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THE STRUCTURE OF LICENSING CONTRACTS*

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Industrial organization theory has explored several issues related to licensing, but empirical analyses are extremely rare. We amass a new and detailed dataset on licensing contracts, and use it to present some simple 'facts' concerning licensing behavior. Our analysis reveals robust cross-industries differences in several contractual features, such as exclusivity, cross-licensing, ex-ante versus ex-post technology transfers, and licensing to related versus unrelated parties. We offer an interpretation of these facts based on cross-industry variation in the strength of intellectual property rights.

I. INTRODUCTION

LICENSING IS AN IMPORTANT phenomenon for several reasons. It is one of only a few significant methods of technology transfer between firms, and one of the most commonly observed inter-firm contractual agreements. Given the increasing importance of licensing as a tool for managing the intellectual property of firms in 'high technology' industries (Grindley and Teece [1997]), the importance of understanding the economics of licensing seems certain to increase. Further, a better understanding of the structure and motivation behind licensing contracts will surely go a long way toward informing policy issues regarding antitrust enforcement and intellectual property in industries where licensing is common (Ordover [1991]). Appropriately, then, licensing activity has been the subject of much theoretical inquiry. Empirical analyses, however, that inform the development of this theory are extremely rare. Our paper aims to bridge this gap

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by providing what is, to our knowledge, the first large-sample econometric analysis of licensing contracts.

Industrial organization theory has explored several issues related to licensing. Particularly well-developed themes include (i) the relationship between the choice of number of licensees and the existing and resultant industry structure (Arrow [1962], Kamien and Tauman [1984], Katz and Shapiro [1986]), (ii) the division of the value created by a licensing agreement between the licensor and licensees (Kamien and Tauman [1986], Gallini and Wright [1990]), (iii) the likelihood that ex ante or ex post licensing will occur (Gallini [1984], Gallini and Winter [1984], Shapiro [1985]), and the relationship between sequential innovations and licensing strategies (Green and Scotchmer [1994]).

In contrast to this voluminous theoretical literature, empirical analyses of licensing contracts are extremely rare.[1] Two studies, frequently used to motivate a large subset of the theory literature, are early small-sample surveys of licensors and licensees in the US, UK and Canada by Caves *et al.* [1983], and of licensing and patenting practices in the UK by Taylor and Silbertson [1973]. There are also a few clinical and historical studies of licensing practices in particular industries (see, e.g. Grindley and Nickerson [1996] in the chemicals industry and Grindley and Teece [1997] in the electronics industry). To the best of our knowledge, there are no large-sample studies, either cross-industry or industry-specific.

Given this lacuna, our primary objective is to present some simple 'facts' underlying licensing behavior. A major contribution of this exercise is the amassing of a detailed data set on licensing contracts. The sample of deals we study is drawn from publicly available data from Securities Data Corporation (SDC). In its current form, however, these data proved to be of inadequate quality for our empirical work for several reasons. First, our reading of several hundred summary descriptions of contracts allowed us to identify the most commonly discussed contractual features of interest. However, SDC provides information on only a subset of these features. Second, important parts of the data provided by SDC are inaccurate. We describe our detailed efforts to ensure the consistency of the SDC data with other publicly available data sources; in addition, we supplemented this with hand-collected data on publicly disclosed features of licensing contracts not captured by SDC. While this results in the largest such data source on licensing contracts of which we are aware, it is certainly not comprehensive. However, we draw succor from two facts. First, the distribution of licensing contracts across different industries is quite

[1] Our knowledge of licensing, in particular, is significantly further behind our empirical understanding of other issues in contracting (see, for example, Lafontaine and Slade [1997] for a survey of the econometric evidence on retail contracting).

similar to reports from the afore-mentioned surveys. Second, our focus on cross-industry differences in the structure of these contracts makes the likely lack of comprehensiveness of the data less of an issue.

The bulk of licensing contracts are signed in three 2-digit SIC industries, which we refer to in the paper as Chemicals (SIC 28), Computers (SIC 35), and Electronics (SIC 36). Our analysis identifies some strong cross-industry differences in contractual features. We find robust cross-industry differences in: the incidence of licensing activity (both in absolute terms and in relation to total alliance activity), the proportion of ex-ante contracts, the importance of exclusive contracts (with and without contractual restrictions that we can measure in the aggregate data), the proportion of contracts signed among parties with past relationships, and the incidence of cross-licensings.

We discuss explanations for these empirical regularities at the end of the paper. The existing theoretical literature is helpful in explaining some of these cross-industry differences in contract features. However, since many of these models are developed to analyze particular features, it is difficult to reconcile all the regularities within a common framework. In contrast, a theory based simply on cross-industry differences in the strength of intellectual property rights (IPR) appears promising in explaining all the observed regularities. In particular, extraneous assumptions over existing market structure, information asymmetries, or the importance of the technologies being transferred, need not be imposed. We discuss some of the implications of strong versus weak property rights for contract structure. Finally, this discussion suggests that in the development of future theory, it may be useful to consider weak property rights to be a primitive of the contracting environment, rather than as a policy choice variable.

The rest of the paper is organized as follows. Section II describes the construction of the data set. The cross-industry differences in contract features are described in Section III. Section IV discusses possible interpretations of these results. Section V concludes.

II. CONSTRUCTION OF THE DATASET

The data are drawn from the Strategic Alliance database of Securities Data Company (SDC). The sample universe for most of our analysis is all licensing contracts involving at least one US participant,[2] signed during the period 1990–93.[3] Other types of alliances that are covered in the SDC database primarily include joint ventures, R&D agreements, and

[2] While these include primarily private firms, there are a handful of university licensors.

[3] We also use SDC information on other types of contracts, particularly joint ventures, when we examine cross-contract incidence within industries.

marketing agreements, with a small fraction of equipment manufacture and supply agreements. SDC obtains information from publicly available sources, including SEC filings, trade publications and international counterparts, and news and wire sources. Although the database goes back to 1986, SDC initiated systematic data collection procedures for tracking such deals only in 1989; hence, the deal sample prior to 1990 is far from comprehensive. There are 1612 licensing deals tracked over our sample period, with not much aggregate annual variation (as seen in Table I).

The data clearly do not track all such deals consummated by US firms over this period, due to inadequate corporate reporting requirements. However, since this database is probably the most comprehensive source of information on such deals, it is ideal for empirical analysis. The possible lack of comprehensiveness of the data is less likely to be of concern in our analysis, since we focus on cross-industry differences in the incidence of contract features. Further, the distribution of deals is similar to that in earlier small-sample studies. For example, Taylor and Silbertson [1979] focus their efforts on the same industries that have a dominant presence in our database. Caves *et al.* [1983] note that their sample ranges in 'an apparently representative fashion across the chemical, electrical and equipment manufacturing industries.' Also, a study by McShan *et al.* [1989], based on sixty reports regarding licensing contracts filed with the SEC, indicates that two-thirds of the agreements were in areas like pharmaceutical preparations, toilet preparations, electronic computing equipment, semiconductors, surgical and medical equipment, and ophthalmic goods.

SDC provides information on various contract-specific characteristics, including contract type (i.e., whether the contract is a joint venture agreement, licensing agreement, marketing agreement, etc.), identities of participating firms, the date of the agreement, and the SDC code of the *alliance*, which may be different from the SIC codes of the participating firms. Using the Nexis-Lexis database, we supplemented the SDC dataset with information on various deal-specific characteristics described below, and simultaneously checked the accuracy of the SDC data where possible. We were able to find information on 1365 deals, or about 80% of the sample (see Table II(i)); only these deals, which we were able to check using this additional data source, are retained in the final sample used for the analysis.

SDC data on contract type is quite accurate. In a few cases, the transfer or exchange of technology in the licensing deal was also accompanied by the setting up of a joint venture for purposes of research or marketing. Since the inclusion of such deals in the analysis does not create any obvious biases, they are retained in the final sample.

SDC information on whether the participating firm is a licensor, licensee, or cross-licensor is missing for 763 deals and is supplemented with Nexis-source information where available. For the other 602 deals, the

TABLE I
ALLIANCE BREAKDOWN BY INDUSTRY AND TIME

Industry	Year	Licensings	Joint Ven	Other	Total
SIC 28	1990	166	89	172	427
		38.88%	20.84%	40.28%	100.00%
	1991	186	110	241	537
		34.64%	20.48%	44.88%	100.00%
	1992	168	71	173	412
		40.78%	17.23%	41.99%	100.00%
	1993	210	94	217	521
		40.31%	18.04%	41.65%	100.00%
	Total	730	364	803	1897
		38.48%	19.19%	42.33%	100.00%
SIC 35	1990	45	47	146	238
		18.91%	19.75%	61.34%	100.00%
	1991	61	70	242	373
		16.35%	18.77%	64.88%	100.00%
	1992	42	37	152	231
		18.18%	16.02%	65.80%	100.00%
	1993	42	33	130	205
		20.49%	16.10%	63.41%	100.00%
	Total	190	187	670	1047
		18.15%	17.86%	63.99%	100.00%
SIC 36	1990	78	66	177	321
		24.30%	20.56%	55.14%	100.00%
	1991	85	70	246	401
		21.20%	17.46%	61.35%	100.00%
	1992	96	48	190	334
		28.74%	14.37%	56.89%	100.00%
	1993	98	69	252	419
		23.39%	16.47%	60.14%	100.00%
	Total	357	253	865	1475
		24.20%	17.15%	58.64%	100.00%
Other	1990	71	178	141	390
		18.21%	45.64%	36.15%	100.00%
	1991	101	205	204	510
		19.80%	40.20%	40.00%	100.00%
	1992	86	140	132	358
		24.02%	39.11%	36.87%	100.00%
	1993	77	167	154	398
		19.35%	41.96%	38.69%	100.00%
	Total	335	690	631	1656
		20.23%	41.67%	38.10%	100.00%
Total		1612	1494	2969	6075
		26.53%	24.59%	48.87%	100.00%

Note: First row in each cell refers to number of deals; second row to row percentages. 'Other' contracts include R&D agreements, equipment manufacture agreements, and marketing agreements. 'Other' industry includes all other manufacturing industries, SIC 20-39.

