ESSAYS ON RESTRUCTURING AND PRODUCTION DECISIONS IN MULTI-PLANT FIRMS

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AKADEMISK AVHANDLING

som för avläggande av ekonomie doktorsexamen
vid Handelshögskolan i Stockholm framläggs
för offentlig granskning

fredagen den 19 september 2003, kl 13.15
i sal 750, Handelshögskolan
Sveavägen 65, Stockholm

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Dissertation for the Degree of Doctor of Philosophy, Ph.D.
Stockholm School of Economics, 2003

ISBN 91-7258-629-X

Keywords:
agglomeration economies, corporate acquisitions, divestitures, firm-specific assets, high-tech production, mergers and acquisitions, monopolistic competition, multinational enterprises, multi-plant firms, panel-data, productivity growth, research and development

Distributed by:
EFI, Stockholm School of Economics, Box 6501, SE 11383 Stockholm, Sweden

Cover Design:
"Loose Threads and Knowledge Clusters" by the author

Printed by:
Elanders Gotab, Stockholm

Acknowledgments

During my interview for the doctoral program at the Stockholm School of Economics, one of the professors told me that writing a dissertation is a very lonely effort and asked whether I was prepared to undertake it. Without giving the question any deeper thought I answered: “Of course”. During the years that followed, I eventually came to realize what he had meant by the question. The process of transforming research ideas into thesis chapters meant sitting alone in my office every day and reading literature, running regressions and simulations and conversing with myself. For a person who enjoys social interaction this was not easy. However, the feeling a complete solitude was only transient. I could not have written this thesis without help and support from others. Therefore, I would like to express my great gratitude to them.

First, I would like to thank my two advisers, Ari Kokko and Karolina Ekholm. They both have been vital to the success of my work. Ari Kokko, my main adviser, has always encouraged me and given me inspiration to continue even when quitting the program was the most tempting option. He has generously shared everything from his research ideas, funds and projects to knowledge about the best art galleries and restaurants in Hanoi. Most importantly, he has patiently discussed my research problems, read and reread drafts of my thesis chapters and given new suggestions for improvements. Kiitos, Ari!

My other adviser, Karolina Ekholm, became part of the process after I had already started the thesis work. Since the very first meeting, my time with her often felt like true "brain-storming". During these talks if we failed to solve the initial problems at least we identified new ones. I always had to be prepared for criticism from Karolina. However, the criticism was never unjustified and I am very grateful for it. I have also been fortunate to share authorship of one of the essays here with Karolina. She introduced me the art of solving general equilibrium models numerically and suddenly I found it very enjoyable to run GAMS-simulations late at night. It has been very stimulating to work with Karolina. Tack, Lina!

I have been fortunate also for the help of others along the way. Foremost, I would like to thank Fredrik Sjöholm for being an informal acting adviser, particularly during Ari's longer visits to Vietnam. I could always count on Fredrik when I needed to discuss a research problem or when I needed someone to read and comment on my work. Fredrik has contributed many constructive suggestions. I also wish to thank Jim Markusen, Chloé Le Coq, Sune Karlsson, Almas Heshmati, Douglas Lundin, Jens Josephson and Martin Flodén for helpful suggestions and Hiroshi Ono for assistance with STATA related problems. Brita Karlsson at Statictics Sweden has practically made this thesis possible by patiently fulfilling my requests on data material.

In addition, I would like thank all the administrative staff at the Department of Economics and in particular, Ritva Kiviharju, Ingrid Nilsson and Lilian Öberg for helping me with practical problems as well as Christina Lönnblad at Stockholm University for checking the language.

This thesis has benefited from financial support from the following foundations, which I gratefully acknowledge: Tore Browaldhs Stiftelse, Jacob Wallenbergs Stiftelse and Tom Hedelius and Jan Wallanders Stiftelse.

During my time at the Stockholm School of Economics, I have been kindly taken care of by the European Institute of Japanese Studies. I have enjoyed the cheerful atmosphere of the institute, the interesting seminars on Asia, the numerous Friday champagne discussions and the good times with the members of the institute. The people at the EIJS have become my family at the Stockholm School of Economics. I particularly want to thank the head of the institute, Magnus Blomström, for all his support and generosity and Birgitta Schubert for helping me with daily administrative problems.

My stay at the Stockholm School of Economics has enriched me not only in terms of knowledge but also in number of friends. I particularly wish to thank for the friendship of Olivia Kang, Mats Ekelund, Kaj Martensen, Hiroshi Ono, Jody Ono, Chloé Le Coq, Pernilla Sjöquist-Rafiqui, Douglas Lundin and Malin Bergman. I am also in debt to my roommates, Anders Ögren and Krim Talia for being such good company and having a great deal of tolerance with my shifting moods. My friends outside academics have been important for keeping me attached to the "real" world. I wish to thank all of you. Lena and Åsa, your friendship has given me great support! I am also grateful to my parents and brother for supporting me in all that I have chosen to do.

Last but not least, I am indebted to my best friend and beloved husband, Per Ola. Despite his great doubts about economics as a science, he has constantly encouraged, supported and taken care of me throughout my studies. Thanks to him I have been able to complete my work and write these last lines to my thesis. I hope to be able to give as much in return during the coming years.

Stockholm, August 2003

Katariina Hakkala

Contents

Introduction and Summary

This thesis consists of four self-contained essays. The common theme of the essays is the behavior of multi-plant firms. An underlying idea in all four of them is that firms possess intangible assets such as management skills and organizational expertise, technological knowledge, marketing know-how and better access to finance capital or natural resources. These assets are typically specific to the respective firm. Due to market imperfections and failures, firms tend to internalize the advantages of firm-specific assets and exploit them themselves rather than sell or lease them to other firms. For instance, intangible assets are often joint inputs in the sense that knowledge developed by one unit can be transferred to another unit within the same firm at a low cost and without diminishing the amount of knowledge available to the first unit. Furthermore, the assets are typically only partly appropriable by their owner, and the market transactions of the assets are hampered due to information asymmetries between a potential buyer and seller.[1] The literature on multinational firms emphasizes the role of intangible firm-specific assets in creating ownership advantages that, together with location and internalization advantages, explain the pattern of foreign direct investments.[2] The essays in this thesis are based on the view that the ownership advantages created by firm-specific assets are the "*raison d'etre*" of large multi-plant firms. The existence of such assets is assumed to create multi-plant economies of scale and give incentives to make better use of capacity or overheads to gain advantage in size, economies of interdependent activities, integration and/or diversification.[3]

[1] The nature of the market imperfections that give an incentive to internalize the benefits is explained more in detail by the theory of transaction costs, property rights and vertical integration (see e.g. Williamson, 1975, and the survey of this literature in Caves, 1996).

[2] This has been emphasized in work by John Dunning (1977, 1979). For a recent contibution to this literature, see Markusen (2002).

[3] Naturally, single-plant firms may also have valuable intangible assets. The nature of these assets may, however, be such that there are no internalization advantages. For instance, the assets may be more bound to a specific production unit and cannot be shared

Rather than studying the international aspects of firms with intangible assets, the first three essays empirically explore different aspects of multi-plant firm behavior in domestic markets. This analysis has been made possible by the access to unique plant-level data on the thirty largest multinational manufacturing corporations in Sweden. The sample corporations play an important role in the Swedish economy. For instance, the thirty corporations account for about 70 percent of aggregate industrial R&D in 1999.[4] This should be compared with their share of total manufacturing employment, which was about 30 percent during the period of study.

The first essay examines the sources of productivity growth within multi-plant firms and particularly emphasizes the role of external restructuring and ownership changes in explaining why multi-plant firms may sustain higher productivity growth as compared to single-plant firms. The second and the third essay explore the idea that large multi-plant corporations exploit their ownership advantages when acquiring partial- and full-firm assets. The second essay analyzes whether technological intangible assets may explain transfers of productive capacity from acquiring corporations to their target. Indeed, Buckley and Casson (1976) have shown that internalization advantages tend to be greatest in technology-intensive sectors. The third essay explores the idea that multi-plant corporations search for targets matching their firm-specific organizational capabilities when acquiring corporate assets. Uncertainty about the matching outcome explains why some acquisitions end in divestitures. However, the likelihood of a "good" match is expected to increase in the buyer's organizational capabilities.

