NUPI

[606] Working Paper

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Nr. 606 December - 2000

Norwegian Institute of International Affairs

Norsk Utenrikspolitisk Institutt

Utgiver: NUPI

ISSN: 0800 - 0018

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Foreign Ownership, R&D and Technology Sourcing

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Abstract
This paper explores the relationship between domestic R&D and the inflow of foreign capital through foreign direct investment and foreign ownership. The idea that firms invest in a foreign country in order to more easily absorb the knowledge and technology of foreign firms is tested empirically using a unique firm level data set covering foreign ownership and R&D for all Norwegian firms over the period 1990 to 1996. The study gives no clear evidence supporting the existence of such a motive behind foreign ownership. On the other hand, the econometric study indicates that foreign investors may try to exploit their technological advantages in the Norwegian market. The results also show that the degree of foreign ownership is more volatile when firms are highly R&D intensive. We hypothesize that this is due to the fact that large R&D investments often result in large losses as well as gains to the firms.

JEL classification code: F21, O31, O32

1. Introduction

During the last decade, scientists with an interest in economic growth have become increasingly concerned with the importance of technology diffusion.[1] The tendency is probably motivated by a new body of empirical evidence indicating that it is actually possible to trace knowledge and technology flows between economic agents as well as regions and countries. Also, newly developed theories on games with knowledge externalities[2] and new achievements in the theory of growth with external economies[3], have enabled scholars to involve more thoroughly in the problems of growth and technology diffusion. It is commonly held that technology, knowledge and the more general concept of competencies share the properties of what economists often describe as a public good, which refers to goods or services that cannot be completely sheltered from the use of others. In other words, other economic agents are able to appropriate some of the economic value that derives from a new idea or a

* This research project has been financed by the Norwegian Research Council, under the project "Næring, finans og marked", grant number 124567/510
[1] Throughout the paper, I will use the term technology spillovers as a common expression for the spread of knowledge, competencies, procedures and technology. Wherever I need to specify the terminology, I will explicitly confront the reader with a more precise interpretation of the term.
[2] d'Aspremont and Jacquemin (1988), Suzumura (1992) and Simpson and Vonortas (1994).
[3] Here, the book by Grossman and Helpman (1991) stands out as a seminal contribution.

new technology. Furthermore, the imperfect appropriability of technology and knowledge is not solely confined to domestic agents, but also opens for widespread international technology diffusion. In this area, Krugman (1979) showed an early interest in designing a model of technology diffusion between innovating countries in the North and imitating countries in the South, that provided new insights into the forces behind economic convergence and divergence between the various regions of the world.[4]

As the evidence of the existence of international technology diffusion has become more solid over time,[5] it has become increasingly important to understand the mechanisms behind such diffusion. Naturally, *international* spread of technology and knowledge must be transmitted through some kind of interaction between individuals and organizations in the respective countries involved in the diffusion process. In the field of economics, the focus has mainly been directed towards the study of whether technology is transferred through three ways of economic interaction; *international trade*[6], *international labor migration and the international movement of capital through foreign direct investment (FDI) and foreign ownership.* This paper is devoted to the study of the last element, namely technology and knowledge diffusion through foreign ownership and foreign direct investment.

Broadly speaking, foreign presence in industrial activity may generate technology and knowledge spillovers in two ways or alternatively in two different directions. The first mechanism describes the spread of technology from a multinational enterprise (MNE) to the firms and institutions of the host country. Over the last 20 years, a large number of studies have focused on different aspects of foreign business activities and technology spillovers to the host country, and most of them identify significant positive effects on host country productivity, wages or economic growth (see among others Aitken and Harrison (1991), Blomström (1989), Kokko (1992), Mansfield and Romeo (1980), and Wang and Blomström (1992)).

The second type or direction of spillovers is the subject of this study and is in general far less extensively studied. The idea is based on the observation that multinational firms within the same sector often tend to cluster in areas or countries with a high density of firms operating on the technology front (e.g. the computer and semi-conductor industry in the Silicon Valley and the financial industry in London). This could imply that firms tend to invest abroad in order to appropriate technology and knowledge that firms and industries in a given country hold. The nickname for such activity has become *technology sourcing* through FDI. As opposed to the first type

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[4] The model predicted that imitation enables the relatively poor country to increase its rate of growth relative to the growth in the North, thus providing support for growth convergence between countries.
[5] Coe and Helpman (1995).
[6] See Coe and Helpman (1995) for an empirical investigation of R&D spillovers between OECD countries using import flow matrices to estimate the effect of embodied R&D in the imported goods on the total factor

of technology diffusion through FDI which is thought to go along with large investment flows between developed and developing countries, this second kind of technology diffusion is primarily linked to FDI flows between developed countries. This motive for foreign ownership and investment rests on the idea that firms with a multinational strategy constantly search for new technology and knowledge in order to maintain competitiveness. If the front edge technology is placed in a country where the firm has no activities, and the spread of knowledge is limited geographically, it is hard to learn from this technology (see Maurseth and Verspagen (1999) and Jaffe and Trajtenberg (1996) on the limits to international diffusion of technology and knowledge). The acquisition of front edge firms or simply establishing a subsidiary closer to such firms or industries may improve the ability to learn from and absorb the local technology. Technology sourcing through FDI is consistent with the existence of foreign owned firms that are relatively technologically less advanced as well as less competitive compared to the domestic firms. This prediction stands in strong contrast to the well known asset exploration argument, stating that multinationals will only be observed in countries where they have some kind of competitive advantage. [7]

The existing empirical literature on technology sourcing as a motive for FDI is primarily based on studies of foreign direct investment flows on a rather aggregated level (see section 2 for more on this). However, based on a large firm level database for Swedish multinationals, there has been published a series of studies that try to explain the motives for Swedish firms investing abroad. The technology sourcing motive is one of them, see e.g. Braunerhjelm and Svensson (1996), Fors (1998) and Braconier, Ekholm and Knarvik (2000). A common feature in these studies is that we know a lot about the investing firm but we have only highly aggregated information about the place they invest.

In this study, we approach the issue of technology sourcing from a somewhat opposite direction. Here, we make use of a large Norwegian firm level panel database that maps the degree and composition of foreign ownership in nearly all Norwegian firms within the industry sectors over a 7 year period. As far as we know, such an extensive database on foreign ownership cannot be found in other countries. We merge these data with firm level R&D statistics and data covering economic variables for each firm. This way, we are able to thoroughly investigate how foreign investors respond to changes in firm as well as industry characteristics in the country where the technology sourcing is supposed to be observed. Furthermore, using the OECD R&D statistics, we also identify the R&D intensity of the foreign owner's home industry. This way, we are able to study whether relatively technology poor foreign investors are attracted to technology rich sectors in Norway. There are several reasons for why an investor may find it interesting to invest abroad. This paper also discusses a series of alternative

productivity in the receiving country. For a summary of theoretical contributions in the study of trade and technology, see Grossman and Helpman (1991).

[7] See Dunning (1977), Caves (1996) and Ethier (1986).

factors that may attract or repel foreign investors, such as firm characteristics, firm performance, and market concentration.

By definition, FDI accounts for all strategic investments undertaken outside the investors' home country. The definition of strategic investment is not always clear, and it is by all means wider than the establishment of fully owned firms abroad. In this study, we also look into foreign investments that represent a share of ownership in firms located in Norway. Furthermore, we are able to both identify new foreign investments as well as dis-investments undertaken by a foreign owner.

So far, empirical studies of technology sourcing as a motive for FDI have not provided a uniform answer as to whether the motive is identifiable or not. In section 2 we briefly survey this literature and provide a synthesis of the overall impression. Section 3 contains a theoretical discussion of the possible interactions between technology differences on the one hand and FDI on the other. Here we particularly emphasize the rivaling motives of so-called asset exploitation and asset exploration among foreign investors. We discuss these issues in light of conclusions based on some recent studies within the industrial organization literature. Section 4 briefly survey the extent of foreign ownership in Norway in order to give the reader a feel of the ownership structure of the country.

In section 5, we present an econometric analysis of the relationship between foreign ownership on the one hand and technology and knowledge in Norwegian firms and industries, measured in terms of R&D activities, on the other hand. The analysis departs from some of the theoretical prediction on technology sourcing outlined in section 3, and tests the empirical relevance of these predictions. With the possible exception of the transport equipment industry, the study gives no support to the idea that technology rich industries tend to attract foreign ownership. It is also shown that foreign owners with a relative technology advantage are more active as investors in Norway than foreign owners originating from less R&D intensive industries. These results may be seen as evidence undermining the technology sourcing motive for foreign ownership and investment. Furthermore, the study shows that foreigners have concentrated their ownership to firms that are large, have high labor productivity and are placed in sectors with much R&D activities and high market concentration (few firms competing). On the other hand, the firms' own R&D activities are not strongly correlated to the degree of foreign ownership.

2. A brief look at earlier empirical studies

The lack of a good statistical source covering international FDI flows and ownership structures, as well as technology and knowledge indicators, has contributed to a tendency where a small number of research teams have used country specific or bilateral data to analyze the relationships between foreign ownership and technology. One group has published extensively on the basis of data covering Japanese investment in the US. Another group has utilized the rich information on the foreign activities of Swedish firms collected by IUI in Stockholm. Lately, a few studies have attempted to provide multi country surveys based on the merger of different statistical sources or a somewhat more aggregated data set. For a more extensive survey and a critical evaluation of the literature on technology sourcing through FDI, see Grünfeld (2000a).

The most frequently cited analysis on the links between knowledge/technology and FDI is an econometric study by Kogut and Chang (1991) where Japanese FDI into the US is evaluated on the background of Japanese and US industry characteristics. The authors use Japanese and US R&D as percentage of total sale as the main explanatory variable. The sum of these two components was believed to drive Japanese investment in the US since technology intensive sectors rely more heavily on R&D competition. The difference between these two components represents the motive for technology sourcing. Their results show no significant impact of R&D differences on FDI, hence the technology sourcing argument is not directly supported. However, when the sample was split into acquisitions, joint ventures and new plants, R&D difference became significant for joint ventures.[8] In a more recent paper by Barell and Pain (1999), US investments in European countries were regressed upon a set of variables including US R&D in the investing industry as well as the R&D intensity in the host country industry. The study gives strong support for a positive relationship between US FDI and host industry R&D intensity.

