ETLA
ELINKEINOELÄMÄN TUTKIMUSLAITOS
THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
Lönnrotinkatu 4 B 00120 Helsinki Finland Tel. 358-9-609 900
Telefax 358-9-601 753 World Wide Web: http://www.etla.fi/

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Laura Paija

ALLOCATION OF CONTROL RIGHTS TO CUSTOMISED PRODUCTS: EMPIRICAL ANALYSIS OF FINNISH SMEs

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ABSTRACT: Collaborative product development plays a pertinent role in many buyer-supplier relationships. It typically involves innovative components as the outcome of customisation and related R&D activities. The allocation of intellectual property rights (IPRs, e.g., patent, copyright, and trade secret) to collaborative output is a central aspect of buyer-supplier contracts. As IPR ownership provides the right to economically exploit and further develop an intellectual asset, they involve an incentive to allocate resources in asset development.

Collaborative R&D usually involves contracting under uncertainty, as the precise outcome is not known at the time of contracting. Economic theory suggests that in pursuit of the optimal outcome, contracts allocate control right to the party whose investment is more critical in increasing output value. Firms' relative bargaining power is another theoretical determinant of control allocation.

This paper looks into Finnish buyer-supplier relationships producing IPRs as an outcome of a customisation process. With survey data on 302 suppliers, representing most industrial sectors, the importance of investment criticality and bargaining power in determining IPR allocation mode is estimated. The Finnish evidence implies that firms are concerned about the quality of project output, and thus allocate ownership rights according to relative resource contributions. Bargaining power seems to have, yet with reservation, minor impact on the allocation mode.

KEY WORDS: buyer-supplier relationships, intellectual property rights (IPRs), contracts, customisation, bargaining power.

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TIIVISTELMÄ: Tuotekehitys on noussut merkittäväksi yhteistyöalueeksi yritystoiminnassa. Tuotantopanosten räätälöinti ja kehittäminen asiakkaan erityistarpeisiin synnyttää usein innovatiivisia ratkaisuja ja niihin liittyviä immateriaalioikeuksia (esim. patentteja, tekijänoikeuksia ja liikesalaisuuksia). Yhteistyössä syntyneiden immateriaalioikeuksien jakaminen onkin keskeinen kohta yritysten välisissä sopimuksissa. Immateriaalioikeudet mahdollistavat kehitystyön tulosten taloudellisen hyödyntämisen ja edelleen kehittämisen, ja näin ollen niiden omistus sisältää vahvan panostuskannustimen.

Yritykset joutuvat tavallisesti sopimaan t&k-yhteistyöstä epävarmuuden vallitessa, tavoiteltavaa lopputulosta kun on usein mahdoton ennalta täysin määritellä. Talousteorian näkökulmasta yritykset pyrkivät optimaaliseen lopputulokseen ja jakavat näin ollen innovaation omistusoikeuden sille osapuolelle, jonka panostus innovaation kehittämisessä on tärkeämpi. Yritysten neuvotteluvoima on toinen teorian tunnistama omistusoikeuden jakoon vaikuttava tekijä.

Tässä artikkelissa tarkastellaan sellaisia suomalaisia asiakas-toimittajasuhteita, joissa immateriaalioikeuksia syntyy yhteistyötä edellyttävän räätälöinnin tuloksena. Useimmat toimialat kattavaa kyselyaineistoa hyödyntäen tutkimuksessa arvioidaan panostusten kriittisyyden ja neuvotteluaseman merkitystä immateriaalioikeuksien jakamisessa. Suomalaisaineiston perusteella voidaan päätellä, että yritysten toimintaa ohjaa laadun tavoittelu, koska osapuolten panostukset selittävät merkitsevästi immateriaalioikeuksien jakoa. Neuvotteluvoimalla sen sijaan näyttää – joskin tietyin varauksin – olevan vähemmän sijaa omistuskysymysten ratkaisussa.

AVAINSANAT: asiakas-toimittajasuhteet, immateriaalioikeudet, sopimukset, räätälöinti, neuvotteluvoima.

Allocation of control rights to customised products: Empirical analysis of Finnish SMEs

1 Introduction

1.1 Background

The increased knowledge-intensity of products and increased competitive pressures have forced firms to specialize on few core competences, and consequently to get access to non-core resources through collaborative arrangements. Indeed, the late 20th century witnessed an extensive restructuring of industrial production in which collaborative product development has played a pertinent role. Particularly in research-intensive sectors partnerships between small innovative firms and large established companies have characterised the phenomenon.

Since the primary objective of most inter-firm development projects is the creation of novel solutions, the allocation of control to the output is a central contractual issue. In other words, firms need to decide upon who has the right to use, modify, and resell the jointly produced asset. Intellectual property right (IPR) allocation in the context of horizontal collaboration, i.e., between firms that compete in the product market, has been a major concern of competition and innovation policy debates, involving the delicate balance between efficient cooperation of innovative resources and anticompetitive behaviour of firms. In the context of vertical relationships, i.e., those between buyers and suppliers, the IPR allocation issue involves different kinds of efficiency concerns. The social costs of inefficient contractual outcomes in vertical relationships are likely to be negligible compared with those incurred by collusive contracts. Therefore, buyers and suppliers are allowed to contract on the allocation of control within the relatively flexible laws of intellectual property and contract. Nevertheless, economic efficiency *is* at stake in contracts allocating control between vertical partners, as well. It has implications for output quality (through incentives to innovate) and firms' viability (through scale economies), and thereby to social welfare.

In knowledge-intensive economies intellectual capital has replaced physical capital as the most valuable asset of firms, and awareness of the importance of systematic protection and development of intellectual assets has increased rapidly in firms. Unconcerned management of intellectual assets easily erodes the basis of viable business and firm value if the fruit of intellectual work fails to remain in the firm. Particularly in replicable products the embedded knowledge asset can be a source of prolonged cash flow and economies of scale and scope. The *determinants* of IPR allocation in innovative relationships should therefore be of major managerial interest for firms aiming at upholding growth and improving their competitive position.

1.2 Research Questions, Objectives, and Restrictions

This paper reports the interim results of a work in progress. The research question addressed in this paper is: What determines the allocation of control rights to output customised to the specific needs of the buyer? The objective of the study is to test the empirical importance of the factors of control allocation, suggested by the property rights theory. More specifically, with reference to the theory, the purpose of the study is to investigate whether it is the bargaining power or "brain power" that rules in contracts distributing control.

The unit of analysis is a buyer-supplier relationship, yet with an emphasis on the supplier's perspective. The empirical analysis is limited to relationships in which intellectual property rights (IPRs) are created as part of a customisation process. Other contractual issues, such as cash flow rights (royalties and licence fees) and exclusivity rights, are outside the scope of this study.Even though the property rights theory originates from theories of efficient industrial organization, make-or-buy considerations are excluded from this work. Also innovations created under employment relationships (i.e., under vertical integration) are outside the scope of this study (see Aghion & Tirole, 1994; Hart & Moore, 1990).

When the production of an intermediary product involves investments – be it tangible or human effort – by both the buyer and the supplier, the allocation of ownership rights to the output is not trivial, since ownership gives right of control to the future exploitation of a productive asset, such as intellectual property. In many cases, both the buyer and the supplier have interest in gaining control to the asset to improve their positions in their own markets. The buyer may want to preserve the competitive advantage that the non-standard input will produce in relation to its competitors. The supplier, in turn, may be able to apply the solution in its other customer relationships, and thereby gain competitive advantage as regards to other suppliers.

The property rights literature suggests that there are two fundamental factors determining control allocation between collaborating firms. These are firms' relative bargaining powers and the relative significance of the resources they invest in the production process. In this paper, I conduct an empirical test of these hypotheses using a data set on Finnish SMEs. The empirical analysis looks into the significance of these factors in affecting the probability of the supplier assigning away control on the IPRs created in the customisation process.

Empirical work in the field of the property rights theory has remained scarce, and it has produced somewhat mixed results. The empirical analysis in this paper brings in two aspects that distinguish it from previous work. First, the analysis here is not sector-specific, and thus

it allows detecting potential inter-industrial differences in contractual patterns.[1] Second, the study makes use of a survey data produced for its particular purposes. Most of prior work has used existing data sources that have necessitated the use of proxies for some central variables. Thus, a better fit between the theory and the empirical variables can be expected from this analysis.

More recent work of Aghion & Tirole (1994), applying the original work of Grossman & Hart (1986) and Hart & Moore (1990) to intellectual assets, has made the property rights theory highly topical in the knowledge-intensive network economy.[2] By testing the hypotheses proposed in the literature, the objective of this work is to contribute to its establishment. The choice of SMEs as sample firms allows detecting the impact of resource-based bargaining power on control allocation. More generally, the work relates to the issue of small firms' ability to accumulate proprietary knowledge assets, and thereby sustain viable business and growth.

In Finland, the pronounced reliance of the economy on one large and globally successful firm, Nokia, has been a national concern over the last decade. The need for "new Nokias" to diversify the industrial knowledge base, and to even out the dependence of one single company and industry makes the question of IPR allocation among creative firms thus relevant. To date, research on this topic in Finland has remained sector- (Leiponen, 2004) and case-specific (Ali-Yrkkö & Hermans, 2002).

This does not mean that the companies in the sample would be Nokia's subcontractors. Their exact number is not known, and it is likely that in this cross-sectoral data relatively few firms have direct ties to Nokia. It is also important to note that I do not suggest that all IPRs should always remain with the supplier. Instead, in line with the property rights theory, the interest is in *efficient* allocation of control rights, i.e., the allocation mode that produces highest value added in vertical relationships.

1.3 Definitions of Contractual Rights

Even though contributions to the property rights literature are attributed to a small number of scholars there is notable incoherence in the use of terminology, which seems to partly stem from the different organisational arrangements, in which the property rights issue is considered. I will therefore next discuss in some detail the concepts used in the literature and define the terminology for the rest of the work.

[1] In the context of international joint ventures Bai & al. (2003) controlled for the industry-average advertising and R&D intensities to capture the effect of industry characteristics on control allocation. These measures were used as indicators of the partners' contribution to the joint venture rather than to detect inter-industrial differences in contractual pattern.

[2] By the notion of network I refer to organisational entities involving firms' specialisation and collaboration.

