposal. A number of other companies also presented SDRAM proposals at this meeting, including Texas Instruments, Toshiba, and Hewlett-Packard.

At the JC-42.3 meeting on December 4-5, 1991, IBM made a presentation comparing HST to SDRAM. Also at the JC 42.3 meeting of December 4-5, 1991, NEC presented results of a non-JEDEC meeting held in Portland, Oregon on October 24, 1991

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[17] McGuire decision, ¶ 307; see also, Infineon website at: http://www.infineon.com/dram_memory.htm. "Synchronous DRAM is a DRAM technology that uses a clock to synchronize signal input and output on a memory chip. The clock is coordinated with the CPU clock so the timing of the memory chips and the timing of the CPU are in sync."

[18] McGuire decision, pp. 47-49

to discuss high bandwidth DRAM. The conclusion from that meeting was that a fully synchronous DRAM with all signals referenced to a single positive clock edge would best meet system requirements. At the JC-42.3 meeting held on February 27-28, 1992, NEC, Hitachi, Fujitsu Toshiba, Mitsubishi and Sun all made presentations regarding synchronous DRAM devices.

These companies also made presentations regarding asynchronous DRAM technology, and the JC-42.3 subcommittee continued to develop various asynchronous DRAM standards while it was standardizing synchronous DRAM. But the future lay with synchronous DRAM. At a DRAM Task Group meeting on April 9-10, 1992, NEC, Fujitsu, Toshiba Samsung, Hitachi and Mitsubishi presented proposals for a fully synchronous DRAM. Following the April 1992 DRAM Task Group meeting, the JC-42.3 subcommittee decided to pursue a fully synchronous DRAM rather than IBM's toggle mode.

At the JC-42.3 meeting on March 3-4, 1993, the subcommittee voted unanimously to send 14 SDRAM ballots to Council to become approved as a standard for SDRAM intended for publication as Release 4 of the 21-C standard. The ballots were sent to the Council after the vote. At the JC-42.3 meeting on May 19-20, 1993, IBM reported to the full JC 42.3 subcommittee that the SDRAM ballots had gone to Council and that all council members, apart from AT&T, had supported the ballots. On May 24, 1993 the JEDEC Council formally approved adoption of the standard in Release 4 of the 21-C standard.[19] In November 1993 JEDEC published the SDRAM standard as JEDEC Standard No. 21-C Release 4. JEDEC published its standard for SDRAM as part of Release 4 of JEDEC Standard 21-C in November 1993.

Thus, JEDEC JC-42.3 was expanding upon its traditional responsibilities to enhance performance in addition to ensuring interoperability. This effort was undertaken

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[19] McGuire decision, ¶ 354

by an organization whose membership encompassed virtually the entire solid state industry, which was responsible for the manufacture of parts for the PC, laptop, and server businesses. JC-42 membership consisted of almost all DRAM memory companies, SRAM memory companies, logic companies, customers of memory, and "interconnect" companies such as socket manufacturers and testing companies.

This context is an important consideration when analyzing empirical results. The crucial element, perhaps, is the degree of activity taking place within the JC-42.3 subcommittee (network) relative to non-JC-42.3 subcommittees in the early 1990s. For example, a total of 119 ballots were passed or rejected by the JC-42.3 subcommittee in the years 1990 to 1993, compared to a total of 55 ballots passed or rejected by the three remaining subcommittees in these years. The emphasis on the "bottleneck" problem likely underlies the magnitude of activity on the JC-42.3 subcommittee relative to the three remaining subcommittees. Moreover, the JC-42.3 subcommittee was assuming the novel responsibility of developing performance specifications, which was relatively unprecedented given its conventional responsibility of merely ensuring plug compatibility of the DRAM chip with the motherboard of a computer.

Another important consideration is that the JEDEC standard setting process was historically a slow-moving process. JEDEC participants, collectively representing almost the entire solid state industry, often had significant differences of opinion concerning various solutions to the technical challenges facing the JEDEC standards development effort. From time to time, ballots failed or were put on hold in the JEDEC committees because the committees did not reach a consensus. A committee could pass items individually but place the individual items on hold until an entire list of related items needed to define a single standard was complete; once that group of ballots was complete and passed, the committee could motion them to go to Council for publication. If the JEDEC committee approved a standard, the proposed standard was sent by ballot to the

JEDEC Council, which then, by consensus, had to approve the ballot in order for the proposal to become a JEDEC standard. The JEDEC Council would give due consideration to any committee votes cast in opposition to the proposed standard. Thus the standard setting process at JEDEC required years to adopt a new standard or change an existing standard.

Coupled with JEDEC procedure that explicitly encourages members not to lobby other members to approve ballots, the DRAM standard setting effort in the early 1990s took place in a novel and highly deliberative atmosphere. These are important considerations when analyzing the impact of network connections on the standard setting process. Although this study is narrowly concerned with internal network participation, future work that examines centrality in internal and external networks over a longer period time would do well to consider the degree of impact from networking given the assumption of new responsibilities and generational change in technology. In this study, however, these institutional anomalies provide an interesting context in which to interpret the impact of standard setting activity – in terms of sponsored items and number of motions for ballot proposed – in the years before the SDRAM standard was developed.

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VI. The Data

This study utilizes cross-sectional and panel data. I utilize panel data to analyze the JC-42 standard setting process in the years 1990 to 1993. I utilize cross-sectional data to analyze the JC-42 standard setting process in the years 1991 to 1993. The purpose of using cross-sectional data is to analyze the impact of standard setting activity – in terms of sponsored items and number of motions for ballot proposed – in the years prior to 1991. Thus, cross-sectional analysis tests the significance of previous standard setting activity and networking given the shift from asynchronous to synchronous DRAM technology that officially occurred with NEC Corp's proposal for a fully synchronous DRAM in May 1991.[20] Panel analysis focuses on variation in the effects of networking in the years when the "bottleneck" problem was of central concern.

The main source of data for this study consists of minutes of JC-42 subcommittee meetings throughout the 1990s.[21] The minutes of JC-42 subcommittee meetings record key decisions made during the standards development process, including motions and votes.[22] The minutes were intended to be a chronological statement of events and occurrences in the meeting.[23] They also contain logs that summarize the overall status of sponsored items – the name of the firm sponsoring the item, when items were first presented, when they were balloted and by what subcommittee, and when they were balloted and either approved or rejected by the JEDEC Council.

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[20] Since I was unable to collect data on sales for the late 1980s, it is not possible to construct a panel dataset spanning the entire period for which I have collected data on sponsored work items and balloting activity. If I had been able to collect sales data, I would also have been able to collect IP data from the Cornell micro-patent database.

[21] The CD containing meeting minutes for the years 1990 to 1999 was generously provided to me free of charge by JEDEC in the interest of academic research, under conditions that copyright not be infringed and the CD be returned upon completion of its use. Two logs were illegible and thus I do not include data from these logs, but given the duplicative nature of the logs, it is likely that most, if not all, items in these logs appeared in other logs.

[22] McGuire decision, ¶ 256

[23] McGuire decision, ¶ 256

I have constructed a raw dataset that includes, from the logs, the number of items sponsored per member per year from 1985 to 1993,[24] the year in which the item was first presented to the relevant subcommittee (if available), the subcommittee on which the item was balloted and year it was balloted,[25] whether the balloted item passed or failed, the year the item was balloted by the JEDEC Council, and whether the JEDEC Council approved the item for publication as a standard.[26] I record these data per firm, though the individual representatives of these firms present at meetings were not always the same individuals from one meeting to the next.

Data on the intellectual property portfolio of firms were obtained from the Cornell micro-patent database. Three sets of data were obtained: number of US patents granted to firms per year for the years 1990 to 1993, number of non-US (England, France, Germany) patents granted in the years 1990 to 1993, and number of non-US (England, France, Germany, Spain, Japan) patent applications filed in the years 1990 to 1993.[27] The analysis ultimately does not consider the role of non-US patent applications because of concerns about the data-gathering process.[28] The variables employed in the cross-sectional

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[24] Many items in the logs attached to minutes for meetings during the early 1990s (particularly in 1990 and 1991) were presented for the first time in the latter half of the 1980s. These logs also contain information on items balloted by the relevant subcommittee and approved by the JEDEC Council during the late 1980s.

[25] I tally the total number of motions for ballot by summing the ballots that passed and failed; but I do not include motions that are still pending because the logs do not clearly identify when a motion is pending.