Braconier, Ekholm and Knarvik (2000) use Swedish firm data on multinational activities to map whether FDI works as a channel for R&D spillovers. Here the authors focus on productivity gains through FDI[9], as opposed to explaining the FDI flows. The study gives no evidence supporting that outward FDI by Swedish firms affects productivity through the channeling of R&D. In other words there is no evidence supporting the existence of positive productivity effects from technology sourcing through foreign ownership and FDI. Braunerhjelm & Svensson (1996) use the same data set in order to investigate whether multinational firms are more attracted to industries or clusters abroad. These firm level sales data are regressed upon a large set of variables. The core explanatory factors are *agglomeration,* which is measured as the industry's share of total employment in the country, and

[8] These results were confirmed in a later study by Anand and Kogut (1994).
[9] The study is based on the idea developed by Coe and Helpman (1995).

number of *scientists, engineers*. The agglomeration measures have a significant effect on foreign affiliate sales in the country. Hence, the paper supports the idea that foreign activity is attracted by industrial agglomeration in the host country. Although affiliate sales may depend on the amount of investment in the country, sales is only a weak proxy for foreign investment. Thus results from this study give only limited insight to the understanding of links between technology sourcing and FDI.

Neven and Siotis (1996) undertake an empirical analysis of technology sourcing through FDI with a wide geographical coverage using OECD industry data. In this study, the FDI flows between Japan, the US, UK, Germany, France and Italy were investigated based on data covering 8 industry sectors. FDI flows were regressed upon the R&D intensity both in the host industry and the industry of origin, measured as industry R&D expenditures over production value. As in Kogut and Chang, the paper also tests a specification with R&D differences and sums. In addition, a set of explanatory variables is included in order to capture the more traditional factors behind FDI flows. In concordance with the studies on US and Japanese FDI, investors from these countries seem to be partly motivated by technology sourcing. However, in the cases of intra-European FDI, there was no evidence of such a motive.

Martin and Velazquez (1997) also use OECD data to test an econometric model for FDI flows on the national level between 24 countries. The study indicates that higher relative R&D intensities are accompanied by more FDI. In other words, FDI flows between industrialised countries do not seem to be specifically attracted to areas with a high knowledge and technology intensity. This observation is incompatible with the technology sourcing hypothesis, but supports the theory of asset exploitation and use of technological advantages. In evaluating the quality of this study, one should ask whether macro data can shed light on investment behavior and transmission mechanisms that are strongly linked to firm behavior and industry conditions.

In a rather extensive study of patent data, Cantwell and Janne (1999) tried to test whether MNEs tend to invest abroad and search extensively for foreign knowledge and technology within the same activity or technological group using the concept of revealed technological advantages. Except for German companies in Italy, firms from other countries tend to engage in technological activities similar to those in the home country. According to their results, the MNEs primarily base their investments on their own technology advantage, and less on the sourcing of technology from host country firms.

3. Some theoretical predictions on FDI when technology spillovers matter

Traditionally, the theoretical literature on FDI has been based on models that allow firms to service a foreign market either through exports or through foreign production which requires investments in production equipment. This investment decision is treated as FDI. The choice between servicing the foreign market through exports or FDI is primarily a question of weighing fixed costs related to FDI against the variable costs associated with transporting a product to the foreign market (see Motta (1992) for more on this subject and Caves (1996) for a broad discussion). Allowing firms to differ with respect to technological capabilities (or alternatively marginal costs) has a clear effect on the choice between exports and FDI in such a setting. The best way to illustrate this effect is to introduce a simple model for international trade and FDI based on a Cournot duopoly. For simplicity, assume that the world exists of two firms (*i=1,2*) where firm 1 is located in a foreign country and firm 2 is located in the market we study. Hence, firm 1 is the only firm that engages in trade or FDI. Firm 1 confronts the following profit functions depending on whether it is exporting or undertaking FDI:

(1)
$$p_1^{E} = (1-q_1-q_2)q_1 - (b-x_1+t)q_1$$
$$p_1^{FDI} = (1-q_1-q_2)q_1 - (b-x_1)q_1 - F$$

Here, q_i is output and b is a fixed marginal cost component. The variabel x_i represents the level of technology of the firm, and a better technology is believed to reduce the marginal cost of production. The variable t is trade costs and F is the fixed cost relating to a foreign direct investment. The profit function is based on a linear demand function where the price is a decreasing function of total output in the market. Being only able to supply the home market, firm 2 faces the following profit function

(2)
$$p_2 = (1-q_1-q_2)q_2 - (b-x_2)q_2$$

where there are no trade costs. The 2 firms play a Cournot game in outputs, where they maximize profits with respect to their own output. The Nash equilibrium output in such a game is given by

(3)
$$q_1^{E*} = \frac{1}{3}(1-b+2x_1-x_2-2t) \qquad q_2^{E*} = \frac{1}{3}(1-b+2x_2-x_1+t)$$
$$q_1^{FDI*} = \frac{1}{3}(1-b+2x_1-x_2) \qquad q_2^{FDI*} = \frac{1}{3}(1-b+2x_2-x_1)$$

Here we assign a superscript to firm 2 equilibrium output in order to distinguish between the case where firm 1 exports and undertakes FDI. The equilibrium output is an increasing function of the firm's own technology level and a decreasing function of the competitor's technology level. This is due to the fact that a higher technology level brings down marginal costs and gives the firm a cost advantage that allows it to capture a larger share of total supply in the market. Also we see that as trade costs increase, the output of firm 1 will fall when it is exporting. On the other hand, the output of firm 2 will grow since the trade cost represents a cost advantage for the domestic firm. Profits in this model is an increasing function of output given by: $p_i = q_i^2 - F$ where F only enters for firm 1 and only if it involves in FDI. Hence, the qualitative effects on output also apply to the effects on profits. Taking the derivative of the profit function with respect to own technology gives:

(4) $$\frac{\partial p_1^E}{\partial x_1} = \frac{4}{9}\left(1 - b + 2x_1 - x_2 - 2t\right) \quad < \quad \frac{\partial p_1^{FDI}}{\partial x_1} = \frac{4}{9}\left(1 - b + 2x_1 - x_2\right)$$

The reason why profits in the exporting case increases slower than it does in the FDI case when the technology level is improved, is to find in the optimal output response. Since a higher technology level gives the firm a cost advantage relative to the competitor, output will increase. With higher output, the average cost will falls faster when you only face a fixed cost relating to FDI as opposed to variable transport costs. Thus, the larger the technology advantage is, the larger is the output volume of the foreign firm, and the more likely is the firm to involve in FDI. On the other hand, by reversing the argument, we find that the larger firm 1's technology disadvantage is, the larger is the likelihood of observing firm 1 as an exporter. This story describes analytically the term *asset exploitation in FDI* which was first introduced by Dunning and Narula (1995). The term refers to multinational firms that involve in foreign operations (e.g. through FDI) in order to exploit their technology advantages gained through extensive R&D activities.

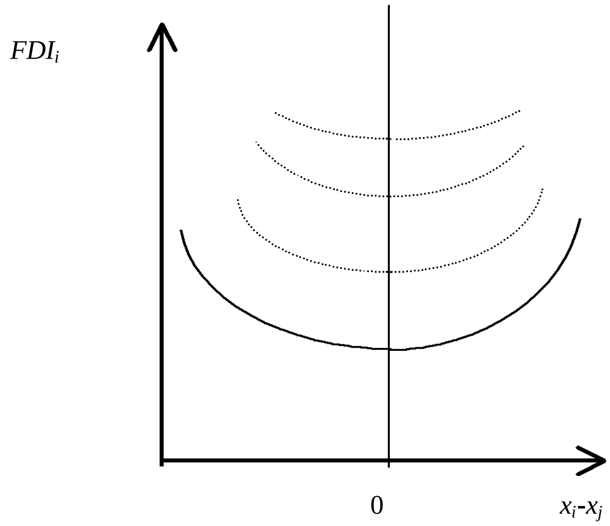
If we now take into account that technology or alternatively knowledge is not perfectly appropriable, meaning that some a the firm's technology may leak to competing firms, the picture outlined above becomes more complex. Such technology spillovers imply that the cost advantage obtained through a higher technology level is not solely gaining the firm alone, but other competing firms may also gain as they too become more competitive through learning. This problem is thoroughly discussed in relation to FDI by e.g. Petit and Sanna-Randaccio (2000) in the case with symmetric firms, and by Veugelers and Vanden Houte (1990) and De Bondt et al. (1988) looking at the asymmetric case. In order to illustrate the effect of technology spillovers in the outlined model, we substitute the existing cost functions $c_i = b - x_i$ with the following expression: $c_i = b - x_i - g_i x_j$ where the spillover parameter g_i varies between 0 and 1. If g_i equals 1, all the technology developed in one firm is shared by the others. If the value is 0, there are no spillovers. For simplicity, we only allow technology spillovers when firm 1 undertakes FDI, however, the analysis would generate similar results if we assumed that spillovers through exports existed but were smaller. Substituting for costs in (3) gives the following expression for profits in firm 1:

(5)

$$p_1^{FDI} = \frac{1}{9}(\overbrace{1-b+2x_1-x_2}^{\textit{traditional effect}} \overbrace{+2g_1x_2-g_2x_1}^{\textit{spillover effect}})^2 - F$$

Here, we have split the expression for FDI equilibrium profits into two, the first one we name the *traditional effect* of technology differences, which is equivalent to the already discussed effect above. The second effect is named the *spillover effect*, which captures the impact of technology being imperfectly appropriable. Basically, the effect is a composition of two spillovers, the spillover from the domestic firm 2 to the foreign firm 1 (g_1) and the spillover from firm 1 to firm 2 (g_2). A higher technology level in firm 2 contributes negatively to firm 1 profits through the traditional effect, but positively through the spillover effect. The story is of course reversed when we look at the effect of the technology level of firm 1. Now, we see that if the spillover from firm 2 to firm 1 (g_1) is large (larger than 0.5), the negative traditional effect is outweighed by the positive spillover effect. In addition, if the leak of technology from firm 1 to firm 2 is small, we may confront a situation where $p_1^{FDI} > p_1^{E}$, although the inequality sign would be reversed if we only considered the traditional effect. This is the case where a foreign firm decides to involve in FDI motivated by the leak or sourcing of technology and knowledge from the domestic firm. In terms of the taxonomy introduced by Dunning and Narula (1995), we face so-called asset exploring FDI. The alternative expression used in this paper is *"technology sourcing through FDI"*. It states that a relatively technologically disadvantage firm may still find it optimal to service a foreign market through FDI although the traditional arguments for such a choice are not there. If the spillover to the foreign firm is large under FDI, the technology sourcing motive becomes magnified as the technology level of the domestic firm increases.