TABLE II(i)
SAMPLE ATTRITION ACROSS INDUSTRIES

Sample	SIC 28	SIC 35	SIC 36	Other	Total
All Alliances	2618	1382	2015	3211	9226
	28.30%	14.98%	21.84%	34.80%	100.00%
Licensing Deals*	730	190	357	335	1612
	45.29%	11.79%	22.15%	20.78%	100.00%
Deals Found	628	158	314	265	1365
	46.01%	11.58%	23.00%	19.41%	100.00%
Compustat Data**	344	101	204	160	809
	42.52%	12.48%	25.22%	19.78%	100.00%

Notes: First row in each cell refers to number of licensing deals; second row to row percentages.
* Non-licensing contracts include joint ventures, marketing agreements, equipment manufacture agreements, and R&D agreements.
** Information on firm size (for at least one of the participating firms in a deal) is available in 809 of the 1365 deals for which we have contract-specific information.

SDC classification of licensor and licensee is always found to be accurate. However, cross-licensings appear to be significantly overstated (we are unable to fathom the method behind SDC's coding, nor did conversations with SDC's data collection arm prove insightful). Our operative criterion for identifying a cross-licensing agreement is that each party was the current or intended provider of some technology to the other, as well as the current or intended recipient of some technology from the other, regardless of whether or not the technology was deemed 'equal' enough for no compensating royalties to accompany the agreement.[4]

We choose the contractual features to focus on in the following manner. To the extent that publicly available data exist, we first look for contract features that have been discussed extensively in the theoretical literature. While we are able to code some of these, there are several others that are probably better addressed in an industry-specific study of licensing activity. For example, we are able to obtain information on the exclusivity of transfers, on the extent to which there is cross-licensing, and on whether a contract is signed prior to the development of the technology (ex-ante licensings) or not, but we are unable to gather enough information on the form of payment (royalties versus fixed fees). One dimension of interest

[4] Telsio [1979] refers to an agreement as a cross-license only where there is a mutual technology exchange considered equal enough to not require compensating payments, and classifies other mutual technology licensing arrangements separately; we make no such distinction. There are two additional points worth noting: (i) There were no cross-licensings involving more than two firms. (ii) A handful of cross-licensings involved a combination of current and prospective technology transfers. The dual ex-ante/ex-post nature of such agreements is picked up in our coding of other contract-specific attributes (see below).

which is suggested by the public record, but which has not received any attention in the literature, concerns the identity of the licensee: in particular, whether any past relationships exist between licensor and licensee.

Information on contract exclusivity is significantly understated in the SDC coding. SDC identifies about 10% of the deals in the sample to involve exclusive transfers, whereas we identify more than 30% involving such allocations. We classify a deal as endowing exclusive rights to the licensee if it is so mentioned in the public announcement following the contract signing.[5] Such deal-specific information is not disclosed in many cases, however; hence, we probably underestimate the incidence of exclusive transfers. There is no reason, though, to expect that there is any systematic variation across industries in the extent to which such information is disclosed or not.

Defining exclusivity is not unambiguous. For example, while a licensee could get exclusive rights to a technology for use in a particular market, the scope of the relevant market-for-use may be restricted by additional temporal, product, or geographic restrictions included in the contract. In practise, such restrictions are common. Thus, a worldwide exclusive license for broad use over an unlimited time period is quite different from an exclusive right to use the technology for five years in Japan for a well-defined use. In order to distinguish such cases, we additionally coded any mention of such restrictions or clauses in the contract announcement;[6] by combining this with the information on exclusivity, we are able to construct a finer measure of exclusivity. There may be additional cases, however, where contract restrictions may not be announced, and exclusivity is (and vice versa); we distinguish such cases where we are unsure about the scope of exclusivity from the others, in the estimation.[7]

In order to track the incidence of relationships between firms, we use the following decision rule: the firms in a contract are coded as having a past relationship if: (1) the announcement mentions that the parties had ‘a

[5] For the most part, these publicly available descriptions do not suggest whether an exclusive contract restricts the *licensor* from using the technology or not. Oster [1994], p. 307, for example, defines exclusivity to include this feature as well.

[6] All restrictions that we coded had to do with limitations on product or geographic markets, or were related to time restrictions (always less than 10 years). Prior field studies (Taylor and Silbertson [1973], Caves *et al.* [1983]) have documented the existence of several other classes of interesting restrictions (including requirements for technology flowback from licensee to licensor, restrictions on passing on the technology to other parties, minimal acceptability of quality standards and recourse arrangements in the event the licensee fails to meet such standards, etc.) However, such restrictions do not appear to be reported publicly. An industry-specific study might be better placed to obtain such detailed information.

[7] A handful of deals involve both exclusive and non-exclusive transfers: thus, firm A might license one technology to firm B for exclusive use, and a different technology to firm B for non-exclusive use. We code these as exclusive deals on the grounds that they contain some exclusive components; excluding such deals, however, does not affect the results.

past relationship'; or (2) we could successfully identify any mention of a (separate) contractual arrangement involving the participating firms during a two-year window prior to the signing of the current contract; or (3) we could identify any other significant association between the participating firms during the same time window. These latter associations include the following three cases (cited in declining order of observed frequency): first, one of the parties was either founded by the other, or was a former subsidiary spun off by the other at some time in the past;[8] second, the licensee is a firm founded as a result of discoveries made under university auspices at some past time, and which are not related to the agreement in question between the university and licensee; and third, there is common board membership,[9] or the movement of a senior manager from one firm to the other in the past, and who is currently involved in licensing negotiations.

We distinguish between relationships of the kinds described above and those in which the current deal is merely a renewal or renegotiation of a past agreement (i.e., the underlying technology is the same). Further, we distinguish those deals in which the parties were involved in the past via patent litigation, and the current contract is signed as a settlement of such litigation.[10] In all other cases, we are uncertain if the current contract actually represents a new relationship between the firms, or if we are simply unable to track any prior relationship between the firms. As a result, we tend to underestimate the presence of prior relationships between firms. However, as before, there is no reason to expect that there is any systematic variation in tracking this across industries that would bias our results. Limiting our search for past relationships to the two-year period prior to the agreement is not restrictive since virtually all references to past relationships during this window occur in a nine-month period prior to the deal announcement.

The information on firm identities and alliance SIC codes is extremely accurate. The description of each of the agreements is always consistent with the two-digit SIC code within which the agreement is classified by SDC. While we have no systematic way of checking the three-digit SIC classification assigned by SDC to a particular agreement, we note that: (a) the classifications in the three-digit categories that account for the

[8] Taylor and Silbertson [1973] point out that licensing to subsidiaries is fairly common. However, firms may not often use formal agreements to provide know-how to subsidiaries, and technologies are often transferred 'wherever they are required' (page 138). The different, and altogether less formal, calculus that appears to be employed with regard to subsidiary licensing is consistent with there being no mention of such licensing deals in either SDC data or in Nexis-source descriptions of the identifiable agreements.

[9] Common board membership is identified only when it is cited in public announcements.

[10] Some deals may involve both past relationship in other areas, and litigation over the relevant technology; hence, these codes are not necessarily mutually exclusive.

majority of agreements (see Section III) appear to us to be accurate, and (b) our empirical analysis relies largely on distinctions between licensing agreements at the two-digit level.

Variation in contract incidence over time allows us to examine time variation in contract structure, resulting possibly from secular changes in the characteristics of technologies being transferred. SDC data on contract dates are not accurate for a significant fraction of the deals. In most cases, the extent of inaccuracy is within one to two months.[11] In some cases, the reported data appear to coincide with the date on which the agreement was finally signed; in other cases, they seem to coincide with the date on which agreement negotiations appear to have begun. In any event, the exact date is not crucial to our current effort,[12] although event study analyses using SDC data would contain fairly serious biases in the absence of such corrections.

We attempted to collect additional deal-level information on the nature of the technology. One important feature that we code is the distinction between already-developed technologies and those for which patent protection has been obtained or is pending and 'prospective' or 'ex-ante' transfers. It is much more difficult to identify the 'technology cohort', i.e., whether the technology is newly developed or has existed a while.[13] Distinguishing between process and product innovations is also interesting, but is extremely difficult to code in a sensible way. In particular, process innovations, generating cost-reductions due to changes in input requirements or improvements in technology or process, almost always generate some product enhancement (either in attributes, or quality and performance), thus making it difficult to separate the two.[14]

Most of the information was collected by three different researchers (the authors and a research assistant), with deals randomly assigned across the three researchers. We checked all the relevant variables in different parts of the sample for consistency in coding across researchers, primarily by examining summary statistics. Our discomfort with both the 'new/old technology' variable and the product-process classification stems from such an examination. We were also unable to identify with any degree of precision whether the technology represented a marginal versus a

[11] SDC also uses a flag to indicate the perceived accuracy of the alliance data. We have not checked whether this reasonably captures the extent of inaccuracies in the date field.

[12] The only place where the date matters is when we use Compustat size data for participating firms (in a specification check for one of the hypotheses). As long as the coded data is in the right quarter, there are no measurement errors introduced. Such errors are probably not significant even in other cases, since there is strong persistence in firm size across quarters.

[13] See, for example, Caves *et al.* [1983].

[14] See also Clark and Wheelwright [1993].

fundamental innovation.[15] Finally, although we coded a brief description of the nature of the technology, and any other comments related to the contract structure (such as equity participations, funding for further technology development, etc.), there is not sufficient data on these measures to include them in the estimations.