Trade and production, as Furubotn & Pejovich (1972) point out, involve contractual arrangements to permit the exchange of "bundles" of property rights.[3] In their pioneering work Grossman & Hart (1986) identify two types of rights that can be contractually traded: *specific rights* and *residual rights*. Specific rights are those that can be specified in a contract, while residual rights are those that provide control on all aspects of the asset that have not been explicitly given away by a contract. Thus, while specific rights provide limited right of asset utilization, residual rights involve asset ownership and power to exercise control. To illustrate, a rental agreement gives a right to employ an asset, such as an apartment or a car, but only to the extent that has been specified by the contract. All remaining aspects concerning the asset's utilization, alteration, and transfer to third parties remain at the renter's discretion.

Some authors (Aghion & Tirole, 1994) ignore this distinction between the two dimensions of control. By using the more standard term property rights they, however, make implicit reference to Grossman & Hart –like residual rights. Hart & Moore (1990), in turn, while silent about specific rights, specify the meaning of residual rights to signify merely an ability to exclude others from using a productive asset.

In Lerner & Merges (1998) the generic term control right is used to refer to residual rights (i.e., "right to make decisions about issues that cannot be contractually specified"; ibid. p. 125). Nevertheless, the authors remark that property rights (i.e., ownership) are but *one* aspect of control rights. In the context of R&D alliances (which are to be distinguished from vertical relationships) control rights consist of both asset ownership *and* the management decisions and government structures related to the asset and the alliance. This implies that residual rights are not embodied exclusively in asset ownership, like Grossman & Hart initially suggested. It suggests that, generally speaking, *managerial* aspects may also be unambiguously defined and the actions to be taken in every state of the future are not specified by the contract. Thus, there remains scope for residual rights of control outside asset ownership.

Again in the context of alliances, Elfenbein & Lerner (2003) underline the distinction between specific and residual rights on the one hand, and ownership and control on alliance-related decisions on the other. However, the empirical content they give in their analysis to specific rights (called loosely "control rights") is somewhat overlapping with the residual rights of Lerner & Merges (1998).

Yet another approach to definitions is provided by Bai et al. (2003) who distinguish between ownership and the right of control on decisions in asset-related issues, yet in their analysis of

[3] "Bundles" refer to the set of rights that are conveyed in the transaction. Furubotn & Pejovich (1972, p.1139) provide an example illustrating the worth of a house, which is contingent on, say, the right to exclude gasoline stations from the immediate vicinity of the building.

joint ventures, equity shares of partners are treated as a revenue-sharing device as ownership in joint ventures is, by definition, shared.

It is obvious that the research contexts in which the terminology and definitions have been developed are an important source of the existing inconsistency. Specific rights stipulated to limit the extent of ownership rights concern somewhat different issues in different kinds of interfirm arrangements, such as alliances, joint ventures, and vertical relationships – not to mention intra-firm i.e., employment relationships. In principle, alliances and joint ventures need to distribute control on a range of decisions concerning the governance of relationship assets, while contracts in vertical relationships concentrate on allocating right of use, modification, and resale to the more or less jointly produced product.

In this work I adhere to those definitions that best fit the contractual aspects observed in vertical relationships. In the tradition of Grossman & Hart, I distinguish between residual and specific rights of control. I restrict the definition of residual right to asset ownership, and use it as a synonym to property right. In this work, specific rights are defined as control rights that restrict the free use of property rights. Examples of specific rights in buyer-supplier contracts are clauses of exclusivity rights, which limit the extent to which the owner of relationship output can economically exploit it. Specific rights are however, as noted above, outside the focus of this work.

2 Theoretical Foundation and Prior Empirical Work

2.1 Property Rights Economics

The property rights theory looks into the decision making function of the productive firm, and as such it emerged originally from the post-war criticism of the traditional theory of production and exchange. In a classical market "product is sold at uniform price to all comers without restriction" (Williamson, 1985, p. 23), and there is no time lag between signing and fulfilling the obligations of the contract. As firms move away from traditional market exchange they need to formulate an agreement to cover the period between promises and execution, which is plagued by uncertainty.

The economics of property rights stems from the theory of incomplete contracting. The main line of argument of the property rights literature is that asset ownership matters for economic behaviour, and more precisely, for incentives to allocate resources (money or effort) into activities that affect the asset's value. Property rights to an asset confer the right to use it, change its form and substance, and transfer some or all rights in the asset through

rental or sale (Furubotn & Pejovich, 1972). In other words, ownership carry with it a "permission to do things" with the assets (ibid.).

One can identify two major branches of property rights literature, which study the incentive implications of property rights in different contexts. One considers the *separation* of ownership and control. The focus is on decision making *within* organizations and on strategies (penalty-reward structures) aligning the incentives of agents and the objectives of asset owners. This perspective has allowed rejection of profit maximization as the primary objective of economic agents.

The other line of research within the property rights domain, on which this paper draws, looks into the *allocation* of ownership (together with control) *between* organizations. The fundamental question addressed in the related literature pertains to optimal organisation of transactions, i.e., whether a production phase should be carried out inside or outside hierarchies, thereby building on the work initiated by Coase (1937) and Williamson (1975; 1985). The ownership of productive assets is at issue since it carries incentives to allocate resources in the transaction. The property rights theory concerning ownership allocation is largely attributed to Grossman & Hart (1986) and Hart &Moore (1990). A later contribution to the theory, which is particularly pertinent to the research question of this paper, has been proposed by Aghion & Tirole (1994). It is concerned with a contractual relationship between a research unit and a user of its output, i.e., innovation, and the optimal allocation of property rights to the intellectual asset.

The standard model in the Grossman-Hart-Moore framework involves two firms contracting on producing an output. It is assumed that *ex post* benefits from the relationship depend on idiosyncratic investments made *ex ante* by each party. The model involves contracting under uncertainty about the future states of the world, and therefore production decisions cannot be specified at the time of signing the contract. Moreover, firms pursue "self-interest with guile" (Williamson, 1985), i.e., behave opportunistically should an occasion open up (Klein, Crawford, & Alchian, 1978). Thus, designing a complete contract that would account for all possible contingencies would be extremely costly. Allocation of property rights to relationship outcome (or, productive assets, depending on the model context) is therefore used as a mechanism to induce incentives to invest the critical resources in the relationship.

The basic premise of the theory is that in order to increase the probability of *ex post* benefits from the relationship, firms need to make relationship-specific investments *ex ante*, that is, in the production phase. Investment decisions are made independently and non-cooperatively. Ownership rights to productive assets (Grossman & Hart, 1986) or to assets produced *in* the relationship (Aghion & Tirole, 1994) will affect the distribution of *ex post* benefits, since the

firm with residual rights will be in control of production decisions in case of missing contractual provision. Less formally, the firm with ownership rights will be able to use, modify, and economically exploit the asset in all other circumstances but those specifically stipulated by the contract. The fundamental assumption of the theory is that possession of such rights has a positive impact on investment incentives.

The main question is how should property rights be allocated to produce an optimal outcome. Grossman & Hart (1986, p. 691) argue that when residual rights are allocated to one party, they are lost by a second party, and this "inevitably" creates distortions in incentives to invest. In other words, there is no first-best solution to the allocation problem, since each ownership structure will lead to distortion in the *ex ante* investment: the firm with ownership rights is likely to overinvest, while the other with no such rights is expected to underinvest. The consequence of distortion depends on the party who has residual rights, since it is assumed that the investments made by each party are dissimilar in their ability to increase *ex post* benefits. Grossman & Hart (1986) conclude that the optimal contract assigns ownership rights to the firm whose *ex ante investment is more critical in the achievement of an optimal outcome*.[4]

Aghion & Tirole (1994) propose an additional determinant of property rights allocation, which is *bargaining power*. Availability of alternative exchange partners is mentioned as a source of such power. The authors introduce the case of a cash constraint supplier (that is a research unit in the Aghion & Tirole model), and predict that in such a case the probability of *inefficient* property right allocation increases. More precisely, the Grossman & Hart-like optimal solution may not be achieved since a buyer with superior bargaining power may not have an incentive to assign IPRs to the supplier even if the supplier's investment was more critical in the achievement of an optimal output. This implies supplier's underinvestment, and consequently, lower innovative content of the output than would have been accomplished had the supplier obtained the IPRs and, with them, the high-powered incentives to invest more in the R&D process.

Why would the buyer choose to compromise on the quality of innovation? Aghion & Tirole point to the fact that when the buyer is in the bargaining position to keep hold of the IPRs, a cash-scarce supplier cannot compensate the buyer for a transfer of ownership. Thus, by retaining the ownership right the buyer optimises his individual payoff, which is below the social optimal, i.e., more inventive outcome, but exceeds his payoff from the even inferior alternative i.e., assigning the IPRs to the supplier without compensation.

[4] More precisely, denoting the firms as Firm 1 and Firm 2, Grossman & Hart (1986) specify that Firm 1 control will be desirable when Firm 1's investment is much more important than Firm 2's, so that Firm 2's underinvestment is relatively unimportant, *and* when Firm 1's overinvestment is a less severe problem than underinvestment. The reverse condition applies for the desirability of Firm 2's control.

What if the supplier is in a dominant position to negotiate (say, it has other buyer candidates whereas the buyer has no alternative suppliers)? Then the model predicts that optimal solution will *always* be achieved. If the supplier's investment is more critical in the R&D process it keeps the IPRs to itself. If in turn the buyer's is investment is more efficient in increasing the value of the output, the supplier assigns the IPRs to the buyer in exchange for a cash transfer.

Thus, Aghion & Tirole propose that the allocation of property right to an innovation is determined by the relative importance of investment criticality (the Grossman & Hart-solution) *and* bargaining power of the contracting parties.

2.2 Prior Empirical Research

Based on their theoretical research on the management of innovation (with various extensions not discussed here) Aghion & Tirole (1994) conclude that when intellectual inputs dominate, as for software and biotechnology, independent units will often perform research. Along theses lines Lerner & Merges (1998) have applied the Aghion & Tirole model to biotechnology alliances. In this context young innovative firms typically lack financial resources and operational capabilities to efficiently proceed through the resource-consuming product development and testing phases to the commercialisation of the product. Lerner & Merges note that these firms are often in a weak position in the capital and financial markets owing to informational asymmetries surrounding firms' projects. Consequently, increasing number of alliances between small and large firms has emerged in this field. Biotechnology projects represent a typical case of a complex and uncertain contractual setting, and the importance of IPRs is pronounced for viable future business. To wit, Lerner & Merges use supplier's cash constraint not only as an indicator of an inability to compensate the buyer for IPR assignment, as Aghion & Tirole, but also as a feature that emasculates its bargaining status.