[26] A slight bias could arise in the analysis due to data entry mistakes. The data are extracted from item logs attached to meeting minutes of each subcommittee meeting over the course of four years (1990 to 1993). The item logs from one meeting to the next were highly duplicative; item logs are not unique to a specific meeting, but rather summarize items relevant to the discussions and purposes of that meeting. Thus, most items appear frequently in multiple item logs. These data were hand-entered over the course of four months and required a Herculean effort to ensure that all item data were entered uniquely; however, time constraints do not allow me to check the accuracy of data entry. All errors are my own, but I am confident they would have at most a minor effect on the results given scale effects. Also, I treat items with a decimal suffix as separate items even though they may be sections or extensions of a specific item (indicated by the whole number), under the assumption that they are listed separately and thus a focus of specific and separate discussion. Also, they are voted upon separately in addition to the non-decimal item number.

[27] Search term used: when the number of patents that came up was small enough, I counted the number of times the company name showed up; if the number was too high, I did my best to guess a search term that would only bring up the company name, but there may have been cases when the database produced patent applications of other companies, probably because the name of the company in which I was interested showed up somewhere in the application; this error should be small.

[28] My search criterion specified date issued rather than date filed for some companies, and I have not had enough time to correct this mistake.

analysis measure the average number of US and non-US patents granted per year from 1990 to 1993. Intellectual property is assumed to measure the technological resources of a firm, though it is not possible given time and knowledge constraints[29] to isolate the fraction of patents granted that are directly relevant to the standard.

Firm size is measured using net revenue data obtained for the years 1990 to 1993 from mergentonline, which provides net revenue data per firm for the past 15 years. In most cases, data are not available for years prior to 1992. Moreover, in some cases data are available only as far back as 1994, and in a few instances 1996 or 1997. Except when data are available only for 1996 or 1997, I compute the average net revenue per firm from 1990 to 1993 (or 1994-95) in the cross-sectional dataset; otherwise, I take the sales data from 1996 or 1997, with the underlying assumption that relative differences in firm size have not changed in the course of a few years. The panel dataset drops observations for which sales data are not available in any particular year. Thus, panel data analysis focuses almost exclusively on variation across the latter two years of the dataset, which provides an important consideration when interpreting results. However, I present results from regressions that do not include the sales data in order to consider a larger dataset with variation across a lengthier period of time. Firm size is assumed to measure market power and overall resources of a firm. It also may indicate the willingness of firms to influence standards development because size could be correlated with the probability that firms have a stake in the outcome of the standards development process.

I conducted internet research to collect a list of consortia and associations affiliated with the semiconductor industry. I was able to identify the following semiconductor consortia, forums, or industry associations: Sematech, Fabless Semiconductor Association, Focus Center Research Program, Global Semiconductor

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[29] In principle, in order to isolate the fraction of patents granted directly relevant to the standard would require time to review every patent granted, as well as the technical expertise to assess the relevance of the patent to the standard.

Forum, Institute for Interconnecting and Packaging Electronic Circuits, Semiconductor Equipment and Materials International, Semiconductor Equipment Assessment, Semiconductor Industry Association, Semiconductor Research Corporation, Semiconductor Test Consortium, Silicon Integration Initiative, SLDRAM/SyncLink, Solid State Energy Conversion Alliance, Spirit Consortium, Universal Transportable Memory Association, and the UXP Initiative. I was able to gather data from only two organizations.[30] Data on networking ***outside*** the JEDEC JC-42 committee thus consist of membership data from Sematech, a semiconductor consortium for which membership data were provided to me for the years 1990 to 1993 and Semiconductor Industry Association, an industry association for which membership data were provided to me for the years 1990 and 1992.[31]

Thus, I gathered membership data from 13 percent of industry consortia and associations. However, this number is misleading because some organizations were conceived post-1993 and were not relevant to this study. For example, the SLDRAM/SyncLink Consortium was formed in 1995 to develop an alternative SDRAM standard after Intel developed its own set of SDRAM specifications for next-generation DRAM.

The SLDRAM Consortium emerged out of concerns that Intel was attempting to "corner" the DRAM market. The consortium was attended by Apple Computer, Fujitsu Ltd., Hewlett-Packard Company, Hitachi Ltd., Hyundai Electronics Industries Co., Ltd., IBM Microelectronics, IBM World Procurement, LG Semicon Co., Ltd., Matsushita Electric Co., Micron Technology, Mitsubishi Electric Corp., MOSAID Technologies, Mosel-Vitelic, Motorola, NEC Corporation, Nippon Steel Corp., Oki Electric Industry Co., Ltd., Samsung Electronics Co., Ltd., Siemens, Texas Instruments, Inc., Toshiba

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[30] I obtained these data from representatives with whom I spoke on the phone who sent me the membership data by email.

[31] I am informed that membership was mostly consistent from year to year for this organization, and I have thus assumed that a member in 1992 was also a member in 1991 and 1993.

Corp., Vanguard International Semiconductor, and VLSI Technology. All of these companies were members of JEDEC, and thus this consortium, given its DRAM focus, would seem to have provided an ideal networking opportunity for JEDEC members. But the consortium was founded in 1995 and is not relevant to the period covered by this study. Future research that examines DRAM standard setting throughout the 1990s would account for membership in this consortium. In addition, future research would distinguish between semiconductor organizations primarily dedicated to DRAM standard setting and those that are not so dedicated.

Since information culled from external organizations is so limited, I do not consider these data in the analysis. Moreover, membership in the two organizations for which I obtained data in these years is comprised almost exclusively of US firms. According to its website, Sematech "was formed in 1987, when 14 US-based semiconductor manufacturers and the US government came together to solve common manufacturing problems by leveraging resources and sharing risks."[32] Moreover, Semiconductor Industry Association is a US-based trade association whose membership consists of either US-based companies or foreign companies with US subsidiaries.[33]

In summary, I have collected raw data from the Cornell micropatent database, mergentonline, consortia/industry associations, and the meeting minutes of JC-42 subcommittee meetings in the years 1990 to 1993. The two dependent variables are number of JEDEC Council approvals and number of motions proposed to the JC-42.3 subcommittee that pass committee vote. In the panel dataset, the dependent variables are for the years 1990 to 1993. In the cross-sectional dataset, the dependent variables are for the years 1991 to 1993 (the years in which the synchronous DRAM, or SDRAM, standard was set). The number of JEDEC Council approvals measures the fraction of items

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[32] http://www.sematech.org/corporate/history.htm; membership opened to foreign companies beginning 1994.

[33] This information was provided to me in a phone call with a representative of the organization.

presented (sponsored) by a firm for discussion on any of the four JC-42 subcommittees – thus relevant to any aspect of memory technology – ultimately approved by the relevant subcommittee and the JEDEC Council, thus being published as a standard. The number of motions for ballot passed by JC-42.3 measures the fraction of items presented (sponsored) by a firm ultimately approved by the JC-42.3 subcommittee – thus directly relevant to DRAM standards.

The main explanatory variables are sponsored items, firm size, intellectual property portfolio, and networking *within* JEDEC. I originally considered a proxy for networking *outside* JEDEC measuring the number of memberships in external organizations – consortia and industry associations – per year from 1990 to 1993, but have dropped this variable given the concerns expressed above.[34] The proxy for networking *within* JEDEC is the number of JC-42.3 and non-JC-42.3 meetings attended in the years 1990 to 1993. I also considered number of motions proposed in JC-42.3 and non-JC-42.3 meetings in the same years as a proxy for network centrality, but given concerns about whether a true network connection is manifested in the motion I use this variable only to control for volume of ideas presented and ignore its interpretation as a network variable.

The cross-sectional dataset is designed to test the impact of standard setting activity and networking prior to commencement of SDRAM standard setting efforts in 1991. The variables for standard setting activity and networking include number of sponsored items in the years 1985-90, number of sponsored items in the years 1991-93, number of JC-42.3 and non-JC42.3 meetings/motions in the years 1985-90, and number of JC-42.3 and non-JC-42.3 meetings/motions in the years 1991-93.

A total of 165 companies are listed as present or absent (thus identified as a member) during at least one subcommittee meeting during the years 1990 to 1993.

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[34] Results include insignificance of the coefficient estimate, as well as a negative correlation between standard setting influence and external networking.

Ninety-seven of these companies were listed as present or absent during at least one JC-42.3 subcommittee meeting during the years 1990 to 1993.[35] After removing observations due to data limitations, and accounting for all assumptions,[36] the dataset consists of 66 observations (firms) for each variable in the cross sectional dataset but sales, for which I have 65 observations. Panel data consist of 260 observations for all variables but sales, for which I have 149 observations due to inability to collect data for most firms in the years 1990 and 1991.[37] The sample size consists of approximately 40 percent of the total number of companies listed as a member in at least one JC-42 committee meeting in the years 1990 to 1993 (relevant for the "Council approvals" dependent variable), or 60 percent of the total number of companies listed as a member in at least one JC-42.3 subcommittee meeting during these years (relevant for the "JC-42.3 successful motions" dependent variable). Tables 2 and 3 provide summary statistics and descriptions of cross-sectional and panel variables included in model specifications presented in subsequent sections. A list of the companies in the dataset is provided in Table 1.

