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BECOMING AN ACQUIRER AND BECOMING ACQUIRED

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Tiivistelmä

Tämä tutkimus tarkastelee Suomen yrityskauppoja vuosina 1994 - 1999. Tutkimuksessa analysoidaan erityisesti yrityskauppojen syntyyn vaikuttaneita tekijöitä. Näissä tekijöissä kiinnitetään erityinen huomio uuden teknologian tuottamiseen ja hyödyntämiseen. Tutkimuksessa testataan empiirisesti, vaikuttavatko yrityksen T&K-investoinnit yrityskaupan syntymisen todennäköisyyteen. Kaupan syntymistä analysoidaan tuolloin sekä ostavan että myynnin kohteena olevan yrityksen kannalta. Keskeisen tutkimustuloksen mukaan T&K-investoinnit lisäävät sen tapahtuman todennäköisyyttä, että yritys ostaa toisen yrityksen. Tämä tulos osoittaa, että yritykset eivät näytä erikoistuvan joko ostamaan teknologiaa (yrityskaupoin) tai tuottamaan sitä itse. Yritys näyttää ostavan toisen innovatiivisen yrityksen lähinnä silloin, kun se on omalla T&K-toiminnalla vahvistanut niitä tietoja ja taitoja, joita tarvitaan ostettavan tietopääoman hyödyntämiseen.

Toisen keskeisen tuloksen mukaan T&K-investoinnit lisäävät myös todennäköisyyttä, että yritys joutuu kaupan kohteeksi. Tämä jälkimmäinen tulos pätee kuitenkin vain muussa kuin raskaasti investoivassa prosessiteollisuudessa[1]. Näyttääkin siltä, että sellainen teknologiayritys on houkutteleva oston kohde, jolla ei ole vahvaa asemaa tuotemarkkinoilla. Näitä teknologiassa vahvoja ja muussa toiminnassa heikkoja yrityksiä tuntuu olevan muualla kuin prosessiteollisuudessa. Yrityksen omat T&K-investoinnit eivät lisänneetkään sen tapahtuman todennäköisyyttä, että prosessiteollisuudessa toimiva yritys joutuisi kaupan kohteeksi. Tämän havainnon nähtiin vahvistavan sitä käsitystä, että prosessiteollisuudessa omaan T&K-toimintaan runsaasti investoinut ja sen vuoksi tuotantokustannuksiltaan tehokas yritys ostaa tehottomamman yrityksen, jonka T&K-panostus ei välttämättä poikkea keskitasosta.

[1] Prosessiteollisuuteen on luettu elintarviketeollisuus, tekstiilien valmistus, puu- ja paperiteollisuus, kustantaminen ja painaminen, öljy- ym. tuotteiden valmistus, muiden kemikaalien kuin lääkeaineiden valmistus, kumi- ja muovituotteiden valmistus, ei-metallisten mineraalituotteiden valmistus, perusmetallien valmistus, sähkö-, kaasu- ja lämpöhuolto sekä veden puhdistus ja jakelu.

Preface

This project is ordered and funded by Tekes, the National Technology Agency. The aim of the study was to analyse the motives of mergers and acquisitions and empirically test whether mergers and acquisitions were used as means to transfer technology. The report was written by Eero Lehto from the Labour Institute for Economic Research and Olavi Lehtoranta from the Statistics Finland. We are grateful for the contribution of Markus Koskenlinna and Ari Mikkelä who supervised the work at Tekes. We would also like to thank other experts from Tekes and Tanja Tanayama from VTT, Group for Technology, for their comments.

The data for this study was provided by the Statistics Finland. In this project we also exerted an extra effort to gather the data on mergers and acquisitions. We would like to thank Janne Holkko for the assistance in the collecting of this data. We are grateful to Paul Dillinghan for checking the English language.

Helsinki, January 2002

Eero Lehto and Olavi Lehtoranta

Abstract

This paper considers mergers and acquisitions in Finland. More specifically, we focus on the reasons behind acquisitions and mergers. We take a closer look at a firm's orientation toward R&D and the use of high technology. We empirically test how R&D affects the likelihood of acquisitions. Both the probability that a firm acquires another firm and that a firm is acquired by another firm is then analysed. According to the central finding of this study, the high level of R&D, given the firm size, increases both the probability of becoming both the subject and the object of an acquisition. This result shows that, contrary to some earlier findings (concerning the USA)[2], firms do not seem to specialize in their strategies either to invest in their own R&D, or alternatively, to buy innovations from the market. Our results indicate that for established firms it is also important to invest in one's own R&D in order to sustain the capacity to utilize the other firms' R&D and to confirm bargaining power when the terms of acquisition are negotiated. The result also shows that R&D investments increase a firm's attraction as a target for an acquisition. This result also shows that there often exist such positive externalities, which arise with knowledge capital and which can be internalized by combining both the acquirer's and the target firm's assets.

[2] See Hall (1987) and Blonigen and Taylor (2000).

1. Introduction

This study investigates the motives for the restructuring in which an acquirer obtains a majority ownership of a target firm or of an autonomous part of a target firm. The incidence of these events is explained by both the acquirer's and the target firm's characteristics.

Most empirical research on mergers and acquisitions, however, investigates how mergers and acquisitions (M&A) affect firms’ post-trade behaviour, typically, in terms of stock prices, profitability and productivity. The empirical literature from the 1970s and 1980s has found out that mergers create value mostly for the stockholders of the target firm (see Mandelker (1974), Jarrell et al., 1988 and Mueller’s (2001) recent survey). Many studies later report of negative returns on acquirers (see Franks et al. (1991), Agrawal et al. (1992) and Leeth and Borg (1994)).

Many authors consider that the acquirer’s poor post-merger performance is a result of managerial failure. Then the managers’ "empire building" to which Schumpeter (1934) referred many years ago is seen the main motivation in M&A. Some kind of hubris was also seen to seize the managers, in consequence of which they pay more than the true value of the firm (Roll, 1986).

Besides empire building and the existence of economies of scale and scope, various synergy gains are seen as the main motives for M&A. In particular, many studies on the airline industry have found explicit evidence that horizontal mergers lead to an increase in market power (Evans and Kessides, 1994 and Borenstein, 1989).

But synergy (or complementarity) may arise with the appearance of new technology.[3] Then the essence of M&A can be regarded as a kind of "knowledge transmission" – as Malerba and Orsenigo (1997) call it. So it is possible that innovative activity – which creates new knowledge assets and reforms the nature of old assets – makes the assets of two firms complementary and thus generates "synergies" between the firms. These benefits can then be materialized if either an acquiring or an acquired firm obtains ac-

[3] For example, Andrade et al. (2001) stress that most of the acquisitions and the mergers were associated with regulatory and technology shocks.

cess to the relevant knowledge. Below we discuss the reasons why this access can sometimes be attained in a most convenient way through M&A.

The complementary nature of assets is usually seen to be associated with the location of various firms in the vertical structure of the industry. In the high tech sectors, especially, the start-up firms, being heavy investors in R&D, have not established their position in the product market. In these circumstances, for a start-up innovator cooperation could provide a possibility to exploit the distribution channels, regulatory or manufacturing expertise and brand name of the incumbent firm, as noticed by Teece (1986). The merger would promote the same aim. The sunk costs of the incumbent would then affect the distribution of the returns of innovation. The structural asymmetries can also lead to a situation where some firms specialize in acting only in the market for ideas. Tirole (1989) and in Gans et al. (2000) referred to this possibility. In this case, the R&D of the start-ups can be regarded as a strategic substitute for the incumbent's own R&D. Blonigen and Taylor (2000) found that R&D intensity negatively contributes to the firm's propensity to acquire, although the number of firm trades is higher in high tech industries. These results are interpreted to indicate that firms in the same industry either make the necessary innovations for themselves, or alternatively, buy these innovations.

Granstrand and Sjölander (1990) have found that in Sweden there is just this kind of specialization. At a certain stage a small innovative firm tends to merge with a larger firm. According to Gans et al. (2000) the larger firm starts to cooperate with a smaller firm – and possibly buys it – most likely if the smaller firm is able to safeguard its innovation by patent or by other means, and if the smaller firm has not made the necessary investments to enter the product market.