Lerner & Merges' empirical findings from a sample of 200 alliances between biotechnology firms or biotechnology and pharmaceutical firms are consistent with the supplier's cash-constraint hypothesis of Aghion & Tirole: the greater the financial resources of the R&D firm, the fewer control rights are assigned to the financing firm. Their analysis produce, instead, mixed evidence on firms' concern about efficient allocation of property rights, since the results are not robust to the choice of investment criticality indicator.[5]

[5] Two alternative indicators are used: a dummy indicating early-stage alliances (i.e., projects in the discovery through pre-clinical research phase), and the number of the R&D firm's patent awards related to the alliance. A low number of patents is taken to indicate an early-stage project. Both indicators gain statistically significant coefficients, but they provide contradicting evidence of firms' Grossman & Hart-like value-maximisation considerations.

Interestingly, however, Lerner & Merges found that when a small number of related patents were used as an early-stage indicator the probability of the supplier's ownership increased only in those projects in which the supplier was cash constraint. There was strong evidence on fewer control rights assigned to financing firms if the suppliers had both strong financial *and* patent position (a significantly negative interaction term between the number of patents and the supplier's financial condition). Lerner & Merges conclude that the relative financial status of the alliance partners seems to be, at least in the biotechnology industry, the primary determinant of control allocation, while there may be alternative explanations for why suppliers' patents, as early-stage indicators, should increase or decrease the amount of control gained.

A recent study on 106 alliances between Internet-related firms by Elfenbein & Lerner (2003) produced somewhat opposite results. Strong statistical support was found for the positive relationship between investment effort and asset ownership, while there was somewhat weaker evidence for the significance of bargaining power in allocating ownership.[6]

The study of Bai et al. (2003) on international China-based joint ventures provides a slightly different angle to the property rights issue, since ownership of assets is shared, by definition, between partners. The *proportion* of foreign ownership was positively related to R&D intensity and negatively to the advertising intensity of the joint venture's industry. The intensities can be seen to reflect the relationship-specific efforts that are implicitly *anticipated* from the partners – R&D input from the foreign and advertising activities from the local firm. The empirical model of Bai et al. did not include bargaining power as an explanatory factor of control allocation.

Arora & Merges (2004), based on their theoretical analysis, as well as existing empirical studies and data on certain knowledge-intensive industries, argue that IPRs provide a fallback option for the supplier in case of contract termination. They conclude that the supplier's IPR ownership is a *precondition* for optimal supplier effort and, through high-powered incentives it produces a more efficient outcome than vertical integration. In other words, Arora & Merges argue that stronger IPR protection on assets produced during a relationship is likely to induce more R&D because it decreases the customer's opportunistic behaviour (expropriation) and the supplier's risk of sunk cost of relationship-specific investments.

Building on the extant property rights theory, Leiponen (2004) introduces a novel set of explanatory factors explaining allocation of control rights. In her empirical work on knowledge-intensive business service firms, she finds that characteristics of the firm's

[6] Elfenbein & Lerner (2003) and Bai et al. (2003) conducted separated analyses of the allocation of specific and residual rights, thereby acknowledging the division suggested by Grossman & Hart (1986), and found differences in the mechanism these two types of rights were allocated.

(service) product and learning strategy have implications for the allocation of control of output. More explicitly, firms whose capabilities are controlled by individual employees are more likely to yield control rights to the customer, while firms whose competence resides in organizational resources, i.e., more standardized and replicable solutions, usually retain control to the output produced. These differing patterns of contractual behaviour are rationalised by the different opportunity costs related to the underlying products. Firms who have created proprietary and replicable service packages value control rights more highly than those whose service is more specialised for an individual customer's purposes. Put differently, in the latter case scale returns are not likely to increase with the ownership of residual rights to the highly customised output.

Moreover, Leiponen found that firms who accumulate their knowledge base *incrementally* through learning by doing and on the job training are those who are more likely to assign control to output to customers. Those firms, in turn, who engage in collaborative activities *with the aim of knowledge accumulation* are those who most probably also hold on to the control of their output. Finally, in Leiponen's analysis, the original property rights theory is supported with regard to bargaining power, while the proxy used for relative investment criticality is not statistically significant. Within the relatively narrowly specified sector of knowledge-intensive business services significant variation in contractual modes between sub-sectors were found.

To conclude, the evidence on the property rights theory remains somewhat inconsistent reflecting differing measures and empirical environments. In what follows, I will test the standard hypotheses of the theory experimenting with several empirical variables approximating the constructs of bargaining power and relative investment criticality. I will also experiment across different measures of the dependent variable, i.e., IPRs allocated to the customer in non-standard exchange relationships. The impact of inter-industrial differences will be controlled for more explicitly than in previous work, most of which have been industry-specific. Analysing the control right allocation issue across different industries increases generalisability of results.

3 Empirical Analysis

3.1 Empirical Model

Hypotheses

The Aghion & Tirole (1994) model proposes that efficient property right allocation is always achieved if the supplier of an R&D intensive product has discretion over the allocation of property rights. It is impossible to directly test the theory since it involves highly non-

measurable variables, such as intangible investments (effort), utilities of the firms, and the value of the innovation to the buyer. For empirical testing more operational hypothesis need to be devised. In line with previous empirical work, I test the following hypotheses derived from the theoretical foundation attributed to Grossman & Hart (1986), Hart & Moore (1990), and Aghion and Tirole (1994):

In vertical relationships involving customised output the probability of the customer's IPR ownership is expected to:

- increase with the importance of his own investments.
- decrease with the importance of the supplier's investment.
- increase with factors improving his own bargaining power.
- decrease with factors improving the supplier's bargaining power.

Survey design and the sample

The data used in this work draw from a survey data commissioned by The Research Institute of the Finnish Economy ETLA ,and its subsidiary Etlatieto Ltd. It was collected in three stages, in late-2001, late-2002, and mid-2003. The primary objective of the survey was to collect data on funding sources of SMEs, and to detect problems in their finance availability and innovation activities. All the three surveys were carried out as computer-assisted telephone interviews by Tietoykkönen Ltd, a private company for research and marketing information services. The CEO or the CFO were the primary respondents.

The sample concerned initially 936 Finnish SMEs[7] (out of the 2600 contacted) across most business sectors, excluding only the agriculture, finance, and real estate (see Hyytinen & Pajarinen, 2002). Technology-based firms were over-sampled, representing 60 per cent of the sample. The target population consisted of active for-profit firms registered in Finland. Proprietorships, partnerships, and subsidiaries were excluded from the sample. The second survey round produced 830 completed questionnaires (see Väänänen, 2003).

The third survey included questions designed for the purposes of this study. The respondents of the original sample were the target group, out of which 883 were reached, and 746 completed the questionnaire. To the 137 non-respondents, the following reasons pertained: too busy (43,80%), not entitled to provide the requested information (24.09%), the firm no longer exists (8.03%), other reason (24.09%). Out of the sample of 746 firms, 665 firms had other firms or organizations as their main customers, and thus met the primary condition to be included in this study.

[7] Firms were considered an SME if it had less than 250 employees and its annual turnover was under 40 million euros or is total assets were less than 27 million euros.

To refine the sample for this study the following steps were taken. Only firms that had responded to all three questionnaires were included. Firms that did not fit in the SME size limits or were resalers of other firms' products where excluded from the sample. To analyse the allocation of control on output produced in a customer relationship also firms that did *not* customise their products were also excluded. Finally, firms that did not produce any IPRs in the process of customisation were dropped out, and 326 firms were left to constitute the total sample of this study.

The research tool (i.e., the third survey questionnaire) was created on the basis of the property rights literature and interviews with representatives of supplier firms and an entrepreneur association as well as discussions with two economic researchers of the biotechnology industry and a jurisprudent. The tool was assessed by and discussed with several economic researchers, and finally piloted by telephone with three company representatives operating in the information-intensive services, medium high-technology, and basic services sectors (see Table B in the appendix for definitions) after which minor alterations in the original question formulations were made.

The complexity of firm relationships creates great challenges to empirical inquiry. While the theory of property right analyses control allocation at the level of a transaction, the survey data provides information about relationships, i.e., a series of transactions between a supplier and a buyer. But suppliers' relationships vary by customer and by product supplied within a particular relationship, and also by external conditions (e.g., the characteristics of different markets in which the firm operates). Consequently, the design of the questionnaire needed to fix some aspects of relationships to reflect a "typical" project in a certain relationship to approximate the contractual setting described in the theory.

In the set of questionnaire items concerning contractual issues and customer relationship firms were asked to answer with their most important customer (in terms of sales) in mind. Moreover, some other qualifiers (e.g., "ever", "in general", "measurably") were used to capture the "general tendency" in the key customer relationship. However, I recognise the difficulty that sample firms are likely to have had in responding to questions concerning a very complex issue.

Operationalisation of the concept of IPRs required its disintegration into specific IPR types. Three IPR types were considered the most relevant and common in the context of the study. These include: inventions that qualify for patenting, copyrights, and trade secrets. Since firms' understanding of IPRs may vary, some examples of each type were provided to respondents (see Table A).

Data on firms' personnel size, assets, and sales revenue are drawn from a financial statements database provided by Asiakastieto Oy. For missing observations of accounting data I have used observations of the previous year.

Variables

All the variables concerning the customer of the relationship involve the *key customer*, defined as the most important customer in terms of sales. If the supplier has several customers of primary importance the responses relate to the one who the supplier subjectively regards as the most important. Only firms that customise their product(s) to the specific needs of the customer *and* produce IPRs in the process are included in the analysis.

There are several solutions to constructing the dependent variable, i.e., the customer's IPR control. The two provided here are not affected by the fact that all three types of intellectual property are not pertinent to all buyer-supplier relationships. The construction of a dummy for customer's IPR ownership required several steps. To increase the reliability of the research tool, (the survey questionnaire), the generic concept of IPR had to be divided into separate types of IPRs, which differ significantly in terms of substance matter, application formalities, and the strength of legal protection.[8] Three different types of intellectual property were selected to present those most commonly created in customer relationships. These are patentable inventions[9], copyrights, and trade secrets. For each type, a binary variable was created to indicate the customer's ownership. More precisely, the variable was constructed so that each variable obtained a value of 0 if: *a)* the type of intellectual asset ever emerges as an outcome of customisation (otherwise treated as missing), and *b)* if the asset in this case remains to a large extent[10] under the *supplier's* property right. Thus, the case in which the customer receives property right was assigned a value of 1.