This prediction can also be found in Fosfuri and Motta (1999) using numeric simulations in a model where both firms are allowed to enter the competitor's home market and where the technology follower is the only firm that can take advantage of the spillovers. In Grünfeld (2000b), we are presented with a similar story, but here spillovers also exist when firms export, and both the technology advanced and the less technology advanced firm have the ability to learn from each other. In this model, it is shown that when both firms are allowed to enter the other's home market through FDI, we will observe that both the technologically advanced firm and the technology follower will chose to undertake FDI when technology differences are larger. In other words, the theory predicts that we shall observe an asset exploiting firm with a high technology level and an asset exploring firm with a low technology level at the same time. If this proposition has empirical relevance, one should expect a pattern of FDI that relates to technology or alternatively R&D differences in the following way:



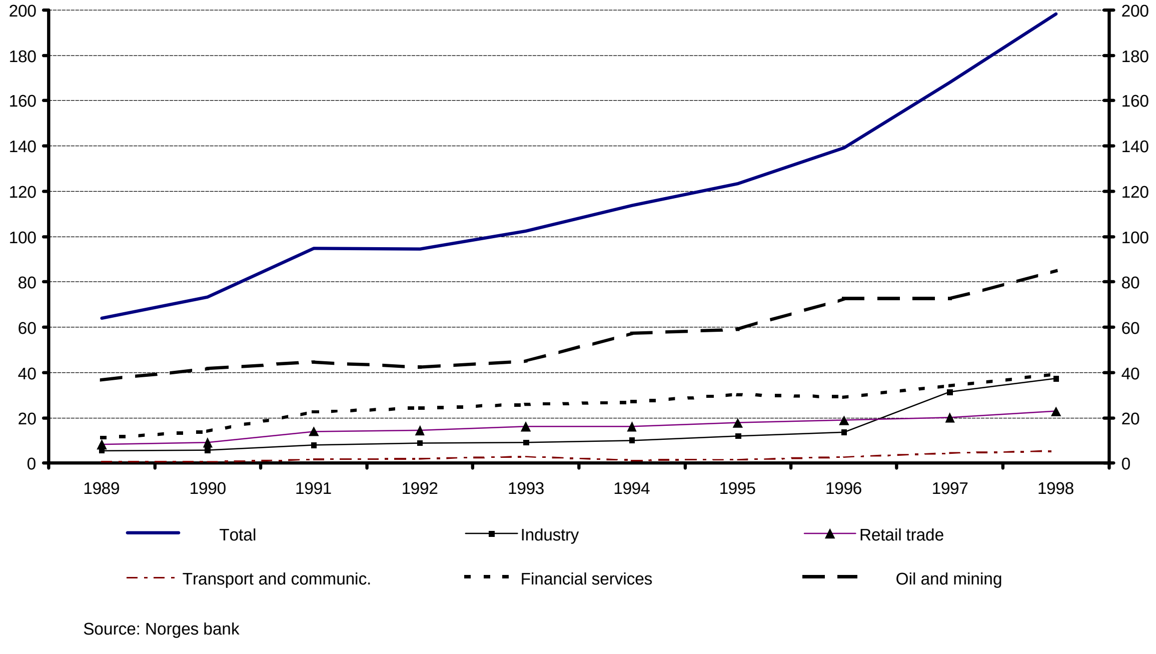
The u-shaped curve illustrates the point that large technology differences drive FDI for both kinds of firms. The stapled and less curved lines illustrate that a more technology advanced or technology intensive industry will display more FDI in this kind of models. This is due to the structure of the model where a higher technology level in both firms reduces marginal costs and gives a higher market output. In line with the traditional arguments this will increase the incentives to undertake FDI, even when firms become more similar in terms of technology levels.

The outlined model is in principal based on the idea that FDI relates to the establishment of a new production unit abroad. However, FDI in the model may also be treated as the acquisition of an existing firm located in the market, where the acquisition price is represented by the variable F.[10] On the other hand, the model structure is not directly designed to study how technology differences affect the willingness to join mergers with involve in partly ownership in firms located in the foreign market. Another important aspect, which is not touched upon in this framework, is the presence of so-called absorptive capacity. Cohen and Levinthal (1989) show that the ability to absorb technology and knowledge from external sources like competing firms, is a function of the firm’s own R&D activities. In other words, in order to be able to learn from others, you need a certain level of knowledge yourself. This effect may alter the equilibrium outcome in the model since the spillovers running from the domestic firm to the foreign firm become a function of the foreign firm’s technology level too.

4. Foreign investment and ownership in Norway

The presence of foreign ownership and foreign interests in Norway, e.g. represented by FDI, has increased vastly over the last 10 years. In Figure 1, FDI is decomposed into sectors, showing that the oil and mining sector is the dominant attractor of foreign capital. A comparison with other relevant countries reveals a slower growth in FDI inflows in Norway than one should expect. In Table 1, we compare the inflow of FDI as a proportion of domestic investment in different countries. Sweden has a remarkably strong presence of foreign investment, followed by the UK and Denmark.[11] It is generally assumed that small open economies have a larger proportion of foreign capital in the capital market than larger countries. The argument is equivalent to the one for international trade, based on larger and more self-sufficient goods and capital markets in larger countries. Thus, if we compare FDI inflows to Norway with the EU average in Table 1, they come out as rather low.

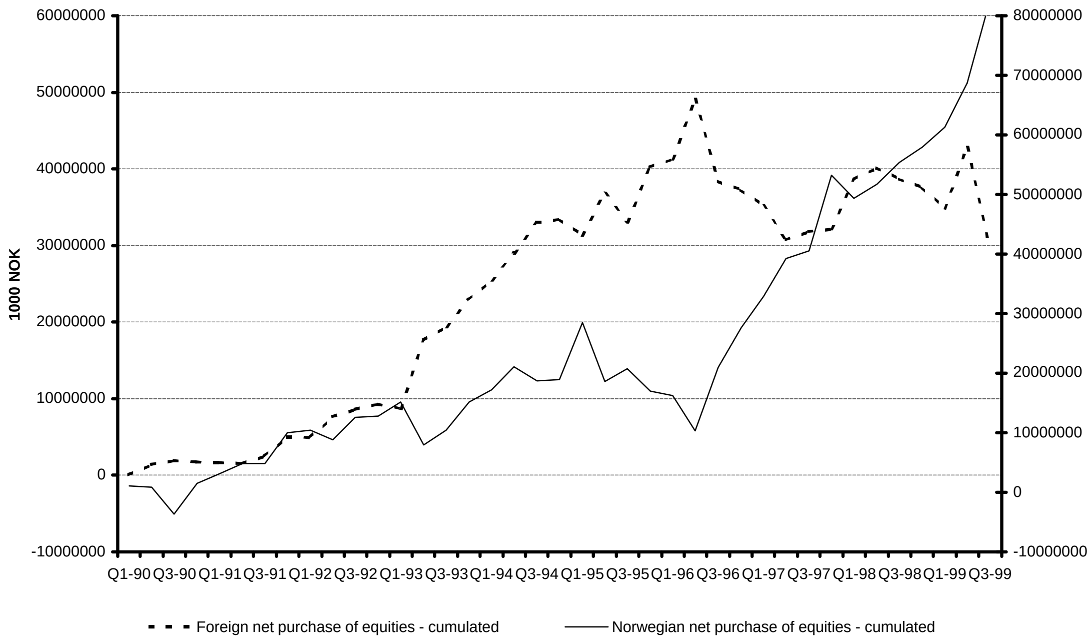
Figur 1: Stock of FDI going to Norwegian sectors



[10] The relationship between technology measured in terms of R&D intensity and domestic acquisitions is explored by Blonigen and Taylor (2000).

[11] This says something about the intensity of foreign presence in a country's capital market.

Figure 2: Net sales and purchase of Norwegian registered equities



In Figure 2, we take a closer look at foreign ownership in Norwegian registered securities and equities[12] over the last 10 years. The data shows that foreigners were net buyers until mid 1996, thereafter they have principally operated as net sellers. This is important to notice since the data in the econometric study in section 5 only covers the period 1990 to 1996. After 1996, there was a noticeable shift in the way foreign investors operate in Norway. Evidence from the Norwegian register of acquisitions at the Ministry of Industry and Trade supports the trend outlined in Figure 2, possibly with the exception of the development in 1999.

Table 1: FDI inflows as percent of gross fixed capital formation

	Norway	Sweden	Denmark	USA	Germany	UK	EU	Japan	Korea	World
Ave.1986-90	3.7	4.0	2.5	6.9	2.0	14.6	5.9	0.1	1.2	4.1
1991	-0.2	14.2	7.3	3.0	2.3	9.4	5.7	0.1	1.0	3.5
1992	3.2	-0.2	4.7	2.2	1.4	9.2	5.4	0.2	0.5	3.6
1993	6.2	14.5	6.8	5.1	0.5	10.9	5.9	na	0.5	4.3
1994	8.4	23.4	18.9	4.7	1.6	6.1	5.6	na	0.6	4.6
1995	4.8	42.9	12.4	5.8	2.3	11.9	7.2	na	1.1	5.4
1996	6.2	13.6	2.2	7.0	1.1	14.5	6.8	na	1.3	5.8
1997	8.1	35.0	8.3	9.3	2.3	18.6	8.6	0.3	1.8	7.7
1998	8.7	na	na	na	na	na	na	na	na	na
1999	16.1	na	na	na	na	na	na	na	na	na

Source: UNCTAD: World Investment Reports (1993-1999) na = not available

[12] Here approximately 80% of the value is related to firms registered on Oslo Stock Exchange.

With respect to data on foreign ownership, Norway is in a unique position. Since the early seventies, Statistics Norway has undertaken a “near census” survey of foreign ownership in firms registered in the country. The data set is named SIFON and includes information on foreign ownership shares, the registered value of firm equity, a distribution of foreign owners specified for 24 countries and regions, the share of the largest single foreign owner and whether the firm is owned by a mother company with foreign ownership. So far, we have not succeeded in identifying such a data set in other countries, hence the statistics provides a unique possibility for studying a wide range of issues that relate to foreign ownership and investment.