We do not use additional firm-level information in most of the analysis below. Where we do, such information is obtained from the Center for Research in Securities Prices (CRSP) and Compustat databases, and we discuss the ensuing sample attrition in the relevant section below.

III. EMPIRICAL ANALYSIS

In this section, we present the results on inter-industry variation in the incidence and structure of licensing contracts, proceeding sequentially through several contract features. Then, we examine whether, and which, subsets of features tend to be observed together in contracts.

III(i). *Aggregate Licensing Activity and Ex-ante Transfers*

The incidence of licensing activity across industries, aggregated at the two-digit SIC level, is given in Table I, and is evenly distributed over the four years 1990–93. Almost 80% of licensing deals occur in three industries: 46% in Chemicals (SIC 28), 12% in Industrial Machinery and Equipment (SIC 35), and 22% in Electronic and Electrical Equipment (SIC 36). Given that these form the core of 'high technology' industries, it is not surprising that a substantial fraction of all contracts involving the transfer of knowledge occurs within these industries. Most contracts appears to involve the transfer of a single technology.[16] About half of all deals involve cross-border transfers, with the US participant(s) being the licensor in more than two-thirds of such transfers. While the contract descriptions indicate that virtually all licensing contracts involve the transfer of technology, a few cases involve the transfer of know-how. Compared with intellectual property transfers, deals involving the transfer of other intangible assets, such as the rights to a firm's 'brand name', are rare.[17]

For each of these industries, more than two-thirds of licensing activity is concentrated within a single three-digit cluster. For example, 81.37% of all licensings in Chemicals occur in Drugs (SIC 2830). Drug production

[15] Several models distinguish different results for drastic versus non-drastic innovations, e.g., Katz and Shapiro [1986].

[16] A random search of 100 non-cross licensing deals indicated that only two of these involved an exchange of multiple technologies.

[17] Most such transfers occur within textiles.

based on recombinant DNA technology and immunotherapy, including rights to (the production and process know-how for) gene therapy, monoclonal antibodies, antisense technologies, and other techniques for protein synthesis, form the basis of many such transfers. Other transfers involve novel drug delivery systems, new therapeutic compounds, or diagnostic tests. The other dominant sub-segments, shown in Table II(ii), are Computers and Office Equipment (SIC 3570), Communications Equipment (SIC 366), Electronic Components and Accessories (SIC 367), and Surgical and Medical Instruments and Supplies (SIC 3840). Within SIC 35, most transfers (74.68%) involve innovations in computer hardware relating to the production of workstations, laptops, personal digital assistants, or other electronic products or software including word-processor code, scanning software, imaging software, graphics design software, tool kit software, font technology software, etc. The bulk of transfers (62.74%) within SIC 36 relate to the manufacturing of integrated circuits and memory technology (SIC 3670), with another 25% of transfers based on interconnect, networking, or other telecommunications technologies (SIC 3660). Finally, most transfers (60%) within SIC 38 are based on novel non-invasive medical or surgical instruments or products, as well as new diagnostic testing products. Hereafter, we focus on comparisons at the two-digit level, with the industries referred to as Chemicals (SIC 28), Computers (SIC 35), Electronics (SIC 36), and Others.

The relative importance of licensing activity, as a fraction of the total

Table II(ii)
Three-digit SIC Breakdown for Final Sample

Two-digit SIC	Three-digit SIC	Deals	Perc.	Agg. %
SIC 28	Drugs	511	81.37%	37.44%
(Chemicals)	Other	117	18.63%	8.57%
SIC 35 (Industrial and Commercial Machinery)	Computers and Office Equipment	118	74.68%	8.64%
	Other	40	25.32%	2.93%
SIC 36	Communications Eqp.	80	25.48%	5.86%
(Electronic and Electrical Eqp. and Components)	Electronic Components and Accessories	197	62.74%	14.43%
	Other	37	11.88%	2.71%
Other	Surgical and Medical Instruments and Supp.	86	32.45%	6.30%
	Other	179	67.55%	13.11%
Total		1365	—	100.00%

Notes: 'Perc.' denotes percentage of deals within two-digit industry that are in given three-digit SIC. 'Agg.%' refers to percentage of deals in entire sample that are in given three-digit SIC.

number of alliances within each industry, varies substantially across these industries (Table I; 'alliances' here are defined to include the various other types of inter-firm agreements mentioned earlier that are included in the SDC database). Licensing deals account for more than one-third of all alliances in Chemicals, but for only 18% and 24% in Computers and Electronics respectively.[18] Further, almost 24% of licensings within Chemicals are signed prior to the development of the technology (see Table III(i)); in many of these, the licensee provides R&D financing to the licensor in exchange for future rights exclusive or otherwise to the resulting technologies. In contrast, fewer than 6% of contracts in Computers and Electronics involve ex-ante technology transfers. Apart from incidence, there is also variation in the contractual details of the licensing agreements that are entered into in these industries. We turn to these in the remaining sub-sections.

III(ii). *Relationships*

Almost 30% of all licensing deals (Table III(i), Column 5) are signed between firms having prior relationships (we also refer to these as 'related firms' below). Another 2% of deals represent contract renewals or renegotiated agreements, and about 3% of deals are signed as part of litigation settlements. Computer and Electronics firms have a higher tendency to contract with related firms (39% and 35%) compared with firms in Chemicals (28%) or other industries (23%). Cross-border transfers are also more likely to involve firms with prior relationships (34%, compared with 26% for domestic transfers; see Table III(ii), Columns 1–2).

For multivariate analysis, we use a simple probit model to analyze the decision to license to a related firm. Covariates include industry and time dummies, a dummy variable indicating cross-border transfers, and another indicator variable for whether the license is over a developed technology or a prospective one (see Table IV). The results from this analysis reveal similar inter-industry differences (Table IV, Column 1). The incidence of relationships is significantly higher in Computers and Electronics relative to the other industries. Using the probit coefficients to recover the underlying probabilities, we find that the probability of licensing between related firms is about 46% in Computers and 42% in Electronics, compared with 34% in Chemicals.[19] While the effects for Computers and Electronics

[18] In Anand and Khanna [1995], we examine the incidence of joint ventures versus licensing contracts motivated from an underlying managerial choice model. Differences in contract choice across industries are not examined there, however.

[19] The estimated probability of observing licensing between related parties in industry j is given by: $\eta_{ijt} = \Phi(\overline{X_{ijt}}\beta + I_i\gamma_j)$, where I_i are industry dummies with coefficients γ_j and $\overline{X_{ijt}}$ denotes the mean values of the other covariates (with coefficient vector β).

Table III(i)
Summary Statistics

Contract feature		SIC 28 1	SIC 35 2	SIC 36 3	Other 4	Total 5
Prospective technologies		140 22.58%	9 5.73%	17 5.47%	17 6.46%	183 13.55%
Relationships (N = 1365)*	Prior relationship	168 28.14%	57 38.78%	102 35.42%	58 23.39%	385 30.08%
	Other	429 71.86%	90 61.22%	186 64.58%	190 76.61%	895 69.92%
Relationships (N = 809)	Prior relationship	92 28.05%	41 43.62%	67 37.02%	36 24.49%	236 31.47%
	Other	236 71.95%	53 56.38%	114 62.98%	111 75.51%	514 68.53%
Exclusive	Worldwide Exclusive	117 19.02%	4 2.53%	5 1.60%	23 8.71%	149 11.04%
	Other exclusive	196 31.87%	25 15.82%	46 14.70%	78 29.55%	345 25.56%
	Unknown	226 36.75%	84 53.16%	167 53.35%	137 51.89%	614 45.48%
	Non-exclusive	76 12.36%	45 28.48%	95 30.35%	26 9.85%	242 17.93%
Restrictions**		249 40.42%	46 29.11%	96 30.67%	110 41.83%	501 37.11%
Cross-Licensing		66 10.30%	21 13.12%	64 20.06%	24 8.99%	175 12.62%
Excl-Restrns	[E,NR]***	162 26.64%	11 6.96%	24 7.84%	45 17.31%	242 18.17%
	[E,R]	151 24.84%	18 11.39%	27 8.82%	56 21.54%	252 18.92%
	[NE,NR]	201 33.06%	101 63.92%	191 62.42%	105 40.38%	598 44.89%
	[NE,R]	94 15.46%	28 17.72%	64 20.92%	54 20.77%	240 18.02%

Notes: First row in each cell refers to number of deals within industry with given contract feature. Second row refers to percentage of deals within industry with given contract feature.

* Of the 1365 deals for which we have contract-specific information, 28 deals represent renewals of prior licensing deals, and an additional 42 deals are signed as a settlement of patent litigation; these are excluded from the cross-tabs here. For 15 deals, information is available only on the identities of the licensor/licensees.

** Restrictions include product, temporal, or geographic restrictions on licensee use of technology.

*** Refers to Exclusive transfers with No announced restrictions; similarly for other codes.

TABLE III(ii)
SUMMARY STATISTICS (CONT'D.)

Contract feature		Domes 1	Int'l 2	Total 3
Prospective technologies		93 13.54%	89 13.67%	182 13.60%
Relationships (N=1365)*	Prior relationship	176 26.43%	209 34.04%	385 30.08%
	Other	490 73.57%	405 65.96%	895 69.92%
Exclusive	Worldwide exclusive	105 15.20%	44 6.68%	149 11.04%
	Other exclusive	155 22.43%	190 28.83%	345 25.56%
	Unknown	330 47.76%	284 43.10%	614 45.48%
	Non-exclusive	101 14.62%	141 21.40%	242 17.93%
Restrictions**		209 30.16%	292 44.44%	501 37.11%
Cross-Licensing		84 11.72%	91 13.58%	175 12.62%

Notes: As for Table III(i). 'Domes' refers to deals in which all participating firms are US firms; all other deals are 'Int'l'.

are not significantly different from each other, the difference between these and other industries is significant at the 1% level. Finally, transfers to related firms in cross-border transfers is greater by 8% relative to domestic transfers.

