R&D Spillovers and Information Exchange: A Case Study*

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Abstract

We develop a model where R&D spillovers arise from the firms' incentive to exchange the R&D information after the investment cost has been sunk. In our model the information exchange is more likely to occur in industries with a more extensive product differentiation. The model thus predicts that the maximum incentives to exchange information can be found from the vertically related industries. Finally, we offer a real information-exchange agreement between Micronas and Micro Power Systems as an example.

JEL Classification: O31, O32, O34, L15, L63

1. Introduction

R&D spillovers are usually modelled as an automatic result of firms' investment in R&D (see De Bond, 1996, for a survey). In recent years, however, quite a few studies have attempted to explain them in various ways (see, e.g., Katsoulacos and Ulph, 1998, Kultti and Takalo, 1998, Amir and Wooders, 1999, Kamien and Zang, 2000, Martin, 2001). Systematic empirical evidence on the explanations, however, is scant. The aim of this study is to employ the relatively abundant data[1] on a real information-exchange agreement between two semiconductor manufacturers, Micronas and Micro Power Systems to evaluate the explanation by Kultti and Takalo (1998). They show that R&D spillovers can be endogenised in the sense that even without spillovers firms have an incentive to exchange the R&D information after the investment cost has been sunk.

In 1980 three Finnish companies Nokia, Aspo and Salora established a research joint venture called Micronas in order to develop semiconductors. Underlying the project was the transition in the semiconductor industry. Until the late 70s semiconductors were rather homogenous products that were available from numerous manufacturers. In the late 70s it became evident that in the future an increasing amount of semiconductors will be application-specific. In other words, the degree of product differentiation was changing. The world-wide demand for semiconductors was also outrunning production capacity. The prospects at least in the minicomputer industry were favourable in that the total market for computer semiconductors of $900 million in 1980 had been estimated to grow 20-25 percent a year. As against other countries with a significant electronics industry, Finland had

[1] Some of our information has been gathered from public sources, but our evidence mainly consists of the private documents on the files of Nokia and Micronas. The data extends to 1992 after which the Finnish owners sold Micronas to a Swiss company. The data and events are described in detail in Takalo and Kultti (1999) and used in Kultti and Takalo (2000, 2001). In this article we focus on previously unused material.

no semiconductor business of its own, which worried both the venture partners and policy-makers. The firms did not consider it desirable to rely solely on foreign suppliers and technology; they and the policy-makers believed that semiconductor manufacturing would be integrated so that companies in the electronics industry would make their own semiconductors.

The initial technology was bought and transferred from an American company, Micro Power Systems Inc. (MPSI), in 1980. The contract with MPSI was detailed and complicated, including equity participation clauses. Even so, co-operation with MPSI ran into difficulties because of disagreements about the interpretation of the contract. The research joint venture also encountered various other troubles, and as a consequence its ownership structure changed several times. Neither as a joint venture nor as Nokia's subsidiary Micronas was ever profitable (see Figure 1). Finally, after years of dismal economic performance, it was sold to an outside party in 1992, who rapidly rendered Micronas economically viable, by 1994 net profits were considerable. In 1999 former Micronas became again an independent Finnish firm through management-by-out arrangement. It changed its name to Micro Analog Systems.

In this article we focus on the information exchange agreement between Micronas and MPSI that was made on 1989. We first demonstrate how R&D spillovers can be explained as the outcome of simple information-exchange game, and then we offer the information-exchange agreement between Micronas and MPSI as an example. In contrast to Kultti and Takalo (1998), we choose the spillover specification initiated by Ruff (1969) that was subsequently made well-known by Spence (1984) and Kamien, Müller and Zang (1992). The specification postulates the spillover effect on R&D dollars.[2]

[2] In Kultti and Takalo (1998) the spillover effect is on final outcomes as in d'Aspremont and Jacquemin (1988). Although this spillover specification is perhaps more commonly used, Amir (2000) shows that such a spillover effect is too strong rendering the models invalid for large values of the spillover parameter. He advocates the specification employed in this study.