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[35] The McGuire decision (¶253) states that, in 1991, the JC-42.3 subcommittee consisted of approximately forty to fifty member firms. The 97 firms counted in the dataset is larger most likely because it tallies more years, and includes members even if they were only listed as an "absent member".

[36] I have removed observations if IP or firm size data was unavailable. I also removed observations if it was unclear which company to which the data were applicable. This latter problem arises because sponsor names are abbreviated in the item logs, and I must infer the name of the sponsor from the abbreviation. In most cases, this is easy (SMS refers to Samsung, TSH refers to Toshiba, HTI refers to Hitachi, and so on). But for example, it was unclear whether DEC referred to Dana-Elec Corporation or Digital Equipment Company, in which case I remove the observation; it was also unclear whether DTB or DBK referred to a company named Databook. In some cases, I assumed that a firm has two abbreviations which show up in the logs. For example, I assume CMP and CMPQ both refer to Compaq Computer. Moreover, I assume MCH and MCHP both refer to Microchip Technology.

[37] The cross-sectional dataset includes observations for the firm VIA Technologies, but the panel data does not.

Table 1: List of JEDEC Members

JEDEC Member	Location
Actel Corporation	US
Advanced Micro Devices	US
Altera Corporation	US
Apple Inc.	US
Aspen Semiconductor	US
Atmel Corporation	US
AT&T	US
Cirrus Logic Inc.	US
Compaq Computer	US
Cray Research Inc.	US
Cypress Semiconductor	US
DATA I/O	US
Dell Inc.	US
Electronic Design	US
Fujitsu	Non-US
GSI Technology	US
Harris Corp	US
Hewlett Packard Company	US
Hitachi Limited	Non-US
Hynix	Non-US
IBM Corporation	US
Integrated Device Technology	US
Infineon Technologies	Non-US
Intel Corporation	US
Lattice Semiconductor	US
LSI Logic Corporation	US
Matsushita	Non-US
Microchip Technology	US
Micron Technology Inc.	US
Mitsubishi Electric	Non-US
MOSAID Technologies Inc.	US
Mosel-Vitelic	US
Motorola Corporation	US
National Semiconductor	US
NCR	US
NEC Corp	Non-US
OKI	Non-US
Philips	Non-US
Quality Semiconductor	US
Rambus	US
Ramtron	US
Raytheon	US
Robinson Nugent	US
Samsung Semiconductor	Non-US
Sanyo	Non-US
SEEQ Technology	US
Sharp Microelectronics	Non-US
Siemens	Non-US
Silicon Graphics Inc.	US
Silicon Storage Technology	US
Simtek	US
Smart Modular Technology	US
Sony Corp	Non-US
Sun Microsystems Inc.	US
Teradyne Inc.	US
Texas Instruments	US
Toshiba	Non-US
TrueVision	US
Unisys Corporation	US
VIA Technologies Inc.	Non-US
VLSI Technology Inc	US
Wang Labs	US
Western Digital	US
Xicor	US
Xilinx Inc.	US
Xerox	US

VII. Empirical Analysis

The general framework of analysis in this paper tests the dependence of number of JEDEC Council approvals and the number of motions for ballot proposed to the JC-42.3 subcommittee that pass committee vote on networking within the JC-42.3 and non-JC-42.3 committees (networks), as well as number of items sponsored, intellectual property portfolio, and firm size. As mentioned above, I originally considered networking ***outside*** JEDEC, consisting of membership in external consortia and industry associations related to the semiconductor industry, but I have since dropped this variable due to data restrictions. Networking ***within*** JEDEC consists of attendance at meetings conducted by JC-42.3 and non-JC-42.3 subcommittees.

I distinguish between JC-42.3 and non-JC-42.3 subcommittees to distinguish between DRAM and non-DRAM-related standard setting activity, and also to account for differences in the magnitude of standard setting activity by JC-42.3 and non-JC-42.3 subcommittees, due most likely to the focus on DRAM standard setting by the JC-42 committee during these years. A total of 119 ballots were passed or rejected by the JC-42.3 subcommittee in the years 1990 to 1993, compared to a total of 55 ballots passed or rejected by the three remaining subcommittees in these years. The cross-sectional data reveal that the JC-42.3 subcommittee passed or rejected 80 balloted items in the years 1991-93, compared to 89 balloted items in the years 1985-90. These numbers compare to 64 and 31 balloted items passed or rejected by non-JC-42.3 subcommittees in the years 1991-93 and 1985-90, respectively.

I considered the number of total motions for ballot proposed during JC-42.3 and non-JC-42.3 subcommittee meetings, but have since dropped the interpretation of this variable as a proxy for internal networking because it is unclear whether this variable manifests a network connection. The "motion for ballot" was interpreted as a proxy for degree centrality.[38] In order for a firm to make a motion to the relevant subcommittee, it must obtain a “second” to support its motion – i.e., it must develop a “network connection”. The number of motions by a firm is thus a measure of its internal network centrality. However, the extent to which the motioning company and the “second” work together to develop the item in preparation for committee ballot is unclear. Moreover, the current variable for number of motions most likely overstates centrality since it does not identify the number of unique “connections” made. One firm may obtain the same “second” for multiple motions.

Another caveat is that the item sponsor may not necessarily be the firm to make a motion to ballot. The item logs are constructed to give the impression that the item sponsor is also the company to make the motion, since the logs indicate the name of the company which sponsors the item, and then indicate whether the item is balloted by the relevant subcommittee and/or JEDEC Council. The meeting minute summaries indicate that in many cases the item sponsor also makes a motion to ballot, but this is not always true. According to JEDEC:

> There is no requirement or obligation that the sponsor of a proposal must also be the one to motion the proposal to ballot. It is not uncommon to have several companies participate in a proposal, prior to the proposal being balloted (in its original form, a modified form, or as part of a larger proposal). The motion to ballot is often made by the original (or current) sponsor, but may also be made by another company supporting the proposal.

Thus, to the extent that items sponsors do not make the motion to ballot, and to the extent that companies generate more motions than unique connections, the variable

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[38] Degree centrality is a measure of networking activity in the literature on social networking; it is equal to the sum of unique connections between a firm and all other firms within a network.

measuring ballot motions overstates centrality. In addition to the fundamental concern about whether a “connection” is even formed, I do not interpret this variable as a networking proxy.

Nevertheless, I include number of motions in the analysis to control for volume of activity when attempting to explain number of Council approvals obtained by a firm. The number of sponsored items controls for the volume of ideas that firms present in the standard setting process. However, the number of sponsored items does not necessarily have to lead to successful standard setting efforts. As stated above, the motion for ballot initiates the process of getting the item established as a standard. A firm may present few items but have a higher probability of establishing any one item as a standard, whereas other firms may present several items but have less success getting them approved by the relevant subcommittee and/or JEDEC Council. It would seem that the value of an idea is reflected in its ability to pass committee vote, and ultimately Council vote. It may be that many items presented in the period of study were not relevant to the DRAM standard and never gained traction given the focus on addressing the “bottleneck” problem at the time.

Motions for ballot arise out of work items. A member proposes an item for discussion, and then can make a motion to have the item balloted if it convinces another member to "second" the motion. No member can propose a ballot to be motioned if there is no item to be balloted. Number of items thus controls for a firm’s total volume of ideas proposed in the standard-setting process. But number of motions controls the volume of “good” ideas proposed – that is, ideas that gain sufficient traction for a firm to make a motion to have the item balloted.

In the cross-sectional dataset, I distinguish between sponsored items and motions for ballot in two periods: 1985-90 and 1991-93. This distinction permits us to isolate the impact of work items and ballot motions directly relevant to the SDRAM standard, under the assumption that only work items and motions presented in the years

1991 to 1993 are relevant to the SDRAM standard.[39] A positive coefficient on the number of items sponsored or motions in the years prior to 1991 would indicate that historical activity *per se* in the standard setting process, regardless of the technology involved, contributes to firm influence; however, a positive coefficient on number of items sponsored or motions in the years 1991-93 suggests that the technological content matters. This latter possibility would provide a way to isolate granularity in technical expertise not afforded by standard IP variables.