The incidence of relationships may be correlated with firm age. For example, older firms are more likely to have had past relationships simply by virtue of their age.[20] If the age distribution of firms varies systematically across industries, this may explain the observed inter-industry differences. In order to correct for this potential bias, we include firm size as a proxy for the age of a firm. Since data on firm sizes are obtained from Compustat (which tracks public corporations only), information on firm size is obtained for only 1171 firms. Indeed, sample attrition in Chemicals is slightly greater than for the other industries (see Table II(i), rows 3–4),

[20] This follows even if the conditional probability of forming relationships does not vary with age.

TABLE IV
MAXIMUM LIKELIHOOD ESTIMATION OF INCIDENCE OF CONTRACT FEATURES

Variable	1. Rel (i)	2. Rel (ii)	3. Excl (i)	4. Excl (ii)	5. Cross-lic
SIC 28	0.1364 (0.1051)	0.1160 (0.1421)	0.1709** (0.0808)	0.2537** (0.0815)	−0.0072 (0.1326)
SIC 35	0.4337** (0.1379)	0.4700** (0.1773)	−0.5939** (0.1107)	−0.2890** (0.1097)	0.2093 (0.1629)
SIC 36	0.3399** (0.1168)	0.3232** (0.1510)	−0.6644** (0.0922)	−0.3338** (0.0919)	0.5167** (0.1362)
1990	0.1216 (0.1068)	0.3041 (0.1788)	−0.0566 (0.0852)	0.0503 (0.0855)	0.1998 (0.1318)
1991	0.1040 (0.1016)	0.3246 (0.1725)	0.1189 (0.0806)	0.2228** (0.0811)	0.1506 (0.1271)
1992	0.1440 (0.1048)	0.2862 (0.1755)	0.1319 (0.0832)	0.0184 (0.0832)	0.3696 (0.1252)
Ex-post	−0.1108 (0.1102)	−0.1658 (0.1468)	−0.4664** (0.0901)	−0.2842** (0.0904)	−0.4590** (0.1250)
Int'l	0.2188** (0.0747)	0.3287** (0.0988)	−0.2185** (0.0596)	−0.2390** (0.0597)	0.0902 (0.0895)
Avg Size		0.0845** (0.0231)			
Constant	−0.8159** (0.1525)	−1.0222** (0.2287)			−1.1436** (0.1828)
κ_1			−1.6100** (0.1273)	−1.2484** (0.1282)	
κ_2			0.2389* (0.1220)	0.0545 (0.1299)	
κ_3			0.7418** (0.1244)	0.6771** (0.1239)	
L	−765.69	−441.35	−1584.59	−1659.76	−492.11
N	1273	746	1343	1327	1349

Notes:
1. Rel = 1 if license has prior relationship with licensor.

$$2.\ \text{Excl (i)} = \begin{cases} 3 & \text{if worldwide exclusive transfer} \\ 2 & \text{if other exclusive transfers} \\ 1 & \text{if non-classifiable transfer} \\ 0 & \text{if non-exclusive transfer} \end{cases}$$

$$2.\ \text{Excl (ii)} = \begin{cases} 3 & \text{if exclusive contract with no restrictions} \\ 2 & \text{if exclusive contract with restrictions} \\ 1 & \text{if non-exclusive or non-classifiable contract with no restrictions} \\ 0 & \text{if non-exclusive or non-classifiable contract with restrictions} \end{cases}$$

4. * Refers to parameter significance at 10% level; ** refers to significance at 5% level.

5. Int'l is a binary variable identifying cross-border transactions. Avg Size refers to mean assets of participating firms in transaction, measured in '000's of dollars. κ_i indicates break points between categories in ordered logit estimations. *L* is log-likelihood; *N* is number of observations.

consistent with the hypothesis that industry effects may reflect unobserved size differences.[21]

However, for this smaller sample, both the aggregate incidence of relationships and cross-tabulations of the variation in relationships across industries are very similar to the earlier figures (Table III(i)), suggesting that the industry effects are robust. This is confirmed in the multivariate probit estimates where, even after controlling for firm size (averaged over firms in a given deal), we find that inter-industry differences are both significant and similar to the earlier estimates.[22]

Since we can identify relationships between firms only when explicit mention is made of these in the public disclosures (up to two years prior to the contract date), the dependent variable tracking the incidence of relationships will be misclassified in general. Consequently, the parameter estimates including the industry effects will be downward-biased. Since we do not expect the extent of misclassification to vary systematically across industries, however, the inter-industry differences will not be biased. In the appendix, we explicitly examine the sensitivity of our results to the degree of misclassification, and we find that our results are quite robust.

III(iii). *Exclusive Rights and Accompanying Restrictions*

37% of all contracts involve some form of exclusive rights being allocated to the licensee (see Table III(i)). In 11% of deals, licensees get worldwide exclusive rights to the use of the technology, while exclusivity within a restricted geographic domain is granted in another 26% of transfers. In 45% of contracts, we cannot ascertain the type of exclusive rights granted. About 18% of contracts assign non-exclusive use to the licensee.

The incidence of exclusivity varies considerably across industries. More than half of all transfers in Chemicals involve some exclusivity clause, with worldwide exclusivity being granted in almost 40% of these. Conversely, only 12% of contracts are explicitly non-exclusive. Exclusive transfers are much less common in Computers (18%) and Electronics (16%), but are frequent in the other industries (38%). Similarly, the fraction of transfers

[21] The median size of firms involved in licensing deals in Chemicals is lower than the 25th size percentile in Computers, which is comparable to that in Electronics. The differences at the 3-digit SIC level are even more striking: the median size in SIC 3570 (Computers) and 3670 (Semiconductors) exceeds the 75th percentile in Chemicals. Thus, while many firms in Chemicals are small and specialize in research, a large fraction of innovations in other industries occur within larger firms.

[22] If we include only those deals on which we have data on *all* participating firms, the coefficient estimates are similar (although standard errors are larger, given the smaller sample size).

that are non-exclusive is greater than 25% in Computers and Electronics, compared with about 10% in the other industries.[23]

Fewer exclusive transfers are observed in cross-border transfers than in domestic transfers (35% versus 38% respectively; Table III(ii), Columns 1–2); however, these differences are not significant. Similarly, the probability of exclusive transfers is slightly higher when the licensee is a US firm (40%) relative to when it is a non-US firm (35%) (these figures are not shown in the table).

For multivariate estimation, we construct an ordinal dependent variable, y^e_{ijt}, that tracks the incidence of exclusivity as follows: $y^e_{ijt} = 3$ for contracts involving worldwide exclusive transfers, $y^e_{ijt} = 2$ for contracts involving exclusive transfers which are non-classifiable further, $y^e_{ijt} = 1$ for contracts whose announcements contain no information on exclusivity, and $y^e_{ijt} = 0$ for non-exclusive transfers. Estimation then proceeds using a standard ordered probit specification:

$$p(y^e_{ijt} = n) = p(\kappa_{n-1} < X_{ijt}\beta + \varepsilon^e_{ijt} < \kappa_n)$$

where $n \in \{0, 1, 2, 3\}$, κ_j define the cutoff parameters for each category, with $\kappa_0 = -\infty$, and $\kappa_N = \infty$; and X_{ijt} refers to contract-level characteristics as before, including industry dummies. ε^e_{ijt} is assumed to be normally distributed.

Inter-industry differences are highly significant after controlling for other contract-level differences (Table IV, Column 3). The probability of observing worldwide exclusive contracts in Chemicals is approximately 17%, compared with 4% and 3% in Computers and Electronics respectively, which are also significantly lower than in other industries (11%). Similarly, non-exclusive contracts are much more likely to be observed in Computers and Electronics (31% and 33% respectively). All these differences between industries (except between SICs 35 and 36) are significant at the 1% level.

The probability of observing exclusive contracts in cross-border transfers is 41%, compared with 33% for domestic transfers, similar to the earlier univariate estimates. Exclusive rights are also much more likely to be allocated to the licensee for prospective technologies (59%, versus 34% for developed technologies).

Contracts may include various restrictions on the licensee's use of a technology. Thus, the degree of exclusivity actually granted to the licensee

[23] For the results to be materially affected by unclassifiable observations on exclusivity, there would have to be fairly dramatic inter-industry differences in the extent of unreported exclusive agreements. As an example, compare SIC 28 and SIC 35 in Table III. Suppose that the fraction of unreported exclusive agreements in SIC 28 is the same as the fraction of reported exclusive agreements. One can calculate that, for the true incidence of exclusive agreements in these two industries to be identical, one would need 116% of the unreported agreements in SIC 35 to be exclusive.

may depend on the scope of these restrictions. About 37% of contracts make explicit mention of such restrictions, concerning field of use, geographic domain, or the contract length. More restrictions are observed in transfers in Chemicals (41%) compared with Computers and Electronics (about 30%). We use this information on contract restrictions in the data to construct a more refined measure of exclusivity as follows: exclusive rights with no mention of accompanying restrictions are classified as 'most exclusive' ($y^{e'}_{ijt} = 3$) followed by contracts in which exclusive rights are granted with accompanying restrictions ($y^{e'}_{ijt} = 2$).[24] Non-exclusive contracts for which there is no mention of other restrictions are classified as less exclusive than either of these cases ($y^{e'}_{ijt} = 1$). Finally, non-exclusive contracts with restrictions imposed on the licensee are classified as the 'least exclusive' contracts ($y^{e'}_{ijt} = 0$).