The fourth essay, coauthored with Karolina Ekholm, extends the analysis to encompass the international aspects of multinational firms. In this essay, we develop a theoretical model analyzing the localization decisions of multi-plant firms beyond the national borders. More specifically, we develop a

by other units as a firm-specific joint input.

[4] Own calculations based on data provided by Statistics Sweden. The share was 65 percent in 1993.

two-country model where firms can choose to separate their innovative activities generating an intangible asset from the production of the final good. In our model, there are two agglomeration forces: knowledge spillovers associated with R&D and backward and forward linkages associated with high-tech production. We analyze how the interplay of these forces affects the localization decisions of the firms. Below, the four essays are summarized in more detail.

Chapter 1

This essay analyzes corporate restructuring and its role in generating productivity growth in a sample of large manufacturing corporations in Sweden. In studies on industry-level productivity, the main sources of productivity growth are often defined as the productivity growth occurring within firms and that due to entry, exit and reallocation of market shares between firms within industries. In addition to "internal" factors, such as technology upgrading and downsizing within plants that remain part of corporations thorough longer periods, the productivity growth of a multi-plant corporation may also increase as a result of "external" restructuring, as inefficient plants are divested or closed down and replaced by more productive new or acquired plants. In particular, the role of ownership changes of plants in generating productivity growth has not yet been much examined. Some recent findings demonstrate that there is reason to focus on multi-plant firms. For instance, Haskel et al (2000) examine productivity growth in the UK manufacturing sector and find that surviving single-establishments had almost zero productivity growth, while surviving establishments that were part of multi-establishment firms accounted for nearly half the overall productivity growth between 1980 and 1992. Including entry and exit, the contribution of multi-plant firms to total productivity growth was 79 percent. These results suggest that multi-plant firms make an important contribution to overall productivity growth.

To explore the importance of organizational change for the productivity growth of multi-plant firms, this essay uses plant-level data for the sample of the largest manufacturing corporations in Sweden for the 1986-96 period. With this data, I first examine the extent of external restructuring by quantifying the job flows caused by changes within continuing plants and those due to acquisitions, sell-offs, start-ups and closures of plants. The second part of the paper analyzes how the corporate restructuring is associated with productivity growth.

By decomposing corporation-level productivity growth into different sources, it is found that the contribution of external restructuring, including ownership changes, start-ups and closures of plants, to the productivity growth of corporations was up to 47 percent during the 1986-96 period. The results suggest that the productivity of large multi-plant corporations grew almost twice as fast as that of single-plant firms with the same internal productivity growth, due to their organizational flexibility. A regression analysis shows that the sample corporations generated productivity growth by starting productive new plants rather than by sourcing productivity growth through acquisitions of more productive plants from other firms. However, there is strong evidence indicating that the corporations outsourced low productivity plants to other owners through sell-offs. The results may be interpreted as sell-offs having played an important role in a rationalizing process where less productive plants were sold or closed down and replaced by more productive new plants.

The relative importance of external and internal sources of productivity growth is found to vary substantially with the business cycle at the corporation level. In times of lower productivity growth, the decompositions show that a large contribution to productivity growth stems from acquisitions and divestitures of plants. The external restructuring thus seems to compensate for low or even negative productivity growth within the continuing operations of the corporations, which may explain why multi-plant corporations were able to sustain higher productivity growth throughout the business cycle.

Chapter 2

In this essay, I investigate the role of knowledge capital in explaining post-acquisition productivity growth of plants acquired by the sample of large Swedish corporations. In addition to conducting R&D, many firms, particularly in industries where innovation is important, are engaged in mergers and acquisitions (M&As) to get access to the firm-specific knowledge capital of other firms. Despite the fact that several studies have found technology sourcing to be an important motive for M&As, the effects of knowledge capital on the merging firms remain rather unexplored.

The empirical literature provides plenty of evidence on the positive effects on productivity of knowledge capital internal to the firm. It also provides evidence of so-called spillover effects, that is, effects arising when firm-specific knowledge diffuses to other firms without a 'direct purchase'.[5] However, the effects of knowledge transfers in connection with M&As have not been studied in great detail. The study goes beyond the analysis on gains from mergers by investigating the factors explaining the gains.

Recently, Maksimovic and Phillips (2001) have analyzed the market for corporate assets and found that acquired plants increased their productivity when acquired by firms with a higher productivity than their own. When plants were purchased by a buyer with lower productivity, on the other hand, the productivity of the purchased assets fell. Furthermore, they found that the acquisition of a more productive plant resulted in gains to the existing assets in the same industry. They interpreted these results to be consistent with buyers purchasing productive expertise that can be transferred to the existing assets of the acquirers.

This essay builds on the results of Maksimovic and Phillips (2001) and takes the analysis one step further by examining whether there is evidence of

[5]For overviews, see e.g. Mairesse and Sassenou (1991) and Griliches (1995).

the transferred productive capacity being knowledge capital. First, I examine whether there is evidence of transfers of productive capability in plants acquired by large Swedish manufacturing corporations. Second, I analyze whether the acquiring corporations' knowledge capital, proxied by measures of R&D and skilled labor, explains post-acquisition productivity growth of the acquired assets. Knowledge capital is thus defined as an intangible asset consisting of accumulated technological "know-how", product and process innovations involving investments in R&D and inputs of skilled labor. In order to capture the joint-input characteristics of knowledge capital, I define the proxy variables at the corporation level rather than the level of an acquiring affiliate firm.

The empirical analysis finds that when targets were acquired by relatively more productive corporations, they experienced positive growth in productivity relative to the industry average. The opposite holds for plants acquired by relatively less productive corporations. These results suggest that productive buyers had expertise or resources to improve the productivity of the targets. In order to examine whether there is any evidence of knowledge transfer, I estimate the effect of buyers' knowledge capital on the productivity growth of the acquired target. R&D expenditures for the whole corporation are not found to have any effect. One difficulty in interpreting this result is that corporation level R&D may be too aggregated as a measure of the "effective" fraction of the buyer's knowledge capital. .More specific measures may be required to capture the impact of the buyer's knowledge capital. In particular, large diversified corporations may have several operations where knowledge capital in one industry may be of limited use for operations in another. It is found in the study that the buyer's skill intensity in the segment of the acquired plant is positively related to the post-acquisition productivity growth of the target. This is interpreted as evidence of knowledge transfer at the level of the specific industry of the acquired target.

Chapter 3

This essay studies corporate asset acquisitions and, in particular, addresses the issue of divestitures. Several studies on firm-level data have found that acquisitions often end in divestitures. The agency theory suggests that corporate managers being the agents of shareholders is fraught with conflicting interests and that managers have incentives to cause their firms to grow beyond an optimal size (Jensen, 1986). Due to the dubious motives of managers, many acquisitions are assumed to be ex-ante inefficient and to end in divestitures. The high rates of divestitures have been interpreted as evidence consistent with the agency theory.

More recent literature challenges the conventional view by arguing that acquisitions end in divestitures for a variety of reasons and should not necessarily be regarded as ex ante failures (Weston, 1989, Kaplan and Weishbach, 1992). Matsusaka (2001) views diversifying acquisitions as experiments undertaken by firms to find new business opportunities matching their capabilities. According to this view, the future value of an experiment cannot be perfectly foreseen and, therefore, some acquisitions are likely to turn out to be poor and end in divestitures. In this sense, divestitures can be regarded as a consequence of successful experiments: the firm learned the value of its organizational capabilities in its target activities.