In two theoretical papers of this project[4] we have focused on those factors which make the firms merge rather than cooperate. We first consider (in Lehto, 2002a) a situation where the innovative start-up sells its innovation to some firm who is established in the product market. If the income from innovation is not verifiable, any contract or even licensing concerning the sharing of the profit stream generated by an innovation is ruled out. It would then be sensible to sell the innovation by auction or through some other mechanism in which several product market firms make bids. But if we assume as Choi (2001) that the start-up firm's input is also needed in the commercialization phase, there

[4] Lehto (2002a) and (2002b).

arises a moral hazard problem related to the start-up's post-trade effort in commercialization. We show that by a merger, which intensifies the start-up's incentive to exert commercialization effort, the moral hazard in question can be effectively alleviated. In some respects our analysis comes close to the paper by Aghion and Tirole (1994)[5], who also prove that by ownership arrangement some incentive problems can be solved when contracting is ruled out. Our theoretical findings suggest that in high tech sectors many mergers can be explained by the problems related to access to the product market and the fact that an innovator's input is also required in the commercialization phase. This could be one reason why the high requirements of knowledge capital may encourage M&A activity.

Above, the imperfect contracting was seen as a major precondition for M&As. In addition to this, the difficulties in transmitting the accumulated knowledge as a patent or in the form of another literal document may prevent the use of licensing and other contractual mechanisms as a device of knowledge transmitting. Typically knowledge capital overlaps human capital. Because of this, the most efficient way to transmit new technology on some occasions is to make people move from one firm to another firm. For both parties – for the transferor and the receiver of new technology – the mutually beneficial way to implement the knowledge transmission concerned is M&A.

There are many studies on learning-by-doing in an industrial context that indirectly indicate that knowledge capital is built in the form of human capital. Irwin and Klenow (1994) found that in the semiconductor industry a firm learns three times more from its own cumulative production than from another firm’s cumulative production. This approach is also used to locate such inter-firm differences in technological knowledge that affect a firm’s capacity to adopt new technology. In a recent study Cabral and Leiblein (2001) have shown that in the semiconductor industry only a firm’s cumulative production experience in the latest technology has an impact on the likelihood of adopting new technology. These findings also tell us about the potentiality for technology transfers. Then those firms who are more experienced – due to their own R&D – are the potential transferors, and, respectively, those firms whose technology is obsolete – partly because they have neglected their own R&D – are potential transferees. Because experience

[5] The approach of Aghion and Tirole (1994), differs from ours , in that they focus on the innovative effort and not on commercialization of the existent innovation. The parties in their paper are then an innovator and the investor.

moves from one firm to another typically with people, M&A becomes the relevant means to transfer technology.

Cohen and Levinthal (1989) also point out that in those cases in which new knowledge (innovation) is not capital embodied, its exploitation requires more complementary internal effort and more pre-existing expertise in the area. This suggests that the willingness to transmit knowledge capital though M&A can be strengthened by a firm's own R&D investments in the past.

But isn't it, however, still possible that firms in high tech sectors would specialize either to make technology themselves or to buy it in the market. In another paper (Lehto 2002b) we model a situation with many innovators and product market firms in the same market. It turns out that it is not optimal for the product market firms to neglect their own R&D insofar as all the firms are equally efficient in producing innovations. One motivation for one's own R&D is that it fits relatively better than outside R&D to meet the firm's requirements. Despite better matching, stochasticity associated with the success in own R&D makes unlucky firms once in a while go to the outside market. Thus it is very possible that obtaining innovation at an outside market (through licensing or a merger) is related rather to this stochasticity than to the existence of specialized strategies in obtaining new knowledge. In addition, one can imagine that the matching of innovation (to meet those requirements, which are derived from a firm's position in the product market) is also stochastic. Then, due to bidding mechanism, the price of an outside innovation for the product market firm is inversely related to the value of the firm's own innovation. This also brings about a reason for a firm's own R&D despite the possibility to obtain innovation (or knowledge capital) at the market.

It is possible that a firm's own high R&D mainly indicates that there are differences in "shadow prices" of new knowledge. If a firm with its own high R&D is unlucky in own R&D it obtains an innovation from outside – often through M&A – more eagerly than an average firm. In this sense one's own high R&D may positively contribute to M&A. Related to this, it is evident that one's own R&D can also create some positive externalities, which decrease the costs of transferring knowledge from other firms. By its own R&D the firm's own understanding of high tech increases and its capacity to absorb outside knowledge increases as well, and so the possibility to transfer knowledge through a merger becomes even more attractive. If we also take this effect into account, it could be possible that a firm’s own R&D rather increases than decreases the likelihood of those M&As which are related to knowledge transfers.

In fact, many authors have recognized the dual role of a firm’s own R&D. Cohen and Levinthal (1989) have noticed that by means of its own R&D the firm produces innovations and, on the other hand, develop and maintain its capabilities to assimilate and exploit externally available information. From this it follows that the firm’s R&D stock should, for its part, encourage the firm to acquire new knowledge through a firm’s own R&D or from external sources. But does this not mean that own R&D can also motivate the firm to acquire knowledge through M&A?

We have presented some reasons which oppose those findings of Blonigen and Taylor (2000), according to which the firm's own R&D or, rather, R&D intensity negatively explains the likelihood of acquiring. In fact, our empirical findings strongly show that the acquirer's own R&D positively contributes to the probability of acquiring which is quite opposite to the finding of Blonigen and Taylor (2000).

We also discovered the likelihood that a firm acts as an acquirer or that a firm is acquired increases in the number of those firms in the industry (by three digit SIC) whose R&D stock is positive. This result may indicate that the matching concerning the outside innovation (or knowledge capital) improves when the market enlarges. On the other hand, it is possible that by the increase in the number of actors, the innovator firm's share of the trade increases, which for its part increases the probability of M&A insofar as it is the product market firm who decides about the rules of the game.[6]

In the analysis above we considered a rather asymmetric situation in which only the acquirer has established presence in the product market. Gallini and Winter (1985) and also Katz and Shapiro (1985) have analysed a situation in which the innovation has generated asymmetry in the marginal costs of two incumbent firms. The authors show that under quite general conditions licensing occurs even if some market power is lost to the competitor. If licensing were ruled out because of the imperfect nature of the information, the more advanced technology could, however, be transferred through an arrangement concerning the ownership.

[6] This mechanism is described more closely in Lehto (2002b).

In the processing industries entry requires sunk costs. In this sense all the firms are incumbents, which suggests that in the processing industries, especially, the difference in marginal costs may lead to M&A, by which doubling of fixed costs is avoided. Insofar as the cost differential is caused by R&D, one would imagine that the low R&D firm – whose operational costs are high - is then acquired by the high R&D firm whose operational costs are low. The benefits from this kind of technology transfer are larger, the larger the size of the target firm is. Therefore one may expect that the size of the firm positively contributes to the probability of the contingency in which a high cost firm is bought by a low cost firm.

One may assume that insofar as a product innovation is involved, the fixed costs – typical of processing industries – may still play an important role. Then it could also be beneficial for both firms – for the innovator and for the non-innovating incumbent firm – that the application of an innovation is enlarged through mergers and acquisitions to cover the non-innovator’s production also.

In industries other than the processing industries entry costs are not necessarily as high as in the processing industries. In those industries firms may, however, be quite asymmetric as far as their presence in large-scale operations is concerned. A large-scale operation requires fixed investments with sunk costs. Therefore it is still apparent that an important precondition for those M&As also which are motivated by knowledge transmission is to ensure access to the incumbent’s physical capital and other assets which are necessary for nation-wide or global coverage.

Empirical findings concerning the processing industries alone confirm the above reasoning to some extent. It turns out that in the processing industries a firm’s own high R&D no longer positively affects the probability that a firm is acquired by another firm. Unlike the processing industries, in other industries a firm’s own R&D positively contributes to the likelihood that the firm is purchased by another firm. This proves that in the processing industries one motivation of M&A is to transfer technology from the more efficient acquirer to the less efficient target firm. The result concerning the other industries, on the other hand, confirms the previous results obtained by Granstrand and Sjölander (1990) according to which for many innovative firms access to the product market is gained only through a merger with a firm which has established its presence in the product market.