In the standard version of the mushrooming literature on R&D cooperation, the firms engage in Cournot competition with the additional feature that before production they may invest in cost-reducing R&D activities. These activities are characterised by spillovers; one firm's investment reduces the other firms' costs. The spillover is not perfect but there is a spillover parameter which is between zero and unity.

We show that Kamien, Muller and Zang's (1992) model is outcomewise equivalent with the following model. The firms make decisions in three stages; at the first stage they invest in cost-reducing R&D as in Kamien, Muller and Zang's (1992). There are no spillovers but the firms reap the full value of their investment. At the second stage the firms play a game where they may exchange their R&D results if both agree. We assume that the firms can make full use only of the R&D that they have conducted themselves. The value of other firms' R&D results is captured by a parameter between zero and unity. When it is the same as the spillover parameter in the original model, these two models yield the same outcome. The firms have an incentive to exchange research information after the R&D investments have been made. In particular, we show how the information exchange is more likely to occur in industries with a more extensive product differentiation. We then show that the incentive to exchange R&D information is stronger in a vertical relationship than in a horizontal relationship.

Our findings may partially explain some information-sharing arrangements in high tech industries such as cross-licensing and patent pooling agreements. Such an information-sharing agreement was made between Micronas and MPSI; for other examples, see e.g., Bessy and Brousseay (1998), Clark, Piccolo, Stanton, and Tyson, (2000), Arora, Fosfuri, and Gambardella (2001), and Rahnasto (2001). There is also a link between the predictions of our model and the widespread R&D cooperation in vertically related industries (e.g., Pisano, 1991, Bonaccorsi and Lipparini, 1994, Bidault, Despers, and Butler, 1998, Sakakibara, 2001, and Sobrero and Roberts, 2002).

In section 2 we construct a model where R&D spillovers arise from the firms' incentive to exchange the R&D information after the investment cost has been sunk. The events associated with the information exchange between Micronas and MPSI are described in detail in section 3. We also reproduce the confidentiality and disclosure clauses that amend the contract of the technology transfer. In section 4 we provide a systematic evaluation of the events.

2 A model of R&D spillovers and information exchange

We first present a version of Kamien, Muller, and Zang's (1992) model and then show how the spillover parameter can be explained as the outcome of simple information-exchange game. In our explanation we emphasize the degree of product differentiation.

2.1 Kamien, Muller, and Zang's model

There are two identical firms i and j. The inverse market demand function faced by firm i is $p_i=a-q_i-\gamma q_j$ where a is the demand intercept and $\gamma\in[0,1]$ is the substitutability parameter. Both firms operate as a monopoly if $\gamma=0$, and when $\gamma=1$, both goods are perfect substitutes. At the first stage the firms invest x_i, x_j in R&D, and in the second stage they engage in Cournot competition by choosing production q_i, q_j. The unit costs of firm i's production are $c-f(x_i+\beta x_j)$ where f is an R&D production function satisfying $f'>0$, $f''<0$ and $f(0)=0$. The degree of spillover is captured by $\beta\in(0,1)$, i.e. investment in R&D by firm j also decreases the costs of firm i. Given the Cournot competition in the second stage, the equilibrium profits of firm i can be expressed as

$$\pi_i = q_i^2 - x_i\,, \tag{1}$$

where

$$q_i = \frac{a - c + 2f\left(x_i + \beta x_j\right) - \gamma f\left(x_j + \beta x_i\right)}{2+\gamma}\,, \tag{2}$$

is the equilibrium quantity of firm *i*, and x_i and x_j are the equilibrium R&D investments of firm *i* and *j*.

2.2 The model with exchange of information

We consider a three-stage game. In the first stage the firms invest non-cooperatively in R&D and the second stage involves the decision to exchange information. In the last stage the firms decide about quantities in a Cournot manner. The model is the same as in Kamien, Muller, and Zang's (1992) except for two features. We assume that there are no spillovers, but there is the second stage game in which the firms decide whether to exchange their research information.