The distribution of this ordered variable across industries, shown in Table III(i), confirms the earlier inter-industry differences. For example, about two-thirds of exclusive transfers within Computers contain accompanying contract restrictions, compared with less than half in Chemicals. Similar inter-industry differences are observed after controlling for other contract-level characteristics (Table IV, Column 4). The probability of the licensee being granted 'most exclusive' rights is about 25% in Chemicals, versus 10% in Computers and Electronics; these differences are significant at the 1% level. Conversely, the probability of observing 'most restrictive' transfers is more than 26% in Computers and Electronics, compared with 11% in Chemicals.[25] Similarly, exclusive rights are more likely to be allocated for prospective technologies and in domestic transfers.

III(iv). *Cross-Licensings*

About 13% of all transfers are cross-licensings, many of which occur as part of a patent litigation settlement. However, cross-licensings are much more commonly observed in Electronics (20%), where most of these deals concern semiconductor technologies. In other industries, the incidence of cross-licensings is much lower (about 10%). In addition, cross-licensings are more likely to be observed for the transfer of technologies that are not yet developed (21%, versus 12% for ex-post transfers). While the incidence of cross-licensings in domestic transfers is slightly lower than in cross-border transfers, the difference is not significant. Similar results obtain after controlling for other contract characteristics (Table IV, Column 5).

[24] We do not distinguish between exclusive worldwide transfers and other exclusive transfers here.

[25] We cannot directly test the appropriateness of the ordering of the dependent variable by comparing these estimates to those from an unordered (multinational) probit estimation, since the two models are non-nested.

III(v). *The Joint Incidence of Contract Features*

Thus far, we have considered the incidence of contract features individually. However, it may be that a given feature is likely to be observed only together with other particular ones in the licensing contract, e.g., it may be possible that a licensor is more inclined to offer an exclusive contract to a related party than an unrelated one. Ignoring this jointness in the incidence of various features may lead us to overstate the cross-industry differences described above, to the extent that the variety of differences in contract structure outlined there are simply parts of the same coin.

To uncover such 'decision dependence', we examine the joint incidence of the various contractual features—exclusivity, relatedness of partners, and cross-licensing here. Doing so also allows us to infer the extent to which these features are complements or substitutes in the licensing process. We assume the following simple behavioral structure for these contracting decisions d_i^e, d_i^r, and d_i^c, by licensor i at time t:

$$d_{it}^r = \begin{cases} 1 & \text{if } X_{it}\beta^r + \varepsilon_{it}^r > 0 \\ 0 & \text{otherwise} \end{cases}$$

$$d_{it}^e = \begin{cases} 1 & \text{if } X_{it}\beta^e + \varepsilon_{it}^e > 0 \\ 0 & \text{otherwise} \end{cases}$$

$$d_{it}^c = \begin{cases} 1 & \text{if } X_{it}\beta^c + \varepsilon_{it}^c > 0 \\ 0 & \text{otherwise} \end{cases}$$

where the joint distribution of the unobserved components, $f(\varepsilon_{it}^r, \varepsilon_{it}^e, \varepsilon_{it}^c)$, is assumed to be trivariate normal with correlation matrix Γ, where:

$$\Gamma = \begin{bmatrix} 1 & \rho_{re} & \rho_{rc} \\ \rho_{re} & 1 & \rho_{ec} \\ \rho_{rc} & \rho_{ec} & 1 \end{bmatrix}$$

ρ_{re} is the correlation coefficient between d_{it}^r and d_{it}^e. This correlation may reflect either jointness in the decision to allocate exclusive rights and license to a related party, or may reflect the presence of unobserved factors that affect both decisions. ρ_{rc} and ρ_{ec} are similarly defined for the other pairs of variables. The joint probability of observing these contract features is therefore given by:

$$\begin{aligned} p(d_{it}^r = 1, d_{it}^e = 1, d_{it}^c = 1) &= p(\varepsilon_{it}^r < X_{it}\beta^r, \varepsilon_{it}^e < X_{it}\beta^e, \varepsilon_{it}^c < X_{it}\beta^c) \\ &= \int_{-\infty}^{X_i\beta^r} \int_{-\infty}^{X_i\beta^e} \int_{-\infty}^{X_i\beta^c} f(\varepsilon_{it}^r, \varepsilon_{it}^e, \varepsilon_{it}^c; \Gamma) \end{aligned}$$

The likelihood function in turn is then given by:

TABLE V
JOINT ML ESTIMATION OF RELATIONSHIPS, EXCLUSIVE RIGHTS, AND CROSS-LICENSING

Variable	1. Relationships	2. Exclusivity	3. Cross-lic
SIC 28	0.2249* (0.1278)	0.2813** (0.1134)	−0.2917 (0.2247)
SIC 35	0.5112** (0.1647)	−0.6625** (0.1730)	0.0665 (0.2651)
SIC 36	0.4151** (0.1405)	−0.7816** (0.1456)	0.5093** (0.1983)
1990	0.2316* (0.1281)	−0.1745 (0.1281)	0.2559* (0.2170)
1991	0.1589 (0.1249)	0.2189** (0.1195)	0.1220 (0.2256)
1992	0.2543** (0.1228)	−0.0407 (0.1206)	0.5437** (0.1867)
Ex-post	−0.0237 (0.1380)	−0.4320** (0.1257)	−0.7397** (0.1854)
International	0.3741** (0.1038)	−0.1449 (0.1097)	−0.1429 (0.1833)
Constant	−1.0548** (0.1860)	0.1526 (0.1667)	−1.0556** (0.2722)
ρ_{re}		−0.0911 (0.0611)	
ρ_{rc}		−0.3963** (0.1340)	
ρ_{ec}		0.1207 (0.0951)	
$\mathscr{L}$		−1565.18	
N		1087	

Notes: The table refers to joint maximum likelihood estimation of the decision to contract with a related party, to grant exclusive rights, and to cross-license or not. The correlation in decisions is given by the matrix Γ.
* refers to parameter significance at 10% level; ** refers to significance at 5% level.

$$\mathscr{L} = \prod_i \left(\sum_j \sum_k \sum_l p(d_{it}^r = j, d_{it}^e = k, d_{it}^c = l) \right)$$

where $j, k, l \in \{0, 1\}$.[26] The results of this estimation are shown in Table V.

The estimates of ρ_{re} and ρ_{ec} are −0.09 and 0.10 respectively, with both being insignificant at the 10% level. Thus, we cannot reject the hypothesis

[26] The usual restrictions are imposed on Γ in order to ensure that it is positive definite; see Greene [1997]. The papers in the November 1994 symposium on multivariate probit models in the *Review of Economics and Statistics* also highlight the difficulty in formulating these restrictions explicitly for T-variate problems with more than three dependent variables.

that these decisions are made independently of each other. However, our estimate of ρ_{rc} is -0.396, and, significant at the 1% level, implying that cross-licensings tend to occur more frequently between unrelated parties. This result accords with intuition as well, since cross-licensing deals are often the result of litigation which is presumably less likely to be observed if the contracting parties have ongoing relationships. Thus, the decision to cross-license appears not to be independent of whether the two parties have existing relationships or not.

The cross-industry differences in contract features are similar to those obtained earlier, in many cases even more pronounced than before.[27] The average incidence of related-party licensings and non-exclusive contracts is still much higher in Electronics and Computers, and significantly lower in Chemicals, than in other industries. Similarly, cross-licensings are on average much more likely to be observed in Electronics. Thus, even after correcting for possible complementarities and substitutabilities between contract features at the deal level, the industry effects are robust, pointing to the fact that each of these inter-industry differences in contract features stem from industry-specific characteristics rather than common unobserved factors or 'decision-dependence' at the level of the deal.

IV. DISCUSSION

In this section, we attempt to explain the cross-industry differences in the incidence of contractual features. We first draw on the existing theoretical literature to interpret our findings. The literature is suggestive of possible explanations for some contractual features, though no direct attempts to test these theories exist. We also propose an alternative explanation, based on cross-industry variation in the strength of intellectual property rights (IPR), that is consistent with all the empirical regularities identified above. Finally, we contrast this explanation with others in the existing literature.

Some of the contractual features that we have analyzed—the choice of ex-ante versus ex-post licensings, the rationale for exclusive contracts, and the incidence of cross-licensing transfers—have received attention in various studies. Gallini and Winter [1985], for example, provide a rationale for ex-ante licensings: firms engaged in research activities might choose to prospectively license their future discovery to potential rivals who are considering similar research. The softening in R&D competition that otherwise results might outweigh the costs of creating a potential

[27] The correlation coefficients in Γ are identified by the variation in the contract-level joint incidence of the contract features. The industry effects are identified by aggregate-level differences in the incidence of the various contract features across industries. Thus, a higher aggregate incidence of relationships and non-exclusivity in Computers, for example, need not provide any information about the correlation of these variables at the level of each deal.

competitor. The focus of their study is not on explaining cross-industry differences in the incidence of ex ante licensing such as those we uncover. Hence, absent a study that focuses on the development of measures of R&D intensity, it is difficult to tell whether cross-industry variations in the need to mitigate the threat from potential rivals explain the variations in the proportions of ex ante licensing that we observe.

The rationale for exclusive contracts has been widely explored as well.[28] In one of the early studies, Katz and Shapiro [1986] argue that complementarities in consumption may lead firms to license technologies non-exclusively, with the aim of 'setting the standard' early on. This explanation may be promising as well in explaining the higher incidence of exclusive contracts in Chemicals, since fewer such network externalities exist there relative to the computer and electronics industries. As an example that highlights the importance of such externalities in the other industries, Ordover [1991: pp. 50] cites the case of the workstation manufacturer, Sun Microsystems, widely licensing its workstation technologies to aid in its being accepted as a standard.