The analysis in this paper is motivated by a desire to test the strategic significance of networking *within* JEDEC JC-42 subcommittees in the context of standard setting efforts by these committees in the years when DRAM standards were a primary concern. In general, I consider a hypothesis that is conceptualized in the following two equations:

1. Motions for ballot proposed during JC-42.3 subcommittee meetings that pass committee vote = f(IP(+), firm size(+), items sponsored(+/-), number of JC-42.3 and non-JC-42.3 meetings (+), number of JC-42.3 and non-JC-42.3 motions (+))

2. Council approvals = f(IP(+), firm size(+), items sponsored(+/-), number of JC-42.3 and non-JC-42.3 meetings (+), number of JC-42.3 and non-JC-42.3 motions (+))

The control variables are items sponsored,[40] number of motions for ballot, number of US and non-US patents granted per year,[41] and firm size as measured by sales data.

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[39] The logs show that most items that reach the balloting stage are balloted within a year of being presented to the committee for the first time, so items sponsored in the years 1991 to 1993 should necessarily be positively correlated with motions for ballot in the years 1991 to 1993.

[40] In the cross-sectional dataset, the variable is number of items sponsored in the years 1991 to 1993. In the panel datasets, the variable is number of items sponsored in the years 1990 to 1993.

The internal networking variable is number of JC-42.3 and non-JC-42.3 meetings attended. The cross-sectional analysis controls for the shift in focus of standard setting efforts from ensuring plug compatibility to enhancing technological performance by distinguishing between standard setting data before and after the transition from asynchronous to synchronous DRAM technology. Thus, cross-sectional analyses seek to explain the influence of standard setting activity in years prior to 1991 on standard setting activity during the years the SDRAM standard was being developed.

Hypothesis: Number of JC-42.3 and non-JC-42.3 meetings at which a member is present contributes to number of JEDEC Council approvals and number of motions for ballot proposed in JC-42.3 meetings that pass committee ballot

This hypothesis posits that standard setting influence can be traced to number of JC-42.3 and non-JC-42.3 meetings attended. Participation in meetings can be active or passive; members can develop items or simply observe and perhaps contribute to discussions. Either way, firms become aware of the direction of standardization for both memory technology in general and DRAM technology in particular. Being aware of the direction of memory standards in general is important not simply because of the importance of memory technology *per se*, but because parts compatibility, rather than network compatibility, is the driving force of DRAM standardization.

DRAM chips are not manufactured in a vacuum – compatibility with multiple components on a motherboard is crucial for the chips to have utility to the consumer. Thus, a firm that is aware of standards development in related technologies (i.e., memory technology in general) should have more capability refining and presenting work items

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[41] In the cross-sectional dataset, the variable tested is the average number of patents per year for the years 1990 to 1993.

that ultimately meet with JC-42.3 and JEDEC Council ballot approval. For example, the JC-42.5 subcommittee had responsibility for standardization of memory modules, the devices in which a DRAM chip is nested with other DRAM chips on the motherboard.[42] Thus, a reasonable conjecture is that participation in JC-42.5 meetings is likely to have a positive impact on DRAM standards development in JC-42.3 meetings (i.e., number of motions that pass JC-42.3 ballot). In general, then, it is expected that increasing number of meetings attended in any of the four subcommittees should contribute to standard setting influence. The rationale is the complementary nature of the technologies and the fact that parts compatibility is the driving force of standardization.

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[42] See Elpida website at: http://www.elpida.com/en/contacts/faq.html#techm-df; “A DRAM chip packaged in TSOP, TCP, etc., is called "component", and its capacity is normally described in "bit" units. By contrast, a memory module consists of several DRAM components mounted on a board, allowing easy mounting in a PC, etc. The capacity of a memory module is normally described in "Byte" (= 8 bits) units.”

VIII. Empirical Technique

This analysis makes use of cross-sectional and panel datasets with count dependent variables. The empirical technique is Poisson maximum likelihood estimation (MLE), with negative binomial MLE used as a substitute when tests indicate the presence of over-dispersion. Poisson is a standard distributional assumption for count dependent variables in the absence of over-dispersion.

Panel regressions employ fixed and random effects, but the frequency of zero outcomes severely truncates the data in fixed effects models. To allow for analysis of a fixed firm-level impact in random effects models, I follow Wooldridge (2002) and include firm-level means as an attempt to isolate the fixed effect between panel clusters from the firm-level changes that take place within panel clusters. Time dummies are included to account for any time-specific variation that may occur. Given the lack of sales data for the years 1990 and 1991, panel data consider variation almost exclusively across the years 1992 and 1993, though I drop sales data in some panel specifications in order to consider the effects of increased variation in the dataset.

Although fixed effects are consistent, random effects models are more efficient but require zero correlation between the error term and the explanatory variables. I have not run a Hausman test to compare the fixed and random effects estimators. Since data limitations affect random effects models much less severely than fixed effects models, I discuss results in the random effects models because they reflect a larger sample size and greater degree of variation. However, I note that the use of fixed effects is probably more appropriate given that data are observed at the level of the firm. It would be sensible to assume that firm-level effects are fixed rather than random across time, particularly in an industry such as computing in which the firms have well-established characteristics such as location, product portfolio, and sales force. On the other hand, it is perhaps possible that the dynamic nature of technological change in this industry could be better reflected in random effects across time.

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IX. Empirical Results

Tables 2 and 3 present summary statistics for variables in the cross-sectional and panel datasets.

Table 2: Summary Statistics for Variables in Cross-Sectional Dataset

Variable	# Observations	Mean	Std Dev	Maximum	Minimum
Council approvals	66	0.76	1.72	9	0
JC-42.3 motions that pass	66	1.14	2.93	18	0
Items sponsored, 1991-93	66	4.48	8.34	34	0
Items sponsored, 1985-90	66	4.09	7.23	34	0
Sales	65	9,540,000,000	16,800,000,000	64,000,000,000	1,355,319
US patents	66	164.49	286.65	1,140	0
Non-US patents	66	61.14	171.70	1,100	0
JC-42.3 meetings, 1990-93	66	8.14	6.64	17	0
Non-JC-42.3 meetings, 1990-93	66	14.58	14.11	45	0
JC-42.3 motions for ballot, 1985-90	66	1.35	2.95	14	0
JC-42.3 motions for ballot, 1991-93	66	1.21	3.03	18	0
Non-JC-42.3 motions for ballot, 1985-90	66	0.47	1.34	7	0
Non-JC-42.3 motions for ballot, 1991-93	66	0.97	2.46	16	0

Table 3: Summary Statistics for Variables in Panel Dataset

Variable	# Observations	Mean	Std Dev	Maximum	Minimum
Council approvals	260	0.26	0.78	7	0
JC-42.3 motions	260	0.42	1.37	13	0
Items	260	1.52	3.48	23	0
Sales	149	9,850,000,000	17,700,000,000	124,437	67,200,000,000
US Patents	260	167.02	291.10	1,179	0
Non-US Patents	260	62.08	172.82	1,247	0
JC-42.3 Meetings	260	2.07	1.83	5	0
Non-JC-42.3 Meetings	260	3.7	3.87	13	0
JC-42.3 Motions	260	0.47	1.46	13	0
Non-JC-42.3 Motions	260	0.23	0.77	6	0

Tables 4 and 5 present results of cross-sectional and panel analyses of standard setting influence on the JEDEC JC-42 committee. I am interested in understanding the impact of internal networking on the ability of firms to push items through the standard setting process – gaining approval of DRAM-related items by the JC-42.3 subcommittee in particular, or gaining approval of an item related to memory technology by the JEDEC Council in general. The former provides a context in which to study the impact of networking on DRAM standard setting efforts. The latter provides a context in which to study the impact of networking on standard setting efforts for memory technology. In either case, I analyze the impact of networking in years when DRAM technology was a central focus of standard setting activity.

Networking is measured by the number of JC-42.3 and non-JC-42.3 meetings attended per year. As mentioned above, this variable is designed to reflect the impact of increasing participation in the JC-42.3 and non-JC-42.3 networks, where networks refer to formal meetings convened by JEDEC members to discuss ideas related to memory technology and standards. It is possible that number of JC-42.3 and non-JC-42.3 motions reflects centrality in these networks, but as discussed above it is not possible without further information to detect whether motions reflect explicit connections between firms. Thus, I consider motions only as a variable to control for volume of ideas presented in the standard setting process.

Table 4 presents the results of cross-sectional analysis. Table 5 consists of four versions which present results, in order, of including the basic control and networking variables (Table 5a), the same variables and an additional dummy to control for the presence of US and non-US-based firms (Table 5b), the same variables and the dummy but with sales excluded (Table 5c), and a final version that excludes sales and implements firm-level means in random effects models.