R&D may also create new assets whose exploitation no longer belongs to the parent firm's competence. One can imagine that in these circumstances the property rights to the new assets are allocated to those who have the expertise to benefit from them. This may lead to managerial buy-outs or to divestitures, incidences that are registered in our data as purchases and/or sales. Thus, at least partly, the discovered positive impact from R&D stock on the acquisitions ratio may reflect this tendency toward fragmentation.

In the literature, restructuring of industry has also been explained by the tendencies to tighten managerial control.[7] It is possible that an originally abundant cash flow tends to increase R&D investments excessively. To discipline the manager, the firm is reconstructed (possibly taken over) and the leverage is increased, after which space for the manager to manoeuvre is narrowed, as a consequence of which the level of R&D lowers. Investigating the post-acquisition behaviour of the acquiring firm, Hall (1990) obtains only very weak evidence for this kind of behaviour. But this story can also be used to explain the impact of R&D on reconstructing. The positive impact of the target firm's R&D on M&A can then be considered as a sign of a measure to discipline managers. It is then natural to assume that the excessive R&D investments have lowered the profit ratio and that a firm has run into debt. We, however, find no effect from the profit ratio on the probability that a firm is acquired. Instead, we find that the debt ratio negatively affects the likelihood that the firm is acquired. These findings do not fit story about disciplining the manager especially well. Therefore, we interpret that a positive impact of the target firm's R&D on the likelihood of acquisition indicates rather that there has emerged an opportunity to benefit from the transmission of technology through M&A. The negative impact of debt ratio may then tell us that the markets for debt-ridden firms are a kind of "market for lemons". The real quality of these firms is the seller's private information, and an acquirer's risk of buying an overpriced bad firm will collapse the market or make the market for these firms very thin.

[7] See discussion in Hall (1990).

2. Data

2.1. Mergers and acquisitions

We have used the data of the tax authorities and the National Board of Patents and Registers as the main data source of mergers and acquisitions over the 1994–1999 period. These data can be found in the Business Register of Statistics Finland. In the Business Register a merger may have been recorded several times a year. Firstly, it may have been recorded as a ”normal merger”, where different firms are merged to form a new firm, then as an undefined merger and lastly, when more information on the event has been collected, for example as a purchase of a firm, where a firm will be merged with another established firm. In this study we aimed to use all the original data sources obtained from the tax authorities and the Trade Register and being available from the year 1994 onwards (excel sheets on mergers).

The data of the tax authorities and the Trade Register were supplemented with the data collected by the Talouselämä magazine. They include the name of the buying firm, the name of the target firm, the amount of the sales turnover and personnel in the target businesses having a turnover of more than FIM 2 million.. We have taken into account only domestic acquirers and domestic targets. Those acquisitions in which foreign firms purchase business units locating abroad and belonging to some Finnish group of enterprises are excluded.

If a firm sells only a part of its businesses, which is quite a common case, the selling firm or its parent firm will have been recorded as the target firm, with the exception of the situation when the target unit is clearly in a different branch of industry or locates abroad. When it is obvious that a domestic firm declares its R&D expenditures at an enterprise group or division level, the parent firm or division level has been recorded as the target firm, so that we could link the data correctly. The ID numbers of the acquiring and target firms have been gathered from the CD-ROM of the Register of Organization Numbers. When investigating the history of mergers the Internet Service of the National Board of Patents and Registers has also been utilized.

The data on mergers and acquisitions used in this study are not complete, as they seldom are. For example, we do not know the receivers of all unit transfers, nor do we know the sellers in some transfers. We can, however, count the numbers of mergers and acquisitions and the numbers of acquiring and target firms from our data sets quite representatively for the latter part of the 1990s.

2.2. R&D data

Data on firms' internal R&D investments are obtained from R&D surveys from the years 1985, 1987, 1989 and from the years 1991–1999. R&D investments in 1996 have been obtained from the 1996 innovation survey. The coverage of the R&D surveys varies between years. In the years 1985, 1987, 1989 and 1995 data were more extensive than in the years 1991–1994, 1997 and 1998. Data sets for the even years 1992, 1994 and 1996 were smaller. R&D surveys have been carried out annually from the year 1997 onwards.

A firm can reply to an R&D survey at firm, enterprise group or some other level.[8] In R&D surveys these replies have been recorded on the ID numbers of the original target firms or on the ID numbers of their parent firms. The panel data on firms' R&D investments have been constructed by approximating missing observations by means of observations in other years. Firstly, we approximated R&D expenditures for all the years from the start-up year of the firm or at least from the year 1960 until the first observation and, on the other hand, from the last observation until the closed-down year of the firm or at most until the year 1999 by carrying on the same value of the first or, respectively, the last observation at fixed prices. Then we filled in the gaps between observations with linear interpolation. In deflating the current values of R&D expenditures we used the private sector's earning level index.

The firm's own R&D stocks for all the firms included at least once in an R&D survey were compiled for the period 1985–1999 by using the deflated values of the original and approximated R&D investments and the annual depreciation rate of 0.15.

2.3. Other data sources and panel data

[8] There are about 50 companies in the R&D panel that have replied at an enterprise group level.

Besides the Business Register, Talouselämä magazine and R&D surveys, we have used the Financial Statements Data of Statistics Finland in this study. In the R&D panel we have included all those business firms of which information can be found in the Business Register and at least once in an R&D survey over the period of 1985–1999. We have estimated firm-level R&D stocks (knowledge capital) for all these firms over the whole time period. Furthermore, we have restricted the analysis to the 1994–1999 period (for lagging regressors 1989–1999) and to the manufacturing industries (SIC 15-37), construction (45), wholesale and commission trade (51), transport, storage and communications (60–64), computer and related activities (72), research and development (73), business and management consultancy, holdings (741), technical consultancy and analysis (742, 743), advertising (744) and other social or personal services (90–93). These branches of industry are the widest covered in R&D surveys.

2.4. Number of acquiring and target firms

The number of acquiring firms in the R&D panel varies from 163 to 209 over the years 1994 to 1999. During the same period of time the total number of acquisitions and mergers varies from 247 to 339. In proportion to the total numbers of firms in the same industries the numbers of acquiring firms are largest in the processing industries[9] and smallest in other industries. The same holds for the number of domestic target firms: proportionally most of them are in processing industries, even though the absolute majority lie in other industries.

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[9] The processing industries are here defined to include the manufacturing of food and beverages, textiles and wearing apparels, wood and paper products, printing and publishing, oil and chemicals except pharmaceuticals, rubber and plastic products, other non-metallic mineral products and basic metals, and electricity, gas and water supply.