Studies on cross-licensings have argued that these are more likely to be observed in industries where technological change is cumulative. The logic is that firms, recognizing that each of their research programs builds on the intellectual property of other firms, will cross-license to each other in an attempt to avoid mutual disruption of research activity. Grindley and Teece [1997], for example, opine that the 'strongest examples of cumulative systems technologies are in electronics, including semiconductors and computers' (Page 10). This might explain the lower incidence of cross-licensings in Chemicals relative to Computers and Electronics.[29]

Thus, there exist plausible explanations for the observed cross-industry variation in ex ante licensings, exclusive licensings, and cross-licensings, although the explanations for each of these contract features rely on very different strategic incentives. Much less has been said on the issues of the aggregate incidence of licensing activity and of related-party transfers. It is not difficult, however, to posit market-structure based explanations for each of these as well. For example, differences in the size distribution of firms across industries might explain differences in the propensity to license exclusively—ceteris paribus, an exclusive license might offer greater dissemination of a licensor's innovation in an industry dominated by a large downstream firm than in a more fragmented industry. However, a simple analysis of data on market structure across the various industries

[28] See, for example, Shapiro [1985].

[29] Cross-licensings have also been studied in Fershtman and Kamien [1992], where the focus is on understanding the effects of ex post cross-licensing on ex ante incentives to conduct research. Eswaran [1994] studies cross-licensing as a collusive mechanism in a repeated game setting.

suggests that inter-industry differences in exclusivity are not being driven by differences in industry concentration.[30] As another example, it could be that there are simply more existing relationships in general between firms in Computers and in Electronics than in Chemicals; then, the finding of a greater incidence of licensings to related parties in Computers and in Electronics would simply reflect the ambient extent of relationships in these industries. While these explanations are plausible, they rely in each case on particular assumptions concerning market structure which, ultimately, is endogenously determined as well.

One promising approach that may explain all the empirical regularities described above starts from the observation that the strength of intellectual property rights varies substantially across industries. In industries where property rights are weak, firms are likely to structure contracts and relationships to guard against opportunism (Williamson [1975]).[31] The observed pattern of contracts is then found to closely reflect the predictions that are obtained from this framework. In contrast to some of the previously mentioned models, this approach requires assumptions only on technological primitives; in particular, no assumptions need be made on the nature of demand, on market structure, or on the nature of technological advance. Moreover, a large body of evidence provides sufficient basis for the assumptions concerning the differences in the strength of property rights across industries.

A cumulative body of evidence shows that in many industries—particularly computers and electronics—patents often fail to ensure that the patent-holder appropriates the gains from her innovation, whereas in others such as Chemicals patent protection is much stronger. Some scholars have treated the strength of intellectual property rights to be a policy choice variable.[32] However, this literature does not provide any guidance about how this choice varies, or should vary, across industries.

[30] Concentration ratios appear to be, if anything, higher in industries which exhibit a higher incidence of non-exclusive licensings. The data we used to construct Herfindahl indices for each of the two- and three-digit industries which account for most licensing activity were firm-level sales data for all publicly traded firms within these industries in 1993 (obtained from Compustat). These indices are 0.07 in SIC 283, 0.18 in SIC 357, 0.27 in SIC 366, and 0.08 in SIC 367; C-10 ratios across these industries are more similar: 80% in SIC 283, 79% in SIC 357, 79% in SIC 366, and 65% in SIC 367. These data suggest that differences in industry concentration do not appear to be driving the variation in exclusivity.

[31] Anton and Yao [1994] develop a model to consider the effects of weak property rights on a licensor's ability to appropriate surplus from an innovation. For a survey of empirical analyses of how opportunism is constrained by vertical integration, franchises, informal contracts, marketing relationships, and other hybrid contracts, see Shelanski and Klein [1995]; licensing is conspicuous by its absence in this review essay.

[32] For example, see the literature on the positive and normative consequences of the choice of patent length and breadth, including Gilbert and Shapiro [1990], Klemperer [1990], Scotchmer and Green [1990], Gallini [1992], Green and Scotchmer [1995], and Chang [1995]. Lerner [1994] provides an empirical analysis on the effects of patent scope on firm value.

An alternative reason for weak IPRs is that it is difficult to clearly specify the content and boundaries of knowledge and other intangible assets.[33] This has two implications. First, it makes it difficult to prevent others from cheating by imitating the production of the asset ex-post. Second, property rights themselves will be hard to define since it is difficult to specify what the underlying asset is. In such cases, contracts designed to prevent cheating by others in the form of either patents or decentralized agreements between firms will be fundamentally incomplete. Thus, it is sensible to consider weak IPRs a consequence of bounded rationality rather than purely of intentional design.

Patenting activity offers tangible evidence of the ambiguity in description of technologies. Numerous judgement calls have to be made by the Patent Office regarding the specification and claims of each application. Merges and Nelson [1990, p. 841] point out that 'the legal principles and objective evidence often leave considerable room for discretion', both in Patent Office decisions involving the scope of patents and in the litigation that often accompanies a patentee's allegations that her patent has been infringed upon. There is substantial evidence to indicate that the extent of ambiguity, and the resulting problems associated with contracting over technologies, differs across technologies some technologies are more easily described than others. In particular, there are substantial differences across the three industries—Chemicals, Computers, and Electronics—which account for a disproportionate share of licensing activity.[34]

IV(i). *Evidence on Cross-Industry Differences in the Strength of Property Rights*

Several authors emphasize that a number of common elements distinguish the entire corpus of activity in chemicals from other industries.[35] In particular, the rise of polymer chemistry, advances in chemical engineering, and the advent of recombinant DNA technology have made it much easier to specify and communicate technological know-how in this industry than it used to be, or currently is in a number of other industries. Pharmaceutical patents, in particular, can be made very strong. Moreover, since a slight change in the underlying gene sequence of a protein can result in very different functions, it is very difficult, for example, to invent around a patent on a drug. It is also possible to patent particular molecules, building blocks for innovations (such as enzymes, proteins, hormones), and drug delivery

[33] See Feinstein and Stein [1988] and Trebilcock [1986] for a discussion.

[34] Merges and Nelson [1990] provide several examples that illustrate some of these issues.

[35] See, for example, Landau and Rosenberg [1992], and Arora and Gambardella [1996].

systems. Levin *et al.* [1987, p. 798] find that patents are significantly stronger in chemicals than in semiconductors. These results are also borne out by earlier work by Scherer *et al.* [1959], Taylor and Silbertson [1973], Wilson [1975], Mansfield [1986], and by more recent survey evidence provided by Cohen *et al.* [1996].

The electronics industry is markedly different from chemicals. Levin *et al.* [1982, p. 80] indicate that, while certain innovations can be patented in semiconductors, 'what appears impossible to patent is the actual physical layout of an integrated circuit of even moderate complexity. The principal reason for this is the difficulty of rendering a full verbal description of the circuit layout.' The ineffectiveness of patent protection has resulted in substantial imitation around other firms' innovations, as well as a well-established 'reverse engineering' industry (Levin *et al.* [1982, p. 81]). Firms, however, do not sue others for infringement of their patents because they know they are equally likely to be infringing on other firms' patents in the future, a situation that Von Hippel [1988] cites a manager describing as a 'Mexican standoff.'

In contrast to these industries, computer software has been protected until recently by copyright law. Copyright attaches only to an expression of an idea, not the idea itself, making it considerably easier to invent around these rights. Another important feature of copyright law, distinct from patent law, is that a firm's copyright is not held to be infringed if another firm independently creates the article in question. Moreover, since there is no process of application or 'definition of claims, the scope of copyright protection is ultimately defined by litigation' (Besen and Raskind [1991, p. 11]). There is much debate in the software industry about the novelty surrounding a piece of software (Landes and Posner [1989]); moreover, the industry appears to condone the borrowing of ideas (Samuelson and Glushko [1989,p.136–37]), and court rulings about the scope of protection have varied over time (Dam [1995]).[36] As such, the protection afforded by copyright law is not as strong as that afforded by patent law.

Thus, the ability to appropriate the gains from innovation differs systematically across industries, and appears closely linked to the ability to clearly articulate the know-how embodied in the underlying technologies. In chemicals, articulating such information is easy, hence contracts specifying the limits to its use can be more easily designed. In

[36] Uncertainty about how legal rulings on intellectual property cases will be resolved may also therefore be a cause of weak property rights. One of the important causes of such uncertainty, however, is the lack of precision in knowhow about a field, or in specifying the boundaries of legal claims over knowledge. In practise, it would appear difficult to disentangle uncertainty emanating from the legal regime from uncertainty emanating from the state of knowhow in a particular field.

Electronics and Computers, however, information is highly context-dependent and cannot be crystallized to 'abstract generalizations' (Arora and Gambardella [1994]); hence, contracting on this information is also more difficult.

IV(ii). *Implications for the Structure of Licensing Contracts and Relationships*

We now turn to exploring the implications of such cross-industry differences for the structure of licensing contracts. We consider each of the features in Section III in turn.

Incidence of licensing contracts. For weakly protected technologies, licensing is likely to be less desirable since there is always the possibility that the licensee will be able to invent around the technology ex post and renege on the terms of the agreement. As such, the benefits of licensing decrease relative to commercializing the technology in-house and relative to pursuing other means of inter-firm technology transfer (e.g. joint ventures), where the disclosure of information may be better controlled by the researcher Ordover [1991, p. 50]. For the same reason, joint ventures should be more likely to occur in industries with weak IPRs to the extent that it is easier to monitor and control the activities of partners in such arrangements than via arms-length licensing contracts. Hence, both the aggregate incidence of licensing activity, as well as the ratio of licenses to joint ventures (i.e., the relative incidence) is likely to be greater when property rights over technologies are strong, ceteris paribus.

One might expect the aggregate incidence of licensing activity to increase in the number of firms in the industry. Indeed, a simple count of the number of publicly traded firms in the various industries suggests that such a relation, albeit weak, does exist.[37] However, since the boundaries of firms (hence, the number of firms in the aggregate) are likely to be influenced by the strength of property rights as well (see Anand and Galetovic [1998] for a formal analysis), this relation is also consistent with the property rights-based explanation posited here.