Table A1 gives a brief summary of the distribution of foreign owned firms in Norway in 1995. Almost 50% of all foreign owned firms operate in the wholesale sector, whereas only 10% of the firms are placed in traditional industry sectors. The number of foreign owned firms in the sectors extracting oil is surprisingly low compared to the FDI intensity in these sectors. However, this discrepancy is probably explained by the large size of firms in this sector. The sector *other business services* is also well represented with foreign owned firms. Here, we find activities like consulting, high-tech services, etc. Rusten, Kvinge and Jacobsen have merged the SIFON statistics with information from the Norwegian general firm registry (BOF) in order to identify employment in foreign owned firms in Norwegian business sectors. Their findings are summarized in Table A2.

The figures in Table A2 show that the industry sectors employ almost 50% of all those who are employed in foreign owned firms. The industry is also the economic sector with by far the strongest influence of foreign ownership measured in terms of the employment structure. Other important sectors are *other services* and *retail trade*. Once again, although the oil sector appears as important in terms of FDI, the foreign capital flowing into this sector employs few people and is spread out to a small number of companies.

5. Econometric evidence

5.1 A description of the data

We combine a number of data sets which make it possible to take account of a large set of alternative explanatory factors that may affect the extent of foreign ownership in Norwegian firms over the period 1990 to 1996. In order to do so, we have merged the SIFON data set described in section 4 with the Norwegian biannual statistics on R&D, which covers R&D activities in all Norwegian firms with more than 20 employees. Finally, the Norwegian Industrial Statistics (NIS) has been merged together with the two mentioned data sets in order to identify firm characteristics like employment, production, value added, investment, wage costs, market concentration, taxes, subsidies, as well as the insurance value of firm capital. In order to avoid anomalies in small firms, we restrict the data set to all firms with more than 20 employees, which is also consistent with the limits of the R&D statistics.

NIS only covers data for firms in the manufacturing sectors, which means that it is not possible to undertake a thorough study of foreign ownership in the service sectors and the oil sector. This represents a significant caveat to the analysis of foreign ownership in Norway, since we know from section 4 that these sectors contain most of the firms with foreign origin and dominance. According to Table A1, approximately 10% of all firms with foreign majority ownership are operating in the manufacturing industries,[13] but if we look at Table A2, the number of employees in industry firms with foreign ownership interests represented close to 50% of all employees in firms with some foreign ownership in 1996.

Tables 2 through 4 present the characteristics of foreign owned firms in the manufacturing sectors. Note that only approximately 5% of the firms in these industries have foreign ownership (see Table 2). If we restrict it to single foreign majority owners, we are down to approximately 2%. Although the number of representations is small, the importance of firms with foreign ownership is considerably larger. According to Table 3, firms with a single foreign majority owner employed more than 17% of all workers in these sectors in 1996. These firms also stood for almost 20% of the industry value added and investment. If we look at the R&D activities, the dominance of the few foreign firms was even larger, as 30% of all R&D employment related to such firms. When we look at all firms with some foreign ownership interests, they represented 2/3 of all R&D undertaken in the manufacturing industries. On this background, there is reason to claim that firms with foreign ownership are over represented when it comes to R&D activities.

The characteristics of foreign owned firms in different industry sectors are displayed in Table 4. Refined petroleum products (nace23), rubber and plastic commodities (nace25) and telecom and television equipment (nace32) were the sectors that are most exposed to foreign majority ownership in 1995. This is an interesting observation because these sectors partly represent some of our traditional comparatively competitive sectors, and partly sectors that policy makers see as the future growth sector in Norway, i.e. telecommunication and information technology. Sectors that has shown a decline in production over the last decades, like textiles, wearing apparel and leather products are characterized by barely no foreign interests.

[13] If we look at all firms with foreign interests, the ratio increases to approximately 14%.

Table 2: Number of firms in the data set specified for degrees of foreign ownership

	Share of foreign ownership >0%	>=50%	=100%	Single owner >=50%	Total
1990	286	155	135	148	3289
1991	414	215	184	137	3207
1992	437	221	190	140	3142
1993	450	232	201	152	3147
1994	475	275	235	169	3264
1995	517	277	227	172	3343
1996	487	267	210	187	3456
All years	3066	1642	1382	1105	22848
Percent of total number	13.4	7.2	6.0	4.8	100.0

Table 3: The presence of foreign ownership in Norwegian industry sectors

Percent of total	Man hours	Value added	Investment	R&D employment
	Firms with foreign owners (>0%)			
1990	23.2	29.9	34.9	
1991	34.4	39.9	53.1	67.4
1992	36.1	40.3	58.7	
1993	38.2	43.8	54.3	77.0
1994	38.2	45.2	49.3	
1995	40.1	50.1	53.5	67.9
	Single foreign majority owner (>=50%)			
1990	7.8	8.5	12.2	
1991	12.1	13.4	15.3	18.2
1992	12.2	12.7	12.8	
1993	13.2	14.8	18.5	22.7
1994	14.2	16.2	18.8	
1995	15.3	19.2	22.6	30.6
	Fully foreign owned firms (=100%)			
1990	5.7	6.6	8.2	
1991	10.0	11.1	10.5	15.5
1992	10.6	11.0	9.1	
1993	11.4	12.8	15.8	19.4
1994	12.1	14.3	16.2	
1995	12.4	15.9	16.7	21.0

Table 4: The importance of foreign ownership in Norwegian industry sectors (1995)

Percent of total		Firms with foreign owners (>0%)				Single foreign majority owner (>=50%)				Share of total industry
Industry	NACE-2	Man hours	Value added	Investment	R&D emp.	Man hours	Value added	Investment	R&D emp.	value added
Mining of metal ores	13	44.7	66.6	53.0	14.0	16.4	15.0	3.6	0.0	0.3
Other mining and quarrying	14	18.9	21.7	22.9	5.8	9.3	12.7	7.4	3.2	1.2
Food and beverages	15	29.3	45.2	32.8	55.0	8.9	18.2	11.3	14.8	19.1
Textiles	17	6.5	6.7	3.4	10.4	5.3	5.6	1.6	10.4	1.1
Wearing apparel	18	2.5	1.1	2.0	76.9	2.5	1.1	2.0	76.9	0.4
Leather products	19	9.1	9.7	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Wood products	20	18.7	23.1	32.0	20.5	0.7	0.7	0.3	0.0	3.6
Pulp and paper	21	77.9	85.0	77.5	67.3	8.0	4.1	3.6	18.9	6.6
Publishing and printing	22	31.3	40.8	27.3	5.0	4.3	4.6	6.3	0.0	10.2
Refined petroleum products	23	46.2	56.8	89.7	3.1	29.7	46.3	89.6	0.7	0.7
Chemicals and chemical products	24	91.0	89.6	91.3	91.7	15.8	18.5	17.4	1.3	10.0
Rubber and plastic products	25	35.3	36.1	47.9	55.3	28.7	28.2	32.9	52.5	1.8
Other non-metallic minaral products	26	49.9	58.2	75.5	72.6	19.6	24.8	57.0	24.2	3.1
Basic metals	27	66.4	72.2	69.6	91.8	20.0	17.3	34.7	6.3	8.4
Fabricated metal products	28	15.2	17.6	27.7	38.2	6.9	8.6	19.6	21.2	4.6
Machinery and equipment	29	36.1	39.7	47.7	71.8	10.4	12.1	15.0	6.2	6.6
Office machinery and computers	30	13.7	20.2	8.5	10.5	0.0	0.0	0.0	0.0	0.3
Electrical machinery	31	39.1	48.2	71.7	71.1	13.9	12.0	18.1	42.6	3.3
Telecom and television equipment	32	77.7	84.0	86.9	92.7	28.2	34.5	38.3	56.7	1.7
Medical and optical instruments	33	54.7	58.2	80.0	78.5	6.4	7.9	5.7	17.9	1.9
Motor vehicles	34	57.9	57.7	85.2	87.9	6.0	5.2	1.8	15.9	1.2
Other transport equipment	35	47.7	50.0	67.2	69.8	7.0	6.9	5.9	23.2	10.6
Furniture	36	10.7	14.5	14.2	11.1	2.9	3.0	1.4	3.0	2.9
Recycling	37	31.0	38.3	25.2	-	18.9	24.6	23.1	-	0.1

In order to identify the technology level of the foreign investors, we use the ANBERD statistics on industry R&D in the OECD countries to calculate the industry R&D intensity in the largest foreign owners' home country. Since we are not able to directly identify in which industry the foreign owner has its main activity in the home country, we assume that the industry affiliation at home is the same as the industry where the foreign owner has placed his investment in Norway. This is a rather strong assumption and must be treated as the best approximation of the technology level associated with the foreign owner.[14]

5.2 The econometric model

The econometric model is designed to explain how the presence of foreign ownership in firms located in Norway is affected by shifts in the technology and knowledge of firms and industries located in the same country and the technological capabilities of the foreign owner. According to the outlined models in section 3, one may find that foreign firms (owners) are attracted towards industries that display a highly developed technology base, since such industries may diffuse both knowledge and technology to competitors. It is generally believed that firms and industries that operate on the technology front spend a lot on R&D. In order to absorb this knowledge or technology, the foreign investor does not necessarily have to acquire or invest in a R&D rich firm. The greenfield establishment of a subsidiary or the acquisition of a less R&D intense firm may still allow the owner to appropriate spillovers from other firms in the industry. Thus, in the econometric models described below, the amount of R&D and the R&D intensity in the industry where the foreign owner has invested are core variables in the analysis together with the R&D intensity associated with the foreign owners home base.