In the second stage the firms play a simultaneous-move game in which they can choose 'yes' or 'no'. If both choose 'yes' they exchange R&D information. In all other cases they do not exchange the information. If firm *i* gets firm *j*'s information, its costs are reduced by $f(x_i+\beta_i x_j)$, and similarly for firm *j*. Otherwise firm *j*'s R&D expenditure does not affect firm *i*'s costs.

If both firms say 'yes' in equilibrium their profits are as in Kamien, Muller, and Zang's (1992) since the spillover parameter is assumed to be the same, and the firms foresee the exchange of information that they naturally incorporate in their investment decision. Our equilibrium concept is a Nash equilibrium in undominated strategies.

PROPOSITION 1. *The firms always exchange information if the degree of spillover is symmetric, i.e.* $\beta_i = \beta_j = \beta$.

Proof: Consider the case with potentially different betas. The unit costs in the case of information exchange are $c\text{-}f(x_i+\beta_i x_j)$ and $c\text{-}f(x_j+\beta_j x_i)$. The profits of firm *i* as a result of this exchange are given by

$$\pi_i = \left[\frac{a - c + 2f\left(x_i + \beta_i x_j\right) - \gamma f\left(x_j + \beta_j x_i\right)}{2+\gamma}\right]^2 - x_i \,. \tag{3}$$

Without information exchange the profits of firm *i* are

$$\pi_i = \left[\frac{a - c + 2f\left(x_i\right) - \gamma f\left(x_j\right)}{2+\gamma}\right]^2 - x_i \,. \tag{4}$$

At the second stage R&D costs have already been sunk, and comparing (4) to (3) we see that 'yes' is a weakly dominant strategy, if and only if

$$\frac{f\left(x_i + \beta_i x_j\right) - f\left(x_i\right)}{f\left(x_j + \beta_j x_i\right) - f\left(x_j\right)} \geq \frac{\gamma}{2} \,. \tag{5}$$

This holds trivially for all $\gamma \in [0,1]$, since $x_i = x_j = x$ when $\beta_i = \beta_j = \beta$.

QED

It is obvious from (7) that the degree of spillover need not be symmetric; it is a dominant strategy for either firm to choose 'yes' as long as its cost reduction is at least half of the rival's cost reduction. Moreover, *the incentive to exchange information is increasing in the degree of product differentiation*, so that in perfectly segmented markets, i.e. when γ=0, they will always choose 'yes'. This suggests that the incentive to exchange information after the R&D costs have been sunk should be particularly strong in vertically related industries.

2.3 R&D spillovers and information exchange in vertically related industries

The extensive literature on R&D spillovers almost exclusively deals with the horizontal relationships. To the best of our knowledge, the only exceptions are Banerjee and Lin (2001) and Ishii (2001) where the vertical R&D spillovers are exogenous. We now repeat the analysis of the previous section, but instead of the horizontal duopoly competition, there are two firms in a vertical relationship. Firm d is a downstream firm and u is an upstream firm. The downstream firm uses a unit of input provided by the upstream firm to produce a final product.

The model has many similarities with the model of the previous section. The firms' decision variables are quantities and R&D investments. The R&D production functions for firm d and u are $f(x_d+\beta x_u)$ and $f(x_u+\beta x_d)$; there are R&D spillovers between the firms. As in the previous section, the inverse demand for the final product is linear, $p_d=a-q_d$. A key difference is that the unit costs of the downstream firm 's production include the price of the input, i.e., the unit cost of firm d is

$$C_d=c+ p_u - f(x_d+\beta x_u). \qquad (6)$$

where p_u is the price of the input. Since firm d operates as a monopoly in the final product market, its output, for a given input price, is