Table 4 presents cross-sectional results with robust standard errors. Tests uncover no evidence of over-dispersion, so Poisson and negative binomial regressions using mean dispersion generate equivalent results. These results suggest that only attendance in non-JC-42.3 meetings has a positive and (slightly) significant impact on standard setting influence in terms of Council-approved standards publications. It is perhaps unsurprising to find a relation between Council approvals and meetings attended, since items were developed and balloted in the course of these meetings, but given the focus on DRAM standards at the time, it is rather unexpected that number of non-JC-42.3 meetings has a significant impact (though a smaller coefficient value) rather than number of JC-42.3 meetings.

If attendance at a committee meeting has the same marginal impact regardless of the subcommittee, this disparity may simply reflect the greater number of meetings held by the three non-JC-42.3 subcommittees compared to the number of meetings held by the lone JC-42.3 subcommittee. But given that number of JC-42.3 meetings and not number of non-JC-42.3 meetings had a (positive) significant impact on successful JC-42.3 motions, a differential marginal impact across subcommittee meetings may still exist. Nonetheless, the significance of the coefficient on number of non-JC-42.3 meetings may simply indicate that despite the publicity surrounding DRAM standard setting at the time, the JEDEC JC-42 committee was still actively involved, perhaps more involved, in the general development of standards for memory technology at the time. Perhaps this general focus simply reflected the need to develop standards for technologies that complement the next-generation DRAM standards.

Table 4 also shows that number of motions proposed to non-JC-42.3 subcommittees in the years 1985-90 positively and significantly contributed to number of Council approvals in the years 1991-93. This result may be due to lags in the time it takes for items balloted by a subcommittee to ultimately be approved by the JEDEC

Council. But it is rare that a Council-approved item originally sponsored (e.g.) in 1988 or 1989 achieves Council approval in 1991-93. Many, if not most, items that pass committee vote are deliberated by the JEDEC Council within a year. Thus, it appears that volume of "good" ideas presented in non-JC-42.3 committees in the years prior to 1991 (i.e., prior to SDRAM standard setting efforts) may have contributed to efforts to get sponsored items approved by the Council and thus published as a standard. This result may reflect a ***reputation advantage*** gained from previous success in standard setting efforts.

JC-42.3 motions proposed pre-1991 and in the years 1991-93 have a strongly positive and significant impact on successful JC-42.3 motions in the years 1991-93, though JC-42.3 motions in the years 1991-93 are significant at only the 10 percent level. I have included total motions in 1991-93 to control for volume in the cross-sectional dataset but not in the panel dataset because the degree of correlation is smaller in the cross-sectional data (88 percent – similar to items sponsored) and thus can be assumed to have explanatory power. Motions in the years 1985-90 is more significant, suggesting that historical number of sponsored items that made it through committee vote has a positive and significant impact on DRAM standard setting influence in the years 1991-93, suggesting once again that having a reputation for proposing "good" ideas contributes to firm influence.

Among controls, firm size as measured by average net sales 1990-93 had a positive impact on Council approvals and JC-42.3 motions that pass committee vote, but the result is only significant with successful JC-42.3 motions as dependent variable. Intellectual property, however, had a consistently negative impact on both measures of standard setting influence, though significant only for the effect of US patents on number of JC-42.3 motions that pass. The negative coefficient on US and non-US patents may reflect the novelty of technologies considered for incorporation in the SDRAM standard in the years 1991-93. Patents granted would reflect technologies for which firms sought protection in earlier years and thus these technologies may not be relevant to the new generation of technology being considered. Moreover, although the JEDEC manual does not, in principle, disapprove of standardization of proprietary technology, the results could possibly suggest a bias among JEDEC members against firms with strong intellectual property claims.

The cross-sectional model produces a negative but insignificant correlation between sponsored items 1985-90 and number of Council approvals and successful JC-42.3 motions 1991-93, perhaps reflecting irrelevance of items sponsored in years prior to SDRAM standards development. The coefficient on items sponsored 1991-93 is positive (as expected), though also insignificant suggesting that, again, sponsored items *per se* do not matter so much as presenting sensible items. The fact that number of motions proposed is more likely to have a significant impact on Council approvals and successful JC-42.3 motions suggests that presenting “good” ideas that gain traction is more important than total volume of ideas *per se*.

Overall, cross-sectional results suggest that internal networking can have the positive impact expected, though the significance of non-JC-42.3 meetings for Council approvals is perhaps surprising given the emphasis on DRAM standards at the time. Also, evidence suggests the possibility that motions proposed pre-1991 contributes to standard setting influence, though non-JC-42.3 motions are more likely to impact Council approvals while JC-42.3 motions are more likely to impact successful JC-42.3 motions. The discrepancy in impact of JC-42.3 and non-JC-42.3 activity – in terms of meetings attended and motions – is an interesting result given the significance of DRAM standards, but may simply reflect that only so much work was required to establish a DRAM standard, and that general memory standards development was still alive and well at the time.

Table 4: Poisson MLE Cross-Sectional Analysis Of Council Approvals and JC-42.3 Passed Motions
1991 to 1993

	Council Approvals[1]		JC-42.3 Passed Motions[1]	
	Coefficient	Std Error	Coefficient	Std Error
Constant	-3.0973 ***	0.7356	-3.2074 ***	0.7537
Items Sponsored, 1991-93	0.0865	0.0581	0.0678	0.0527
Items Sponsored, 1985-1990	-0.0174	0.0493	-0.0385	0.0464
Sales	3.46E-11	2.24E-11	4.83E-11 ***	1.85E-11
US Patents	-0.0006	0.0015	-0.0020 *	0.0011
Non-US Patents	-0.0053	0.0036	-0.0045	0.0030
JC-42.3 Meetings, 1990-93	0.0534	0.0461	0.1662 **	0.0675
Non-JC-42.3 Meetings, 1990-93	0.0341 *	0.0205	-0.0189	0.0328
JC-42.3 Motions for Ballot, 1985-90	0.0897	0.1423	0.2972 **	0.1225
JC-42.3 Motions for Ballot, 1991-93	-0.0452	0.0955	0.1592 *	0.0876
Non-JC-42.3 Motions for Ballot, 1985-90	0.2530 **	0.1093	0.0654	0.1471
Non-JC-42.3 Motions for Ballot, 1991-93	0.0864	0.1227	-0.1007	0.1394

Notes: Test rejects over-dispersion, so Poisson and negative binomial yield equivalent results. Poisson with mean dispersion is used.
There are 65 observations in the dataset.

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

[1] Data are for the years 1991-93.

Panel data results do not isolate the impact of standard setting activity pre-1991 on standard setting activity 1991-93, but reflect variation in the impact of networking and controls on standard setting influence across the years 1990 to 1993. Because sales data are rare for the years 1990 and 1991, panel data reflect variation almost exclusively in the years 1992 and 1993, though I include specifications in which sales data were dropped to consider increased variation. I report the results of Poisson MLE models with fixed and random effects in table 5. When tests reveal the presence of over-dispersion, I report results of negative binomial MLE.

These models also implement time dummies to control for any time-specific variation that may affect results. Fixed effects models are severely hampered by data truncations due to many zero outcomes, and thus I generally – though not exclusively – discuss results from random effects models. But I implement firm-level means in random effects models (Table 5d) in conformity with Wooldridge (2002). Results are not included for specifications that do not converge in the log likelihood. I proceed on the assumption of zero correlation between the effect and the explanatory variables.

Table 5a presents results of specifications that include the basic controls and the internal networking variable that measures number of JC-42.3 and non-JC-42.3 meetings attended. Random effects yield an insignificant coefficient on the number of JC-42.3 meetings, but the coefficient on non-JC-42.3 meetings is positive and significant. Also, non-JC-42.3 motions are positive and significant in random effects models. Results are not affected by time variation. This result conforms to cross-sectional results and is a bit surprising given the emphasis on DRAM standards during this time, but may simply reflect that non-DRAM-related standardization was alive and well.

Random effects models do not yield any significance on the coefficients of controls or networking proxies when analyzing successful JC-42.3 motions, but fixed effects models indicate that number of items, sales, non-US patents granted, number of

JC-42.3 meetings attended, and non-JC-42.3 motions can all have a significant impact, though only sales has a positive impact and significance depends on whether we account for time variation. The negative coefficient on JC-42.3 meetings is confusing and may reflect data limitations in fixed effects models.