The econometric model has the following structure:

$$\begin{aligned}
\textbf{(6)}\quad & d_FOR_SHARE_{it} = Xb = a + b_1 VAH_{i,t-1} + b_2 WCH_{i,t-1} + b_3 sSUBSVA_{i,t-1} + b_4 TAXVA_{i,t-1} + b_5 R\&D_{i,t-1} \\
& + b_6 INDR\&D_{k,t-1} + b_7 R\&DINT_{i,t-1} + b_8 HERFIN_l + b_9 SIZE_{i,t-1} + b_{10} INVINT_{i,t-1} + b_{11} FOR_R\&DINT_{i,1-t} \\
& + b_{12} REL_R\&DINT_{i,1-t} + b_{13} RELRD_SQ_{i,1-t} + \sum_{t=1992}^{1996} d_t D_t + e_{it}
\end{aligned}$$

where i is an index over firms, t represents time, k is an industry index defined at the nace 2 digit level and l is an industry index defined at the nace 5 digit level. The left hand side varable $d\_FOR\_SHARE_{it}$ is the change since last year in the largest foreign owner's share of total equities in the firm. Throughout the study we focus on the largest owner's behavior since this is the foreign investor that

[14] An alternative yet more crude measure is based on the R&D intensity in the investor's home country at large.

probably has the largest strategic interest in the ownership. VAH_{it} is value added per man hour in the firm, WCH_{it} represents hourly wage costs, $SUBSVA_{it}$ is subsidies relative to value added and $TAXVA_{it}$ is the same ratio for product taxes.[15] $SIZE_{it}$ is the size of the firm in terms of total employment, $INVINT_{it}$ is the intensity of investment in the firm relative to total employment and $HERFIN_{l}$ is a Herfindahl concentration index measured at the 5 digit nace level in order to assure that competition is measured in the correct industry group. The Herfindahl index is time invariant. D_t are year dummies that may play an important role since Norway went through several policy shifts during the period that affected the investment climate for foreign investors. First of all, a large tax reform that included capital and company taxation was introduced in 1992. In 1994, Norway joined the single European market and had to implement and adapt to EU rules on capital regulation etc. A new publicly administered foreign ownership register was implemented and rules and limits on foreign ownership were transformed and liberalized. At the same time, the Norwegian economy went through a business cycle upturn with strong improvements in firm and industry profitability.

The R&D activities of firms, industries and foreign owners are represented by the following variables[16]: $R\&D_{it}$ is the number of R&D man-hours in the firm. The variable is composed by both in-house and externally provided R&D activities in order to take account of the firms' total R&D activities. $R\&DINT_{it}$ is the firm's R&D intensity measured in terms of the total work force. $INDR\&D_{kt}$ is the total number of man-hours in the industry where the firm is located net the firm's own R&D input. The variable is calculated on a 2 digit nace level. The emphasis on industry R&D implies that we only focus on intra industry spillovers.[17] However, since much of the technology in the industry sectors is rather specialized, there is good reason to expect that such spillovers are stronger than inter industry spillovers. $FOR\_R\&DINT_{it}$ is the R&D intensity associated with the largest foreign owner in the firm. The variable is calculated in the following way:

(7) $$FOR\_R\&DINT_{it} = \frac{R\&D_{kst}}{X_{kst}}\left(FOR\_SHARE_{it}\right)$$

where $R\&D_{kst}$ is the R&D expenditures in sector *k*, country *s* at time *t*, and X_{kst} is the gross production in the sector. The country *s* is the one where the largest owner has his home base. We weight the variable with the foreign owner's ownership share in the firm in order to take account of the importance of the foreign owner's absorptive capacity. Here, we implicitly assume that the larger the ownership share is, the larger is the foreign owners local involvement, and thus the stronger is his

[15] The tax variable does not represent firm taxes, but taxes levied on the production, e.g. environmental taxes.
[16] All R&D variables are lagged 1 to 2 periods due to the fact that the R&D survey is only performed bi annualy.
[17] See Bernstein and Nadiri (1988) for more on intra- versus inter-industry spillovers.

ability to absorb the knowledge and technology in the firm as well as the industrial environment surrounding the firm (see section 5.1 for more on this varable). $REL\_R\&DINT_{it}$ is defined by:

(8) $$REL\_R\&DINT_{it} = \left(\frac{R\&D_{kst}}{X_{kst}}\right) / \left(\frac{INDR\&D_{kt}}{SIZE_{kt}}\right)$$

where $SIZE_{kt}$ is the number of employed in the industry *k*. Hence, the variable measures the R&D intensity associated with the foreign owner relative to the R&D intensity in the industry where the foreign owner has an interest. Finally, $RELR\&D\_SQ_{it}$ is defined by

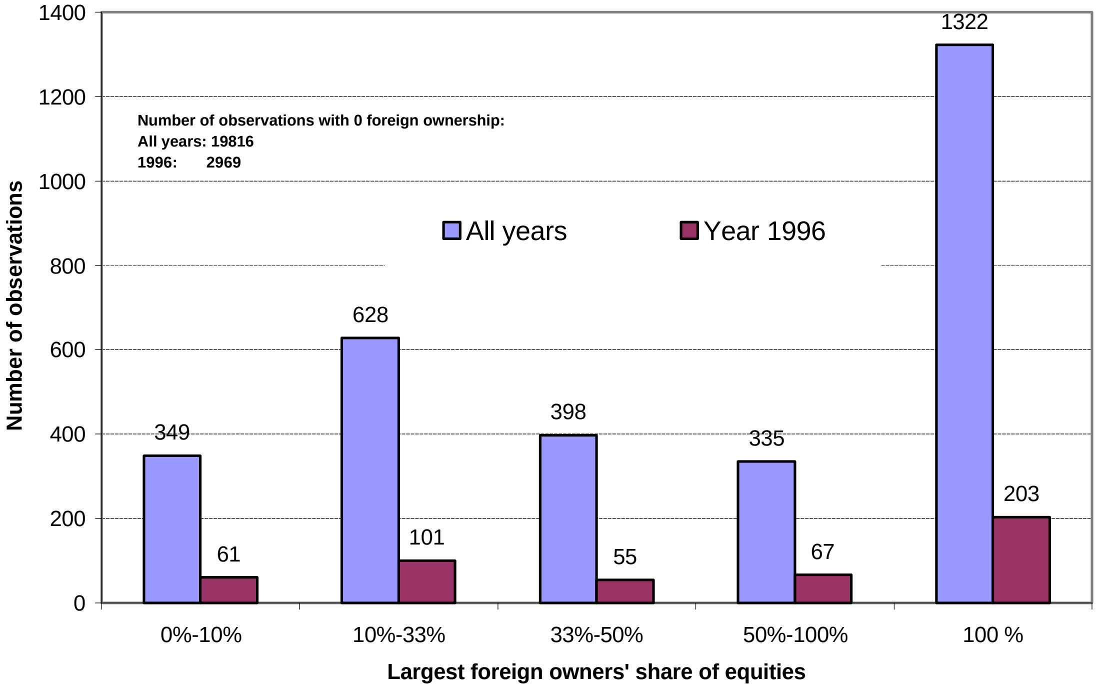
(9) $$RELR\&D\_SQ_{it} = \left(REL\_R\&DINT_{it} - average\left(REL\_R\&DINT_{it}\right)\right)^2$$

The rationale behind including this variable is based on the theoretical prediction in section 3 where the link between foreign direct investment and technology differences is best described by a non-linear relationship. In other words, foreign direct investment is expected to be most frequently observed where the foreign investor either has a large technology advantage or a large technology disadvantage. If this is the case, we should observe a positive coefficient attached to this variable.

All explanatory variables are lagged one year in order to avoid causality problems and to take into account that a decision with respect to changes in the degree of ownership takes time.

The data on foreign ownership is registered in terms of percentage ownership shares. The panel of firms spans over the period 1990 to 1996, and we have no information on the ownership structure before 1990.[18] Most likely, the vast majority of firms with foreign ownership interests had a similar ownership structure before 1990. Hence, the decision to invest in a firm located in Norway or alternatively establish a new fully owned firm in the country may be explained by conditions in a period prior to our data set. Keeping this in mind, in order to investigate the relationships between foreign ownership, R&D and economic characteristics of the firm, we are forced to study changes in foreign ownership within the period as opposed to the absolute value of foreign ownership shares in the firms. One enriching implication of studying *changes* in foreign ownership shares is that the model we estimate implicitly becomes a firm fixed effects model. Hence, we are automatically adjusting our estimates for firm specific effects in the data set.

Figure 3: The distribution of foreign ownership shares in the data set



As illustrated in Figure 3, the distribution of foreign ownership among Norwegian industry firms is strongly dominated by those firms that have no foreign interests at all. Thus, variable FOR_SHARE as well as the variable d_FOR_SHARE will have a large number of zeros. In order to structure the data, we divide the observation into five mutually excluding categories[19]:

Category 1: No foreign ownership in period *t-1* and no foreign ownership in period *t*.

Category 2: Foreign ownership in period *t-1*, but no change observed between *t-1* and *t*.

Category 3: An increase in the foreign ownership share from period *t-1* to period *t*.

Category 4: A reduction in the foreign ownership share from period *t-1* to period *t*.

Category 5: A new firm enters with foreign ownership in period *t* (*t*>1990).

The number of observations within each category is distributed as follows:

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
# of observations	14674	1459	758	410	161

[18] As mentioned earlier, the SIFON data set goes far beyond 1990, but structural changes in the data set makes the data much more comprehensive after 1989. Hence, comparisons with pre 1990 data is troublesome.

The large number of observations without foreign ownership raises the problem of estimation with limited dependent variables and sample selection bias. Although there has been no observable foreign interests in these firms, the desire to actually invest in these firms may still be real. If we skipped these observation, we would lose valuable information that may explain reasons why foreign investors increase or decrease their ownership shares in firms located in Norway. If the dependent variable was FOR_SHARE and not the change in this variable, we could solve this problem using a Tobit model with 2 sided censoring since the dependent variable would take on values between 0 and 100.[20] However, the issue of estimation in this case is further complicated by the fact that our dependent variable take values from –100 to +100, with a clustering of observations at the values –100, +100 and 0 (ref. category 1 and 2). I order to deal with this problem we estimate four different models that each and one may shed light on the outlined econometric equation in (6).[21] Model 1 is a Probit model with the following structure:

(10) $$prob\ \ y_{it} = \begin{cases} 1 & if\ cat\ 3,4\ or\ 5 \\ 0 & if\ cat\ 1\ or\ 2 \end{cases} = \frac{e^{Xb}}{1+e^{Xb}}$$

Here, we are only identifying factors that shift the probability of observing a change in the equity share of the largest foreign owner. In other words, this model is not able to distinguish between a reduction and an increase in the foreign ownership share. Model 2 brings model 1 one step further based on the 2 stage Heckman procedure. Here we use information from the Probit model by constructing a sample selection bias correction variable, the so-called Heckman's lambda given by $l_{it} = f(y_{it})/F(y_{it})$ where *f(.)* is the normal density distribution and *F(.)* is the cumulative density distribution. In model 2, we include Heckman's lambda into equation (3) and estimate it using OLS at the second level which provides unbiased estimates corrected for the selection bias at the value 0. However, since change in foreign ownership can not exceed –100 and +100, we still have a censoring problem to deal with. In model 3, we apply a Tobit model with 2 sided censoring at –100 and + 100 at the second level instead of standard OLS. This way, all conceivable selection biases are taken care of

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[19] Ideally, we should also have a category for exiting firms. However, the data set is not designed to provide information on exits, and if we observe that a firm leaves the sample within the observation period, it could just as well be due to a change in the statistical registration of the firm.