This essay aims at investigating whether the idea that asset acquisitions can be regarded as experiments is supported by empirical evidence. The framework for experimental acquisitions suggested by this paper is based on Matsusaka's (2001) model, where firms maximize their revenue and in each period, choose between the strategies of specialization, diversification through acquisition, or liquidation of a previous match. In the framework of this essay, corporations have one core business and can make experimental acquisitions of additional assets both in related and unrelated industries. All acquisitions are assumed to involve uncertainty about the matching outcome. Once the value of a match is revealed, the buyer decides whether to keep or divest the target.

The empirical analysis of the paper uses data for asset acquisitions made by the thirty largest manufacturing corporations in Sweden during the period of 1986-96. It is found that 37 percent of the plants acquired by the corporations were divested, that is, sold or closed down, within three years after acquisition. I use information on plant performance, the buyer's organizational capabilities and how the buyers' expertise is related to that of the target to assess how the degree of experimentation is related to the likelihood of an acquisition to end in a divestiture. The time dimension is important for exploring the importance of the experimentation hypothesis. It can be argued that acquisitions that turn out to be poor matches are likely to end in separations relatively soon, when the value of the match between an acquirer and a target is revealed. The empirical analysis therefore examines divestitures taking place within a few years after acquisition.

The results show that plants that were relatively less productive in their industries and in relation to the buyer's core businesses were more likely to be divested. While we do not have a precise benchmark for the optimal level of matching quality, the fact that the likelihood of divestiture is sensitive to the plant's productivity relative to its industry is consistent with corporations searching for matches optimizing their resource allocation. Growth in real or relative labor productivity is not found to explain the probability of divestiture. Thus, there is no evidence of value destruction in terms of declining productivity leading to divestitures, which would support the agency theory. However, the initial relative productivity is found to explain the likelihood of divestiture of plants belonging to multi-plant firms during the second year after acquisition. I interpret this evidence to indicate that rationalization rather than poor matching may have been a reason for these divestitures.

Furthermore, the plants acquired by corporations with a higher R&D intensity were less likely to be divested. However, the results indicate that the more different the acquiring corporation and the acquired target were in terms of technology levels, the more likely was the match between them to end in a separation. The probability of divestiture was higher in segments ranked as more distant to the largest segment of a corporation. This evidence supports the view that diversifying acquisitions are more likely to end in divestitures because they involve more uncertainty about how well the organizational capabilities of the buyer match targets in industries where corporations are assumed to be less experienced. In sum, the odds for a sustained match were better the larger the organizational capabilities of the buyer and the closer the target activities were to the core competence of the buyer. The results are interpreted as consistent with the view that acquisitions involving a higher degree of experimentation were more likely to end in separations.

Chapter 4

In this essay, we develop a two-country model where firms may choose to locate their R&D activities and their production plants in separate countries. In most economic models, R&D is simply assumed to be located with the rest of the firm's activities. An implication of this assumption is that countries with a comparative advantage in knowledge creation would also have a comparative advantage in high-tech production. However, a substantial part of world R&D is carried out by multinational enterprises (MNEs) that carry out operations in many countries. Traditionally, R&D activities seem to have been strongly concentrated in the parent firm, implying that R&D has primarily taken place in the home country of these firms. This tendency is often taken to be the main explanation why certain small countries, such as Sweden, with large R&D expenditures in relation to GDP do not export high-tech goods to the extent motivated by their R&D expenditures. The apparent geographical separation between R&D and production activities suggests that an appropriate analysis of the location choice of high-tech firms should allow for such a separation.

In our model, there are two agglomeration forces: knowledge spillovers associated with R&D and backward and forward linkages associated with high-tech production. The backward and forward linkages create incentives for high-tech firms to concentrate production in the larger economy.[6] This aspect of the model is similar to recent models within the so-called "new economic geography" (see Fujita, Krugman and Venables, 1999). In addition to this "pecuniary" externality, we allow for a technological externality that creates incentives for firms to locate R&D labs in proximity to other R&D labs. We focus on the location of high-tech production from a small-country perspective and assume an asymmetry between countries in terms of their size. Further, we analyze how the location choices of high-tech firms are affected by the strength of pure externalities generated by R&D activities and the strength of pecuniary externalities generated by linkages, thereby being able to address issues related to the ambition of many small, industrialized countries of attracting high-tech production. The analysis is related to work by Markusen (1997, 2002), which shows that a small country may end up headquartering vertically integrated multinationals with production in the larger country when the smaller country is relatively skill-abundant and trade costs are relatively low. A crucial difference between this analysis and that by Markusen, however, is that agglomeration economies may not only affect the location of production activities, but also that of non-production activities.

Because skilled labor is assumed to be used in both production and R&D, the tendency for production activities to concentrate in the large country, thereby putting upward pressure on the return to skilled labor, implies that, at the same time, there may advantages associated with locating R&D in the small economy. When trade costs are such that the advantages of locating production in the large country are especially large while the technological

[6]The backward linkage is related to the increase in demand arising when a firm moves its production to a certain region, while the forward linkage is related to the decrease in wage costs when nominal wages fall to compensate for falling consumer prices, due to reduced imports (Krugman, 1991, Fujita et al., 1999, Chapter 5).

externality is not too weak or strong, we get multiple equilibria: in one equilibrium, R&D activities are completely concentrated in the smaller economy and in another, they are spread out between the countries. With strong R&D spillovers, R&D becomes concentrated in either country.

We also compare different outcomes with respect to the degree of product variation and welfare. For low/intermediate trade costs, the most beneficial case for the large country from a welfare point of view is when R&D is concentrated in the small country. In this case, resources are freed up for the production of high-tech goods in the large country. Because the consumer price index increases with the share of imported products, this means that real income will be higher than when these resources are spent conducting R&D. For the small country, it is most beneficial to have R&D activities concentrated in the large country. It is thus not necessarily welfare improving to be specialized in R&D activities, even if they are associated with technological spillovers that are national in scope. For both countries, free trade generates the highest level of welfare.

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CHAPTER I

Corporate Restructuring and Labor Productivity Growth*

Katariina Hakkala

Abstract

This paper analyzes corporate restructuring and its role in generating productivity growth in a sample of large manufacturing corporations in Sweden. It is found that external restructuring, including ownership changes, start-ups and closures of plants, accounted for up to 47 percent of the productivity growth of the sample of corporations during the 1986-96 period. The results indicate that the productivity of large multi-plant corporations grew almost twice as fast as that of single-plant firms with the same internal productivity growth, thanks to their organizational flexibility. Divestitures of poorly performing plants were found to play a particularly important role in the replacement process generating productivity growth.

Keywords: corporate restructuring, labor productivity growth

JEL classification: G34, D24

*I thank Ari Kokko, Fredrik Sjöholm, Jonathan Haskel and seminar participants at Nordic International Trade Seminars in Copenhagen and the Stockholm School of Economics for helpful comments. Financial support from Tore Browaldh's Foundation is gratefully acknowledged.

1 Introduction

In studies on industry-level productivity, the main sources of productivity growth are often defined as the productivity growth occurring within firms and that due to entry, exit and reallocation of market shares between firms within industries. Internal productivity growth has been analyzed in micro-level productivity studies that have emphasized factors such as downsizing (Oulton, 2000), research and development (e.g. Scherer, 1983, Griliches, 1986),[1] the introduction of new technology and organizational change (Gregg et al, 1993, Haskel and Szymanski, 1997) and increased competition (Blanchflower and Machin, 1996, Nickell et al, 1992, and Nickell, 1996). The other source of productivity growth is a process of external restructuring whereby incumbents with high productivity grow and gain market shares, while low productivity establishments exit and are replaced by more productive entrants. The role of external restructuring in generating productivity growth has been emphasized both by theoretical studies on industry dynamics (Jovanovic, 1982, Cabral, 1993, Hopenhayn, 1992 and Pakes and Ericson, 1995) and empirical studies analyzing the sources of aggregate productivity in the whole economy or an industry.[2]

However, none of this research focuses on the role of restructuring within multi-plant corporations in generating productivity growth. The micro-level studies touch upon issues associated with firm-level restructuring, but leave fundamental questions regarding the sources of corporate productivity growth unanswered. Some recent findings demonstrate that there is reason to focus on multi-plant firms. For instance, Haskel et al (2000) examine productivity growth in the UK manufacturing sector between 1980 and 1992 and

[1] See e.g. Mairesse and Sassenou (1991) for a survey of firm-level studies on R&D and productivity.