Next, I combined these individual measures into an aggregated dependent variable, implied by the theoretical literature. I constructed a dummy for the **customer's IPR control,** which obtained the value of 1 if the customer receives one or more of the three potential IPR types created in the relationship, and 0 if the supplier retains all the ownership rights. This asymmetric choice of the cut-off point was dictated by the disproportional distribution of

[8] For example, for an invention to qualify as patentable it needs to exhibit novelty, non-obviousness, and usefulness, and therefore its occurrence can be expected to be lower than the other two types, but patented inventions enjoy relatively strongest protection within the legal system. Copyright protects only the expression of the original work, and therefore it can be circumvented with little modifications to the primary object. Trade secrets are protected to the extent that the firm takes measures to prevent them from diffusing. As compared with patent, trade secret is protected by suppression of knowledge, while patents involve detailed revelation of information. As compared to patents, copyrights and trade secret gain legal protection without a formal application process making them much less costly means of protection. Also, patents apply only in the countries where they are filed, while the other two property rights are in principal universally protected by international conventions.

[9] Patentable inventions instead of patents are used here because I am primarily interested in the inventive content of the output rather than the legal instrument by which it is finally protected. More importantly, patenting is an *ex post* process undergone by the firm who gains the ownership of the invention.

[10] With the provision of " to a large extent" I allow for the possibility of ownership sharing.

observations on IPRs ownership (see Table D). However, the dummy variable still remains unevenly distributed, which may decrease the precision of estimation results.

I checked for the robustness of results using an alternative measure that allows for shared ownership. I calculated the ratio of the number of IPR types allocated to the customer to those created in the relationship. Owing to the small number of observations with fraction values (i.e., shared ownership) the variable was transformed so that these observations were combined into an "intermediary" group. So, the variable **customer's IPR control share** obtained the value of 0 (no customer's control on produced output), 1 (shared control), or 2 (customer's control on all output).

The property rights theory does not suggest IPR type-specific diversity in the determinants of allocation. However, with the three different types of IPRs at hand (i.e., **patentable inventions**, **copyrights**, and **trade secrets)** I was able to check whether their allocation follow a similar model in terms of explanatory factors. A similar kind of disintegrated analysis has been conducted by Elfenbein & Lerner (2003), who found some indications of differences in the importance of bargaining power in the determination of ownership to Internet-related assets (servers, URL, and customer data). Relative importance of effort was found very significant irrespective of asset type.

Considering the bargaining power of the supplier, some authors within the property rights theory (Aghion & Tirole, 1994; Lerner & Merges, 1998) point to the lack of alternative exchange partners and scarce financial resources as sources of deteriorated bargaining power. In fact, deficiency of *any* kind of resource that is limited in supply and critical for the survival of a firm is likely to increase its dependence on those who have those resources. Or, the other way around, resource abundance endows a firm with superior bargaining power relative to their resource scarce contractual partners.

Pfeffer & Salancik (1978) put forward, within the organizational theory, a set of conditions under which resources provide bargaining power within exchange relationships. Power stems from 1) *resource importance* i.e., magnitude of exchange and criticality of the resource in achieving strategic objectives; 2) *discretion over resource allocation* through possession (e.g., knowledge), property rights (e.g., intellectual property), or access to resources controlled by others;[11] and 3) *concentration of resource control*, i.e., the relative volume of resources controlled. Moreover, resource dependence relates both to *input acquisition* (supplier relationships) as well as to *output disposal* (customer relationships) (Jacobs, 1974). Yet, to be precise, output disposal comes down to input (i.e., cash) acquisition. To operationalise bargaining power, I introduce a set of measures derived from the Pfeffer & Salancik's classification.

[11] While possession provides a direct and absolute discretion of a resource, property rights provide only an indirect discretion requiring the support of the legal system (Pfeffer & Salancik, 1978).

The first set of bargaining power variables relate to the supplier's characteristics. The size of the firm is the most common measure of relational power. Since various size measures, such as total assets, number of employees, and turnover are highly correlated for most firms, I use here the number of **personnel** as the size indicator.[12] The supplier's size is assumed to be negatively related with the customer's IPR ownership.

For detecting the effect of supplier's cash constraint, I use a dummy for the supplier's **equity constraint** as a measure of the Aghion & Tirole-type bargaining setting, which assumes a positive relation between the constraint and the customer's IPR ownership. The equity constraint indicator equals 1 if *a*) the firm has needed equity funding but, despite of the need, has not even attempted to acquire it from the private sector, owing to anticipated high transaction costs, or the firm's doubts as to its ability to succeed, or *b*) all its equity acquisition efforts have failed in the private equity market.

The supplier's **market share** is brought in as an indicator of the supplier's competitive position in its main market(s), or, put the other way around, the presence of alternatives available for the customer. Larger market share should thus decrease the probability of IPRs going to the customer. The variable accounts for a firm's market share in its main market for the product or those products, which accrue over 90 per cent of sales. If a respondent was unable to indicate a numerical response, he/she chose a predefined category of market share relevant to the firm (see Table A). To transform the categorical scale into a continuous one, each category observation was assigned the mean value of its category.

The **age** of a firm is another common measure of a firm's position in contract negotiations. The younger the firm, the more eager it can be expected to be in reaching agreements to establish its position in the market and to generate sales inflow (Venkataraman, Van de Ven, Buckeye, & Hudson, 1990). Therefore, we can anticipate firms to yield in to customers' demands in the early stages of their operation, and thus, a negative sign to the variable.

The next set of bargaining power variables control for some characteristics of the key customer and its relationship with the supplier. A dummy variable is used to indicate a **dominant customer** whose sales are over five times larger than those of the supplier. A dominant size of the customer firm is expected to increase the probability of its property right control.

An alternative sign of the customer's significance is the degree of **capacity occupation**. A dummy is created to check whether the customer occupies more than half of the supplier's capacity (including production facilities and personnel services), which is likely to improve such a dominant customer's bargaining power. Therefore, a positive relation between the

[12] Experimental regressions using alternative measures of size confirmed that the results are not affected by the choice of measure.

customer's IPR control and its large share of the supplier's production capacity is anticipated.

Next, a set of variables intended to capture the effect of each partner's investment on the customer's IPR control. Aghion & Tirole (1994) distinguish different sorts of investment by which the customer may contribute to the product development process. These include financial resources as well as non-pecuniary contributions, such as proprietary technological information made available to the supplier, or interaction with the supplier to enable tailoring an innovative output to the final demand. In reality, we may expect a mixture of these investment items, and Aghion & Tirole note that in most cases different forms of the customer's investments produce equal theoretical results. In the present empirical model the customer's investments are of the non-pecuniary kind. The importance of the **customer's investment** is measured by a dummy that obtains a value of 1 if the customer participates in the development of the customised product to a very or quite importance extent, and otherwise 0.

The degree of supplier's **specialisation** in terms of production activities is included in the analysis. A dummy variable was created for those firms who accrue over 90 per cent of their sales revenue from one product or service entity. A highly limited product range reflects a strategy of concentrated resource investments, which in turn, is a potential indicator of *ex ante* investments made in product development. Moreover, specialization has the well-known advantages for firms' competitive advantage, e.g., expertise in the technology and market characteristics, and economies of scale, which improve a firm's competitive advantage in face of its more generalist competitors, and increases its weight as a contracting party.

However, specialization is not a sufficient condition for important prior investments: a firm can be a standard "one-trick pony" making no effort in enhancing its expertise. We can also think of opposing effects of specialization on the supplier's contractual success in retaining control rights. Namely, a highly focused firm is exposed to a demand risk, and it also signals reduced ability to switch over to other products. Consequently, dependence on customers in one or few product markets increases. Thus, the direction of the effect of specialization on the IPR contract content cannot be anticipated.

The supplier's **R&D intensity**, i.e., share of R&D investments of total sales, is used to approximate the general technological level of the supplier's output, and its effort in creating intellectual property. It is therefore assumed that the higher the supplier's relative expenditure on R&D, and the more it values IPRs created in customer relationships, thereby decreasing the likelihood of the customer's IPR ownership. R&D intensity can also be considered as a weak proxy of the supplier's investments in resources used in the customer relationship. Survey respondents were urged to provide the value of their R&D investments

in euros. If an exact numerical response was not available, predefined R&D intensity categories were used. Categorical responses were transformed into numerical observations by assigning the variable the mean value of the respective category.

To check whether R&D activity in specialized firms have a specific effect on IPR contract outcome, I introduce an interaction term to capture the combined effect of the supplier's specialization and R&D intensity. The interaction term obtains the value of the supplier's R&D intensity when the supplier is specialised (with the respective dummy variable equalling 1), and 0 otherwise. I regard this variable as an indicator of the supplier's focused product development strategy**,** which aims at the accumulation of distinctive knowledge in a particular technology. The higher the relative R&D expenditure is in a specialised firm, the more it is assumed to value new product-related knowledge created in relationships, and the more determined it is in retaining control to new knowledge assets. This variable is akin to Leiponen's (2004) learning-by-doing strategy discussed above.

I also control for firms' industrial environment in anticipation of systematic differences in contractual modes prevailing in different industries. The sample firms are divided into five groups according to the level of their product technology, as suggested by OECD (1999). The definitions of the five industrial groups, labelled as high technology, medium-high technology, information-intensive service, basic manufacturing, and basic services and trade, are provided in Table B. Despite the fact that different industrial sectors differ in terms of IPR intensity, there are no grounds to anticipate any particular sector being more likely to assign IPRs to the customer than some other.

Finally, a few points concerning other factors potentially affecting contractual allocation of control rights need to be made. Looking at contracts through the lens of the property rights literature excludes other contractual issues, yet the value of a contract for the parties concerned is composed of a number of issues. In fact, retaining control rights may not necessarily be the primary objective of a firm. [13]

Cash flow rights to future surplus are another mechanism used to solve the incentive problem (see e.g. Holmström & Milgrom, 1994). Elfenbein & Lerner (2003), for example, observed in their empirical work the considerable attention given by contracting parties to the specification of contingent payment terms. In buyer-supplier relationships the compensation to the supplier for the output can be either a lump sum transfer (cash payment for the transfer of property right or license fee for the right to use the output) or a portion of the cash flow from future sales (royalty payment). Since property right to a

[13] For example, in internet portal alliances Elfenbein & Lerner noted that contracts served in the late 1990s as a signaling device for the stock market, and concluded that large payments at the cost of control rights may have been preferred by a partner who wanted to maximize the signaling effect of the contract.

productive asset involves an option for future revenue, the sum paid to the supplier decreases with the supplier's property right.