[20] Foreign investors could ideally want to increase their ownership shares further although they already posit 100% of the stocks in the firm.

[21] A commonly applied approach to the outlined problem of explanatory variables that are limited from below and above is to perform a transformation of the data. A possible transformation of our variable containing changes in foreign ownership could be based on a logistic transformation of the following kind:

$x_{it} = \frac{1}{b}\ln\left(\frac{y_{it}+100}{100-y_{it}}\right)$ where y_{it} is the original observation varying between –100 and +100 and x_{it} is the transformed one, varying between minus and plus infinity. However, since we observe a clustering of observations around the extreme points, the transformation would provide a relatively large number of observations with the value of infinity. We find this problematic and drop the estimation using transformed data.

and the model should provide correct estimates. Finally, in model 4 we estimate the following multinomial logit model :

(11)

$$prob\ \ y_{it} = \begin{cases} 0 & if \quad cat\ 1\ or\ 2 \\ 1 & if \quad cat\ 3 \\ 2 & if \quad cat\ 4 \end{cases} = \frac{e^{Xb(r)}}{\sum_{r=0}^{2} e^{Xb(r)}}$$

where *r={0,1,2}* is an index over the 3 alternative categories. The multinomial logit model allows us to identify the factors that affect the probability of observing a negative or a positive shift in foreign ownership shares in the firm relative to the probability of seeing no shift at all (category 0). This give additional insights compared to the Probit model where the distinction between negative and positive shifts was unidentified.

A Hausman specification test did not reject the null hypothesis stating that the data could be estimated as a pooled data set instead of a full panel. Consequently, in the econometric exercises reported below, we have pooled the panels.

5.3 Results

In Table 5, we report on how foreign ownership correlates with the variables entering the econometric equation. The results are based on the standard Tobit model in order to account for censoring bias in the data set. It is important to notice that these estimates are not to be confused with the results of the econometric study outlined above, they are simply a way of looking at what goes along the degree of foreign ownership in Norwegian firms. The results show that foreign ownership in Norwegian manufacturing industries correlates negatively and significant with the number of R&D employees in the firms. This is interesting since we know from the summary statistics that foreign owned firms independent of the degree of foreign ownership are much more R&D intensive than firms without foreign ownership. This tells us that high R&D intensities are primarily found in firms with a small foreign ownership share. Furthermore, foreign investors are over-represented in R&D rich industries. Our measure of the foreign owners' R&D intensity at home *(FOR_R&DINT)* correlates strongly with the degree of foreign ownership in Norwegian firms. The same also accounts for variable measuring relative R&D intensities.

Table 5: What goes along with foreign ownership?
Tobit estimates with left and right side censoring

Foreign ownership share	Coef.	Std. Error	
VAH	27.03	(8.12)	***
WCH	1278.65	(68.41)	***
SUBSVA	-28.42	(9.70)	***
TAXVA	-70.52	(33.40)	**
R&D	-0.33	(0.12)	***
INDR&D	0.06	(0.01)	***
R&DINT	-1.09	(15.65)	
HERFIN	208.99	(13.85)	***
SIZE	5.47E-05	(5.54E-06)	***
INVINT	0.89	(0.54)	
FOR_R&DINT	15.39	(4.46)	***
REL_R&DINT	2.22E-03	(1.07E-04)	***
RELR&D_SQ	-1.68E-09	(1.28E-10)	***
1992	-4.33	(7.07)	
1993	-7.68	(7.09)	
1994	-12.05	(7.02)	
1995	-9.30	(6.93)	
constant	-431.31	(15.24)	***
Number of obs	15042		
LR chi2	2919.7		
Prob>chi2	0		
Log likelihood	-11417.7		
R^2 (pseudo)	0.114		

* = 10% level of sign. ** = 5% level of sign. *** = 1% level of sign.

Furthermore, foreign ownership is correlated positively and significant with the labor productivity in the firm (*VAH*). Since labor productivity is higher in such firms, it is probably not surprising that a higher share of foreign ownership in a firm goes along with higher are hourly wage costs (*WCH*). This tendency was already pointed out by Kvinge (1994), based on data from the eighties. Thus, broadly speaking, workers are better paid in foreign owned firms. Foreign ownership is also positively correlated with the degree of market concentration (*HERFIN*) in the industry. So, foreign owned firms operate in sectors with less fierce competition. Finally, foreign owned firms are generally larger than purely nationals, an observation that does not surprise the informed reader, knowing that multinationals and their subsidies often are vastly larger than their local counterparts.

Table 6: Explaining changes in foreign ownership (Full data set)

	Model 1			Model 2			Model 3			Model4					
	Probit			2 stage Heckman with OLS			2 stage Heckman with Tobit			Multinomial logit					
Change in foreign ownership share	Coef.	Robust Std. Err.		Coef.	Robust Std. Err.		Coef.	Robust Std. Err.		Coef.	Robust Std. Err.		Coef.	Robust Std. Err.	
										Category 1: Increase			Categoty 2: Reduction		
Heckmans lambda				-2.03	(3.19)		-2.05	(1.38)							
VAH	0.03	(0.08)		0.23	(0.44)		0.23	(0.42)		0.04	(0.18)		-0.03	(0.45)	
WCH	7.16	(0.85)	***	-11.55	(20.13)		-11.60	(8.67)		12.28	(1.67)	***	16.01	(2.17)	***
SUBSVA	-0.02	(0.03)		-0.02	(0.09)		0.02	(0.08)		-0.20	(0.36)		-0.01	(0.04)	
TAXVA	0.03	(0.14)		0.10	(0.25)		0.11	(0.29)		0.59	(0.95)		-1.97	(0.95)	
R&D	0.00	(0.00)		-0.01	(0.01)		-0.01	(0.01)		-0.004	(0.00)	*	0.00	(0.00)	
INDR&D	0.000	(0.000)		-0.001	(0.001)		-0.002	(0.003)	*	0.000	(0.000)		0.000	(0.000)	**
R&DINT	1.43	(0.36)	***	0.92	(1.93)		0.92	(1.06)		2.51	(0.61)	***	2.51	(0.62)	***
HERFIN	0.78	(0.20)	***	-0.54	(2.28)		-0.55	(1.10)		1.40	(0.39)	***	1.50	(0.44)	***
SIZE	4.68E-07	(1.28E-07)	***	-1.98E-07	(1.00E-06)		-2.06E-07	(5.06E-07)		9.49E-07	(2.68E-07)	***	9.71E-07	(2.57E-07)	***
INVINT	0.01	(0.01)		0.04	(0.04)		0.04	(0.32)		0.02	(0.18)		0.02	(0.02)	
FOR_R&DINT	-0.07	(0.10)		-0.72	(0.63)		-0.72	(0.23)	***	-0.16	(0.16)		-0.17	(0.35)	
REL_R&DINT	1.89E-05	(2.58E-06)	***	9.91E-05	(5.64E-05)		9.97E-05	(2.02E-05)	***	3.58E-05	(5.68E-06)	***	4.44E-05	(1.07E-05)	***
RELR&D_SQ	-3.37E-11	(7.08E-12)	***	-1.04E-10	(1.00E-10)		-1.04E-10	(3.76E-11)	***	-6.40E-11	(1.76E-11)	***	-1.31E-10	(5.01E-11)	***
1992	-0.26	(0.07)	***	-1.59	(0.88)		-1.60	(0.41)	***	-0.77	(0.17)	***	0.08	(0.38)	
1993	-0.15	(0.06)	***	-1.88	(0.71)	**	-1.90	(0.32)	***	-0.65	(0.17)	***	0.69	(0.25)	***
1994	-0.42	(0.10)	***	-1.04	(1.26)		-1.05	(0.57)	**	-1.09	(0.26)	***	-0.30	(0.38)	
1995	-0.16	(0.08)	***	-1.76	(0.58)	***	-1.78	(0.33)	***	-0.76	(0.26)	***	0.76	(0.26)	***
1996	-0.70	(0.12)	***	-2.75	(0.60)	***	-2.77	(0.28)	***	-0.50	(0.36)		0.81	(0.21)	***
constant	-2.82	(0.12)	***	8.14	(9.93)		8.20	(4.24)	*	-5.09	(0.26)	***	-7.42	(0.34)	***
Number of obs	18259			18259			18256			18259					
Wald chi2	1568.08					LR ch	983.31			4130.35					
Prob>chi2	0			0			0			0					
Log likelihood	-3397.06						-68223.8			-4128.25					
R^2 (pseudo)	0.21			0.052			0.0072			0.1869					

Heteroskedasticity robust standard errors which are adjusted for clustering on industry group (Nace 2 level)

* = 10% level of sign. ** = 5% level of sign. *** = 1% level of sign.

Table 7: Explaining changes in foreign ownership (Limited data set)
Only firms with foreign ownership in period t-1