[2] See e.g. Baldwin and Gorecki, (1991), Baily, Hulten and Campbell, (1992), Baldwin, (1993), Griliches and Regev, (1995), Liu and Tybout, (1996), Olley and Pakes, (1996), Aw, Chen and Roberts, (1997), Foster, Haltiwanger and Krizan, (1998) Levinhson and Petrin, (1999) and Haskel, Heden and Disney (2000).

find that surviving single-establishment firms had almost zero productivity growth, while surviving establishments that were part of multi-establishment firms accounted for nearly half the overall productivity growth. Including entry and exit, the contribution of multi-plant firms to total productivity growth was 79 percent. This result suggests that multi-plant firms make an important contribution to overall productivity growth.[3] Research on job flows by Schuh and Triest (2000) finds, in turn, evidence of a large share of the job reallocation between plants owned by multi-plant firms occurring within these firms. Aggregating over different types of firms yields that three fourths of the reallocation of jobs between manufacturing plants occur between firms and one fourth within firms. This finding suggests an extensive restructuring within multi-plant firms.

The question this paper aims at answering is how restructuring within multi-plant corporations is associated with productivity growth. In addition to "internal" factors, such as technology upgrading and downsizing within the plants that remain part of corporations over longer periods, the productivity of a multi-plant corporation may also increase as a result of "external" restructuring, as inefficient plants are sold or closed down and replaced by more productive new or acquired plants. In particular, the role of ownership changes of plants in generating productivity growth of multi-plant corporations has so far not been examined to any considerable extent. Whether multi-plant firms derive their productivity growth from internal or external sources is essential since productivity growth is closely associated with economic growth. It is believed that factors such as intangible assets used as joint inputs and economies of scale and scope may create a competitive advantage and explain the leading position in productivity held by multi-plant firms. These factors generate "real" productivity growth within firms and contribute to the overall productivity growth of industries. However, if

[3]See also Baily et al (1992) who only report small differences in productivity between plants of single- and multi-plant firms. However, plants that were part of a high-productivity firm also had high productivity.

the main source of productivity growth of multi-plant firms is organizational change, such as acquisitions of more productive plants and divestitures of misfits, the contribution of multi-plant firms to overall productivity growth may be limited.

To explore the importance of organizational change for the productivity growth of multi-plant corporations, this paper uses plant-level data for a sample of the largest manufacturing corporations in Sweden in the 1986-96 period. With this data, I first examine the extent of external restructuring by quantifying the job flows caused by changes within continuing plants and those due to acquisitions, sell-offs, start-ups and closures of plants. The second part of the paper analyzes how corporate restructuring is associated with productivity growth. To distinguish the sources of productivity growth at the corporation level, this paper uses information for all plants directly or indirectly controlled by the corporations through affiliate firms.

The structure of the paper is as follows: Section 2 further discusses the specifics of multi-plant corporations, Section 3 describes the data, Section 4 examines structural change and job turnover within corporations, Section 5 presents the methods and results of productivity growth analysis and Section 6 concludes.

2 Restructuring within Multi-Plant Firms

In the literature on industry dynamics, a firm's life is described as a cycle. In Jovanovic's (1982) model of passive learning, for instance, firms enter an industry when they see a business opportunity, employ labor and other inputs.[4] As the firms operate, they learn about their productivity. Productive firms grow larger and gain market shares, while unproductive ones contract,

[4]See Hopenhayn (1992), Cabral (1993), Hopenhayn and Rogerson (1993), Pakes and McGuire (1994) and Pakes and Ericson (1998), Caballero and Hammour (1994) and Campbell (1997), Cooper et al. (1997) for other theoretical models on industry dynamics with heterogenous firms.

and eventually shut down. A general feature in most models of industry dynamics is that firms evolve and grow organically by hiring more production factors and expanding their current operations if finding it profitable.

The situation becomes considerably more complex when a firm owns more than one plant. Although plants in the same firm may share common characteristics or joint-inputs such as R&D results, management and brand names, plants of multi-plant firms are likely to be heterogeneous. Plants within the same corporation may have different productivity due to plant-specific characteristics and idiosyncratic shocks or industry-specific demand conditions. For instance, new plants tend to be less productive than incumbents, but exhibit substantial productivity growth due to learning effects. Vintage effects may, on the other hand, explain why some older plants are less productive than new ones. One possible explanation of plant-level differences is that different plants operate at different scales.

Profit maximization in multi-plant firms involves decisions regarding several plants, perhaps even in several industries. At one extreme, each plant can be an independent unit producing a distinct product, and can essentially be run without interaction with other units. At the other extreme, all plants are involved in the production of a single final good. Changes in demand, factor prices and technology at any stage of the production process will then affect all plants of the firm. Many multi-plant firms are likely to lie somewhere between these two cases. An implication of a multi-plant organization structure is that firms may continuously restructure their operations. Plants facing decreasing demand or productivity may be contracting and eventually be shut down, as predicted by the models for industry dynamics, but corporations can also try to sell them first and perhaps replace them by acquiring or starting new plants where they see better business opportunities. Maksimovic and Phillips (2002), for instance, find evidence of conglomerate firms becoming more focused when the prospects in their main segments improve by acquiring assets in these segments and selling assets in more peripheral segments. During periods of weak demand in their main business segment, they diversify by acquiring assets in unrelated industries.

Thus, a multi-plant firm's response to changes can be quite different from that of a single-plant firm. For instance, multi-plant firms may be more inclined to neglect businesses that do not perform well, as compared to single-plant firms, because closing down some plants is less dramatic when the firm still continues operating in other businesses. Bernard and Jensen (2002) study plant shutdowns and find that unconditionally, multi-plant firms are far less likely to shut down a plant than a single-plant firm. However, the positive relationship is entirely driven by the better characteristics of plants within multi-unit firms. Accounting for plant attributes such as age, size, productivity etc., these same firms are actually more likely to close a plant.[5]

Multi-plant firms undeniably differ from single-plant firms, but we still do not know much about the implications of these differences. This paper aims at shedding light on some of the particular features of multi-plant firms. By examining the sources of productivity growth at the corporation level, this study extends both the micro-level productivity studies analyzing internal determinants of firm productivity growth and the industry-level studies examining the importance of external restructuring. In comparison with most industry-level productivity studies, an important difference is that ownership changes of plants are regarded as an additional source of productivity growth at the corporation level.[6] As an example, corporations are able to attain productivity growth either by internally improving the productivity of their operations, for instance by investments in R&D, or by acquiring plants or firms with high productivity. Firm-level data might not be able to separate these sources and in most studies on industry level productivity

[5]Audretsch (1994) also found that among new establishments, the likelihood of exit was higher for subsidiaries and branch plants than for independent establishments when controlling for the start-up size.

[6]Baldwin (1992) analyzes the role played by changes in the ownership control of plants for the turnover process and productivity growth in Canadian manufacturing.

using plant-level data, plants changing owners are generally categorized as continuing plants. In this paper, the sources are distinguished as internal and external sources of productivity to a corporation.

3 Data

The data set is a sample of large Swedish corporations. More specifically, the corporations in the sample are the thirty largest multinational manufacturing company groups with their headquarters in Sweden in 1990. Some of the corporations included in the sample have moved their headquarters from Sweden after 1990, but they were still key employers in Sweden in the 1990s. The sample corporations account for about 30 percent of the total employment in Swedish manufacturing industries during the period in question.[7] Statistics Sweden collects information on inputs and outputs of individual establishments and has constructed the data set from its databases on industrial and financial statistics.

The data set includes information on the manufacturing firms and plants under the control of the thirty corporations during the period 1985-98. In the resulting unbalanced panel, the yearly number of plants varies between about 600 and 700. The data set includes plant-level information on output, employment, value-added, intermediate inputs, wages and industry code variables. Plants and firms are assigned identifiers remaining with them over their lifetime. This means that plants can be followed over time and ownership changes, plant births and deaths can be identified. For a more detailed description of the data, see the Appendix.