Ex-ante versus ex-post licensing. Firms may also license prospective technologies in exchange for funding of its research program. The value of such 'ex-ante' contracts is lower when property rights over future technologies are weak, as the investing firm then effectively finances the development of technologies without obtaining any significant advantage

[37] There are 289 such firms in SIC 283, 231 in SIC 357, 166 in SIC 366, and 175 in SIC 367. The numbers across two-digit SIC industries are much more similar to each other (465 in SIC 28, 490 in SIC 35, and 499 in SIC 36).

over its rivals. We should therefore expect that licensing of prospective technologies is more common when IPRs are strong, ceteris paribus.

Contracts between related versus unrelated parties. Weak IPRs over the technology being contracted upon opens the parties up to the possibility of contractual hazards. However, firms are less likely to renege on the terms of an agreement if there is the possibility of future sanction. Such sanctions are much easier to impose if other relationships between the contracting parties exist. In contrast, in situations where IPRs are strong, such contractual hazards are less important, and the prediction is that the licensor is less likely to choose a related party as a licensee.

Exclusive versus non-exclusive contracts. When IPRs surrounding the technology being contracted upon are weak, exclusive contracts are unlikely to effectively restrict access to the technology to only licensed parties, since unlicensed parties will be able to invent around the technology ex post. In contrast, when IPRs are strong, exclusive contracts can meaningfully guarantee exclusivity to the licensee. Thus, in situations of weak IPRs, non-exclusive contracts may reduce the potential for cheating by co-opting the would-be patent infringers.[38] This suggests that the proportion of exclusive contracts should be higher in Chemicals than in Computers and in Electronics, consistent with our analysis of licensing agreements (both with and without associated contractual restrictions).[39]

Cross-licensings. When IPRs are weak, firms have strong incentives to imitate around rivals' patents. Cross-licensing agreements—where each participating firm is a transferor and recipient of a technology—are then efficient contracting arrangements, since they provide access to each other's technologies while precluding the need for each firm to incur costs of reverse engineering. This suggests that we should see a lower proportion

[38] A technology that is well-protected is akin to a 'drastic' innovation, since non-licensed firms may face a significant cost disadvantage relative to licensees. In this case, an exclusive contract mitigates downstream competition and increases the surplus accruing to licensees, and ultimately to the licensor. Thus, the result in the text can also be obtained by a simple reinterpretation of existing models. We are grateful to Mike Whinston for this observation.

[39] If each technology exchange in a non-exclusive contract is counted as a separate license, this would tend to bias the statistics on aggregate licensing activity. This bias tends to work in a direction that favors our IPR interpretation of cross-industry differences, however. In particular, since this bias would tend to overstate the aggregate amount of licensing activity in industries where non-exclusive contracts are common—such as Computers and Electronics—our results which report that the aggregate number of licenses is increasing with the strength of the IPR regime are even stronger.

of cross-licenses in Chemicals, where IPR are relatively strong, than in Computers and in Electronics, where IPR are weaker.[40]

While we do not have reliable data on the payment structure agreed to in these licensing contracts, it is important to note that these may offer an additional instrument to the licensor to circumvent some of the problems posed by weak property rights. For example, to make it less attractive for the licensee to invent around a patent, a licensor might lower the prices (through a combination of changes to the fixed fees and royalty payments), thereby increasing the possibility that a licensing contract will be acceptable to both parties, also thereby affecting the aggregate incidence of licenses in the industry in question. While our data cannot speak to this issue directly, one interpretation of our results is that pricing policies do not adequately substitute for other changes in the contract structure that licensors might impose (such as exclusivity clauses, partner identity, restrictions, cross-licensing, and timing of technology transfer).

To summarize, when IPR are weak, one should see more reliance on non-market transactions, i.e., fewer licensings. Conditional on licensing, one should also see finer restrictions on the contract in such cases, and a move away from arms-length contracting with unrelated parties. Although it is difficult to identify the IPR explanation from others in the absence of finer measures of the strength of property rights, the results detailed in Section III are consistent with each of the predictions outlined here, pointing towards the merit of such an explanation. However, it would be useful to explore each of the predictions outlined above more formally. The discussion here points towards the development of theory that focuses more explicitly on the role of property rights on the structure of technology transfers. In particular, the strength of property rights may be an important technological primitive in such models.

V. CONCLUSION

In this paper, our econometric analysis of a uniquely created dataset has allowed us to assemble some ‘facts’ regarding licensing contracts. We show that licensing activity is concentrated in three 2-digit SIC industries: Chemicals (SIC 28), Electronics (SIC 35) and Computers (SIC 36). Further, conditional on licensing, we discuss the incidence of several important features of such contracts.

[40] In a similar vein, Ordover [1991, p. 48] suggests that when the patent regime provides only narrow patent protection, so that the value of a patent is greatly diminished, there is a greater incentive to cross-license.

Licensing activity is most important in the Chemicals, Computers, and Electronics industries. Within these, the incidence of licensing activity—relative to joint ventures and other alliances—is highest in Chemicals. This industry is also characterized by a much higher fraction of exclusive transfers between firms. Many of these grant worldwide manufacturing and marketing rights to the licensee as well; even when this is not observed, relatively fewer restrictions in the contract are observed in chemical licensings compared with transfers in the other industries.

Licensing contracts in the Computer and Electronics industries are more likely to be signed with firms with whom the licensor has prior relationships, established either through alliance activity, common board membership, or personnel histories. Further, contracts in these industries are usually signed only after completion of the research and development phase. In contrast, a significant fraction of licensings in Chemicals represent transfers of rights over prospective technologies; many of these, in turn, represent financing arrangements with potential downstream users of the innovation. Finally, the Computer and Electronics industries also witness the largest fraction of cross-licensing agreements, of which an important fraction represent the outcome of litigation settlements between the parties.

The establishment of these robust differences across industries raises many interesting questions. What explains these inter-industry differences in licensing activity? To what extent do these reflect underlying differences in the organization of research and development activities? How different is the value created in these alliances across industries? What are the implications of these findings for antitrust policy towards licensings?

One explanation for these patterns that we have explored centers on the differences in appropriability across industries. In particular, weak property rights over technologies in the Computer and Electronics industries may lead firms to structure contracts so as to circumscribe potential imitation. Some of the implications for contract design were discussed in Section IV; it would be useful to develop these more formally, with a view to understanding further the role of property rights on the structure of alliances in high-technology industries. Finally, if property rights *are* significantly different across industries, it may be sensible to view the strength of these rights as a primitive of the contracting environment. Alternatively, it may be worth revisiting the now common assumption in many studies that the scope of intellectual property rights is a policy choice variable.

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APPENDIX

A. *Correcting for Misclassification in the Coding of Relationships*

We examine the sensitivity of estimated industry effects to misclassification of the incidence of relationships.[41] In particular, we assume that we are able to identify the existence of prior relationships between transacting firms with probability $(1-\theta)$ (given that such relationships exist), where $\theta \in [0, 1]$. The misclassification structure is, therefore, given by:

$$p(r_i^0 = 0 \mid r_i = 1) = \theta$$
$$p(r_i^0 = 0 \mid r_i = 0) = 1$$

where $r_i^0 = 1$ for deal i when the existence of prior relationships between the participating firms is mentioned in the contract announcement or in prior public disclosures; and $r_i = 1$ when the participating firms in deal i had prior relationships, which may or may not have been disclosed (i.e. r_i is the 'true' relationship variable). (Time subscripts are suppressed in the notation, and in what follows). The underlying model structure in turn is given by:

$$r_i = \begin{cases} 1 & \text{if } X_i\beta + \varepsilon_i > 0 \\ 0 & \text{otherwise} \end{cases}$$

where F_ε follows a cumulative normal distribution.

The likelihood function can now be written as:

$$\mathcal{L} = \prod_i \left(\sum_i p(r_i^0 = 0 \mid r_i) p(r_i \mid X) \right)^{\delta_0} \cdot \left(\sum_i p(r_i^0 = 1 \mid r_i) p(r_i \mid X) \right)^{1-\delta_0}$$

where $\delta_0 = 1(r_i^0 = 0)$. This expression in turn simplifies to:

$$\mathcal{L} = \prod_i (\theta \cdot F(X_i\beta) + 1 - F(X_i\beta))^{\delta_0} \cdot ((1-\theta) \cdot F(X_i\beta))^{1-\delta_0}$$

We do not estimate θ directly in what follows.[42] Instead, we estimate β for given values of θ, in order to examine the sensitivity of the industry effects to the extent of misclassification. The results, presented in the table below, indicate that the extent of bias in the industry effects increases with the degree of misclassification; however, we underestimate the inter-industry differences by assuming no misclassification.[43] For example, if $\theta = 0.5$, the estimated probability of observing licensings in SIC 35 between firms with prior relationships is 0.75, compared to 0.69 for deals in SIC 36 and 0.56 in SIC 28 respectively; this compares with probabilities of 0.46, 0.42, and 0.34 in the three industries respectively, if $\theta = 0$. The estimated inter-industry differences are lower with lower θ; if $\theta = 0.2$, for example, the respective probabilities are 0.49, 0.45, and 0.35 in the three industries, much closer to the estimates we obtain assuming no misclassification.

[41] See Hausman and Scott Morton [1994] for a general treatment.

[42] This is primarily due to the fact that it is not clear what identifies θ in the given data.

[43] The standard errors presented in the table are, of course, lower than what we would obtain if we estimated θ.