	Model 1			Model 2			Model 3			Model4					
	Probit			2 stage Heckman with OLS			2 stage Heckman with Tobit			Multinomial logit					
Change in foreign ownership share	Coef.	Robust Std. Err.		Coef.	Robust Std. Err.		Coef.	Robust Std. Err.		Coef.	Robust Std. Err.		Coef.	Robust Std. Err.	
										Category 1: Increase			Categoty 2: Reduction		
Heckmans lambda				29.29	(13.69)	**	29.27	(11.80)	**						
VAH	-0.27	(0.28)		-4.14	(4.69)		-4.35	(4.10)		-0.37	(0.49)		-0.66	(0.70)	
WCH	2.44	(0.95)	**	30.93	(25.04)		30.40	(23.05)		1.90	(1.83)		7.09	(1.71)	***
SUBSVA	0.25	(0.15)	*	0.64	(3.91)		0.36	(2.12)		0.40	(0.37)		0.50	(0.28)	*
TAXVA	0.80	(0.34)	**	13.37	(7.52)	*	12.96	(8.95)		1.76	(0.70)	**	-0.53	(0.54)	
R&D	0.00	(0.00)		0.02	(0.01)		0.02	(0.02)		-0.001	(0.00)		0.0010	(0.00)	
INDR&D	0.00	(0.00)	**	-0.01	(0.00)	**	-0.01	(0.00)	***	-0.0004	(0.00)	**	-0.0002	(0.00)	
R&DINT	0.62	(0.23)	***	6.10	(2.48)	**	6.03	(3.35)	*	1.10	(0.43)	***	1.06	(0.42)	**
HERFIN	-0.31	(0.26)		-7.66	(3.69)	**	-7.70	(3.73)	**	-0.58	(0.43)		-0.34	(0.48)	***
SIZE	1.30E-07	(8.80E-08)		1.85E-06	(1.18E-06)		1.79E+00	(1.24E-06)		1.97E-07	(1.69E-07)		2.64E-07	(1.41E-07)	*
INVINT	0.03	(0.03)		0.20	(0.06)	***	0.20	(0.10)	*	0.05	(0.05)		0.04	(0.04)	
FOR_R&DINT	-0.03	(0.08)		-0.79	(0.64)		-0.81	(0.65)		-0.04	(0.09)		-0.02	(0.23)	
REL_R&DINT	4.87E-06	(2.12E-06)	**	1.90E-04	(6.35E-05)	***	2.02E-04	(4.80E-05)	***	8.96E-06	(2.97E-06)	***	8.44E-06	(7.46E-06)	***
RELR&D_SQ	-1.08E-11	(4.55E-12)	**	-3.49E-10	(1.40E-10)	**	-3.52E-10	(1.12E-10)	***	-1.85E-11	(7.00E-12)	***	-3.08E-11	(2.05E-11)	***
1992	-0.49	(0.09)	***	-25.34	(5.09)	***	-26.26	(4.29)	***	-0.97	(0.19)	***	-0.07	(0.36)	
1993	-0.24	(0.08)	***	-20.78	(3.84)	***	-21.67	(2.66)	***	-0.73	(0.18)	***	0.62	(0.26)	**
1994	-0.63	(0.15)	***	-26.27	(6.00)	***	-27.07	(5.44)	***	-1.17	(0.27)	***	-0.40	(0.36)	
1995	-0.25	(0.10)	**	-20.23	(3.09)	***	-21.17	(2.69)	***	-0.81	(0.25)	***	0.69	(0.25)	***
1996	-0.18	(0.15)		-24.43	(2.83)	***	-25.66	(2.33)	***	-0.61	(0.34)	**	0.67	(0.18)	***
constant	-0.25	(0.19)		-7.68	(13.81)		-6.67	(11.55)		-0.27	(0.37)		-2.81	(0.33)	***
Number of obs	2702			2702			2702			2702					
Wald chi2	810.76					LR chi	252.39			5134.84					
Prob>chi2	0			0			0			0					
Log likelihood	-1761.02						-12334.2			-2455.52					
R^2 (pseudo)	0.04			0.088			0.01			0.055					

Heteroskedasticity robust standard errors in parenthesis which are adjusted for clustering on industry group (Nace 2 level)

* = 10% level of sign.   ** = 5% level of sign.   *** = 1% level of sign.

In Table 6, we report the econometric estimates based on the full data set. The first thing to notice is that model 2 and 3 provide few significant coefficients. This implies that very few of the selected explanatory variables are able to explain the quantitative aspects of shifts in foreign ownership when we use the full data set. However, in model 1 and 4 which only report qualitative predictions, the econometric results are more significant. Nevertheless, model 3 identifies that the lower the R&D intensity associated with the largest foreign owner is, the more likely is the foreign owner to increase his ownership share in Norwegian firms. As in model 1 and model 4, the relative R&D intensity variable has a positive coefficient. This result is one of the most robust in the study as it appears in almost all regressions in Table 6, 7 and 8. These results imply that relatively technology advanced foreign investors have a stronger tendency change the degree of foreign ownership, and according to model 3, the tendency is stronger in the direction of an increase as compared to a decrease. However in model 4, it is shown that the more technologically advanced the foreign owner is, the larger is also the probability of a reduction in the ownership share as compared to the probability of no change at all. Furthermore, the variable RELR&D_SQ has a negative coefficient in both model 1, 3 and 4. Thus the u-shaped pattern outlined in section 3 is absolutely not supported, but rather the opposite.

In model 1 and 4 we find that the R&D intensity of a firm contributes to a higher probability of both a reduction and an increase in the largest foreign owner's share of equities. This may be driven by the fact that highly R&D intensive firms confront a larger risk due to the probability of large gains and losses as the R&D efforts succeed or fail respectively. This way, it becomes rational to be more volatile on the owner side as the R&D intensity increases. Since we know wage costs tend to increase with the level of technology in the firm, it comes as no surprise that the hourly wage cost variable varies along with the R&D intensity of the firm. Finally, a higher market concentration as well as larger firm size also tend to propel changes in foreign ownership. This may though be the result of the fact that foreign owners are over represented in large firms that are located in concentrated industries. Thus, it is primarily here we are able to observe shifts in ownership.

In Table 7, we list the estimates using a limited data set. Here, we exclude all observations that sort under category 1, i.e. all firms that had no foreign ownership in period *t* and *t-1*.Consequently, the data set is reduced from more than 18000 observation to less than 3000 observations. This way, the number of observed changes in foreign ownership shares is not reduced, but only the amount of observations where the shares remain unchanged at 0%. As mentioned above, the sample reduction has no effect on the coefficients associated to the foreign owner's R&D intensity, nor the variable *RELR&D_SQ*. However, in these regressions, model 2 and 3 report a larger number of significant variables. More specifically, the R&D intensity of firms tends to increase the foreign investors' ownership shares, whereas the amount of R&D in the industry tends to discourage foreign ownership. When we confine ourselves to the limited data set, we find that the Herfindahl index has a negative impact on the foreign investor's willingness to increase the ownership share. However, since the coefficient in the qualitatively dependent models here is insignificant, the strength of this result is rather weak. The results in Table 7 also deviate from those based on the full data set in that subsidies and taxes get positive and significant coefficients in model 1 and 4. More specifically, it is surprising to see that higher taxes tend to support an increase in foreign ownership, whereas subsidies tend to discourage foreign investors. The result may reflect that subsidies are primarily channeled to firms with low profitability and vice versa, yet this should be reflected in the variable for value added per man-hour.

Foreign owners may react radically differently to changes in the characteristics of firms and industries according to their ownership shares. Naturally a foreign owner with 100% ownership firm may respond differently to such shifts than a foreign owner with less than 10% which is often referred to as the demarcation line that defines a direct strategic investment from a portfolio investment where strategic interests are marginal. In order to take this aspect into account, we present two regressions in Table 8 where one only refers to the largest foreign owners with between 10% and 33% (minority owners) of the firm shares, and the other to such owners with share sizes between 33% and 100%. The sample is split at 33% since shares larger than this most often have a blocking power and thus may be regarded as majority owners. In this case we only report using a multinomial logit model. The econometric results using a split sample and limited sample does not provide us with a large amount of statistically significant information. We find that industry R&D activities reduce the likelihood of observing a increase in the ownership share of minority owners, but it has no effect on majority owners. As reported in the un-split sample, the probability of observing a reduction as well as an increase in the minority owners' shares increases with the R&D intensity of the firm. However, this is not the case for foreign majority owners. Finally the relative R&D intensity variable representing the relative technological strength of the foreign owner reduces the probability of a share reduction among minority owners, whereas it increases the probability of both observing a reduction and an increase in shares among foreign majority owners.

The last econometric exercise splits the sample into 7 industry groups that form distinctly different technology classes and operate with widely different R&D intensities. Such an industry split may help to solve the empirical problem relating to the fact that we may observe both asset exploring investments (i.e. technology sourcing motivated foreign ownership) and asset exploiting foreign activities at the same time. In other words, when we split the sample into industry groups, we may observe that technology sourcing is a motivation for foreign ownership in one industry group whereas the technology strength of the foreign owner's home base is the motive behind foreign presence in another. The estimates presented in Table 9 only relate to model 4, since the 2 stage Heckman models did not perform well in the split samples. Furthermore, only the qualitative value of the significant coefficients are reported in order to only focus on the main tendencies. The first thing to notice here is

Table 8: Explaining changes in foreign ownership

	Firms with foreign ownership share higher than 10% and lower than 33%						Firms with foreign ownership share higher than 33%					
	Multinomial logit						Multinomial logit					
Change in foreign ownership share	Coef.	Robust Std. Err.		Coef.	Robust Std. Err.		Coef.	Robust Std. Err.		Coef.	Robust Std. Err.	
	Category 1: Increase			Categoty 2: Reduction			Category 1: Increase			Categoty 2: Reduction		
VAH	1.01	(0.76)		0.99	(0.75)		0.99	(0.82)		0.58	(0.92)	
WCH	5.44	(7.07)		7.45	(5.57)		3.62	(2.64)		11.52	(4.79)	**
SUBSVA	-1.10	(2.59)		-1.24	(2.88)		-0.11	(0.15)		0.13	(0.18)	
TAXVA	1.24	(1.03)		-23.28	(18.65)		144.17	(77.26)		137.41	(77.33)	*
R&D	0.007	(0.01)		0.01	(0.01)		0.001	(0.00)		4.65E-04	(0.00)	
INDR&D	-0.001	(0.001)	**	-7.00E-05	(0.001)		9.89E-05	4.90E-04		-5.910E-05	(4.89E-04)	
R&DINT	-1.74	(0.92)	*	-3.01	(1.35)	**	1.75	(2.12)		2.21	(2.13)	
HERFIN	-0.50	(0.74)		-1.40	(0.78)		-0.73	(0.68)		-0.52	(0.86)	
SIZE	4.30E-08	(1.12E-07)		-7.09E-08	(1.65E-07)		-2.57E-07	(1.54E-07)	*	2.08E-08	(1.03E-07)	
INVINT	0.12	(0.08)		0.11	(0.08)		0.17	(0.13)		0.09	(0.13)	
FOR_R&DINT	0.93	(0.41)		-1.51	(0.75)	**	0.52	(0.25)	**	0.56	(0.28)	*
REL_R&DINT	1.29E-05	(2.58E-05)		-1.47E-05	(1.39E-05)		1.34E-06	(6.47E-06)		6.28E-06	(5.79E-06)	
RELR&D_SQ	3.71E-11	(1.65E-10)		1.89E-10	(8.82E-11)	**	1.07E-11	(2.12E-11)		-2.13E-11	(3.19E-11)	
1992	0.76	(0.61)		-1.22	(0.59)	**	-0.20	(0.38)		1.27	(0.64)	
1993	1.12	(0.68)	*	0.23	(0.58)		1.07	(0.42)	**	2.34	(0.60)	
1994	-0.89	(0.98)		-1.42	(0.95)		-0.04	(0.57)		-0.55	(0.77)	
1995	0.44	(0.58)		-0.42	(0.55)		0.27	(0.60)		2.60	(0.55)	
1996	-0.72	(0.46)		-0.80	(0.53)		1.26	(0.73)		1.40	(0.61)	
constant	-1.14	(1.12)		-0.57	(0.74)		-2.10	(0.70)		-4.33	(0.95)	
Number of obs	503						562					
Wald chi2	258.04						516.77					
Prob>chi2	0						0					
Log likelihood	-462.55						-495.48					
R^2 (pseudo)	0.1498						0.1702					

Heteroskedasticity robust standard errors which are adjusted for clustering on industry group (Nace 2 level)

* = 10% level of sign. ** = 5% level of sign. *** = 1% level of sign.