Table 1. Numbers of mergers and acquisitions by industry

	1994	1995	1996	1997	1998	1999	ALL	%	Sum of firms	N of firms 1999
SIC95										
Food, beverages and tob	23	25	24	18	14	11	115	6,3	1838	255
Textiles, wearing appar	2	2	6	5	1	7	23	1,4	1659	221
Wood products	8	10	7	6	12	8	51	3,1	1635	236
Pulp, paper and paper p	9	8	5	19	14	7	62	12,1	514	74
Printing and publishing	11	18	19	23	27	11	109	5,5	1992	278
Oil, chemicals, rubber	11	16	21	17	28	21	114	6,1	1868	275
Other non-metallic mine	4	6	6	9	7	8	40	4,5	893	129
Basic metals, fabricate	9	20	16	18	7	14	84	2,3	3719	540
Machinery and equipment	13	18	18	24	25	27	125	3,9	3222	450
Electrical and optical	8	18	12	10	16	18	82	3,1	2645	374
Transport equipment	1	4	2	3	3	2	15	2,0	747	106
Other manufacturing	3	5	7	4	7	4	30	2,0	1475	206
Electricity, gas and wa	13	14	11	10	14	11	73	9,3	789	112
Construction	13	14	18	29	30	30	134	6,4	2091	334
Wholesale trade	37	37	42	37	38	62	253	7,8	3248	518
Transport	10	20	20	13	12	3	78	6,2	1259	205
Telecommunication	1	0	3	4	2	8	18	3,6	499	72
Computer services, r&d	22	19	13	18	33	39	144	4,4	3261	501
Other business services	49	63	63	57	48	43	323	6,4	5061	762
Other services	0	1	1	0	0	5	7	1,0	708	104
ALL	247	318	314	324	338	339	1880	4,8	39123	5752
Non-process industries	164	209	217	218	227	257	1292	4,5	28820	
%	3,6	4,3	4,4	4,3	4,5	6,0	4,5			
Process industries	83	109	97	106	111	82	588	5,7	10303	
%	4,6	5,9	5,5	6,1	6,5	5,6	5,7			
ALL	247	318	314	324	338	339	1880	4,8	39123	
%	3,9	4,7	4,7	4,8	5,0	5,9	4,8			
Total number of firms										
R&D panel										
Non-process industries	4617	4888	4963	5034	5032	4286	28820			
Process industries	1786	1849	1750	1741	1711	1466	10303			
ALL	6403	6737	6713	6775	6743	5752	39123			

The data will suggest that firms in the processing industries, and especially in the pulp and paper industry and in electricity, gas and water supply, are more inclined to business acquisitions. It is obvious that the principal motives for company acquisitions are somewhat different in the processing industries than in other industries. Apart from these branches wholesale trade and transport have also been active in company acquisitions. Proportionally, the highest numbers of target firms can be found in electricity, gas and water supply, telecommunication, manufacturing of transport equipment and chemicals as well as in computer services. The numbers of acquiring and target firms by industry are shown in tables 1 and 2.

Table 2. Numbers of target firms by industry

	1994	1995	1996	1997	1998	1999	ALL	%	Sum of firms	N of firms 1999
SIC95										
Food, beverages and tob	5	9	9	5	5	10	43	2.3	1838	255
Textiles, wearing appar	2	1	1	3	4	7	18	1.1	1659	221
Wood products	5	3	3	5	4	6	26	1.6	1635	236
Pulp, paper and paper p	0	1	3	1	2	2	9	1.8	514	74
Printing and publishing	3	8	7	11	9	7	45	2.3	1992	278
Oil, chemicals, rubber	3	7	13	8	8	10	49	2.6	1868	275
Other non-metallic mine	3	4	1	3	3	1	15	1.7	893	129
Basic metals, fabricate	4	4	10	10	11	7	46	1.2	3719	540
Machinery and equipment	5	10	11	12	17	15	70	2.2	3222	450
Electrical and optical	7	10	5	10	10	11	53	2.0	2645	374
Transport equipment	3	5	2	5	5	0	20	2.7	747	106
Other manufacturing	1	0	1	5	5	2	14	0.9	1475	206
Electricity, gas and wa	5	1	4	2	8	6	26	3.3	789	112
Construction	1	5	2	2	3	7	20	1.0	2091	334
Wholesale trade	5	8	4	8	21	14	60	1.8	3248	518
Transport	0	3	4	4	4	3	18	1.4	1259	205
Telecommunication	0	1	1	5	5	4	16	3.2	499	72
Computer services, r&d	4	11	9	16	21	22	83	2.5	3261	501
Other business services	11	14	14	11	10	9	69	1.4	5061	762
Other services	0	0	1	2	0	6	9	1.3	708	104
ALL	67	105	105	128	155	149	709	1.8	39123	5752
Non-process industries	39	71	65	91	112	107	485	1.7	28820	
%	0.8	1.5	1.3	1.8	2.2	2.5	1.7			
Process industries	28	34	40	37	43	42	224	2.2	10303	
%	1.6	1.8	2.3	2.1	2.5	2.9	2.2			
ALL	67	105	105	128	155	149	709	1.8	39123	
%	1.0	1.6	1.6	1.9	2.3	2.6	1.8			
Total number of firms										
R&D panel										
Non-process industries	4617	4888	4963	5034	5032	4286	28820			
Process industries	1786	1849	1750	1741	1711	1466	10303			
ALL	6403	6737	6713	6775	6743	5752	39123			

3. On the method

The firm as an acquirer – negative binomial model

When considering how a firm behaves as an acquirer the dependent variable (in this study) will be the number of purchases per firm. To overcome some deficiency of the Poisson regression we use negative binomial count dependent variable models to analyse the acquisition behaviour. [10] The chosen approach to estimate from the panel data the random effects and fixed effects models specifies a dispersion parameter, which is the same for all elements in the same group (firm).

Let y_{it} be the number of firm i's purchases in period t. Let X_{it} be the vector of covariates that affect y_{it}. We can assume that the count variable y_{it} follows Poisson distribution with conditional mean and variance χ_{it}, where $\chi_{it} \mid \delta_i$ ~Gamma(λ_{it},1/δ_i) so that log(λ_{it}) = β'X_{it} and δ_i is a dispersion parameter.[11] This leads to a model

$$(1) \qquad \Pr(Y_{it} = y_{it} \mid d_i) = \frac{\Gamma(l_{it} + y_{it})}{\Gamma(l_{it})\Gamma(y_{it}+1)} \left(\frac{1}{1+d_i}\right)^{l_{it}} \left(\frac{d_i}{1+d_i}\right)^{y_{it}} .$$ [12]

In a random effects model δ_i is allowed to vary randomly across groups. Then the variation between the firms also has an effect on the values of β. Suppose that firm i appears during n_i periods in the panel. The distribution concerned is then the joint probability of counts

$$(2) \qquad \Pr(Y_{i1} = y_{i1}, Y_{i2} = y_{i2}, ..., Y_{in_i} = y_{in_i}) = \int \prod_{t=1}^{n_i} \Pr(Y_{it} = y_{it} \mid d_i) f(d_i) dd_i \ .$$

The more detailed expression for the joint probability corresponding to a random effects model is then derived using expression (1) and assuming that 1/(1+δ_i)~Beta(r,s). The corresponding log likelihood-function is then maximized with respect to β.

[10] Traditionally counts have been presumed to follow a Poisson distribution. However, the Poisson distribution assumes that the mean and variance are equal, but this is typically not the case with the count data. Alternatives to the Poisson, such as the negative binomial distribution, often provide better models of variation among the counts that are overdispersed, that is, the variance is larger than the mean.

[11] Here δ_i is the inverse of the the respective δ_i in Hausman et al. (1984).

In the fixed effects model, the dispersion parameter in a group does not vary randomly. Then the within group (the firm) variation only affects the values of estimated β. The estimator for the fixed effects negative binomial model is obtained from the joint distribution

$$(Y_{i1} = y_{i1}, Y_{i2} = y_{i2}, ..., Y_{in_i} = y_{in_i}) \text{ conditional on } \sum_{t=1}^{n_i} Y_{it} = \sum_{t=1}^{n_i} y_{it} \, .$$

In a panel data the use of contemporaneous regressors easily introduces endogeneity bias, because the strict exogeneity assumption is not met (see e.g. Woolridge, 1997). Even when one uses lagged regressors this requirement is not automatically met. To overcome these difficulties Woolridge develops a GMM-estimation approach for panel and count data models.

The study of Blonigen and Taylor (2000) shows, however, that the endogeneity bias in the context of acquisition analysis is fairly small. Owing to these findings it is sensible in our study to analyse the acquisitions primarily using the negative binomial regression method with panel data.

The firm as a target - logit model

In our modified data the firms appear as a target at most once a year. This makes it natural to analyse the contingency that a firm is sold either as a probit or as a logit model. We experimented with the estimation of both models. Qualitatively, the results obtained in terms of estimated coefficients and their standard deviations from both models are similar. We chose to use the logit model because then the procedure to obtain fixed effects estimates is also available.