TABLE A
ESTIMATING INDUSTRY EFFECTS IN THE PRESENCE OF MISCLASSIFICATION OF 'RELATIONSHIPS'

θ	SIC 28	SIC 25	SIC 36	Constant
0.05	0.1363	0.4451**	0.3499**	–0.7836**
	(0.1073)	(0.1435)	(0.1203)	(0.1544)
0.10	0.1400	0.4599**	0.3609**	–0.7401**
	(0.1102)	(0.1488)	(0.1241)	(0.1591)
0.15	0.1453	0.4758**	0.3736**	–0.6954**
	(0.1136)	(0.1551)	(0.1285)	(0.1646)
0.20	0.1514*	0.4946**	0.3884**	–0.6463**
	(0.1175)	(0.1625)	(0.3884)	(0.1710)
0.25	0.1582*	0.5165**	0.4057**	–0.5923**
	(0.1221)	(0.1715)	(0.1400)	(0.1785)
0.30	0.1664*	0.5431**	0.4264**	–0.5316***
	(0.1275)	(0.5431)	(0.1476)	(0.1876)
0.35	0.1763*	0.5756**	0.4514**	–0.4633**
	(0.1341)	(0.1977)	(0.1571)	(0.1990)
0.40	0.1885*	0.6168**	0.4825**	–0.3850**
	(0.1424)	(0.2177)	(0.1696)	(0.2135)
0.45	0.1992*	0.6602**	0.5195**	–0.2863*
	(0.1534)	(0.2460)	(0.1869)	(0.2332)
0.50	0.2207*	0.7342**	0.5782**	–0.1749
	(0.1680)	(0.2915)	(0.2125)	(0.2607)

* Refers to significance at the 10% level. Parameter estimates of other covariates included in the estimation are not shown here.

REFERENCES

Anand, B. and Galetovic, A., 1998, 'Weak Property Rights and Hold-up in R&D', Harvard Business School Working Paper 99-007.

Anand, B. and Khanna, T., 1995, 'On the Market Valuation of Inter-Firm Agreements: The Computer and Telecommunications Industries, 1990–1993', Paper presented at NBER Summer Conference (Industrial Organization), Cambridge, MA.

Anton, J. and Yao, D., 1994, 'Expropriation and Inventions: Appropriable Rents in the Absence of Property Rights', *American Economic Review*, 84, pp. 190–209.

Arora, A. and Gambardella, A., 1994, 'The Changing Nature of Technological Change: General and Abstract Knowledge and the Division of Innovative Labour', *Research Policy*, 23.

Arora, A. and Gambardella, A., 1996, 'Evolution of Industry Structure in the Chemical Industry', Mimeo; CEPR, Stanford University.

Arrow, K., 1962, 'Economic Welfare and the allocation of Resources for Inventions', in Nelson, R. (ed.), *The Rate and Direction of Inventive Activity* (Princeton: Princeton University Press).

Besen, S. and Raskind, L., 1991, 'An Introduction to the Law and Economics of Intellectual Property', *Journal of Economic Perspectives*, 5, pp. 3–27.

Caves, R., Crookell, H. and Killing, P. J., 1983, 'The Imperfect Market for Technology Licenses', *Oxford Bulletin of Economics and Statistics*, 45, pp. 249–267.

Chang, H. F., 1995, 'Patent Scope, Antitrust Policy, and Cumulative Innovation', *Rand Journal of Economics,* 26, pp. 34–57.

Clark, K. and Wheelwright, S., 1993, *Managing New Product and Process Development: Text and Cases* (Free Press, New York).

Cohen, W., Nelson, R. and Walsh, J., 1996, 'Appropriability Conditions and Why Firms Patent and Why They Do Not in the American Manufacturing Sector', Paper presented at the OECD Conference on New Indicators for the Knowledge-Based Economy.

Contractor, F., 1981, *International Technology Licensing: Compensation, Costs and Negotiation* (Lexington Books, Lexington, MA).

Dam, K., 1995, 'Some Economic Considerations in the Intellectual Property Protection of Software', *Journal of Legal Studies*, 24, pp. 321–377.

Eswaran, M., 1994, 'Cross-Licensing of Competing Patents as a Facilitating Device', *Canadian Journal of Economics*, 27, pp. 689–708.

Feinstein, J. and Stein, J., 1988, 'Employee Opportunism and Redundancy in Firms', *Journal of Economic Behavior and Organization*, 10, pp. 401–414.

Fershtman, C. and Kamien, M., 1992, 'Cross Licensing of Complementary Technologies', *International Journal of Industrial Organization*, 10, pp. 329–348.

Gallini, N., 1984, 'Deterrence by Market Sharing: a Strategic Incentive for Licensing', *American Economic Review*, 74, pp. 931–941.

Gallini, N. and Winter, R., 1985, 'Licensing in the Theory of Innovation', *Rand Journal of Economics*, 16, pp. 237–252.

Gallini, N. and Wright, B., 1990, 'Technology Transfer Under Asymmetric Information', *Rand Journal of Economics*, 21, pp. 147–160.

Gallini, N., 1992, 'Patent Policy and Costly Imitation', *Rand Journal of Economics*, 23, pp. 52–63.

Gilbert, R. and Shapiro, C., 1990, 'Optimal Patent Length and Breadth', *Rand Journal of Economics*, 21, pp. 106–112.

Green, J. and Scotchmer, S., 1995, 'On the Division of Profit in Sequential Innovation', *Rand Journal of Economics*, 26, pp. 20–33.

Grindley, P. and Nickerson, J., 1996, 'Licensing and Business Strategies in the Chemicals Industry', in Parr, R. and Sullivan, P. (eds.), *Technology Licensing Strategies* (John Wiley, New York).

Grindley, P. and Teece, D., 1997, 'Managing Intellectual Capital: Licensing and Cross-Licensing in Semiconductors and Electronics', *California Management Review*, 39, pp. 8–41.

Hausman, J. and Morton, F. S., 1994, 'Misclassification of a Dependent Variable in a Discrete Response Setting', MIT Department of Economics working paper no. 94-19.

Kamien, M. and Tauman, Y., 1986, 'Fees versus Royalties and the Private Value of a Patent', *Quarterly Journal of Economics*, 101, pp. 471–493.

Katz, M. and Shapiro, C., 1986, 'How to License Intangible Property', *Quarterly Journal of Economics,* 101, pp. 567–589.

Klemperer, P., 1990, 'How Broad Should the Scope of Patent Protection Be?' *Rand Journal of Economics,* 21, 113–130.

Lafontaine, F. and Slade, M., 1997, 'Retail Contracting: Theory and Practise', *Journal of Industrial Economics*, XLV, pp. 1–26.

Landau, R. and Rosenberg, N., 1992, 'Successful Commercialization in the Chemical Process Industry', in Rosenberg, N., Landau, R. and Mowery, D.

(eds.), *Technology and the Wealth of Nations* (Stanford University Press, Stanford).

Landes, W. and Posner, R., 1989, 'An Economic Analysis of Copyright Law', *Journal of Legal Studies,* 18, pp. 325–363.

Lerner, J., 1994, 'The Importance of Patent Scope: An Empirical Analysis', *Rand Journal of Economics*, 25, pp. 319–333.

Levin, R., 1982, 'Appropriability, R&D Spending, and Technological Performance', *American Economic Review*, 78, pp. 424–428.

Levin, R., Klevorick, A., Nelson, R. and Winter, S., 1987, 'Appropriating the Returns from Industrial Research and Development', Brookings Papers on Economic Activity, 3, pp. 783–820.

Mansfield, E., 1986, 'Patents and Innovations: An Empirical Study', *Management Science*, 32.

McShan, W. S., Merwin, M. J., Stone, G. B. and Wright, D. R., 1989, 'A Review of Third Party Licensing Agreements: Are Periodic Adjustments Arms-Length?' *Tax Executive,* July–August, pp. 353–358.

Merges, R. P. and Nelson, R. R., 1990, 'On the Complex Economics of Patent Scope', *Columbia Law Review*, 90, pp. 839–876.

Ordover, J. A., 1991, 'A Patent System for both Diffusion and Exclusion', *Journal of Economic Perspectives*, 5, pp. 43–60.

Oster, S., 1994, *Modern Competitive Analysis* (Oxford University Press, New York).

Samuelson, P. and Glushko, R., 1989, 'Comparing the View of Lawyers and User Interface Designers on the Software Copyright Look and Feel Lawsuits', *Jurimetrics*, 30.

Scherer, F. M., Herzstein, S. E., Dreyfoos, A. *et al.,* 1959, *Patents and the Corporation* (Privately Published, Boston).

Scotchmer, S. and Green, J., 1990, 'Novelty and Disclosure in Patent Law', *Rand Journal of Economics*, 21, pp. 131–146.

Shapiro, C., 1985, 'Patent Licensing and R&D Rivalry', *American Economic Review,* 75, pp. 25–30.

Shelanski, H. and Klein, P., 1995, 'Empirical Research in Transaction Cost Economics: A Review and Assessment', *Journal of Law, Economics, and Organization*, 11, pp. 355–361.

Shepard, A., 1987, 'Licensing to Enhance Demand for New Technologies', *Rand Journal of Economics*, 18, pp. 630–638.

Taylor, C. and Silbertson, Z., 1973, *The Economic Impact of the Patent System: A Study of the British Experience* (Cambridge University Press, New York).

Teece, D., 1986, 'Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing, and Public Policy', *Research Policy,* 15, 285–305.

Telsio, P., 1979, *Technology Licensing and Multinational Enterprises* (Praeger Publishers, Connecticut).

Trebilcock, M., 1986, *The Common Law of Restraint of Trade* (Carswell Company Ltd., Toronto).

Von Hippel, E., 1988, *The Sources of Innovation* (Oxford University Press, New York).

Williamson, O., 1975, *Markets and Hierarchies: Analysis and Antitrust Implications* (Free Press, New York).

Wilson, R., 1975, 'The Sale of Technology through Licensing', Ph.D. Dissertation, Yale University.