[7]The average employment share and sales value share of the sample corporations in total manufacturing was 32.8 and 37.7 percent, respectively, in 1985-96.

4 Structural Change, Productivity and Job Turnover

I begin by describing the structural changes in the sample corporations. Figure 1 shows the number of employees and the real sales value of production in the sample corporations and the rest of the Swedish manufacturing sector.[8] In the period 1985-96, Sweden experienced a strong economic boom during the late 1980's and a severe recession in the early 1990's. The figure clearly shows the impact of the economic crisis in 1991-93 on the manufacturing sector. It seems that the sample corporations were not as profoundly hit by the crisis as the rest of the manufacturing sector. After the severe recession, the manufacturing sector recovered both in terms of employment and production. It is remarkable that the production of the sample corporations increased rapidly after the economic crisis, while their employment decreased continuously after the peak year of 1988.

In order to trace patterns of structural change in the sample, Figure 2 shows the allocation of employment for the corporations in 1985, 1990, and 1996 according to an OECD taxonomy of industry groups.[9] The figure shows that in the 1990's, jobs became increasingly concentrated in science-based industries where R&D expenditures are the highest. All other industry groups decreased in employment during the period. Despite the decrease in employment, scale-intensive industries kept their position as the most important sector for the sample corporations, while the science-based industries overtook the differentiated goods industries and become the second most important sector.

The structural changes observable in the data do not necessarily mean that the overall production profile of the sample corporations was changed. Operations contracting in Sweden may have been relocated to other coun-

[8] Continuing corporations (26 of 30) are included. The real sales value is PPI-deflated (1990=100).

[9] For definitions, see the Appendix.

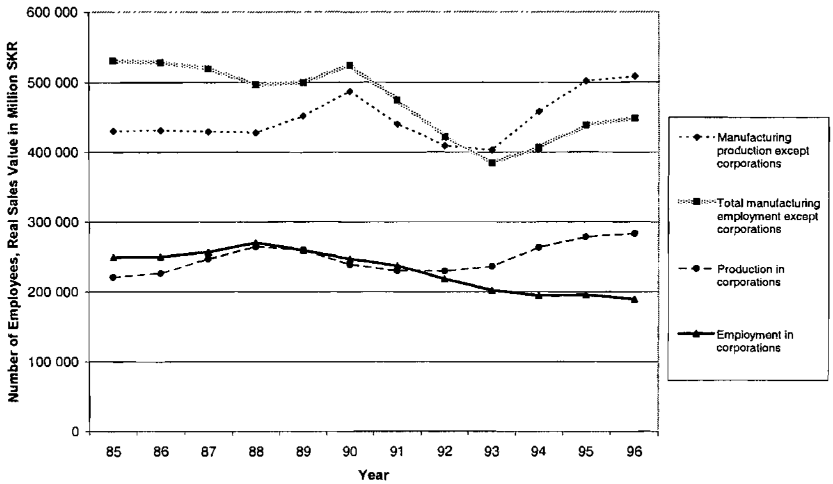

Figure 1: Employment and production in the sample corporations and the rest of the manufacturing sector

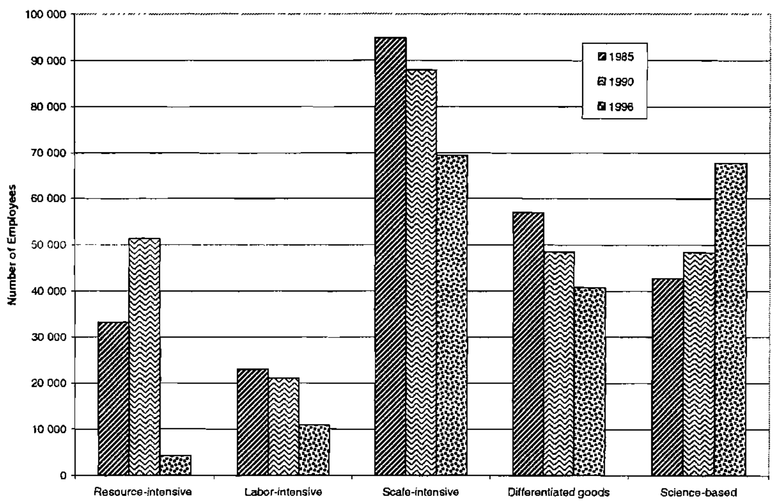

Figure 2: The sample corporation employment by industry groups according to OECD taxonomy.

tries. Fors and Kokko (1999) studied the international operations of some of the corporations included in the sample and found evidence of similar dynamics among the foreign affiliates. Their analysis suggested an opposite direction of change in Sweden and abroad for most industries, which they interpreted as a sign of increasing specialization in the home-country operations of the corporations.

Figure 3 shows the average levels of real labor productivity of the sample corporations and the rest of the manufacturing sector. Productivity is measured as sales value per employee (SV/L) and value added per employee (VA/L).[10] Until the beginning of the 1990s, the sample corporations had modestly higher productivity than the rest of the manufacturing sector. However, the productivity gap seems to have increased dramatically during the 1990s. In that period, the annual rate of productivity growth in the sample corporations was about 7.5 percent (SV/L) while the annual productivity growth in the rest of the manufacturing sector was 3.3 percent. There may be several reasons for the increasing productivity gap. For instance, the fact that the sample corporations became increasingly specialized in science-based industries may explain why they became increasingly more productive. We will return to these issues in the section analyzing productivity growth.

4.1 Job Flows

Next, I examine the gross job flows underlying the aggregated structural changes in the sample corporations described above. The job flows occurring as a result of changes within the continuing plants are considered as internal restructuring, while those caused by sell-offs, closures, start-ups and acquisitions are regarded as external restructuring.

Table 1 lists the definitions of gross employment changes. Continuing plants are defined as expanding and contracting according to the change in the number of employees as compared to the previous year. Entry occurs

[10] Real sales value and value added are computed as PPI-deflated (1990=100).

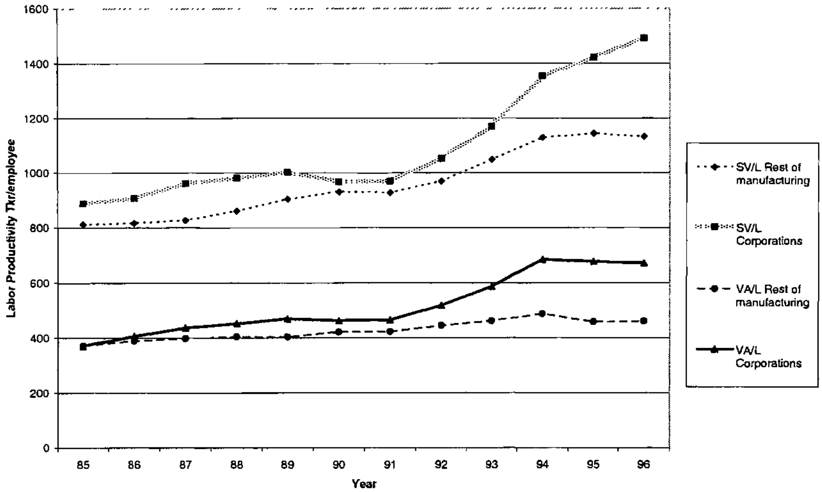

Figure 3: Average labor productivity of the sample corporations and the rest of the manufacturing sector.

when a corporation establishes or acquires a plant, while exit takes place through the closure or the divestiture of a plant.

Rates of entry and exit are computed as percentages with respect to the total employment of the sample corporations in the previous year. The expansion (contraction) rate is measured as the ratio of the number of jobs added (lost) in surviving plants to total employment the previous year. The rate of total job turnover is the sum of entry (start-ups and acquisitions), exit (closures and divestitures), contraction and expansion flows in absolute terms in relation to the total employment of the sample corporations in the previous year.