Let $y_{it} = 1$ when the firm is purchased by another firm in period t. If the firm is not purchased $y_{it} = 0$. Suppose that there are n_i observations for firm i. Let $y_i = (y_{i1}, y_{i2}, ..., y_{in_i})$. For the joint probability of y_i conditional on X_i is obtained the expression

[12] A more detailed description of the negative binomial random effects and fixed effects models is given in Hausman et al. (1984). See also Stata 7 manual pp. 393–394.

(3) $\Pr(Y_i = y_i \mid X_i) = \int_{-\infty}^{\infty} \frac{e^{-v^2/2s_v^2}}{\sqrt{2p}\,s_v} \{\prod_{t=1}^{n_i} F(b' X_{it} + v_i)\} dv_i$

when $X_i = (X_{i1}, X_{i2}, ..., X_{in_i})$ is the vector of regressors and β the parameter vector which is estimated. In (3) v_i is the random effect which is assumed to follow a normal distribution $N(0,\sigma_v^2)$. In addition, it is supposed that

$F(b'X_{it}+v_i) = \frac{1}{1+\exp(b'X_{it}+v_i)}$, if $y_{it} = 1$, and $F(b'X_{it}+v_i) = 1 - \frac{1}{1+\exp(b'X_{it}+v_i)}$, if $y_{it} = 0$.

We use the estimation procedure in which the integral (3) is approximated by the Gauss-Hermite quadrature form. The corresponding log-likelihood function is then calculated using this quadrature.

4. The results

4.1. On the transformation of the R&D variable

There are several alternatives to model the impact of R&D on acquisition likelihood. Blonigen and Taylor (2000) explained the propensity to acquisitions with R&D intensity (the ratio of R&D investment to turnover), total assets as a scale variable and, in addition, some variables which describe the firm's financial position. According to their results, the impact of R&D intensity on acquisition activity is negative.

We experimented with various ways to capture the effect of R&D. In these experiments the probability that a firm becomes a target of acquisition and that the firm acquires another firm was first explained with current R&D variable and current scale variable which was either the number of employees or the fixed-price turnover. Modelling the acquisition probabilities in question, the impact of R&D intensity – specified as a ratio of R&D stock to turnover – is not statistically different from zero. In these experiments we used the fixed-price turnover or the number of employees as a scale variable. Holding the data set fixed, we modified the model so that R&D intensity was replaced by the level of R&D stock. The absolute value of the log likelihood decreased as a sign that the fit of the model improved. This result was obtained in modelling both the probability of becoming an acquirer and a target. The impact of R&D stock also turned positive at the 5 percent significance level. After this experiment we substituted R&D stock by the log of R&D-stock. The fit then improved remarkably in both models. Also taking the log of turnover or of the number of employees improved the fit further. In modelling the probability that a firm acquires or that a firm is acquired, the best couple of regressors turned out to be the log of R&D stock and the log of fixed-price turnover. In this specification the impact of R&D stock on acquisition probabilities in question are positive and very robust to all kind of transformations concerning the basic models.

The results obtained cast doubt on the earlier results obtained by Blonigen and Taylor (2000). One can ask to what extent their results depend on the choice to explain acquisition activity with R&D intensity with no logs[13].

[13] Their results are, however, reported to be robust to various specifications of dependent variable.

4.2. The firm as an acquirer

We first analyse the probability that a firm acquires another firm. The dependent variable is the number of acquisitions for a firm during a year. The estimation results of the negative binomial maximum likelihood estimation concerned are presented in tables 1–4.

The regressors are in log form. The number of acquisitions is explained with

- **Log of turnover at fixed prices**. This regressor takes into account the scale of the acquirer. We expect that a larger scale positively contributes to the number of acquisitions. This result was also obtained in the previous literature (see Hall (1987) and Tremblay and Tremblay (1988)).

- **Log of R&D stock.**[14] Principally, the sign of this regressor can be positive, negative or even zero. We have offered some reasons that the coefficient is positive. It then indicates that it pays for those firms – who are inclined to utilize innovations through acquisitions – to invest in R&D themselves also. A negative sign would, instead, indicate that some firms specialize to obtain innovations (or the results of R&D) through the market and some firms to make themselves the innovations required.

- **Log of the number of those firms in the same industry whose R&D stock is positive.** This variable tells us about the market conditions under which innovations are purchased. To make a hypothesis on the sign of this variable is hampered by the fact that this variable reflects the number of all the firms in the industry and not only the number of those who are potential buyers of technology. If the number of firms is great, it is, however, easier to find in the market (outside the firm) such technology that fits the firm's needs. Owing to this matching effect, the sign of the variable in question could be positive. This variable also captures those effects which describe changes in bargaining power. If the size of the market increases, it is possible that the target firm's share in the trade concerning the innovation increases, and then indirectly affects the likelihood of such acquisitions or

[14] In order to retain the zero observations, we have transformed log(R&D stock) to the form log(R&D stock + c) with c = 0.0001. We also include a dummy variable of value zero when R&D stock is zero and of value one when R&D stock is positive. The combination of the specified dummy and log(R&D stock + 0,0001) makes the R&D coefficient insensitive on the size of increment c.

mergers of which the main motivation is the transmission of technology (see Lehto 2002a and 2002b).

- **Log of the average R&D stock of other firms in the same industry.** This variable describes the market conditions in which technology is transferred, too. On the one hand, this variable tells us about the potentiality and readiness of the competitor to acquire a firm. On the other hand, this variable tells us about the characteristics of the potential target firms. The impact associated with the first mentioned factor is no doubt negative – in the light of the result obtained according to which R&D increases the willingness of a firm to acquire another firm. The sign of the effect which is related to the last mentioned factor depends on the desired characteristics of the target firms. If an acquirer wishes to buy the target firm's knowledge capital, the increase in external R&D tells us that the number of potential targets also increases, and so the effect considered is positive. If the acquirer is looking for a target which has established its presence in the product market but which is inefficient because of the negligent development, the impact considered is again negative.

- **Log of the debt ratio.** According to some earlier results (Blonigen and Taylor, 2000) debt position positively contributes to acquisitions. We also expect that the debt ratio negatively affects the number of acquisitions. This hypothesis is in line with Jensen (1988) who states that better performing firms have the will to acquire.[15]

- **Log of profit ratio (returns to sales)**. The impact of this variable is positive almost for the same reason as the impact of the debt ratio is negative.

Whether the parameters of the model are jointly zero is tested by the Wald test. The quadratic form of the test statistics has the chi-squared distribution. The degrees of freedom are reported in parentheses and the related p-value is reported below the test statistics.

We also report a likelihood-ratio test, which compares the panel estimator with the pooled estimator (i.e. negative binomial estimator with constant dispersion). According to zero hypothesis,

[15] Similar result are also obtained by Tremblay and Tremblay (1988), who consider the beer industry.

the panel estimator is not different from the pooled estimator. This statistics also follows chi-squared distribution.

Table 1. Acquisition propensity estimates, Random-effects negative binomial firm-level model, Dependent variable = the number of acquisitions per firm in each year

Regressor	*Contemporary*	*Lagged*	*Contemporary*	*Lagged*
Constant	-6.956*	-5.861*	-7.088*	-5.983*
	(0.587)	(0.594)	(0.621)	(0.647)
Log RD-stock	0.146*	0.185*	0.088*	0.118*
	(0.025)	(0.026)	(0.027)	(0.028)
Log Turnover	0.563*	0.509*	0.634*	0.563*
	(0.021)	(0.020)	(0.024)	(0.024)
Log number of other firms	0.296*	0.255*	0.262*	0.202*
	(0.039)	(0.039)	(0.042)	(0.043)
Log External R&D	-0.048	-0.061	-0.114*	-0.130*
	(0.040)	(0.041)	(0.042)	(0.044)
Log Debt Ratio			-0.012	-0.173*
			(0.067)	(0.070)
Log Profit Ratio			0.204*	0.083*
			(0.041)	(0.041)
Log likelihood	-5389	-5131	-4652	-4177
Wald chi(2)	1302	1258	1239	1069
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)
LR test vs. Pooled	437	386	322	297
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)
Number of firms	7724	7515	7370	7090
Number of observations	38513	36763	33057	28360

Notes: Standard deviations are in parentheses. * Significant at the 5 percent significance level.