Table 5a: Panel Analysis of Council Approvals and Successful JC-42.3 Motions
Using Maximum Likelihood Estimation
1990 to 1993

Council Approvals	**Fixed Effects[1]**				**Random Effects[2]**			
	Time Dummies[3]		**No Time Dummies[3]**		**Time Dummies[4]**		**No Time Dummies[5]**	
	Coefficient	**Std Error**	**Coefficient**	**Std Error**	**Coefficient**	**Std Error**	**Coefficient**	**Std Error**
Constant	--	--	--	--	-3.1252 ***	0.5611	-3.0013 ***	0.4739
Items	-0.0108	0.0973	0.0079	0.0848	-0.0269	0.0443	-0.0500	0.0399
Sales	6.14E-10 *	3.40E-10	1.40E-10	1.72E-10	-6.40E-12	1.70E-11	-7.78E-12	2.02E-11
US Patents	-0.0006	0.0069	-0.0025	0.0053	0.0013	0.0010	0.0013	0.0011
Non-US Patents	-0.0319	0.0263	-0.0045	0.0217	-0.0027	0.0021	-0.0022	0.0021
JC-42.3 Meetings, 1990-93	-1.1027 **	0.5621	-0.2971	0.3445	0.0385	0.1716	0.0688	0.1492
Non-JC-42.3 Meetings, 1990-93	0.0177	0.1759	0.0017	0.1676	0.1971 ***	0.0727	0.1579 ***	0.0598
JC-42.3 Motions, 1990-93	-0.1544	0.1506	-0.0303	0.1194	0.1342	0.0863	0.1150	0.0826
Non-JC-42.3 Motions, 1990-93	-0.6020	0.5015	0.2021	0.2810	0.5855 ***	0.1282	0.5821 ***	0.1521

Notes: Time dummies are for 1990, 1991, and 1992.
Poisson MLE used except when over-dispersion is found, in which case I use negative binomial MLE.

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

[1] 42 observations and 15 groups.
43 groups (106 observations) dropped due to all zero outcomes.
1 group (1 observation) dropped because only 1 observation per group.
[2] 149 observations and 59 groups.
[3] Tests for over-dispersion not provided in Stata output. I include Poisson MLE results, though they differ with negative binomial.
[4] Test rejects over-dispersion. Poisson MLE used.
[5] Test rejects over-dispersion, but at 11% significance. Poisson MLE used

JC-42.3 Motions that Pass	**Fixed Effects[1]**				**Random Effects[2]**			
	Time Dummies[3]		**No Time Dummies[3]**		**Time Dummies[4]**		**No Time Dummies[4]**	
	Coefficient	**Std Error**	**Coefficient**	**Std Error**	**Coefficient**	**Std Error**	**Coefficient**	**Std Error**
Constant	--	--	--	--	-0.4098	2.8097	-0.9290 *	1.7724
Items	0.0353	0.0506	0.0701 *	0.0396	0.1121	0.0825	0.1350	0.0762
Sales	8.66E-10 ***	3.28E-10	4.05E-10	2.01E-10	0.0000	0.0000	-4.49E-11	6.63E-11
US Patents	-0.0021	0.0068	-0.0077	0.0050	-0.0010	0.0033	-0.0021	0.0030
Non-US Patents	-0.0592 **	0.0243	-0.0410 *	0.0245	0.0050	0.0083	0.0080	0.0076
JC-42.3 Meetings, 1990-93	-1.2048 *	0.6390	0.2881	0.3502	-0.1379	0.7148	0.1384	0.4439
Non-JC-42.3 Meetings, 1990-93	-0.1586	0.2050	-0.1874	0.1665	-0.0850	0.2247	-0.0946	0.2161
Non-JC-42.3 Motions, 1990-93	-1.0703 **	0.4752	-0.4250	0.3551	0.3144	0.4185	0.4825	0.3593

Notes: Time dummies are for 1990, 1991, and 1992.

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

[1] 36 observations and 13 groups.
45 groups (112 observations) dropped due to all zero outcomes.
1 group (1 observation) dropped because only 1 observation per group.
[2] 149 observations and 59 groups.
[3] Tests for over-dispersion not provided in Stata output. I include Poisson MLE results, though they differ with negative binomial.
[4] Test reveals over-dispersion, so negative binomial MLE is used.

Table 5b presents results after distinguishing between US and non-US firms. Effects on Council approvals are virtually identical to results presented in Table 5a, except that number of JC-42.3 motions has a positive and slightly significant impact on Council approvals in random effects models with time-specific variation. However, when we consider successful JC-42.3 motions as the dependent variable, accounting for firm location yields a positive and significant impact of number of JC-42.3 meetings on number of successful JC-42.3 motions, which is what we expect. Moreover, number of sponsored items helps to explain number of successful JC-42.3 motions in random effects models. Finally, the coefficient on US patents is positive only in its impact on Council approvals, so there is still a tendency for IP portfolio to negatively impact standard setting influence.

Table 5b: Panel Analysis of Council Approvals and Successful JC-42.3 Motions
Using Maximum Likelihood Estimation
Accounting for Firm Location
1990 to 1993

Council Approvals	Fixed Effects[1]				Random Effects[2]			
	Time Dummies[3]		No Time Dummies[3]		Time Dummies[4]		No Time Dummies[5]	
	Coefficient	Std Error	Coefficient	Std Error	Coefficient	Std Error	Coefficient	Std Error
Constant	4.0115	16.1832	4.5712	5.2034	-3.0094 ***	0.7470	-3.1675 ***	0.8267
Items	-0.0441	0.1097	-0.0089	0.0628	-0.0244	0.0445	-0.0523	0.0410
Sales	4.81E-10	3.68E-10	1.18E-10	1.10E-10	-5.85E-12	1.56E-11	-7.82E-12	2.05E-11
US Patents	-0.0023	0.0066	-0.0045	0.0055	0.0013	0.0010	0.0015	0.0013
Non-US Patents	-0.0305	0.0263	-0.0048	0.0155	-0.0029	0.0018	-0.0022	0.0022
Location	-2.2831	15.7076	-3.7059	5.0099	-0.1381	0.4885	0.1570	0.6362
JC-42.3 Meetings, 1990-93	-1.0576 *	0.5786	-0.4108	0.3653	0.0094	0.1291	0.0744	0.1515
Non-JC-42.3 Meetings, 1990-93	0.0322	0.1665	0.0611	0.1610	0.2074 ***	0.0528	0.1591 ***	0.0602
JC-42.3 Motions, 1990-93	-0.1572	0.1528	-0.0550	0.1241	0.1455 *	0.0749	0.1144	0.0821
Non-JC-42.3 Motions, 1990-93	-0.5518	0.5453	0.1507	0.3059	0.5843 ***	0.1154	0.5776 ***	0.1535

Notes: Time dummies are for 1990, 1991, and 1992.
Poisson MLE used except when over-dispersion is found, in which case I use negative binomial MLE.
The "location" variable is a dummy equal to 1 if the company is headquartered in the US and equal to 0 otherwise.

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

[1] 42 observations and 15 groups.
43 groups (106 observations) dropped due to all zero outcomes.
1 group (1 observation) dropped because only 1 observation per group.
[2] 149 observations and 59 groups.
[3] Tests for over-dispersion not provided in Stata output. I include negative binomial results because Poisson drops the "location" variable.
[4] Test rejects over-dispersion. Poisson MLE used.
[5] Test rejects over-dispersion, but at 11% significance. Poisson MLE used

JC-42.3 Motions that Pass	Fixed Effects[1]				Random Effects[2]			
	Time Dummies[3]		No Time Dummies[4]		Time Dummies[5]		No Time Dummies[5]	
	Coefficient	Std Error	Coefficient	Std Error	Coefficient	Std Error	Coefficient	Std Error
Constant	--	--	-0.1690	2.8796	-5.3465 ***	1.1884	-3.9179 ***	1.0304
Items	0.0353	0.0506	0.1311	0.0770	0.1606 ***	0.0476	0.0939 ***	0.0313
Sales	8.66E-10 ***	3.28E-10	-4.04E-11	6.44E-11	1.83E-11	1.75E-11	5.09E-11 *	3.00E-11
US Patents	-0.0021	0.0068	-0.0022	0.0031	-0.0004	0.0013	-0.0001	0.0012
Non-US Patents	-0.0592 **	0.0243	0.0073	0.0073	-0.0019	0.0023	-0.0036	0.0027
Location	dropped[7]	dropped[7]	-0.7376	2.1751	0.0686	0.6614	0.2435	0.7395
JC-42.3 Meetings, 1990-93	-1.2048 *	0.6390	0.1572	0.4494	0.5131 **	0.2376	0.5760 ***	0.2065
Non-JC-42.3 Meetings, 1990-93	-0.1586	0.2050	-0.1142	0.2208	0.1137	0.0789	-0.0301	0.0970
Non-JC-42.3 Motions, 1990-93	-1.0703 **	0.4752	0.4480	0.3741	-0.2162	0.2061	0.0176	0.2307

Notes: Time dummies are for 1990, 1991, and 1992.