The annual and average rates of job flows between 1986 and 1996 are shown in Table 2. Two findings are particularly striking. The average annual rate of total job turnover is rather large, on average 24 percent during the 1986-96 period. This implies that one fourth of the jobs was added or lost annually, due to restructuring within the sample corporations. The other

Plant Status	Definition
Expansion	*Plant employment in period t-1 < Plant employment in t.*
Contraction	*Plant employment in period t-1 > Plant employment in t.*
Start-up	*Plant i is present period t, but not in t-1.*
Closure	*Plant i is present in period t-1, but not in t.*
Acquisition	*Plant i is present period t, but not in t-1 in corporation k.*
Divestiture	*Plant i is present in period t-1, but not in t in corporation k.*

Table 1: Definitions of job flows

remarkable result is that nearly half of the total annual job turnover at the corporation level took place in the form of ownership changes of plants. Thus, acquisitions and divestitures seem to play an important role in corporate restructuring.

[Table 2 here]

There are also other points worth noting. The annual rate of job losses was, on average, 13 percent during the 1986-96 period. Jobs disappearing through divestitures of plants accounted for about half of the total job losses. These job losses were probably not so dramatic, since the plants involved were transferred to other firms. However, my measures do not reveal whether the divested plants experienced downsizing after the ownership change. Those job losses that would be regarded as real job losses in industry-level studies, that is, closures and contraction of continuing plants, accounted for the other half of jobs lost. On average, 5.2 percent were lost as a consequence of contraction and only 1.4 percent because of closures of plants. However, it is possible that jobs lost in some plants were replaced by new jobs in other plants within the corporation.[11] The net losses were much smaller than

[11]The evidence by Schuh and Triest (2000) that one fourth of the job reallocation between manufacturing plants occurs within firms suggests internal reallocation to be important.

the gross losses, since the average annual rate of job additions was nearly 11 percent. The real job additions, including start-ups of new plants and expansion of continuing ones, accounted for more than half the jobs added, while the remaining occurred through acquisitions of plants.

The annual rates of job additions and losses over time can be seen in Figures 4 and 5. At a first glance, the different sources of job additions and losses do not seem to follow any specific pattern over time. However, it can be observed that the contraction rate increased markedly during the recession period of 1991-93 and then decreased once more, while the expansion rate decreased during the recession and increased again during the following years of recovery. This suggest that the rates of expansion and contraction follow a cyclic pattern. To find more evidence of a cyclic pattern, simple Pearson correlations were computed between the growth rate of total manufacturing production and the rates of job additions and losses.[12] As seen in Table 2, the expansion (0.72) and contraction rates (0.62) are highly positively correlated with the growth rate in manufacturing production. The correlations indicate that the expansion of continuing plants takes place in booms and downsizing in slumps, as would be expected. However, this does not seem to be the case for other types of job flows. Figure 4 shows the rate of jobs added through acquisitions to follow a decreasing trend since the 1980s. The rate of divestitures shown in Figure 5 fluctuates more over time. It decreased in the recession at the beginning of the 1990s, but increased again in the years of recovery. The rates of acquisitions and divestitures are only weakly negatively correlated with the growth rate in total manufacturing production, which suggests a weak counter-cyclic pattern.

There can be several explanations for the differences in the patterns. Corporate restructuring occurring through acquisitions and divestitures may have completely different causes than when occurring through the expansion

[12]Growth rates of production are calculated from the manufacturing production index (IPI) provided by Statistics Sweden.

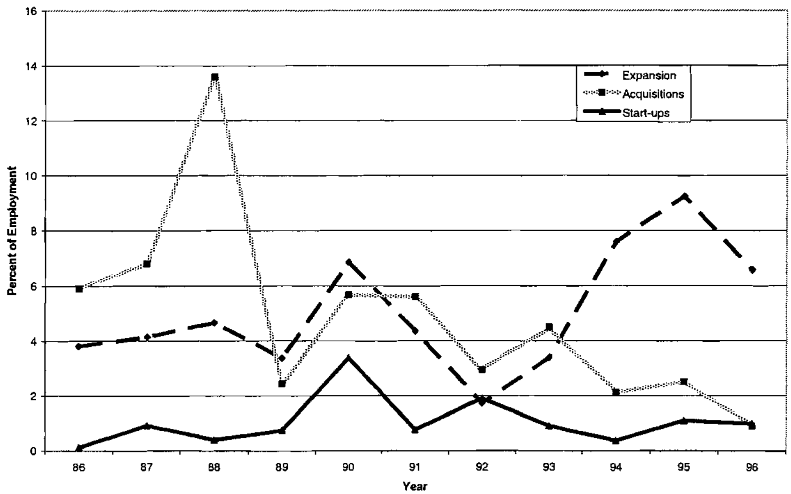

Figure 4: Annual rates of plant-level job additions.

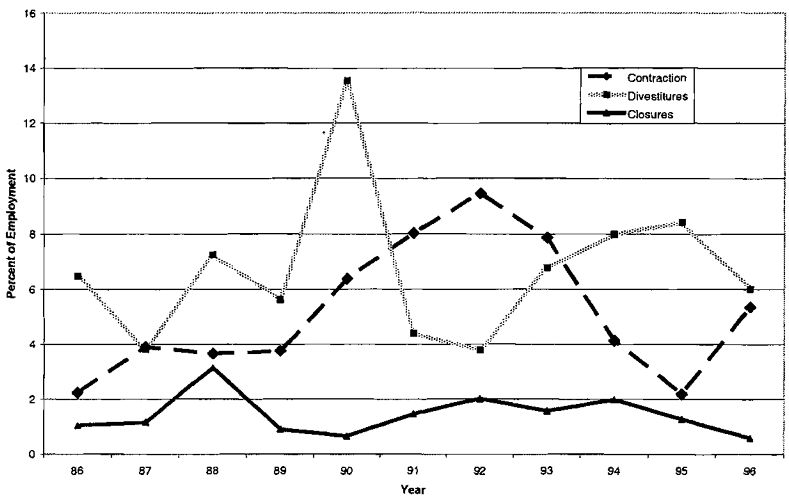

Figure 5: Annual rates of plant-level job losses.

and contraction of continuing plants. Maksimovic and Phillips (2002) find that conglomerate firms become more focused when the prospects in their main segments improve by acquiring assets in these segments and selling assets in more peripheral segments. In periods of weak demand in their main business segment, they diversify by acquiring assets in unrelated industries. The business cycle is also likely to affect the market for plants and firms through prices. Mergers often come in waves. During slumps, plants may be sold at a discount, which can lead to an increasing acquisition activity. However, it is beyond this study to analyze the causes of acquisitions and divestitures. The main finding of this section is that a rather large share of jobs in the multi-plant sample corporations was affected by changes in corporate structure in any given year and that ownership changes account for an important part of this restructuring.

5 Restructuring and Labor Productivity

This section examines how the job flows described in the previous section are related to productivity growth at the corporation level. To quantify the importance of internal and external organizational restructuring on the productivity growth of the corporations, I use decomposition methods developed in industry-level studies on productivity growth.

5.1 Measures of Productivity

The two most common measures of productivity are total factor or multifactor productivity (TFP) and labor productivity. This study uses labor productivity measures. The measure of labor productivity is chosen because the investment data needed for computing TFP are not available at the plant level. Theoretically, TFP is a more appropriate measure of productivity because it takes into account all inputs, not only labor. In practice, the estimation of labor productivity can give better accuracy than TFP, because estimating the value of capital stocks often implies a large error. One shortcoming of labor productivity as an indicator of productivity performance is that it fails to capture changes in factor intensities, which may be a result of the adoption of new technology or changes in factor prices. For example, productivity growth could be caused by a shift to labor-saving, and more capital intensive, technology. Another problem with labor productivity is that average labor productivity has been found to be procyclical in empirical studies.[13] Despite these problems, labor productivity has been found to be highly correlated with other productivity measures.[14]

Labor productivity is measured as the sales value per employee. Sales value per employee is chosen as the main measure of labor productivity because all inputs and input deflators to compute real value added are not available.[15] The real values of sales are attained using industry-specific price deflators.[16] Value added is a preferred measure of output in studies at the aggregate level, because output used as an input by another industry is netted out and problems of double-counting are avoided. However, at the plant level, the use of sales value may be motivated since the problems of double-counting are less severe than at a more aggregated level.[17]

[13]Baily, Bartelsman and Haltiwanger (1996b) test different hypotheses that may explain the procyclical productivity growth that is not driven by technological shocks. Among the explanations studied are plant-level increasing returns to scale, labor hoarding or a contemporaneous productivity penalty induced by changing the scale of operations. They find that plants permanently downsizing disproportionately account for procyclical productivity, and interpret the results to favor an adjustment cost model involving a productivity penalty for downsizing as the largest source of procyclical productivity.