In table 1 we report the results which are obtained by estimating a random effects model. The results show that the impact of R&D stock is positive, contrary to the finding of Blonigen and Taylor (2000). Taking into account the positive point estimate of the turnover variable, the results show that both R&D intensity (the ratio of R&D stock to turnover) and turnover (the scale variable) positively affects the likelihood of acquisitions. The number of other R&D-active firms in the industry almost invariably has a positive effect. The other firms' aggregated R&D stock seems to have a negative influence on the likelihood of acquisitions. This effect is not, however, very robust. The negative sign of the debt ratio also corresponds to the expectations, as well as to the positive sign of the profit ratio. According to a likelihood-ratio test, the random effects estimator is preferred to the regular pooled estimator.

Because the number of firms is large and the time period is short, the above results are also very close to the results which take into account only the "between variation". This is seen when one compares the estimated coefficients of the fixed effects "between variation" model in table 2 with the results reported in table 1.

Table 2. Acquisition propensity estimates, Negative binomial firm-level model, Dependent variable = the number of acquisitions per firm in each year

	Fixed effect within	*Fixed effect within*	*Fixed effect between*	*Fixed effect between*
Regressor	Contemporary	Lagged	Contemporary	Lagged
Constant	-3.330*	0.678	-8.022*	-7.413*
	(1336)	(1.388)	(0.490)	(0.512)
Log RD-stock	0.145*	0.194*	0.061*	0.086*
	(0.060)	(0.062)	(0.020)	(0.021)
Log Turnover	0.238*	0.018	0.621*	0.580*
	(0.050)	(0.052)	(0.019)	(0.019)
Log number of other firms	0.309*	0.163	0.270*	0.237*
	(0.091)	(0.099)	(0.034)	(0.035)
Log External R&D	0.012	-0.035	-0.202*	-0.205*
	(0.094)	(0.104)	(0.035)	(0.038)
Log Debt Ratio	0.037	-0.144	-0.128*	-0.243*
	(0.109)	(0.111)	(0.058)	(0.061)
Log Profit Ratio	0.074	-0.045	0.138*	0.054
	(0.055)	(0.056)	(0.035)	(0.035)
Log likelihood	-1793	-1579	-4785	-4301
Wald chi(2)	46	18	2287	1940
(p-value)	(0.000)	(0.013)	(0.000)	(0.000)
Number of groups (firms)	750	672		
Number of groups (years)			6	6
Number of observations	3845	3255	33057	28360

Notes: Standard deviations are in parentheses. * Significant at the 5 percent significance level.

In table 2 we also report the estimates of the model which takes into account only the within-firm variation. The estimated coefficients of the "between variation” model do not differ much from the estimates of the random effects models, which take into account all variation. In the fixed effects "within variation" model, though, profit ratio and the other firms' R&D stock no longer have a non-zero effect on the acquisition activity. Surprisingly, in this model the acquisition elasticity of R&D stock is higher than in other models The interpretation of this result also is, however, complicated by the fact that the data set in the within-firm estimation includes so few firms because the estimation procedure has removed all those firms which have only one observation and for which the R&D stock is permanently zero.

In table A2 in the appendix we report estimates of the random effects model which includes dummies for each three-digit Nace level. Adding industry level dummies, the impact of external R&D stock turns zero. In other respects the results remain the same.

Table 3. Acquisition propensity estimates in the processing industry. Random effects negative binomial firm-level model. Dependent variable = the number of acquisitions per firm in each year

Regressor	*Contemporary*	*Lagged*	*Contemporary*	*Lagged*
Constant	-5.106*	-5.460*	-5.073*	-5.131*
	(1.295)	(1.353)	(1.252)	(1.250)
Log RD-stock	0.060	0.091	0.075	0.120*
	(0.045)	(0.047)	(0.043)	(0.046)
Log Turnover	0.638*	0.584*	0.624*	0.563*
	(0.049)	(0.050)	(0.046)	(0.046)
Log number of	0.029	0.190	0.018	0.131
Other firms	(0.139)	(0.140)	(0.137)	(0.133)
Log Debt Ratio	0.018	-0.140		
	(0.120)	(0.125)		
Log profit ratio	0.156*	0.079		
	(0.076)	(0.075)		
Log External R&D	-0.264*	-0.223*	-0.275*	-0.195*
	(0.074)	(0.076)	(0.072)	(0.072)
Log likelihood	-1513	-1395	-1627	-1561
Wald chi(2)	436	386	464	439
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)
LR test vs. Pooled	80	74	84	77
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)
Number of firms	2057	1979	2134	2082
Number of observations	9170	7982	10215	9854

Notes: Standard deviations are in parentheses. * Significant at the 5 percent significance level. The model which includes industry-dummies and all the regressors of the first column was not identified.

In tables 3 and 4 we report results when the data is divided into two parts. The theoretical findings of Gallini and Winter (1985) and also Katz and Shapiro (1985)) suggest that in the processing industry it pays for the innovative firm to transfer technology to the less innovative firms who are established in the product market. Therefore, we expect that in the processing industry R&D stock, especially, positively contributes to the acquisition activity. Comparison between the results in tables 3 and 4 show that R&D

stock has a positive impact in both industry groups. In the processing industries the obtained evidence that R&D has a positive impact on the probability that a firm acquires is, however, weak. Only in the model reported in the fourth column of table 3 is the impact of R&D positive at the 5 percent significance level. In another model which also includes lagged regressors, reported in the second column of table 3, the respective impact is positive at nearly the 5 percent (actually at 5.3 percent) significance level. By the obtained evidence so far, we cannot say that the mechanism behind M&A in the processing industries is qualitatively different from that in other industries. In fact, in a subsequent section, in which we model the probability that a target firm is purchased we obtain more evidence which reports that motives behind M&As in the processing industries are not the same as in other industries.

Table 4. Acquisition propensity estimates in the other industries (not in the processing industry). Random effects negative binomial firm-level model. Dependent variable = the number of acquisitions per firm in each year

Regressor	*Contemporary*	*Lagged*	*Contemporary*	*Lagged*
Constant	-7.520*	-6.156*	-7.201*	-5.936*
	(0.758)	(0.792)	(0.710)	(0.721)
Log RD-stock	0.103*	0.139*	0.181*	0.214*
	(0.035)	(0.037)	(0.032)	(0.033)
Log Turnover	0.640*	0.549*	0.551*	0.491*
	(0.028)	(0.028)	(0.024)	(0.023)
Log number of	0.242*	0.187*	0.281*	0.254*
Other firms	(0.048)	(0.049)	(0.046)	(0.046)
Log Debt Ratio	-0.020	-0.191*		
	(0.081)	(0.085)		
Log profit ratio	0.224*	0.078		
	(0.049)	(0.049)		
Log External R&D	-0.037	-0.066	0.041	-0.004
	(0.053)	(0.057)	(0.050)	(0.053)
Log likelihood	-3130	-2776	-3748	-3563
Wald chi(2)	794	683	853	841
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)
LR test vs. Pooled	247	223	354	303
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)
Number of firms	5447	5226	5750	5586
Number of observations	23887	20378	28298	26909

Notes: Standard deviations are in parentheses. * Significant at the 5 percent significance level.

It is, however, remarkable that external R&D has a negative impact in the processing industries and no impact in other industries. This result indicates that in the processing industries the other firms – who possess external R&D stock – represent, firstly, potential buyers of the target firms and, secondly, such targets to which more efficient technology is transmitted. The zero impact in other industries indicates that an acquirer seems to be interested in buying high tech firms. Then an increase in external R&D stock creates a positive effect on the propensity to buy a firm. This effect, together with the negative impact – which resembles the fact that the potential buyers' willingness to buy increases with their own R&D stock – results in estimated zero impact (in table 4).

Tables 3 and 4 report that impact from the number of those firms who have invested in R&D positively affects the propensity to buy a firm in other industries, but that in processing industries this impact is zero. We have argued that the impact considered is expected to be positive. Zero impact in the processing industries may refer to the fact that the large firms in these industries act in the global market. Then the relevant measure is not only the number of Finnish firms.