Other efficiency considerations than those related to incentives may also have implications for the allocation of asset ownership. The existing asset stocks, i.e., *ex ante* investments of the parties play a role as well. The party with complementary assets and capabilities is better equipped to take advantage of and further develop the focal asset. Consequently, the more the buyer and the supplier are different in their core competencies, the less likely there is room for conflicting interests in ownership allocation. Nevertheless, IPR ownership may be desirable for the customer even if the asset was outside its core competences. Ultimately, ownership rights hedge against uncertainty about future contingencies, even though in the "business-as-usual" state of the world the customer would not have an economic interest in controlling the residual rights to the output.[14]

Descriptive and univariate data analysis

Summary statistics of the estimation variables are provided in Table C. Financial constraints seem not be a primary concern among the sample firms: fewer than one out of ten firms have reported difficulty in acquiring equity from the private sector. The customer relationships are characteristically asymmetric in terms of size: 90 per cent of suppliers have a key customer with sales five times larger than their own. Key customer dependence in business operations is nevertheless, on average, at a moderate level: the customer occupies over half of the capacity only in 22 per cent of firms. The mean of sample R&D intensity is relatively high, owing to some firms whose R&D expenditure exceed their sales. Key customers' involvement in output development is important for 65 per cent of suppliers. Firms in the medium high-technology sector have the largest share (31%) while the least represented firms are from the basic services sector (12%).

The distributions of the dependent variables indicating the customer's control on relationship-specific output suggest that it is the *supplier* who gains control on relationship output most of time. Indeed, the supplier receives property rights to all intellectual property that is created in 75 per cent of relationships (Table D). IPR sharing between partners seems more an exception than a rule: in only 20 per cent of those relationships that produce more than one IPR type both partners gain control right. This observation may be a sign of bundling of IPRs in contracts on an "all-or-nothing" basis. There thus may be some contractual mechanism, not accounted for by the theoretical model, that partly determines how intellectual assets are distributed in relationships. In this sample, the bias seems to be in the favour of supplier's ownership.

[14] Here I assume that selling the output to the supplier's other customers would not dissipate rents from the focal customer [cf. \(Arora & Merges, 2004).

Looking at IPR allocation by type (Table C), patentable inventions, as opposed to the other two IPR types, appear least frequently as a relationship output but end up to the customer's control relatively most frequently. Trade secrets are the most common type of intellectual output, while copyright is the IPR type that most likely remains at the supplier's control.

Correlations between estimation variables, provided in Table E, also reflect the bundling effect: there are high significant correlations between the different types of IPR. The aggregated dependent variable for the customer's control show significant positive correlation with the customer's investment criticality, but pairwise correlations with other independent variables are not statistically significant. There is relatively little statistically significant interrelatedness between independent variables, and the absolute values of correlation coefficients give no reason to concern about serious multicollinearity in the following regression analysis.

Are those suppliers that cede IPRs to the customer different from those who retain them? To investigate this question, I run proportion and mean comparison tests for the two groups of suppliers. I test the null hypothesis that suppliers yielding and retaining IPRs are not different in terms of the independent variables. The test results in Table F suggest that the two groups differ in several respects, at least at better than the 10 per cent significance level in one-sided tests. Suppliers that retain IPRs tend to be more R&D intensive, and the customer's involvement in product development is less important for these suppliers. The share of specialized firms in the two supplier groups is approximately the same, *but* R&D intensity among those specialized suppliers that retain ownership is significantly higher than among those that yield property rights away. Moreover, property right owners, as compared to non-owners, are on average larger in size, and their productive resources less occupied by the key customer. The supplier portrait provided by the univariate analysis is consistent with the underlying theoretical considerations.

3.2 Estimation Methods and Implementation

In the following regression analyses concerning the event of the customer's IPR ownership, I estimate the logit model with the maximum likelihood (ML) method. In general terms, the ML estimation generates values for the unknown parameters, which maximize the probability of obtaining the observed data. Logit produces the predicted probability of a positive outcome (i.e., the customer's ownership equals 1) for a given set of independent variables. The partial effect of an independent variable on the probability of a positive outcome is not constant but depends on the values of all independent variables.

The errors in the logit model have standard logistic distribution, which are assumed independently and identically distributed with zero mean and constant variance. Cross-section data, however, often violate the homoskedasticity assumption (Godfrey, 1988; Maddala, 1983). Heteroskedasticity leads to inconsistent estimates in binary choice models and corresponds thus to the case of misspecification in classical linear regression models. Therefore heteroskedasticity-robust standard errors have been recommended instead of standard ML errors since they are asymptotically valid in the presence of any unknown heteroskedasticity (e.g. Johnston & DiNardo, 1997; Wooldridge, 2002). Both standard and robust standard errors are reported in Table G.

In logistic regression the evaluation of observations with large influence on estimated parameters is hampered by the fact that test statistics are not normally distributed, and thus the assessment of "large" influence is ultimately made by subjective judgement (Hosmer & Lemeshow, 2000). I use two alternative statistics suggested by Hosmer & Lemeshow (ibid.), which are Delta $\chi 2$ and Pregibon's Delta β influence statistic. The authors provide rules of thumb to assess influential observations. These are the value of 4 for Delta $\chi 2$, and that of 1 for Delta β, but these "critical" values should, according the authors, be used only as a guideline in tandem with visual assessment of the plots of the diagnostics. I use the rule-of-thumb threshold value for Delta β but for Delta $\chi 2$ the higher value of 5 because the plot of the diagnostics versus the predicted values of the dependent variable produces a uniform curve up until this value. Four observations with poor fit are omitted.

A similar analysis of diagnostics (results not exhibited) for the individual IPR type regressions points to several highly influential cases as candidates for removal. This implies that some important explanatory variable may be missing from the model explaining the division of individual intellectual assets. Since the values of the independent variable for the influential observations are reasonable, I do not remove all of them, but only those with the relatively extreme values of Delta β. This criterion excludes only one observation from each sub-sample. The use of more conventional threshold values would exclude several more observations, which, as said, seem to lack some excluded variable. The detected model misspecification is likely to give rise to biased parameter estimates, and therefore the subsequent regression results of the separated IPR types ownership can be only suggestive.

In the model specification stage alternative measures of size (number of personnel, log of sales, and log of assets in 2002) were tested. The number of personnel was chosen being the only size measure with statistically significance, and the respective model specification had the highest likelihood-ratio index (R^2_{McF}). The choice of the size measure had little effect on other results. I also tested the suitability of the share of the customer's sales of total sales as an alternative to the customer's capacity occupation as an indicator of supplier's dependence. The estimation results of the specification with capacity occupation outperformed in terms

of R^2_{McF} and the LR test, while the choice between measures left other results virtually unaffected.

Two other measures of the supplier's financial status were tested in place of equity constraint. These were the supplier's profit rate and total equity, which, however, suffered from missing observations and did not provide any better explanatory power than the equity constraint measure. The significance of the length of the relationship was also tested as a potential explanatory factor, but ultimately excluded, as it was a variable from outside the testable theory and did not improve the results. I was also able to test the influence of the appropriability regime on control allocation, as suggested by Leiponen (2004). A dummy variable for firms that regard the legal methods of intellectual property protection as important in their industry was introduced in the model, but – conforming the results of Leiponen – gained no statistical support.

The presence of multicollinearity was checked by variance inflation factors (VIF). I ran the ordinary least squares estimation to calculate these factors and used the two commonly applied informal rules of thumb to determine whether correlation between explanatory variables is likely to inflate standard errors (Chatterjee, Hadi, & Price, 2000). According to these rules, multicollinearity is detected if *1*) the largest VIF is greater than 10, and *2*) the mean of all the VIFs largely exceeds 1. In this sample, the VIFs range between 1.03 and 1.90, and the mean equals 1.36, thus, no serious multicollinearity is found.

The analysis of the allocation of different IPR types requires special attention paid to the estimation method. It is reasonable to assume, based on the high correlation coefficients, that some relationship-specific pattern affects the allocation of different types of IPRs in a relationship and therefore we can expect that the error terms of individual equations be correlated. To account for this interrelation, I estimate the equations as a group and apply the seemingly unrelated regression (SUR) procedure using a logit specification. The parameter estimates of the separate logit regressions are used to estimate variance-covariance matrix for the error terms, which are then used in the simultaneous estimation procedure. Linking the equations by their error terms increases the efficiency of parameter estimates.

3.3 Regression Results

The first regression analysis involves the customer's IPR control dummy as the dependent variable. The estimation results of logit regression are provided in Table G. Both maximum-likelihood and heteroskedasticity-robust standard errors are reported. In the subsequent analysis, I refer to heteroskedasticity-robust *t*-statistics. The table also reports the marginal change with all variables at their means.

Looking first at the variables that have statistically significant coefficient estimates, four variables stand out as significant at better than the 10% confidence level. These are the size of personnel and the age of the supplier, the interaction term between R&D intensity and the dummy for specialized suppliers, and the importance of the customer's investment. The customer's dominant (over 50%) share of capacity occupation is significant at the 10% borderline. The direction of the effect of supplier's age on customer's ownership is against the hypothesis that the younger firms would be more likely assignors of IPRs. The signs of the other significant regressors are in the assumed direction, indicating that the probability of customer's IPR ownership decreases with an increase in the supplier's size and R&D investments in the case of focused product line. The probability of the customer's IPR control increases if the customer is a significant business partner both in terms of engaging in product development and employing the supplier's resources. These results provide empirical support to the investment criticality and bargaining-power hypotheses of the property rights theory.

Considering the supplier's product strategy in terms of R&D intensity and product specialisation separately, there is no significant relation to ownership allocation. When interacted, however, their impact on IPR allocation seems to be significant, both statistically and substantively. This result is intuitive: such a strategy reflects a supplier's objective of developing core competences i.e., unique knowledge and skills pertaining to a particular technology, and IPRs developed in customer relationships can be expected to relate to these core competences. Therefore, suppliers with such a "focused product development strategy" most likely want to retain the new pieces of valuable knowledge. Thus, the cost of yielding IPRs away is higher for them than for firms that are, say, specialized in one or few products but do not invest importantly in their development, or for those that are R&D intensive but whose investments disperse over a wide range of product technologies.