[14]See e.g. Foster et al. (1998).

[15]However, a proxy for value added defined as real sales value less real value of outlays for energy and materials (by using average price indices for energy and material inputs in manufacturing) is computed to analyze the sensitivity of the results.

[16]A majority of deflators are assigned at the three-digit level of the Swedish standard for industry classification (SNI69 and SNI92). Some industries with an important share of total manufacturing production are given deflators at a more disaggregated level, while industries with smaller shares have deflators at the two-digit level.

[17]Foster et al (1998) used sales value per unit of labor (man-hours and employees) as their main measure of plant-level labor productivity, but also performed decompositions of labor productivity growth using value added per unit of labor. They report the results

5.2 Decomposition of Productivity Growth

The overall productivity growth within a corporation can be divided into the contributions of internal and external sources by using methods of decomposition originating from studies on industry-level productivity growth. For robustness, I use two different decomposition methods suggested by Foster, Haltiwanger and Krizan (1998) and Griliches and Regev (1992). Foster, Haltiwanger and Krizan (FHK) (1998) propose a decomposition of overall industry-level productivity growth into five components; within, between, covariance, entry and exit effects.[18] The within effect accounts for the contribution of productivity growth within surviving plants. The between effect is the contribution of changes in the shares of the continuing plants, implying that productivity grows if productive plants grow relatively more in an industry. The covariance effect is counted as the product of changing shares and changing productivity of the continuing plants. The covariance effect is positive (negative) when the shares of plants with growing (falling) productivity increase. The entry and exit effects comprise the contributions of new and closed plants to industry productivity. When the less (more) productive plants are closed down and replaced by new more (less) productive ones, the contribution to industry-level productivity growth is positive (negative).

The methods of decomposition for industry-level productivity growth need to be modified for the corporation level analysis. At the corporation level, the between and covariance effects capture the contribution of changes in the shares of the continuing plants within a corporation. Thus, the effects capture the contribution of organizational restructuring within the corporation instead of changes in the market structure of an industry. Another important difference is that entry and exit at the corporation level comprise acquisitions and divestitures in addition to start-ups and closures. The

to be very similar for the two measures.

[18] The method is a modified version of that used by Baily, Hulten and Campbell (1992). See Haltiwanger (1997) for a discussion of the limitations of the original method.

contribution of all these four effects can be computed separately. Furthermore, the contribution of plants changing industries, but remaining in the ownership of the same corporation, is not defined as entry or exit like in industry-level studies. The contribution of these plants can be computed as for the other continuing plants or as a separate effect when the available industry classification so allows.[19]

The average change in the productivity of the corporations, P_t, between year t and $t-k$ is counted as

$$\Delta P_t = \sum \overline{\theta}_c (P_{c,t} - P_{c,t-k}), \tag{1}$$

where $\overline{\theta}_c$ is corporation c's average of the start year and the end year share in the sample and $P_{c,t}$ the real labor productivity of the corporation in year t. To sum across corporations, I consider two alternative weights: output weights and employment weights. A decomposition of ΔP_t in corporation c according to the method proposed by Foster, Haltiwanger and Krizan (1998) is given by

$$\begin{aligned}\Delta P_{c,t} = \sum_{j\epsilon S} \theta_{j,t-k} \Delta p_{j,t} + \sum_{j\epsilon S} \Delta\theta_{j,t}(p_{j,t-k} - P_{c,t-k}) + \sum_{j\epsilon S} \Delta\theta_{j,t}\Delta p_{j,t} \\ + \sum_{j\epsilon N} \theta_{j,t}(p_{j,t} - P_{c,t-k}) - \sum_{j\epsilon E} \theta_{j,t-k}(p_{j,t-k} - P_{c,t-k}), \quad (2)\end{aligned}$$

where $\theta_{j,t}$ is plant j's share in the corporation and $p_{j,t}$ the real labor productivity of plant j in year t and where S, N and E denote surviving, entering and exiting plants. The terms on the right-hand side are the within, between, covariance, entry and exit effects in that order. The within effect accounts for the productivity growth in continuing plants, given unchanged

[19] During the period studied, the Swedish classification of industries (SNI) is changed. A translation of the old, SNI69, to the new, SNI92, involves problems at the disaggregated level. Changes in industries can only be analyzed during the sub-periods of 1985-90 and 1990-96, where the standard remains the same throughout the period.

shares within the corporation. The contribution of changes in the shares of continuing plants implies that productivity grows if productive plants (between effect) or plants with high productivity growth (covariance effect) gain shares within a corporation. The between and the covariance effects are defined as internal restructuring. The entry effect consists of the contributions of new and acquired plants and the exit effect includes the contributions of closed and sold plants. These effects are computed as entry and exit effects in equation (2) and are displayed separately. The aggregated entry and exit effects are defined as external restructuring. To aggregate across plants within a corporation, I use employment weights, but also analyze the sensitivity of the results by using output weights. Employment weights are seemingly more appropriate for labor productivity measures and have been used in industry-level studies by e.g. Griliches and Regev (1995), Baily, Bartelsman and Haltiwanger (1996a) and Foster, Haltiwanger and Krizan (1998).

Foster, Haltiwanger and Krizan (1998) point out that the decomposition method is sensitive to measurement error. For instance, if employment were measured as spuriously high in one period, the result would be a spuriously low measured productivity. The error would yield a negative correlation between $\Delta\theta$ and Δp and a spuriously high within effect. For robustness, we therefore also use a decomposition method proposed by Griliches and Regev (GR) (1992)

$$\Delta P_{c,t} = \sum_{j \epsilon S} \overline{\theta}_j \Delta p_{j,t} + \sum_{j \epsilon S} \Delta\theta_{j,t}(\overline{p}_j - \overline{P}_c) + \sum_{j \epsilon N} \theta_{j,t}(p_{j,t} - \overline{P}_c) - \sum_{j \epsilon E} \theta_{j,t-k}(p_{j,t-k} - \overline{P}_c) \tag{3}$$

where the bar indicates an average of the base year and the end year values. The first and second terms are the equivalent of the within and between effects of the FHK decomposition. The internal restructuring thus only consists of the between effect. The third and the fourth terms are entry and exit effects. The advantage of the decomposition method is that averaging removes some of the measurement error. However, a disadvantage is that the interpretation of the effects is not as straightforward. Averaging the weights implies that the within and between effects reflect the covariance effect to some extent.

5.3 Results

Table 3 shows the results of the decompositions for the 1985-96 period.[20] Each component's contribution is displayed as a percentage of total growth. The results for the two weights and methods differ somewhat, as would be expected. With respect to the relative importance of external restructuring, however, the results are similar for both methods of decomposition. The total contribution of external restructuring is 42-47 of the productivity growth of the sample corporations. This result is striking. Including both internal and external restructuring, the results suggest that the productivity of the sample corporations grew at least twice as fast as that of single-plant firms with the same internal productivity growth.[21]

[Table 3 here]

If we look at different internal sources of productivity growth, it is seen that the most important effect is the within effect: continuing plants had high productivity growth. The within effect accounts for about 45-49 percent of total productivity growth computed with labor weights. The labor weighted results imply that nearly half the productivity growth would have occurred even if the plant shares had remained constant. The between effect, that is the contribution of continuing plants with high initial productivity increasing their share within corporations, varies between 4.3 and 4.5 percent, depending on the method. The covariance effect, the contribution of

[20] Table A2 in the Appendix shows the employment share and the number of plants defined as continuing, changing industry, new, acquired, closed and sold.