$$q_d = \frac{a - c - p_u + f\left(x_i + \beta x_j\right)}{2}. \tag{7}$$

Because the price formation is not focus of this article, we simply follow the standard assumption in the literature (see, e.g., Abiru, Nahata, Rauchauduri, and Waterson, 1998, Banerjee and Lin, 2001, and Ishii, 2001), which takes (7) as the derived demand for the upstream firm. As a result, we obtain from (7) the inverse demand for the upstream firm as

$$p_u = a - c + f\left(x_i + \beta x_j\right) - 2q_u. \tag{8}$$

In the production stage, the upstream firm chooses q_u so as to maximise its profits by taking the decisions of the downstream firm as given. The equilibrium output for the upstream firm is thus given by

$$q_u = \frac{a - 2c + f\left(x_u + \beta x_d\right) + f\left(x_d + \beta x_u\right)}{4}. \tag{9}$$

Substituting (9) for (8) and (7) yields the equilibrium output for the downstream firm

$$q_d = \frac{a - 2c + f\left(x_u + \beta x_d\right) + f\left(x_d + \beta x_u\right)}{4}. \tag{10}$$

The equilibrium profits of the firms *d* and *u* can then be expressed as

$$\pi_d = q_d^2 - x_d. \tag{11}$$

and

$$\pi_u = 2q_u^2 - x_u \,, \tag{12}$$

where q_d and q_u are given by (8) and (9).

Let us now reconsider the three-stage game from section 2.2. In the first stage the firms invest non-cooperatively in R&D. There are no spillovers, but there is the second stage game in which the firms decide whether to exchange their research information. In the last stage the firms decide about quantities non-cooperatively. In the second stage the firms play the simultaneous-move game in which they can choose 'yes' or 'no'. If both choose 'yes' they exchange R&D information. In all other cases they do not exchange the information. If firm *d* gets firm *u*'s information, its costs are reduced by $f(x_d+\beta_d x_u)$, and similarly for firm *u*. Otherwise firm *u*'s R&D expenditure does not affect firm *d*'s costs.

If information exchange occurs for $\beta_d=\beta_u=\beta$, the model is identical to the model presented above in (6)-(12), since the firms foresee the exchange of information that they naturally incorporate in their R&D investment decision. Our equilibrium concept is again a Nash equilibrium in undominated strategies.

PROPOSITION 2. *The vertically related firms always exchange R&D information*

Proof: Consider the case with potentially different betas. The unit cost reductions in the case of information exchange are $f(x_d+\beta_d x_u)$ and $f(x_u+\beta_u x_d)$. The profits of firm *d* as a result of this exchange are given by

$$\pi_d = \left[\frac{a-2c+f\left(x_d+\beta_d x_u\right)+f\left(x_u+\beta_u x_d\right)}{4}\right]^2 - x_d \,. \tag{13}$$

Without information exchange the profits of firm *i* are

$$\pi_d = \left[\frac{a - 2c + f(x_d) + f(x_u)}{4}\right]^2 - x_d \,. \tag{14}$$

At the second stage R&D costs have already been sunk. Comparing (14) to (13) then shows that 'yes' is a dominant strategy even if $\beta_d = 0$.

QED

The explanation of proposition 2 is simple. In a vertical relationship, it is profitable for a firm to share its R&D information even if the firm receives no such information from the other firm. If the downstream firm gives up its R&D information, it decreases the unit costs of the upstream firm and, consequently, the price of the input. Similarly, if the upstream firm gives up its R&D information, it decreases the unit costs of the downstream firm and, consequently, enhances the production of the final good. Since producing a unit of the final good requires a unit of the input, the demand for the upstream firm's product also increases.

By letting γ=0 in the horizontal information exchange in section 2.2, we see the crucial difference between the horizontal and vertical R&D spillovers. When γ=0 the firms *i* and *j* in section 2.2 are monopolies as the firms *u* and *d* in this section. In such an environment, the firm *i* is indifferent whether it should make β_j positive or not, when β_i =0. In contrast, Proposition 2 verifies that firm *d* is strictly better off by making β_u positive even if β_d=0. In other words, the one-way spillovers are never beneficial for both firms in the horizontal relationship, but they are beneficial for both firms in the vertical relationship.