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

[1] 36 observations and 13 groups.
45 groups (112 observations) dropped due to all zero outcomes.
1 group (1 observation) dropped because only 1 observation per group.
[2] 149 observations and 59 groups.
[3] Tests for over-dispersion not provided in Stata output. I include Poisson MLE results because negative binomial does not converge.
[4] Tests for over-dispersion not provided in Stata output. I include negative binomial results because Poisson drops the "location" variable.
[5] Test reveals over-dispersion, so negative binomial MLE is used.
[6] Test reveals over-dispersion, but negative binomial does not converge,. so Poisson MLE is used.
[7] Dropped because it is constant within group.

Table 5c presents the results of excluding sales while still accounting for firm location. This table thus allows us to consider more observations as well as the effects of variation across a longer period of time. The effects are most obvious in random effects models which contain the maximum amount of variation in the dataset. Overall, US patents have a positive impact on Council approvals, while non-US patents have a negative impact, though significance depends on accounting for time variation. Number of non-JC-42.3 meetings, as well as number of JC-42.3 and non-JC-42.3 motions, has a positive and significant impact on Council approvals regardless of time-specific variation, suggesting that number of “good” ideas contributes to the ability to obtain Council approvals, and also that degree of non-DRAM-related internal networking seems to make a greater contribution to Council approvals than DRAM-related networking. This last result may reflect the greater number of meetings that take place across three subcommittees rather than one subcommittee, even in the presence of a possible differential marginal impact of attending different subcommittee meetings.

The effect of dropping sales and accounting for firm location has the most dramatic impact on the effects of variables on successful JC-42.3 motions. All results are significant when accounting for time-specific variation, but non-JC-42.3 activities lose significance when not accounting for time-specific variation. Results are in line with expectations except for the negative coefficient on non-US patents, though this may be due to the irrelevance of non-US patents granted to non-US firms for DRAM related standards.

Table 5c: Panel Analysis of Council Approvals and Successful JC-42.3 Motions
Using Maximum Likelihood Estimation
Sales Variable Removed
1990 to 1993

Council Approvals	**Fixed Effects[1]**				**Random Effects[2]**			
	Time Dummies[3]		**No Time Dummies[3]**		**Time Dummies[4]**		**No Time Dummies[5]**	
	Coefficient	**Std Error**	**Coefficient**	**Std Error**	**Coefficient**	**Std Error**	**Coefficient**	**Std Error**
Constant	-0.0793	2.1208	0.2756	1.7401	-3.6099 ***	0.6128	-3.4096 ***	0.6328
Items	-0.0237	0.0389	-0.0282	0.0373	-0.0187	0.0324	-0.0406	0.0320
US Patents	-0.0017	0.0020	-0.0022	0.0020	0.0014 **	0.0007	0.0012	0.0009
Non-US Patents	0.0074	0.0069	0.0082	0.0068	-0.0028 **	0.0013	-0.0016	0.0016
Location	-0.1789	1.7098	-0.4170	1.5306	0.3344	0.3573	0.4254	0.5138
JC-42.3 Meetings, 1990-93	-0.0617	0.2466	-0.0016	0.2168	0.0348	0.1109	0.1258	0.1231
Non-JC-42.3 Meetings, 1990-93	0.0933	0.0942	0.0397	0.0785	0.2257 ***	0.0451	0.1365 ***	0.0500
JC-42.3 Motions, 1990-93	0.1002	0.0704	0.0982	0.0700	0.1831 ***	0.0566	0.1616 ***	0.0597
Non-JC-42.3 Motions, 1990-93	0.3383 **	0.1711	0.3134 *	0.1651	0.5168 ***	0.0924	0.4593 ***	0.1291

Notes: Time dummies are for 1990, 1991, and 1992.
Poisson MLE used except when over-dispersion is found, in which case I use negative binomial MLE.
The "location" variable is a dummy equal to 1 if the company is headquartered in the US and equal to 0 otherwise.

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

[1] 72 observations and 18 groups.
47 groups (188 observations) dropped due to all zero outcomes.
[2] 260 observations and 65 groups.
[3] Tests for over-dispersion not provided in Stata output. I include negative binomial results because Poisson drops the "location" variable.
[4] Test rejects over-dispersion. Poisson MLE used.
[5] Test rejects over-dispersion, but at 9% significance. Poisson MLE used

JC-42.3 Motions that Pass	**Fixed Effects[1]**				**Random Effects[2]**			
	Time Dummies[3]		**No Time Dummies[4]**		**Time Dummies[5]**		**No Time Dummies[6]**	
	Coefficient	**Std Error**	**Coefficient**	**Std Error**	**Coefficient**	**Std Error**	**Coefficient**	**Std Error**
Constant	-1.8232	2.8573	0.4539	3.1713	-5.5930 ***	0.7866	-3.9976 ***	0.6227
Items	0.0502	0.0427	0.0750 **	0.0350	0.0695 ***	0.0225	0.1115 ***	0.0234
US Patents	-0.0025	0.0032	-0.0036	0.0040	0.0024 ***	0.0007	0.0014 **	0.0007
Non-US Patents	0.0002	0.0036	0.0011	0.0034	-0.0029 **	0.0014	-0.0019 *	0.0012
Location	-1.2232	2.3078	-1.8972	2.9573	0.6788 *	0.4008	0.2816	0.3662
JC-42.3 Meetings, 1990-93	0.4242	0.3979	0.4828	0.3374	0.6404 ***	0.1660	0.4839 ***	0.1416
Non-JC-42.3 Meetings, 1990-93	0.1492	0.1158	0.0496	0.1112	0.1073 **	0.0520	0.0425	0.0484
Non-JC-42.3 Motions, 1990-93	-0.2435	0.2344	-0.3064	0.2324	-0.3238 **	0.1387	-0.2413	0.1554

Notes: Time dummies are for 1990, 1991, and 1992.
Poisson MLE used except when over-dispersion is found, in which case I use negative binomial MLE.
The "location" variable is a dummy equal to 1 if the company is headquartered in the US and equal to 0 otherwise.

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

[1] 80 observations and 20 groups.
45 groups (180 observations) dropped due to all zero outcomes.
[2] 260 observations and 65 groups.
[3] Tests for over-dispersion not provided in Stata output. I include negative binomial results because Poisson drops the "location" variable.
[4] Tests for over-dispersion not provided in Stata output. I include negative binomial results because Poisson drops the "location" variable.
[5] Test reveals over-dispersion at 7% significance, but negative binomial MLE does not converge, so Poisson is used.
[6] Test reveals over-dispersion. Negative binomial MLE is used.

Finally, table 5d illustrates the results of implementing firm-level means. Overall, firm-level changes in variables other than non-JC-42.3 motions do not have an impact on Council approvals, but the positive and significant impact of number of non-JC-42.3 motions suggests that standard setting activity as reflected in non-JC-42.3 motions contributed to firm influence on number of Council approvals. Again, this result is a bit surprising given the focus on DRAM-related standards at the time. However, firm-level means reveal that firms making more JC-42.3 motions were more likely to obtain Council approvals; similarly, for firms making more non-JC-42.3 motions (though with only 10% significance). Results thereby suggest that volume of activity contributed to firm influence, though at the firm level it would seem that non-JC-42.3-related activity was more significant.

Table 5d shows, however, that number of non-JC-42.3 motions and number of non-US patents granted have a negative and significant influence on number of successful JC-42.3 motions at the firm level, in both fixed and random effects models. Coefficients on the firm-level means for sponsored items, number of non-US patents granted, number of JC-42.3 meetings, and number of non-JC-42.3 motions have a positive and significant impact on number of successful JC-42.3 motions. This last result suggests that firms sponsoring more items, possessing more non-US patents, attending more JC-42.3 meetings, and making more non-JC-42.3 motions are more likely to be successful with JC-42.3 motions.

In summary, cross-sectional and panel results suggest that internal networking has the positive impact expected, but a somewhat surprising result is that networking and standard setting activity in the non-JC-42.3 network tended to have a greater influence on Council approvals than networking and activity in the JC-42.3 network. It is surprising to find a greater effect of non-JC-42.3 meetings, and motions, on Council approvals given the central concern of DRAM standards at the time and the amount of DRAM-related activity in JC-42.3 relative to motion-related activity in non-JC-42.3 committees. This is especially true considering the possibility of differential marginal impact of attendance in different subcommittee meetings (non-JC-42.3 meetings have a positive but insignificant effect on successful JC-42.3 motions). However, non-JC-42.3 meetings have a positive and significant influence on Council approvals, whereas JC-42.3 meetings do not. Another surprising result is that coefficients on IP variables tend to be negative, suggesting that large intellectual property holdings can hurt firms in the standard setting process.