4.3. The firm as a target

The estimation results of the logit model, which described the probability of a firm becoming a target of acquisition, are reported in tables 5-8. There is no inevitable positive scale effect. However, because our data also takes into account such targets which are actually a part of the larger parent firm – which is not purchased – the estimated scale effect is easily positive. In addition, if the transfer of a process innovation is involved in an acquisition, the increase in the size of a target firm also increases the likelihood of a trade concerned. R&D stock is also expected to have a positive effect insofar as small and innovative firms - who are not established in the product market – are concerned. In the processing industry, though, it may be very lucrative to transfer technology to inefficient firms. This suggests that in the processing industries the impact of R&D stock is not necessarily positive. It is also expected that a firm in a good debt position and with high profits becomes more easily acquired than other firms.

For the same reasons as in the analysis which concerns the acquirer's motives, so also in the analysis concerning the likelihood of becoming a target firm, the increase in the number of firms in the same industry (whose R&D stock is positive) is expected to increase the explained probability.

When one analyses the probability of becoming a target, the influence of the external R&D on the probability concerned is different from the respective impact in the case in which the buyer's behaviour is modelled. Insofar as the other firms show up as potential targets, the impact considered is negative. This conclusion is again blurred by the fact that the other firms can also be regarded as buyers. Because we did not find any nonzero impact from external R&D stock on the explained likelihood, this variable is, however, omitted from the models considered in this section.

In the context of logit analysis the relevance of the panel-level variation is also tested. Let σ_v denote the standard deviation of the panel-level error term. We then test with a likelihood-ratio test to see whether $r = \frac{s_v^{2}}{s_v^{2}+1}$, labelled rho, deviates from zero. If rho is zero, the panel-level variance component is unimportant, and the panel-level estimator is not different from the pooled estimator.

The estimation results concerning the probability of becoming a target are reported in tables 4-8 and in table A3 in the appendix. We also estimated the models, which also include profit ratio besides the external R&D stock of other firms in the industry. But because the profit ratio – against expectations – had no non-zero impact on the probability of becoming a target, we also omitted profit ratio from the models considered.

Table 5. The probability of ownership changes for the target firm. Random-effects firm level logit model for the panel data. Dependent variable: ownership changes (=1), does not change (=0)

Regressor	*Contemporary*	*Lagged*	*Contemporary*	*Lagged*
Constant	-8.626*	-8.798*	-9.018*	-8.370*
	(0.573)	(0.604)	(0.600)	(0.617)
Log RD-stock	0.100*	0.108*	0.095*	0.113*
	(0.031)	(0.033)	(0.031)	(0.033)
Log Turnover	0.412*	0.426*	0.427*	0.397*
	(0.026)	(0.027)	(0.027)	(0.028)
Log number of other firms	0.154*	0.174*	0.151*	0.158*
	(0.048)	(0.050)	(0.050)	(0.051)
Log Debt Ratio			-0.245*	-0.089
			(0.073)	(0.083)
Log likelihood	-3161	-2976	-2867	-2832
Wald chi(2)	461	435	475	381
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)
LR test of rho = 0	50	48	33	44
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)
Number of firms	7724	7499	7663	7368
Number of observations	38517	36565	37558	32012

Notes: Standard deviations are in parentheses. * Significant at the 5 percent significance level.

The results derived from the random effects model reported in table 5 indicate that R&D-stock positively contributed to the probability of becoming a target. This effect is relatively robust. The number of other firms in the industry also has a positive impact. One can conclude that the same factors are behind this result as in the results concerning the likelihood that a firm acquires. It is possible that in the dense market with many firms the tech seller's position improves and with it the likelihood that technology is transferred through technology firm sales becomes higher. Debt ratio has a negative impact. This result shows that a good rather than bad financial position encourages other firms to purchase.

LR tests indicate (in table 5) that the random effects panel approach is justified.

In table 6 we report results obtained by estimating the fixed effects logit model.

Table 6. The probability of ownership changes for the target firm. Firm level logit model for the panel data. Dependent variable: ownership changes (=1), does not change (=0)

	Fixed-effects within	*Fixed-effects within*	*Fixed-effects between*	*Fixed-effects between*
Regressor	Contemporary	Lagged	Contemporary	Lagged
Log RD-stock	0.427*	0.359*	0.095*	0.116*
	(0.146)	(0.146)	(0.027)	(0.028)
Log Turnover	0.161*	0.157	0.393*	0.360*
	(0.081)	(0.090)	(0.023)	(0.023)
Log number of Other firms	0.205	0.344*	0.141*	0.141*
	(0.169)	(0.175)	(0.045)	(0.044)
Log Debt Ratio	-0.789*	-0.609	-0.161*	-0.003
	(0.150)	(0.165)	(0.069)	(0.076)
Log likelihood	-869	-827	-2851	-2860
LR chi2	54	34	602	512
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)
Number of groups (firms)	537	536		
Number of groups (years)			6	6
Number of observations	2732	2496	37558	32136

Notes: Standard deviations are in parentheses. * Significant at the 5 percent significance level.

The results obtained from the "between variation” indicate that investments in R&D increase the probability that a firm is acquired. The evidence derived from the "within variation” also support the conclusion that R&D investments increase the firm’s attractiveness as a target of acquisition. Again, one should notice that the data set in the “within variation” analysis comprise a relatively small number of firms.

In table A3 in the appendix we report the estimates of the random effects model, which include industry levels dummies. These results confirm the results obtained from other models. At least the positive impact of R&D on the probability of becoming a target seems to be robust.

In tables 7 and 8 we report estimation results when the data is split into the processing industries and other industries. It really appears that in the processing industries the impact of R&D stock is no longer positive. This is very much what is expected. In other industries, on the contrary, R&D stock contributes positively to the acquisition likelihood of the target firm. In this respect the results are different from the findings of analysis concerning the probability that a firm will acquire.

Table 7. The probability of ownership changes for the target firm in the processing industries. Random effects firm level logit model for the panel data. Dependent variable: ownership changes (=1), does not change (=0)

Regressor	*Contemporary*	*Lagged*	*Contemporary*	*Lagged*
Constant	-11.938*	-10.557*	-10.202*	-10.861*
	(1.329)	(1.355)	(1.238)	(1.312)
Log RD-stock	-0.046	0.009	-0.018	-0.001
	(0.057)	(0.063)	(0.056)	(0.062)
Log Turnover	0.546*	0.494*	0.468*	0.523*
	(0.060)	(0.063)	(0.055)	(0.060)
Log number of	0.281	0.237	0.170	0.224
Other firms	(0.175)	(0.174)	(0.169)	(0.169)
Log Debt Ratio	-0.221	-0.173		
	(0.139)	(0.152)		
Log likelihood	-868	-856	-969	-910
Wald chi(2)	153	116	136	131
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)
LR test of rho = 0	9	13	15	16
(p-value)	(0.001)	(0.001)	(0.000)	(0.000)
Number of firms	2123	2045	2134	2082
Number of observations	10071	8731	10216	9855

Notes: Standard deviations are in parentheses. * Significant at the 5 percent significance level.

Table 8. The probability of ownership changes for the target firm in the other (not processing) industries. Random effects firm level logit model for the panel data. Dependent variable: ownership changes (=1), does not change (=0)

Regressor	*Contemporary*	*Lagged*	*Contemporary*	*Lagged*
Constant	-8.173*	-7.772*	-8.096*	-8.140*
	(0.697)	(0.713)	(0.670)	(0.695)
Log RD-stock	0.145*	0.148*	0.146*	0.147*
	(0.038)	(0.040)	(0.038)	(0.039)
Log Turnover	0.398*	0.372*	0.398*	0.395*
	(0.031)	(0.032)	(0.030)	(0.031)
Log number of	0.127*	0.148*	0.152*	0.172*
Other firms	(0.056)	(0.056)	(0.054)	(0.055)
Log Debt Ratio	-0.240*	-0.059		
	(0.086)	(0.098)		
Log likelihood	-1994	-2009	-2188	-2106
Wald chi(2)	327	267	326	307
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)
LR test of rho = 0	21	32	32	31
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)
Number of firms	5696	5474	5750	5586
Number of observations	27487	23405	28301	26913

Notes: Standard deviations are in parentheses. * Significant at the 5 percent significance level.