3. The information exchange between Micronas and MPSI

As described in Introduction, Micronas's technology was initially in 1980 bought and transferred from a smallish American firm, MPSI. The transferred technologies, bipolar linear and CMOS (complementary metal-oxide semiconductor), were rather unusual as they enabled the manufacture of mixed-signal integrated circuits. Such circuits combine both digital and analogue functions in one circuit.

In addition to the relevant technological information, MPSI agreed to provide training in semiconductor design and manufacture. The Finnish partners agreed that Nokia will acquire the technology and place it in the free use of Micronas. The intention was that MPSI would serve as a sub-contractor until a plant was built in Finland. MPSI was also interested in entering the agreement, because its customers feared to be locked into its unique technology. To alleviate this problem, MPSI needed a second source, and Micronas would have been a suitable one. In other words, MPSI expected that if the plant is eventually built, Micronas will become a subcontractor for MPSI.[3]

The original licensing contract signed by Micronas and MPSI in 26th June 1980 contained a detailed description of the actual technology transfer procedures. The technologies were specified by the following clauses.

> *RECITALS OF FACT*
> *MPSI designs, manufactures and markets semiconducters employing bipolar linear and CMOS technologies. Nokia desires to obtain training in such technology and to obtain the right assistance in the development of a plant in Finland for production of semiconducters. In addition, Nokia desires to acquire shares of MPSI's Stock. MPSI and Nokia have a desire to enter into this Agreement by which MPSI will sell to NOKIA (1)*

[3] Micronas was used as MPSI's second source from the beginning of 1986 until the end of 1989. The volume of the second source activity was, however, smaller than the firms had initially expected

350,000 shares of MPSI's common stock and (2) technological information regarding the design and manufacture of semiconductors.

SALE OF TECHNOLOGY

2.1 Sale and Purchase. MPSI hereby warrants that it has valuable expertise and know-how concerning the technology described in the Recitals of Fact to this agreement and has sufficient resources and personnel to perform its obligations

2.2 Design Training. Commencing in approximately October, 1980, MPSI at its plant will train up to five qualified engineers designated by Nokia in the design techniques employed by MPSI in the design of semiconduters utilising CMOS and bipolar linear technology

Yet, the original contract was silent about treatment of the licensed technology after the transfer is successfully completed. Shortly after signing the contract Seiko, the principal shareholder of MPSI, however, took up these issues and required amendments to the original contract.

The first amendment had to do with confidentiality related to the licensed technology. The exact wording of the confidentiality amendment for the contract of the technology transfer is presented below.[4]

CONFIDENTIALITY

a) Nokia agrees to keep strictly confidential all technology disclosed by MPSI hereunder, including but not limited to, all design rules, cell design, documentation setting forth manufacturing processes, specifications regarding equipment utilized in the manufacturing process and other confidential information acquired by Nokia from MPSI in connection with the implementation of this Agreement (the "Technology"). *Nokia will not, without first obtaining the consent of MPSI, communicate the Technology to anyone*

[4] The wording in italics is as in the original contract. The clarifications in parentheses are added by the authors.

than its employees, agents, representatives, subcontractors and sublicensees and then only to the extent necessary to proper exploitation of the Technology in accordance with the provision of this Agreement. Nokia will require all of its employees who are granted access to the Technology and all sublicensees to sign confidentiality agreements and take appropriate action by instruction, agreement or otherwise with other persons permitted access to the Technology as necessary to satisfy this confidentiality provision.

b) The above confidentiality provisions do not apply to information which

(i) is or becomes publicly available through no fault of the parties.

(ii) is released in writing by the party not disclosing the information.

(iii) is lawfully obtained from third parties.