Table 9: Industry specific estimates. Explaining changes in foreign ownership

	Multinomial logit model We only report the qualitative properties of the significant coefficients														
	Wood & Paper		**Publishing**		**Petro. and mineral prod.**		**Metals**		**Machinery**		**Electronics**		**Transport equipment**	
Nace 2 sector	20+21		22		23+24+25+26		27+28		29		30+31+32+33		34+35	
Change in foreign ownership share	Category 1: Increase	Categoty 2: Reduction	Category 1: Increase	Categoty 2: Reduction	Category 1: Increase	Categoty 2: Reduction	Category 1: Increase	Categoty 2: Reduction	Category 1: Increase	Categoty 2: Reduction	Category 1: Increase	Categoty 2: Reduction	Category 1: Increase	Categoty 2: Reduction
VAH	+	+		-			+		+	+				
WCH			+	+	+	+		+	+	+	+	+	+	+
SUBSVA														+
TAXVA	+				+									
R&D				+										+
R&DINT					+	+	+	+			+	+		
HERFIN	+	+	+									+		
SIZE						+			+		+	+	+	+
INVINT	+		-				+		+	+	+	+	+	+
FOR_R&DINT	-	-	+		-	-		-	-	-	+	+	+	
REL_R&DINT	+	+	-		+	+	+	+	+	+	+	+	-	+
RELR&D_SQ	-		+		-	-	-	-	-	-	-	-	-	-
1992							-			+	-			
1993							-				-		-	
1994				-			-	-			-		-	
1995						+			-		-		-	
1996										+	-		-	+
constant	-	-		-		-		-		-	-	-	-	-
Number of obs	1821		2383		1678		2373		1528		1056		1597	
Wald chi2	191.23		1114.13		262.17		9543.3		185.95		181.14		189.78	
Prob>chi2	0		0		0		0		0		0		0	
Log likelihood	-327.48		-501.80		-484.69		-369.98		-346.51		-426.93		-322.21	
R^2 (pseudo)	0.3535		0.2029		0.26		0.2849		0.2611		0.2333		0.41173	

Heteroskedasticity robust standard errors which are adjusted for clustering on industry group (Nace 2 level) that firm characteristics have much the same effect on changes in the share of the largest foreign owner, regardless of industry group affiliation. As opposed to the full sample models, we now observe a positive and significant effect from value added per man-hour in some of the industries (*Wood and paper*, *Metals and Machinery*). The relative R&D intensity variable is found to have a negative effect on the probability of observing an increase in foreign ownership in the *Publishing and Transport equipment industries*. The effect on the probability of observing a reduction is negative or insignificant. These findings may support the existence of technology sourcing in these industry groups. The firm R&D intensity is only found to matter in the 3 industry groups, Petroleum and mineral products, Metals and Electronics. These are industries with a relatively high R&D intensity and a large proportion of R&D activities are undertaken in foreign owned firms (see Table 4).

6. Conclusion

The fast growing body of recent empirical studies focusing on international technology spillovers - either through trade or investment - has provided us with highly divergent conclusions. The case of technology sourcing through FDI represents no exception from this trend. In this study, we have presented an econometric analysis of determinants behind the behavior of foreign owners in firms located in Norway. We have specifically focused on the presence of technology sourcing motives behind the foreign ownership structure in Norway. This motive has been tested using measures of R&D intensities in Norwegian firms and industries as well as R&D intensities associated with the foreign owners' home base. These intensities are used as proxys for the technological level or competitiveness of firms and industries. If a foreign investor has established an ownership interest abroad in order to more easily absorb the knowledge and technology developed in that country, one would generally expect that the technological level associated to the foreign owner was relatively low compared to the technological level in the host country. If it was the opposite way, the foreign owner would have less to learn from investing abroad. In this study, we find no evidence of such behavior. Instead, we find that foreign owners with a relatively strong technology base at home tend to be more active as owners in firms located in Norway. In other words, foreign owned firms in Norway seem to at least partly motivate their activities on their relatively strong technological competitiveness. Furthermore, we find that foreign owners reduce and increase their exposure more frequently in firms that are more R&D intensive. We claim that this could be a result of the high risks associated with R&D based industrial activities as research failures and successes create large losses and gains respectively.

A main problem of identifying motives behind FDI and foreign ownership relates to the fact that different motives push in opposite directions. One good example here is the relationship between geographical distance and FDI. On the one hand, FDI should be encouraged as the distance increases since the firm avoids large transportation costs related to exports. But a large distance will, on the other hand, increase the cultural differences and thus raise transaction and information costs when establishing a subsidiary or merging with a company abroad. In our case the problem relates to the simultaneous presence of asset exploring and asset exploiting motives for foreign operations. The theoretical predictions outlined in this paper are partly designed to avoid such measurement problems since they imply that these motives will result in high foreign activities whenever the relative technological level of the foreign firm is either large or small. Thus, ceteris paribus, foreign investment should be at its lowest when technology levels are rather similar. However, the empirical study presented in this paper gives no support to such an investment pattern.

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Table A2: The number of employed according to sectors and degree of foreign ownership

Norway 1996	NACE2 sector	Foreign majority ownership	Firms with foreign minority shares	All firms
Oil and Mining	10-14	3919	3465	17980
Industry	15-37	38427	78901	255907
Construction	45	7909	6510	82819
Retail trade	50-52	33461	17511	244065
Hotel and Restaurants	55	4363	3013	55511
Transport	60-63	3977	5163	52606
Other services	70-74	27929	14553	120496
Total		119985	129116	829384

Source: Rusten, Kvinge and Jakobsen (1999)

Table A1: The sector distribution of foreign owned companies in Norway

1995		Foreign ownership share					
		Number			Percent of total number		
		Largest owner		All foreign Owners	Largest owner		All foreign Owners
NACE2	Sector	>10%	>50%	>0%	>10%	>50%	>0%
1	Agriculture	3	2	3	0.09	0.07	0.05
2	Forestry	0	0	2	0.00	0.00	0.04
5	Fishing	4	3	52	0.12	0.10	0.94
10	Mining of coal	0	0	1	0.00	0.00	0.02
11	**Extraction of crued oil and natural gas**	**60**	**56**	**92**	**1.75**	**1.87**	**1.66**
13	Mining of metal ores	2	2	3	0.06	0.07	0.05
14	Other mining and Quarrying	13	10	20	0.38	0.33	0.36
15	Food and beverages	24	18	69	0.70	0.60	1.25
17	Textiles	7	6	9	0.20	0.20	0.16
18	Wearing apparel	2	2	2	0.06	0.07	0.04
19	Leather products	3	2	3	0.09	0.07	0.05
20	Wood products	10	8	37	0.29	0.27	0.67
21	Pulp and paper	10	8	30	0.29	0.27	0.54
22	**Publishing and printing**	**43**	**40**	**112**	**1.25**	**1.33**	**2.02**
** 23	Refined petroleum products	0	0	0	0.00	0.00	0.00
24	Chemicals and chemical products	21	18	66	0.61	0.60	1.19
25	Rubber and plastic products	22	20	35	0.64	0.67	0.63
26	Other non-metallic minaral products	25	25	42	0.73	0.83	0.76
27	Basic metals	14	11	28	0.41	0.37	0.51
28	Fabricated metal products	27	23	53	0.79	0.77	0.96
29	**Machinery and equipment**	**44**	**34**	**77**	**1.28**	**1.13**	**1.39**
30	Office machinery and computers	0	0	3	0.00	0.00	0.05
31	Electrical machinery	18	14	37	0.52	0.47	0.67
32	Telecom and television equipment	6	3	12	0.17	0.10	0.22
33	Medical and optical instruments	11	6	25	0.32	0.20	0.45
34	Motor vehicles	6	4	14	0.17	0.13	0.25
35	Other transport equipment	21	19	57	0.61	0.63	1.03
36	Furniture	10	9	21	0.29	0.30	0.38
37	Recycling	5	4	8	0.15	0.13	0.14
13-37	**Manufacturing industry**	**344**	**286**	**763**	**10.02**	**9.53**	**13.79**
40	Electricity and gas supply	2	2	14	0.06	0.07	0.25
45	Construction	82	72	134	2.39	2.40	2.42
50	Vehicle sales and maintainance	62	55	115	1.81	1.83	2.08
51	**Wholesale trade**	**1545**	**1389**	**1840**	**44.99**	**46.30**	**33.26**
52	Retail trade	150	135	294	4.37	4.50	5.31
55	Hotels and restaurants	20	17	55	0.58	0.57	0.99
60	Land transport	26	24	44	0.76	0.80	0.80
61	Water transport	79	55	178	2.30	1.83	3.22
62	Air transport	3	1	6	0.09	0.03	0.11
63	Other transport services	101	81	163	2.94	2.70	2.95
64	Post and telecom	10	7	17	0.29	0.23	0.31
65	Financial services	23	14	58	0.67	0.47	1.05
66	Insurance services	2	2	16	0.06	0.07	0.29
67	Other financial services	26	20	46	0.76	0.67	0.83
70	Real estate services	131	105	313	3.81	3.50	5.66
71	Renting of machinery and equipment	34	31	51	0.99	1.03	0.92
72	Computer services	87	74	136	2.53	2.47	2.46
73	R&D	3	3	10	0.09	0.10	0.18
74	**Other business services**	**450**	**395**	**770**	**13.10**	**13.17**	**13.92**
80	Education	11	10	13	0.32	0.33	0.23
85	Health services	3	2	3	0.09	0.07	0.05
88-99	Other services	173	159	344	5.037857	5.3	6.217242
Total		**3434**	**3000**	**5533**	100	100	100

** The registration in this sector is not consistent with the NIS. In the econometric study, 5 large companies have entered this sector and left service sectors