In contrast to earlier findings in the biotechnology industry (Lerner & Merges, 1998), in this cross-industry data there is no evidence of financial constraint affecting contractual outcome when industry-specific effects are controlled for. However, the uneven distribution of observations on equity constraint decreases the efficiency of the estimate. On the other hand, this result is robust to the use of alternative measures for suppliers' financial position (i.e., profit rate and equity in unreported regressions). The variable for the customer's dominant size suffers also from unevenly distributed observations, and leaves some doubt on the robustness of the result. There is no empirical support to significant systematic difference in the IPR allocation pattern between different industrial sectors.

The results of ordered logit analysis, performed as a robustness check, are provided in Table G. The variable labelled as **IPR allocation** distribute cases according to three allocation outcomes, i.e., whether or not the customer receives property right to all intellectual output,

or whether the IPRs are shared with the supplier. The problem of unevenly distributed observations is aggravated in this analysis, but we observe that the results are robust to the change in the codification of the dependent variable.

Let us evaluate the substantive significance of the variables that gain empirical support in explaining the allocation of IPRs.[15] Since models for categorical outcomes – such as logit used here – are nonlinear, the marginal change with respect to an independent variable is not constant like in linear regression models. Marginal change depends on the values of all variables, which need to be therefore fixed for marginal analysis. Considering changes in predicted probabilities of customer's IPR ownership at the means of all independent variables, we notice in Panel 1 in Table H that the effect of suppliers' focused product development strategy on IPR allocation is indeed important. To assess the economic effect of this interaction term it is most illustrative to compare the customer's ownership probability in relationships with non-specialized and with specialized suppliers (i.e., the value of specialization dummy changes from 0 to 1). At the estimation sample means (R&D intensity equalling approximately 14 per cent) the likelihood of the customer's ownership is .10 lower (decreasing from .22 to .12) in relationships in which the supplier is specialised. The 95% confidence intervals of the probability estimates are however overlapping indicating that the true difference could be smaller or even zero.[16]

The customer's investment criticality has a countervailing effect on control allocation but of lesser magnitude. A discrete change from unimportant to important (i.e., from 0 to 1) customer involvement increases his chance of gaining property rights by approximately .11 holding all other variables at their means. Considering the customer's investment effect in relationships with specialized and non-specialized suppliers (with all other variables at their means) the following effects are observed: with both kinds of suppliers, the customer's investment importance clearly more than doubles his chances of IPR control (from 0.12 to 0.30 with non-specialized and from 0.06 to 0.18 with a specialized supplier), but there is a notable difference in the level of probability depending on the type of the supplier (Panel 2 in Table H).

A unit change in the number of personnel around the mean (19.56) has a negligible effect on IPR allocation: the reduction in the probability the customer's ownership reduces by -.003. Even at very small personnel size the effect remains close to zero. The effect of a unit change in supplier's age around the mean (16.42 years) is of the same magnitude yet in the opposite direction. The effect of the customer's dominance in the supplier's capacity occupation, which is at the borderline of statistical significance, is positive improving the

[15] Marginal analysis at the point estimates offers, of course, only a suggestive idea of the economic importance of the independent variables. The cautious reader is encouraged to refer to the 95% confidence intervals in the Table H.

[16] The 95% confidence intervals are (.0635,.2241) and (.1602,.2980).

customer's chance of ownership by .07. To conclude, the present empirical results suggest that bargaining power has only a secondary impact on control allocation.

The summary statistics in Table I illustrate the distribution of the predicted values of the probability of the customer's ownership for individual observations. The predicted probabilities range between 0 and .71, and the median of predictions is .25 indicating a notable bias towards the probability of suppliers' ownership.

At the mean values of the independent variables the probability of the customer's ownership is as low as .11. What would it be for the "extreme" relationship profiles involving either a supplier with high bargaining power and relatively critical product-related investments, or one with low bargaining power and relatively standard products? I set the values of the variables to their minimum or maximum sample values according to hypotheses set forth above, and the calculation produces the following results.[17] In the case of a "weighty" supplier the probability of the customer's ownership is .00, while in the opposite case of a "light-weight" supplier the customer's chance of getting IPRs is .40.

The results of this analysis provides further support to the observation that IPRs are not symmetrically distributed in vertical relationships, but there is a bias towards suppliers' ownership. In fact, this seems like a plausible result in the light of the substantive and statistical significance of the variables approximating the relative investments of the partners. In vertical relationships that produce non-standard solutions to the customer's needs, the supplier's knowhow can be expected to be important for successful outcome. In other words, there must be some level of *ex ante* investments made by the supplier that the customer considers valuable – if not, the customer could, in principle, resort to in-house production. In the case of a standard solution, in turn, the market would produce the most efficient outcome. In hierarchies and market transactions, to be sure, the issue of IPR allocation becomes trivial. Therefore, in non-standard exchange relationships contracts can be expected to allocate control to a supplier who has done the "groundwork".

However, the importance of *ex post* investments weighs as well, as both the theoretical and empirical results suggest. The more the customer gets involved in the production process the probability of his ownership clearly increases, but much more uncertainty as to positive ownership seems to remain.

Aghion & Tirole (1994), as discussed earlier, state that the ownership is *always* efficiently allocated (i.e., value of output optimised) if the supplier has the decision (i.e., superior bargaining power). Also Arora & Merges (2004) make a strong argument for suppliers' IPR ownership for the sake of efficiency. In the light of the present empirical results it can be

[17] For the industry dummies I use mean values.

argued that firms are more concerned about maximization relationship output than individual benefits reaped by exploiting bargaining power.

The theory of property rights allocation ignores the inherent differences between different types of IPRs. With the data at hand, however, it is possible to investigate whether their distribution in vertical relationships is actually uniformly determined. Since it is reasonable to assume that the error terms between the three individual equations pertaining to patentable inventions, copyrights, and trade secrets are correlated, I apply the seemingly unrelated regression (SUR) method using a logit specification and test whether the parameter estimates across the IPR types are equal.

The estimation results, provided in Table J, suggest that we can reject at the 5% confidence level the hypothesis that the three IPR types are allocated according to the same contractual model (Wald $\chi^2(28) = 44.22$ (adjusted for covariance of error terms), $p=0.0264$). Wald-tests for equality of each variable across equations indicate that the allocation of IPRs differ by type. One should note that in the sub-samples the number of cell observations decreases, and renders the statistical significance of coefficients doubtful. This problem pertains particularly to supplier's equity constraint and the customer's dominant size.

The SUR estimation results indicate that the customer's investments are significant in contracting for patentable inventions and copyrights but not so for trade secrets. In relationships creating patentable inventions the likelihood of the supplier's ownership seems to increase with its market share, while in relationships producing trade secrets the supplier's age has a positive yet substantively negligible impact on their control allocation. The Wald test indicates that the coefficient of R&D investments of specialized suppliers does *not* differ across equations. The p-values of the estimates range between .051 and .127 implying at least a moderate statistical sensitivity of contracts to suppliers' product strategies in all three cases.

Comparing the results from the regression using the aggregated measure of the customer's IPR ownership with those obtained from the simultaneous analysis of individual IPR type ownership, the empirical support for certain explanatory variables is somewhat consistent. Both analyses provide strong empirical evidence for the significance of the relative investments of both partners. Also the supplier's age remains significant in both analyses. The results are mixed as regards to the supplier's size and market share in that these variables gain statistical support only in one of the two regressions. In both models, there was no sign of inter-industrial differences in the pattern of IPR allocation.

3.4 Conclusions

This paper concerns testing the hypotheses of the property rights literature in the context of creative vertical relationships in Finland. Creativeness in buyer-supplier relations refers to

non-standard solutions developed on the basis of the customer's individual requirements. Production of such solutions requires relationship-specific investments *ex post* that are difficult to fully describe *ex ante*. Therefore incentive alignment is important to induce critical investments. The property rights theory allocates control to relationship output to the party whose investment has larger marginal effect on the output. The output of innovative relationships is likely to embed novel components that distinguish it from those existing in the market. Therefore, both parties to the contract may have interest in retaining property right to the asset – yet, as discussed in the paper, there are cases in which there is no case for conflict of interest. Another determinant of ownership allocation acknowledged in the property rights framework is bargaining power.

More recent contributions to the property rights literature argue that control allocation is always efficient if the supplier obtains property rights to the output under contract, since the supplier can always assign *ex post* those rights to the customer in exchange for cash. The reverse case, i.e., the customer's ownership does not necessarily produce the optimal outcome, if the supplier is unable to compensate the transfer due to cash constraint.

The results of this study produced strong empirical support for the firms' being concerned about efficient allocation of property rights in innovative relationships. The empirical measures used for capturing the effect of relative investments showed both statistical and economic significance. For the supplier, focused product range together with R&D investments seem to provide an effective strategy for gaining IPR ownership. The importance of customer's involvement has, however, a countervailing effect, which seems to be by far the most important factor improving the customer's probability of control.

Measures of bargaining power gained much less pronounced empirical support. The age of the supplier was a statistically but not substantively important explanatory factor across regressions. The sign of the relation was also in unexpected direction, suggesting that younger firms are more likely retainers of IPRs. The other power measures obtained less or no empirical support. In contrast to prior evidence, this cross-section data provided no evidence of financial constraint affecting contractual outcome when technology-based industrial sectors were controlled for. In the light of the famous evidence from the biotechnology sector (Lerner & Merges, 1998) the results at hand provide a more encouraging picture of asymmetric collaborative buyer-supplier relationships. Finally, there was no empirical difference as to control allocation pattern between industrial sectors grouped according to the general knowledge-intensity of output.

The present data exhibited strong tendency towards the probability of the supplier's ownership. I argue that in relationships creating customized products the input of the supplier can be expected to be important both *ex ante* and *ex post*, while the importance of

the customer's investment depends on the output characteristics. Hence, the supplier's ownership can be regarded as the default contractual outcome *ceteris paribus*. The empirical finding of the high likelihood of the supplier's control conforms to the theoretical prediction of the optimal control allocation.

It needs to be emphasized that there are rarely standard contractual solutions to the IPR allocation problem. Much more complex and finer aspects than those suggested by the theory are present in contract negotiations. For example, IPR ownership may not be the primary objective of both parties. The model excludes e.g., price as an explanatory variable, which affects the attractiveness of the produced IPRs. Particularly the diagnostics of the estimation results of the individual IPR allocation leads to suspect that the empirical model has not captured some influential aspects of contracts determining control.