(iv) is previously known or developed by Nokia.

The above exemptions (i) through (iv) shall not be interpreted by Nokia as justification to disregard the obligations of confidence set forth in this Agreement mereby because individual portions of the confidential information may be found to be within exceptions, or because the confidential information is implied by but not specifically disclosed in information falling within the exceptions.

In addition to the confidentiality issue Seiko also requested a grant-back provision, i.e., an amendment detailing the rights that each party has on the improvements done to the original technology.

DISCLOSURE OF IMPROVEMENTS OF TECHNOLOGY BY NOKIA

a) Subject to applicable laws, rules and regulations, Nokia hereby covenants and agrees that, during the term of this Agreement it shall keep MPSI advised, in the English language, of all improvements and other developments of the Technology which Nokia may make. Nokia will notify MPSI of its intention to file any patent applications arising out of such improvements and development. Nokia grants to MPSI a non-exclusive, royalty-free license, to make, use and sell without limitation, products arising out of any such improvements or *developments, whether or not patentable, and any patent applications and any patent granted thereon, including renewals ad reissues thereof to the extent that they relate to the subject matter of this Agreement, which licenses shall extend in perpetuity and, in the case of patents, for the full life or term of such patents, but shall not include any right to sublicense.*

b) The provisions of Section 2.15 shall apply mutatis mutandis with respect to the disclosure by MPSI to third parties of improvements or other developments of technology by Nokia which qualify under the criteria set forth in said Section 2.15 with respect to Technology. [5]

These clauses are quite common ways for the licensor to protect its business against leveraging (Rahnasto, 2001). There is thus nothing unusual in the clauses, but they, especially the grant-back provision related to the improvements of the original technology, were brought forth in the controversy on thin-film and BiCMOS technologies between MPSI and Micronas in 1989-1990 that eventually resulted in the information exchange between the two.

During that time the performance of both companies was generally poor. As Figure 1 indicates, Micronas was making heavy losses, and in MPSI the situation was even worse. In the beginning of 1989 MPSI ceased its own production and concentrated primarily on the development of IC-circuits and marketing. Unprofitable products were given down and the rest was planned to be subcontracted to Micronas and a Japanese company, Nippon Precision Circuits, Micronas was already serving as a subcontractor of MPSI. Manufacturing new products for MPSI would, however, have required substantial investments on the physical and human capital of Micronas. The parties could not agree on how to fund the investments and, as a result, no new products were added to the Micronas' product range.

[5] Section 2.15 is the section for confidentiality clause.

During 1989 Micronas made a considerable improvement in one of the products it was making for MPSI. The improvement was created by applying a novel thin-film resistor process, which was a result of a prolonged R&D project in Micronas. At the same time MPSI encountered serious difficulties with its own development work related to thin-film technology. In September 1989 MPSI asked Micronas for a license to its thin-film resistor process. Micronas was, however, unwilling to license the technology, because they regarded it as one of the cornerstones of their future competitive strength. After the initial offer to buy the licence was rejected, MPSI changed its strategy and required Micronas to license the technology freely in accordance with the 1980 agreement. This caused substantial tension between the companies.

MPSI claimed that, despite its requests, Micronas had not informed MPSI of improvements and other developments made to the thin film technology which, as the claim went, was originally transferred from MPSI to Micronas in accordance with the 1980 agreement. According to MPSI the technology had been improved by both companies over the past years. MPSI had freely informed Micronas of its progress, but now Micronas was reluctant to disclose the improvements it had made. In other words, MPSI argued that Micronas violated the grant-back amendment concerning the disclosure of improvements of technology.

In addition MPSI disapproved Micronas’ plans to enter into a joint venture with a company called Sipex Corporation. The aim of the venture was to develop analog circuits using technologies of both companies including the thin film technology of Micronas. According to MPSI such co-operation with another firm contravened the confidentiality amendment of the original agreement.