The upshot is that cross-sectional and panel data uncover evidence to suggest, though with appropriate caveats, that internal networking, in terms of attendance at subcommittee meetings, proved beneficial to firms interested in driving standards development for memory technology in general and DRAM technology in particular on the JC-42 committee during the early 1990s. An additional result is that standard setting activity in terms of number of motions proposed can also have an impact, suggesting that standard setting success can have reputation benefits. Finally, large intellectual property holdings may not contribute to standard setting influence.

Table 5d: Panel Analysis of Council Approvals and Successful JC-42.3 Motions
Using Maximum Likelihood Estimation
Firm-Level Means Implemented
1990 to 1993

Council Approvals	Fixed Effects[1]				Random Effects[2]			
	Time Dummies[3]		No Time Dummies[3]		Time Dummies		No Time Dummies	
	Coefficient	Std Error	Coefficient	Std Error	Coefficient	Std Error	Coefficient	Std Error
Constant	--	--	--	--	-3.2383 ***	0.8705	-3.2440 ***	0.8435
Items	-0.0388	0.0375	-0.0536	0.0362	-0.0433	0.0360	-0.0538	0.0348
US Patents	-0.0024	0.0026	-0.0030	0.0025	-0.0016	0.0023	-0.0024	0.0022
Non-US Patents	-0.0016	0.0083	0.0019	0.0072	-0.0026	0.0084	0.0012	0.0072
Location	--	--	--	--	-0.4209	0.5957	-0.4881	0.6369
JC-42.3 Meetings, 1990-93	-0.1054	0.2390	-0.0558	0.1979	-0.2017	0.2398	-0.1139	0.2036
Non-JC-42.3 Meetings, 1990-93	0.1034	0.0901	0.0584	0.0740	0.1369	0.0948	0.0564	0.0741
JC-42.3 Motions, 1990-93	0.0804	0.0652	0.0735	0.0653	0.0879	0.0612	0.0813	0.0610
Non-JC-42.3 Motions, 1990-93	0.3072	0.1503	0.2795 **	0.1365	0.3297 **	0.1504	0.2789 **	0.1365
Mean items	--	--	--	--	-0.1388	0.1673	-0.1394	0.1708
Mean US patents	--	--	--	--	-0.0003	0.0027	0.0003	0.0028
Mean non-US patents	--	--	--	--	0.0020	0.3079	-0.0018	0.0075
Mean JC-42.3 meetings	--	--	--	--	0.1838	0.3079	0.1178	0.2818
Mean Non-JC-42.3 meetings	--	--	--	--	0.1039	0.1175	0.1673	0.1132
Mean JC-42.3 motions	--	--	--	--	1.1958 **	0.5756	1.2929 **	0.5891
Mean Non-JC-42.3 motions	--	--	--	--	0.9013 *	0.4817	1.0399 **	0.4835

Notes: Time dummies are for 1990, 1991, and 1992.
Poisson MLE used except when over-dispersion is found, in which case I use negative binomial MLE.
The "location" variable is a dummy equal to 1 if the company is headquartered in the US and equal to 0 otherwise.

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

[1] 72 observations and 18 groups.
47 groups (188 observations) dropped due to all zero outcomes.
[2] 260 observations and 65 groups.
Test rejects over-dispersion. Poisson MLE is used.
[3] Poisson MLE used because negative binomial does not converge.
Constant, location, and mean variables dropped because they are constant within groups.

JC-42.3 Motions that Pass	Fixed Effects[1]				Random Effects[2]			
	Time Dummies[3]		No Time Dummies[3]		Time Dummies		No Time Dummies	
	Coefficient	Std Error	Coefficient	Std Error	Coefficient	Std Error	Coefficient	Std Error
Constant	--	--	--	--	-4.8084 ***	0.7259	-4.5680 ***	0.6378
Items	0.0365	0.0230	0.0442 **	0.0212	0.0378 *	0.0222	0.0453 **	0.0206
US Patents	0.0003	0.0021	-0.0002	0.0018	-0.0004	0.0019	-0.0007	0.0016
Non-US Patents	-0.0284 ***	0.0109	-0.0283 ***	0.0096	-0.0264 ***	0.0083	-0.0272 ***	0.0075
Location	--	--	--	--	0.4643	0.2907	0.4243	0.2874
JC-42.3 Meetings, 1990-93	0.1273	0.3525	0.3120	0.2066	0.0754	0.2553	0.2202	0.1827
Non-JC-42.3 Meetings, 1990-93	0.0417	0.0837	0.0398	0.0650	0.0373	0.0868	0.0330	0.0627
Non-JC-42.3 Motions, 1990-93	-0.5446 ***	0.1618	-0.5302 ***	0.1519	-0.5204 ***	0.1488	-0.5079 ***	0.1453
Mean items	--	--	--	--	0.1972 ***	0.0582	0.1936 ***	0.0572
Mean US patents	--	--	--	--	0.0010	0.0020	0.0013	0.0017
Mean Non-US patents	--	--	--	--	0.0238 ***	0.0082	0.0246 ***	0.0073
Mean JC-42.3 meetings	--	--	--	--	0.5578 *	0.2996	0.4206 *	0.2410
Mean Non-JC-42.3 meetings	--	--	--	--	0.0180	0.0986	0.0193	0.0780
Mean Non-JC-42.3 motions	--	--	--	--	0.3170 *	0.1686	0.3201 *	0.1663

Notes: Time dummies are for 1990, 1991, and 1992.

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

[1] 80 observations and 20 groups.
45 groups (180 observations) dropped due to all zero outcomes.
Stata does not provide test for over-dispersion, but Poisson MLE is used because negative binomial does not converge.
[2] 260 observations and 65 groups.
Test rejects over-dispersion.
[3] Poisson MLE used because negative binomial does not converge.
Constant, location, and mean variables dropped because they are constant within groups.

X. Conclusion

This paper finds evidence to tentatively suggest that participation within the JC-42.3 and non-JC-42.3 networks during the early 1990s contributed to firm influence in the JEDEC JC-42 standards development process. A somewhat surprising result is that networking in the non-JC-42.3 network, but not the JC-42.3 network, is significantly correlated with number of Council approvals obtained, in spite of the focus on DRAM standards and degree of JC-42.3 activity in these years.

Another interesting result is that the coefficients on IP variables are frequently negative and occasionally significant, suggesting that IP portfolio may have hurt the ability of firms to influence standards development. This result is partially addressed when distinguishing between US and non-US-based firms, as number of US patents granted has a positive and sometimes significant impact on Council approvals and successful JC-42.3 motions. These results could reflect a bias against firms with large IP holdings, but also could reflect the differential impact of US and non-US patent holdings. An interesting consideration is that JEDEC members were averse to incorporating intellectual property in standards.

This latter possibility is interesting to consider in light of the Rambus case. A central concern in the Rambus litigation was whether JEDEC would have adopted work-around alternatives to four technologies should Rambus have disclosed its intellectual property claims on these four technologies. If the incremental costs of these work-around alternatives exceed the cost of the royalty as a percent of price, it would have been rational for JEDEC to incorporate the proprietary technologies. Of course, the answer depends on the relative costs and benefits of the proprietary and work-around technologies, but to the extent that proprietary technologies are more advantageous and would nevertheless not have been included in the standard given disclosure, results presented in this paper support the argument, though tentatively, that there may have been a bias against firms with large intellectual property holdings.

A future avenue of research would seek to build and exploit a richer dataset covering the period 1985 to 1999. This dataset would incorporate membership in external consortia, industry associations, forums, and other organizations in order to consider the effects of networking outside JEDEC. For example, this research could examine the impact of membership in the SLDRAM consortium formed in 1995 on development of DDR SDRAM standards in the mid- to late-1990s. A richer dataset would also include additional information on DRAM standard setting activity for the years 1985 to 1999 from meeting minute logs from all subcommittee meetings 1990-99.

Future work would also attempt to learn more about the JEDEC standard setting process, in particular whether the motion for ballot represents a true network connection and, if so, review meeting minutes to identify number of unique connections as a proxy for degree centrality within the JC-42.3 and non-JC-42.3 networks. Future research may also employ a richer dataset to analyze the strategic impact of network centrality in particular subcommittees (JC-42.1, JC-42.4, and JC-42.5) on standard setting in the JC-42.3 subcommittee.

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