The measures of investment criticality included in the empirical model are also highly generic. The importance of partners' investments implied by the results lead to suspect that there remain some dimensions of relative investments that are not properly accounted for by the empirical model. One can expect that control allocation is sensitive, for example, to the strategic importance of knowledge embedded in the output, i.e., whether it lies inside or outside each partner's core competencies, and to whether the contract involves refinement of the customer's existing product or an entirely novel product, and to the characteristics of the product, i.e., whether it is replicable or highly customer-specific.

The traditional habit of economists to treat IPRs as a lump overlooks the fact that different IPR items differ substantially from one another. Indeed, one can question whether it is justified to investigate IPRs as a lump, since one could expect differences in the pattern of their control allocation. The results of empirical analysis imply that there are statistically significant differences in the allocation models of individual IPRs, yet data deficiencies undermined the robustness of these results. On the other hand, however, the data revealed significant correlation between the allocations of individual rights. Such contractual bundling of assets can be attributed to the fact that different forms of intellectual property rights are produced in tandem and thus, they are complementary and not sensibly divisible between contracting parties. From this perspective, considering different IPR types as an aggregate can be well justified in economic analysis.

To conclude, there is room for fine-tuning the theory and concepts to better reflect the contractual complexity and array of tools that are in use in firms. Work into this direction has been set off by Aghion & Tirole (1994), who look at more complicated, or *split* property rights observed in research employment contracts. To note, the right of ownership is one of the two contractual rights identified by Grossman & Hart (1986) (i.e., specific rights and ownership rights). Ownership rights can be – and *are* in most contracts – limited by

agreements yielding exclusive rights to the non-owner of IPRs, which thereby reduce the economic value of ownership rights. Empirical research on contracts allocating both types of rights, which remains scant in number, would provide a more accurate insight of contractual behaviour of firms.

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5 Tables

Table A Survey questions and variable scales

Note: This table presents original questions (translated from Finnish) drawn from three consecutive surveys (Survey 1: December 2001- January 2002, Survey 2: November 2002, and Survey 3: June-August 2003) administered by the Research Institute of the Finnish Economy ETLA and Etlatieto Ltd . Some questions forming estimation variables are conditional on previous responses. In such cases the preceding questions are reported prior to the effective question, and their scales are marked behind the question, not in the "Original scale" column.

Variable *Dependent variables*	**Survey question**	**Original scale**	**Transformed scale**	**Survey number**
	Introductory phrase read to the respondent: Please answer to the following questions considering the customer that is the most important for your company in term of sales. In this questionnaire, this customer is referred to as the key customer. *Scales*: Very much=1, quite much=2, little=3, not at all=4; Yes=1, no=0.			
	Consider the product or service, which is the most important in terms of sales in the key customer relationship. How much is the product or service generally customised to the needs of the key customer? (1-4) (If 1-2):			3
Patentable inventions	When your firm customises a product or a service to the key customer do patentable inventions ever come out as an output? (1/0) (If 1): Do patentable inventions remain in these cases to a significant extent under your company's ownership?	1/0	1=0, 0=1	3
Copyrights	Does customisation to your key customer ever develop products with copyrights – such as software, databases, audio-visual or literal products, e.g., reports? (1/0) (If 1): Do copyrights remain in these cases to a significant extent under your company's ownership?	1/0	1=0, 0=1	3
Trade secrets	Does customization to your key customer ever develop solutions that can be considered trade secrets – relating to e.g., production methods, product features, software tools, materials, or business models? (1/0) (If 1): Do trade secrets concerning these solutions remain to a significant extent under your company's ownership?	1/0	1=0, 0=1	3

Variable *Independent variables*	**Survey question**	**Original scale**	**Transformed scale**	**Survey number**
Equity constraint	A. Has your firm attempted to get equity from the private sector within the last 12 months? (1/0) (If A=0) B. Has your firm had the *need* for outside equity finance within the last 12 months, but you haven't attempted to get it from the private sector? (1/0) (If B=1): C. The reason is: a. You got finance from the public sector. b. You did not believe in your possibilities to get equity finance. c. You believed the search costs for finance would be too high, i.e., it would take too much time and resources to find appropriate financiers. d. The real costs of equity would have been too high. e. Some other reason. (If A=1) D. Have your attempts to get equity from the private sector failed within the 12 months? a. All attempts failed. b. Some attempts failed and some were successful. c. All attempts were successful.		1 if: A=1 and D=a, *or* A=0 and B=1 and C=b-e Otherwise 0	2
Market share	(If 1 to Specialization (below)) Estimate the market share of that product or service solution in your main market. (If 0 to Specialization) Estimate the average market share in your main market of those products or service solutions that together account for over 90% of your firm's sales. (Note: Main market denotes the geographical area or industrial sector, which accounts for over 50% of the item's / items' sales.) *(Alternatively*: use response classes (%): 0-5, 6-10, 11-25, 26-50, >50.)	1-100% 1-100%	0-1 0-1 Class mean	1
Age	In which year was your firm established?	(year)	2002-year	1
Dominant customer	Are your key customer's total sales over 5 times larger than your firms'?	1/0	not transformed	3
Capacity occupation	Does the key customer relationship occupy over half of your firm's resource capacity? (Note: resource capacity relates to both personnel and other resources that the catering of the relationship requires.)	1/0	not transformed	3
Customer's investment	Does the key customer participate in the development of the product or service supplied by your firm? (Note: If your firm supplies several items to the key customer, consider the most important in sales terms in this relationship.)	1-4	1 & 2 = 1 3 & 4 = 0	3
Specialization	Does one of your products or service solutions account for over 90% of your firm's sales?	1/0	not transformed	1
R&D intensity	How much was your firm's R&D expenses in the last ended accounting period? (Note: R&D denotes systematic activity with an objective of increasing knowledge or applying existing knowledge to develop new applications. R&D includes both internal and outsourced R&D projects.) *(Alternatively*: Could you estimate using classes below what has been the average R&D share of sales of your firm during the past two years? No R&D activity, 0-1, 2-5, 6-10, 11-50, >50.	(MFIM or MEUR)	(MEUR)/sales in 2000) No R&D activity = 0 Other: Class mean	1

Table B Definition of industrial groups

Industrial group	NACE code	Description
High-technology	244	Manuf of pharmaceuticals etc
	30	Manuf of electrical equipment etc
	321	Manuf of electronic components
	322	Manuf of radio transmitters etc
	353	Manuf of aircraft and spacecraft
Medium high-technology	24	Manufacture of chemicals etc (exl.244)
	29	Manuf of machinery and equipm nec
	31	Manuf of electrical machinery nec
	323	Manuf of radio receivers etc
	33	Manuf of medical instruments etc
	34	Manuf of motor vehicles etc
	352	Manuf of railway and tramway locomotives etc
Information-intensive services	642	Telecommunications
	721	Hardware consultancy
	722	Software consultancy and supply
	73	Research and development
	743	Technical testing and analysis
Basic manufacturing		Manufacturing not elsewhere cited
Basic services		Services not elsewhere cited (exl. finance and real estate sectors)

Table C Summary statistics of estimation variables

Variable	Unit	Obs	Mean	Std. Dev.	Min	Max
Dependent variables						
Customer's:						
IPR control	1/0	302	0.248	0.433	0	1
IPR control share	0-2	302	0.411	0.754	0	2
Patentable inventions	1/0	84	0.298	0.460	0	1
Copyrights	1/0	127	0.145	0.358	0	1
Trade secrets	1/0	284	0.211	0.409	0	1
Independent variables						
Personnel	count	326	19.501	32.921	0	249
Equity constraint	1/0	326	0.092	0.290	0	1
Market share	0.01	276	0.265	0.285	0	1
Age	years	325	16.692	16.354	1	119
Dominant customer	1/0	319	0.903	0.297	0	1
Capacity occupation	1/0	325	0.225	0.418	0	1
Customer's investment	1/0	326	0.647	0.479	0	1
Specialization	1/0	324	0.269	0.444	0	1
R&D intensity	0.01	317	0.164	0.544	0	7.5
High techology	1/0	325	0.172	0.378	0	1
Medium high tech	1/0	325	0.314	0.465	0	1
Info-intensive services	1/0	325	0.212	0.410	0	1
Basic manufacturing	1/0	325	0.182	0.386	0	1
Basic services	1/0	325	0.120	0.325	0	1

Table D Distribution of IPRs created in relationships

Number of IPR types controlled by:		*Supplier* 0	1	2	3	Total
Customer	0	0	141	60	26	227
	1	31	20	5	0	56
	2	15	1	0	0	16
	3	3	0	0	0	3
Total		49	162	65	26	302

Table E Coefficients of correlation of estimation variables

Note: Asterisk denotes statistically significant correlation at th 5% level.