Micronas knew that the new thin-film process was not an improvement in the technology originally transferred from MPSI, but had been independently developed in Finland. Moreover, the technology transfer from MPSI to Micronas merely consisted of the MPSI’s bipolar linear and CMOS technologies, not its thin film process. Micronas thus disagreed with the accusations of having violated the 1980 agreement. Micronas also rejected the allegations regarding the collaboration between Sipex and Micronas. According to Micronas it was a joint product development and marketing agreement, where Micronas designs and manufactures products for Sipex using technologies available to Micronas. No technology transfer was included in the joint venture. Therefore Micronas considered the collaboration with Sipex to be in accordance with the confidentiality amendment of the 1980 agreement.

Micronas, however, was seeking ways to broaden its product range. Because its core technology was rather specialised, it desired to get an access to the industry-standard BiCMOS technology. Micronas knew that MPSI had developed a new BiCMOS process. As a result, Micronas proposed a compromise, in which Micronas disclosed the necessary information about the thin-film process to MPSI and in return obtained the information about the MPSI's BiCMOS technology.

MPSI accepted the proposal given that the information-exchange takes place in a "full engineering meeting" between Micronas and MPSI experts. The essence of "full engineering meeting" was that the meeting is sufficiently long and covers sufficiently many issues so that both parties will be satisfied. In order to learn the thin-film process and to be able to reproduce it, MPSI requested that the meeting includes a review of the process flow details and specifications, the equipment used and the special equipment modifications, and the set-up conditions including drawings. Moreover, MPSI required access to process equipment and procedures. The exchange of information was conducted along these requirements between MPSI and Micronas experts in January 1990.

4. Evaluation

In this article we first show how R&D spillovers can be explained as the outcome of simple information-exchange game between two firms. We consider the incentives to exchange information both in the horizontal and vertical industries. Quite naturally we find that the incentives to exchange information are stronger, the smaller is the intensity of competition between the firms.

We then describe an information-exchange agreement between two firms in the semiconductor industry, Micronas and MPSI, that was made 1989. It seems that the information exchange is roughly in accordance with the model of horizontal competition presented in section 2.2. The firms independently made two cost-reducing process innovations and, at the time of the information exchange, the R&D costs were sunk. Even though initially the technologies of the companies had been identical, their products only partly satisfied the same needs of customers and the homogeneity of the products had decreased over time. There was also a considerable distance between the geographical locations of the companies. In the language of the model, this means that the measure of product substitutability (γ) was well below unity at the time of the information exchange. This can also be seen from the incentives of the companies to enter into the information exchange. Micronas aimed at broadening its product range while MPSI wanted to improve its existing products.

We could also argue that the firms were in a vertical relationship because of the subcontracting between the firms. As we show in section 2.3, the incentive to exchange R&D information is stronger in a vertical relationship than in a horizontal relationship. Nonetheless, we feel that the relationship was horizontal as depicted by the model in section 2.2, because the MPSI's production for Micronas was related to the technology transfer (Kultti and Takalo, 2001) and the supply of Micronas for MPSI was smallish (cf. also footnote 3).

An alternative interpretation of the information exchange is that the firms wanted to avoid a costly lawsuit. The tension between the firms begun when Micronas refused to license its new thin-film resistor process to MPSI. Since intellectual property rights almost by definition allow the owner to exclude the others from using the property, the refusal in itself could hardly have been an issue in a court. Rather, the issue would have been whether the new thin-film process was within the scope of the grant-back provision in the licensing agreement of 1980. As Rahnasto (2001) argues, typically the courts, especially in the U.S., have emphasised that the grant-back provisions should be limited to the licensed technology. Since it was quite clear that the thin-film process would not have infringed the patents governing the licensed technology, it is unlikely that the lawsuit would have realised. Of course, the threat of the legal dispute probably facilitated the information exchange.

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Figure 1

The performance of Micronas.

The figures for year 1981 cover the period 1.10.1980-31.12.1981