The results in tables 4–8 also indicate that the probability of becoming a target is negatively influenced by the indebtedness of the target firm. The evidence of this is, however, weak, and in the process industries indebtedness has no effect.

5. Conclusions

We constructed a data set which makes it possible to analyse mergers and acquisitions in exceptional depth. Therefore, there are not many results in the literature with which the results obtained in this study can be compared. In this study we explain the likelihood that a firm acquires or is acquired by another firm. We try to find out whether the incidences of mergers and acquisitions are influenced by the investments in R&D. We obtained a very robust result which says that R&D investments increase the probability that a firm acquires in all industries. In other than the processing industries R&D stock similarly increases the probability that a firm is acquired by another. In the processing industries, the firm's own R&D stock has, however, zero impact on the likelihood that another firm buys a firm concerned. We interpret these results indicating that mergers and acquisitions are used as instruments to transmit knowledge from one firm to another. In other industries it is evident that knowledge capital cumulated in the target is the main motivation for the purchase. Then a buyer's own R&D – which also increases the probability of the trade – signals that a buyer is efficient in absorbing the purchased new technology and that a buyer has originally oriented in the use of high tech. Perhaps this type of orientation tells us that a buyer has a natural advantage in high tech industries. In the processing industries the motive for acquisition is different. We discovered that in the processing industries technology is rather transmitted from the buyer's firm to the purchased firm. One important precondition for these trades are the high admission costs. It is realistic to assume that in the processing industries all the firms in the market are in that sense incumbent that they have made remarkable, fixed investments, which cause sunk costs.

In an empirical analysis it is difficult to discover in detail all the reasons and mechanism behind the firm trades. We, however, believe that mergers and acquisitions are used as instruments of technology transfers because of the imperfections in contracting. Often it is impossible to quantify the future income accrued from a specific innovation. It is even difficult to find such a measure, for example some sales figure, that describes the income stream generated by the innovation concerned. These difficulties rule out contracted purchases of R&D and even royalty agreements with competing firms. Selling innovations and other results of R&D through a fixed price auction mechanism would overcome the difficulties considered. But, if there is commercialisation work still to be done, and if knowledge capital cannot be separated from human capital, the merger or acquisition becomes the most efficient method to transmit technology.

Appendix

Table A1. Statistics of Basic data set

All industries in the R&D panel	Mean	Std dev.	Y	Xb	X1	X2	X3	X4	X5	X6
N of firms	7370									
N of observations	33057									
Y: N of acquisitions per firm	0.0490	0.3615	1.0000							
Xb: fitted values	-2.1556	1.2638	0.2223	1.0000						
X1: Log RD-stock	-1.8264	8.3147	0.0922	0.2843	1.0000					
X2: Log Turnover	9.2809	1.9770	0.2081	0.9613	0.1894	1.0000				
X3: Log number of other firms	4.7938	0.9694	-0.0044	-0.0300	0.1243	-0.2224	1.0000			
X4: Log External R&D	8.9523	0.9288	0.0120	-0.0085	0.1694	-0.0011	0.2206	1.0000		
X5: Log Debt Ratio	-0.5854	0.6253	-0.0266	-0.1059	-0.0634	-0.0653	-0.0136	-0.1075	1.0000	
X6: Log Profit Ratio	-2.2460	0.9897	-0.0042	-0.0106	0.0550	-0.1709	0.0010	0.0729	-0.2168	1.0000
Processing industries	**Mean**	**Std dev.**	**Y**	**Xb**	**X1**	**X2**	**X3**	**X4**	**X5**	**X6**
N of firms	2057									
N of observations	9170									
Y: N of acquisitions per firm	0.0598	0.3469	1.0000							
Xb: fitted values	-1.7801	1.2563	0.2845	1.0000						
X1: Log RD-stock	-2.7527	8.1536	0.1818	0.5663	1.0000					
X2: Log Turnover	9.9051	1.8417	0.2728	0.9691	0.4610	1.0000				
X3: Log number of other firms	4.2533	0.4393	-0.0448	-0.0526	-0.0201	-0.1188	1.0000			
X4: Log External R&D	8.8338	0.8421	0.0384	0.0779	0.1189	0.2555	-0.3771	1.0000		
X5: Log Debt Ratio	-0.5715	0.5996	-0.0465	-0.1870	-0.1111	-0.1974	0.1307	-0.1562	1.0000	
X6: Log Profit Ratio	-2.2250	0.8786	0.0151	0.0845	0.0411	-0.0174	-0.1391	0.0526	-0.1993	1.0000
Other industries	**Mean**	**Std dev.**	**Y**	**Xb**	**X1**	**X2**	**X3**	**X4**	**X5**	**X6**
N of firms	5447									
N of observations	23887									
Y: N of acquisitions per firm	0.0449	0.3669	1.0000							
Xb: fitted values	-2.2574	1.2710	0.1999	1.0000						
X1: Log RD-stock	-1.4708	8.3486	0.0625	0.1949	1.0000					
X2: Log Turnover	9.0413	1.9749	0.1868	0.9580	0.1188	1.0000				
X3: Log number of other firms	4.9864	1.0508	0.0084	0.0116	0.1251	-0.1866	1.0000			
X4: Log External R&D	8.9896	0.9509	0.0043	-0.0062	0.1760	-0.0698	0.2717	1.0000		
X5: Log Debt Ratio	-0.5908	0.6348	-0.0202	-0.0853	-0.0454	-0.0261	-0.0303	-0.0906	1.0000	
X6: Log Profit Ratio	-2.2541	1.0290	-0.0105	-0.0362	0.0609	-0.2259	0.0249	0.0785	-0.2228	1.0000

Table A2. Acquisition propensity estimates, Negative binomial firm-level model, Dependent variable = the number of acquisitions per firm in each year

	Random-effects *Fixed industry level*	*Random-effects* *Fixed industry level*
Regressor	Contemporary	Lagged
Constant	-9.830*	-7.474*
	(2.146)	(1.332)
Log RD-stock	0.125*	0.148*
	(0.029)	(0.030)
Log Turnover	0.647*	0.566*
	(0.025)	(0.025)
Log number of other firms	0.517*	0.302*
	(0.304)	(0.120)
Log External R&D	0.029	-0.034
	(0.140)	(0.116)
Log Debt Ratio	0.035	-0.134
	(0.067)	(0.071)
Log Profit Ratio	0.195*	0.079
	(0.042)	(0.042)
Log likelihood	-4583	-4116
Wald chi(2)	1383	1191
(p-value)	(0.000)	(0.00)
LR test vs. Pooled	263	242
(p-value)	(0.000)	(0.000)
Number of firms	7370	7090
Number of observations	33057	28360

Notes: Standard deviations are in parentheses. * Significant at the 5 percent significance level.

Table A3. The probability of ownership changes for the target firm. Firm-level logit model for the panel data. Dependent variable: ownership changes (=1), does not change (=0)

	Random-effect Fixed industry level	*Random-effect Fixed industry level*
Regressor	Contemporary	Lagged
Constant	-15.247*	-10.129*
	(2.084)	(0.963)
Log RD-stock	0.066*	0.075*
	(0.034)	(0.036)
Log Turnover	0.482*	0.461*
	(0.030)	(0.031)
Log number of	1.288*	0.313*
other firms	(0.423)	(0.155)
Log Debt Ratio	-0.189*	-0.025
	(0.076)	(0.086)
Log likelihood	-2825	-2784
Wald chi(2)	534	448
(p-value)	(0.000)	(0.000)
LR test of rho = 0	27	36
(p-value)	(0000)	(0.000)
Number of firms	7663	7368
Number of observations	37558	32012

Notes: Standard deviations are in parentheses. * Significant at the 5 percent significance level.

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