	IPR control	IPR ctrl shr	Patentables	Copyrights	Trade secrets	Personnel	Eq.constr.	Market share	Age	Dominant
IPR control	1.0000									
IPR control share	0.9491*	1.0000								
Patentable inventions	0.9428*	0.8961*	1.0000							
Copyrights	0.6755*	0.8521*	0.6187*	1.0000						
Trade secrets	0.8587*	0.9288*	0.4687*	0.6414*	1.0000					
Personnel	-0.0964	-0.0852	-0.0892	0.0734	-0.0887	1.0000				
Equity constraint	-0.0252	-0.0075	-0.0983	0.0040	-0.0265	-0.0828	1.0000			
Market share	-0.0021	-0.0106	-0.2166	-0.0136	0.0205	-0.0197	-0.0632	1.0000		
Age	-0.0320	-0.0295	-0.0787	-0.0895	-0.0349	0.2216*	-0.0493	0.1321*	1.0000	
Dominant customer	0.0291	0.0111	0.0420	0.0563	0.0244	-0.0108	0.0669	-0.0718	-0.0478	1.0000
Capacity occupation	0.0789	0.0918	0.1842	-0.0185	0.0772	-0.0308	0.0067	-0.0458	-0.0809	-0.0480
Customer's investment	0.1643*	0.1386*	0.1959	0.1723	0.1034	0.0306	-0.0093	0.0918	-0.0549	-0.0619
Specialization	-0.0213	-0.0161	-0.0851	-0.0043	-0.0217	-0.0092	0.0707	-0.0303	-0.0092	-0.0171
R&D intensity	-0.0470	-0.0489	-0.0879	-0.0639	-0.0486	-0.0250	0.0422	-0.1039	-0.0659	-0.1473*
High technology	0.0618	0.0884	0.0173	0.1104	0.0664	0.0314	0.0234	-0.0966	-0.1291*	0.0377
Medium high tech	-0.1103	-0.0962	-0.1812	0.0108	-0.1016	0.0639	-0.0553	-0.0368	0.0091	-0.0952
Info-intensive services	0.0779	0.0142	0.2376*	-0.0864	0.0561	-0.1025	0.0424	-0.0309	-0.2390*	0.1432*
Basic manufacturing	-0.0477	-0.0435	-0.0152	0.0040	-0.0539	0.0648	0.0153	0.1211*	0.3897*	-0.1232*
Basic services	0.0480	0.0702	-0.0251	-0.0167	0.0672	-0.0757	-0.0196	0.0604	-0.0244	0.0578

	Capacity	C's investment	Special.	R&D	Hi tech	Med hitech	Info-intens.	Basic manuf.	Basic serv.
Capacity occupation	1.0000								
Customer's investment	0.1330*	1.0000							
Specialization	0.0724	-0.0203	1.0000						
R&D intensity	0.0982	0.0239	-0.0061	1.0000					
High techology	0.0466	0.0110	-0.0375	0.1121*	1.0000				
Medium high tech	0.0321	0.0386	-0.1221*	-0.0337	-0.3086*	1.0000			
Info-intensive services	-0.0058	0.0505	0.0080	0.0198	-0.2369*	-0.3511*	1.0000		
Basic manufacturing	-0.0439	-0.0553	0.0750	-0.0575	-0.2149*	-0.3185*	-0.2445*	1.0000	
Basic services	-0.0406	-0.0659	0.1183*	-0.0389	-0.1685*	-0.2497*	-0.1917*	-0.1739*	1.0000

Table F Summary statistics of one-sided t-tests and proportion tests

H0: Group means (for continuous variables) / group proportions (for dummy variables) are equal.
The sigh of Ha refers to the theoretical assumptions set forth in the main text.
Group 0: Customer's IPR control=0, Group 1: Customer's IPR control=1.

Variable	Group	Obs	Mean	Std. Err.	Std. Dev.	Ha:diff >0 *p*-value	Ha:diff<0 *p*-value
Personnel	0	227	21.399	2.352	35.438	0.025	
	1	75	13.960	2.960	25.639		
Equity constraint	0	227	0.097	0.020	-		0.669
	1	75	0.080	0.031	-		
Market share	0	189	0.272	0.020	0.273	0.488	
	1	67	0.270	0.040	0.325		
Age	0	226	17.398	1.177	17.687	0.226	
	1	75	16.160	1.594	13.806		
Dominant customer	0	221	0.900	0.020	-		0.309
	1	75	0.920	0.031	-		
Capacity occupation	0	227	0.216	0.027	-		0.085
	1	75	0.293	0.053	-		
Customer's investment	0	227	0.590	0.032	-		
	1	75	0.773	0.048	-		0.002
Specialization	0	226	0.279	0.030	-	0.712*	
	1	74	0.257	0.051	-		
R&D intensity	0	222	0.316	0.145	2.160	0.085	
	1	73	0.112	0.030	0.254		

* two-sided test

Table G Estimation results for the likelihood of the customer's IPR ownership in vertical relationships

	Logit model for Customer's IPR control				*Ordered logit model for Customer's IPR control share*		
	Coef.	**Std. Err.**	**Robust Std. Err.**	**p-value**	**Coef.**	**Robust Std. Err.**	**p-value**
Personnel	-0.025	0.011	0.009	0.007	-0.025	0.010	0.010
Equity constraint	-0.311	0.587	0.640	0.626	-0.255	0.681	0.708
Market share	-0.051	0.535	0.568	0.928	-0.124	0.551	0.821
Age	0.021	0.011	0.011	0.057	0.021	0.010	0.044
Dominant customer	0.361	0.569	0.576	0.531	0.280	0.596	0.639
Capacity occupation	0.608	0.362	0.375	0.105	0.663	0.389	0.089
Specialization	0.095	0.413	0.394	0.809	0.195	0.411	0.636
R&D intensity	-0.309	0.566	0.482	0.522	-0.324	0.542	0.550
Specialization X R&D intens.	-5.706	4.498	2.678	0.033	-5.795	2.641	0.028
Customer's investment	1.170	0.384	0.360	0.001	1.170	0.369	0.002
Medium high tech*	-0.736	0.478	0.479	0.125	-0.745	0.490	0.128
Info-intensive services*	0.327	0.499	0.515	0.526	0.140	0.508	0.783
Basic manufacturing*	-0.663	0.549	0.520	0.202	-0.748	0.519	0.150
Basic services*	-0.079	0.553	0.568	0.889	-0.061	0.574	0.916
Constant	-1.939	0.774	0.792	0.014			
Cut-point 1					1.834	0.800	
Cut-point 2					2.392	0.812	
N	241				241		
Log Likelihood	-119.543				-158.145		
LRchi2(14)	33.596				33.575		
p-value	.002				0.002		
McFadden's R2:	.123				0.096		
Pearson chi2(226)	210.10						
p-value	0.769						

Table H Marginal analysis

Panel 1 Marginal effects on the likelihood of customer's IPR control at the means of all variables

Variable	**Marginal effect**	**Std. Err.**	**z**	**P>|z|**	**95% confidence intervals**		**Mean**
Personnel	-0.003	0.001	-2.33	0.020	-0.005	0.000	19.562
Equity constraint*	-0.029	0.053	-0.54	0.589	-0.134	0.076	0.091
Market share	-0.005	0.058	-0.09	0.929	-0.120	0.109	0.270
Age	0.002	0.001	1.68	0.093	0.000	0.005	16.423
Dominant customer*	0.033	0.047	0.70	0.482	-0.059	0.126	0.892
Capacity occupation*	0.071	0.053	1.35	0.178	-0.032	0.174	0.228
Specialization*	0.010	0.041	0.24	0.808	-0.070	0.090	0.286
R&D intensity	-0.032	0.051	-0.62	0.534	-0.131	0.068	0.141
Specialization X R&D intens.	-0.584	0.151	-3.87	0.000	-0.880	-0.288	0.141
Customer's investment*	0.108	0.044	2.42	0.016	0.020	0.195	0.643
Medium high tech*	-0.068	0.044	-1.52	0.129	-0.155	0.020	0.295
Info-intensive services*	0.036	0.060	0.60	0.548	-0.082	0.154	0.195
Basic manufacturing*	-0.058	0.043	-1.36	0.173	-0.142	0.026	0.195
Basic services*	-0.008	0.056	-0.14	0.887	-0.117	0.101	0.129

Panel 2 Predicted probabilities of customer's IPR control for different values of supplier's specialization and customer's investment with all other variables at their means

Customer's investment	Specialization	Predicted probability
0	0	0.118
	1	0.062
1	0	0.302
	1	0.175

Table I Distribution of the probability of customer's IPR control

Percentiles	Predicted prob.	Smallest
1%	0.001	0.0000
5%	0.016	0.0001
10%	0.060	0.0006
25%	0.130	0.0008
50%	0.238	
		Largest
75%	0.381	0.6030
90%	0.462	0.6230
95%	0.503	0.6317
99%	0.623	0.7122
Obs	241	
Mean	0.253	
Std. Dev.	0.156	

Table J Customer's control on three IPR types: Estimation results of seemingly unrelated regression (SUR) procedure using logit

	Patentable inventions			*Copyrights*			*Trade secrets*				
	Coef.	Robust Std. Err.	p-value	Coef.	Robust Std. Err.	p-value	Coef.	Robust Std. Err.	p-value	Joint signif.: Wald chi2(3)	Equal b's: Wald chi2(2)
Personnel	-0.031	0.027	0.237	-0.002	0.012	0.882	-0.033	0.016	0.036	5.30	3.57
Equity constraint	1.119	2.746	0.684	-0.078	1.268	0.951	0.034	0.641	0.958	.30	.29
Market share	-3.566	1.323	0.007	-0.084	1.086	0.938	-0.097	0.613	0.874	7.67*	.6.77**
Age	-0.019	0.017	0.262	-0.020	0.035	0.569	0.021	0.011	0.057	7.94*	6.65**
Dominant customer	1.519	1.048	0.147	0.918	1.065	0.388	0.008	0.579	0.989	2.38	2.16
Capacity occupation	0.246	0.897	0.784	-0.272	0.802	0.734	0.611	0.396	0.123	3.44	1.42
Specialization	0.355	1.431	0.804	1.218	0.900	0.176	0.031	0.418	0.941	1.93	1.79
R&D intensity	0.177	1.110	0.873	1.446	1.880	0.442	-0.670	0.763	0.380	4.66	2.66
Specialization X R&D intens.	-28.057	18.368	0.127	-9.123	4.670	0.051	-7.365	4.204	0.080	7.10*	1.24
Customer's investment	2.189	0.835	0.009	2.794	0.808	0.001	0.444	0.368	0.227	16.84***	10.01***
Medium high tech	-1.239	0.854	0.147	-0.870	0.931	0.350	-0.822	0.516	0.111	3.80	.22
Info-intensive services	1.670	1.290	0.196	-0.837	0.797	0.294	0.230	0.564	0.684	3.60	3.47
Basic manufacturing	0.833	1.007	0.408	-0.352	1.021	0.730	-0.552	0.543	0.309	2.16	1.76
Basic services	-0.463	0.954	0.628	-1.140	1.975	0.564	-0.162	0.587	0.782	.61	.29
Constant	-1.680	1.307	0.198	-4.133	1.293	0.001	-1.141	0.841	0.175	-	-
N = 260											
Wald chi2(28) = 44.22											
p-value = .0264											
Log Likelihood	-27.867			-36.099			-106.559				
LR chi2(14)	30.45			17.10			23.70				
p-value	0.007			0.251			0.050				
McFadden's R2:	0.353			.1915			.1001				

Notes: LR chi2 and McFadden's R2 statistics relate to the individual logit regressions of the first phase of SUR.

*, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

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THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
LÖNNROTINKATU 4 B, FIN-00120 HELSINKI

Puh./Tel. (09) 609 900 Telefax (09) 601753
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