[21] The decompositions are also computed using value added per employee. The results obtained are very similar to those in Table 3.

plants with high productivity growth increasing their share only computed by the FHK method, varies from 9.2 to 55.2 percent depending on the weights used. When output weights and the FHK method are used, the share of the within plant component is much smaller, while the covariance effect is larger, thereby suggesting that the effect of plants with high productivity growth increasing their shares is more important. This is reasonable. With employment weights, the most productive firm may stand still, although it captures much of the output market.

The differences between the methods are more obvious for the components of external restructuring. The contribution of new plants is much larger according the method of FHK than to that of GR. The effect of acquisitions is about 24 percent according to the FHK method and only about 13 percent according to the GR method when using labor weights. For the GR method, the total impact of new and acquired plants is smaller than the impact in the FHK decomposition. One reason for these differences is that averaging corporation productivity in the GR decomposition reduces the large differences appearing in the productivity of new and acquired plants in the end year and average corporation productivity in the base year. The opposite holds for the effects of closed and sold plants. The total shares of net entry and net ownership changes are more similar for the two methods. The contribution of net ownership changes was between 26-35 percent. Net entry contributed an additional 13-17 percent to corporation level productivity growth.

To shed light on the differences in results for the FHK method of different weights, I compute simple correlations between output, employment and productivity growth rates for continuing plants (see Table A3 in the Appendix). As expected, employment and output growth are highly positively correlated. The positive correlation between labor productivity and output growth explains the positive covariance term in the decompositions using output weights. The same result is not obtained using employment weights, since employment growth is weakly negatively correlated with productivity growth. Foster, Haltiwanger and Krizan (1998) obtained similar differences in their results when using output and employment weights for the decomposition of industry-level labor productivity. Interestingly, they found the decomposition of labor productivity using output weights to yield very similar results to those of multifactor productivity decompositions.

The decomposition results seen in Table 3 are the weighted averages for the corporations. While most of the corporations experienced positive growth in labor productivity during the 1986-96 period, their performance was far from conform. It is therefore useful to consider some corporation-specific differences. I compute simple correlations between corporation level employment, output, productivity growth and the components of decomposition (see Table A4 in the Appendix). Employment and output growth are highly positively related to productivity growth, even at the corporation level. It suggests that corporations with high productivity growth were expanding both in terms of employment and sales. The within, covariance, entry and acquisition effects are all negatively correlated with corporation productivity growth. The only component that is rather highly and positively correlated with corporation productivity growth is the effect of selloffs. The between and closure effects are the other effects positively correlated with productivity growth. The effect of selloffs is positively correlated even with employment and output growth, thereby indicating that downsizing at the corporation level does not underlie the positive correlation between the effect of selloffs and productivity growth. The correlations thus suggest corporations with high productivity growth to be rationalizing through selloffs and closures.

It can be argued that the decomposition results are sensitive to the length of the period chosen. Shorter periods tend to be more dominated by cyclical variation in productivity. Furthermore, the number of plants continuing through a longer period may also affect the results. However, it is not clear if a longer period implies an increase in the net contribution of external restructuring. One obvious effect of lengthening the period is that the contribution of entry in the FHK decomposition is likely to be higher, since the difference between the productivity at the end of the period and the initial year generally grows over time. The higher productivity levels at the end of the period also have an impact on the within and covariance effects. The GR decomposition mitigates the impact of these differences using average values of productivity.

To assess the sensitivity of the results for length of period, the compositions are also computed for two sub-periods: 1985-90 and 1990-96. The descriptive statistics showed productivity growth to be much higher during the 1990s than during the 1980s. 1990 represents a peak year in the business cycle of the manufacturing sector and is therefore chosen as a cut-off point for the two periods. Table 4 shows the decomposition results for the two periods.[22] As mentioned above, two additional effects due to changes in industry by continuing plants can be computed for these sub-periods. The results for the 1985-90 period vary, largely depending on the decomposition method. The within effect varies from 23 percent measured with the FHK method to -7.6 percent measured using the GR method. By examining the other components of internal productivity growth, it is obvious that the negative within effect is generated by an expansion of plants with negative productivity growth. This negative effect is captured by the covariance effect in the FHK decomposition, but it affects both the within and between effects in the GR decomposition. The effect of continuing plants shifting their production to other industries is small during the 1985-90 period. The total shares of internal and external sources are comparable for the productivity measures, irrespective of the decomposition method. The share of ownership changes, 67-69 percent of total productivity growth, is remarkably large during the period.

[Table 4 here]

[22] Employment weights are used.

For the 1990-96 period, the results are less ambiguous with regard to the within effect. Both methods show the contribution of the within effect to be about 54-60 percent and the total contribution of the internal sources about 75 percent. Once more, the FHK method yields a higher effect for the acquired plants and a lower for the sold ones than the GR method, but summing the effects of ownership changes yields similar results for both decompositions. The contribution of ownership changes is 17-19 percent of total productivity growth, which is much lower than in the 1985-90 period. These results suggest that the decompositions are not as sensitive to the length of the period as to the business cycle.

To further examine how the business cycle may affect the different sources of productivity growth, the decompositions are computed for the 1990-93 and 1993–96 periods. During the 1991-93 period, the Swedish manufacturing sector experienced negative growth in production, but recovered fast during the following years.[23] Productivity growth in the corporations was positive in both periods, but the annual rate of growth was nearly twice as high in 1993-96. The decomposition results presented in Table 5 show that almost all productivity growth was generated internally within continuing plants of the corporations during the period of high growth in the manufacturing sector. Ownership changes had a small and negative effect on the productivity growth of the corporations.

[Table 5 here]

It may be concluded that the results are sensitive to cyclical variation. The contribution of internal sources varies from 17 to 99 percent between the sub-periods. The contribution of the within effect is relatively more important in the periods of high productivity growth. This result is in line with industry-level studies that have found the within plant component to

[23]The average annual rate of growth in total Swedish manufacturing production was -1.8 during 1991-93 and 8.6 percent during 1994-96. The growth rates are computed from the manufacturing production index (IPI), Statistics Sweden.

be large and positive in periods of robust productivity growth and negative in periods of modest productivity growth (Baily, Hulten and Campbell, 1992, Baily, Bartelsman and Haltiwanger, 1996a and 1996b, and Haltiwanger, 1997). In the long run, however, the contributions of internal and external sources are almost equal. One plausible explanation for the large share of internal productivity growth in the periods of high-productivity growth is that the corporation utilized its spare capacity. However, the capacity utilization data required to explore the relevance of this explanation are not available. Altogether, the results suggest that during times of low internal productivity growth, the corporations are involved in acquisitions of more productive plants and divestitures of less productive ones. This external restructuring seems to compensate for the low, or even negative, productivity growth within their continuing operations.

5.4 Contribution of Acquired and Sold Plants

One of the main results of the decompositions is that the contribution of ownership changes of plants to productivity growth is important, particularly during times of lower overall productivity growth within corporations. However, decomposition methods do not reveal how the contribution is generated. Regarding acquired plants, there are two main possibilities: the contribution was positive because acquired plants had higher productivity growth than other plants, or because the sample corporations acquired plants that were more productive than the incumbent plants. Furthermore, there may be a decompositional effect where entry, including acquisitions and start-ups, is concentrated in high-productivity industries and exit through plant sell-offs and closures mainly occurs in low productivity industries.[24]

[24]To assess the impact of overall structural changes in the sample on productivity growth, decompositions were computed at the two-digit industry level in the 1985-90 and 1990-96 periods. The most important contribution to aggregated productivity growth within the sample was generated within industries. The share of productivity growth generated through an increasing specialization in industries with high labor productivity

To explore what underlies the positive effect of acquisitions and divestitures on the productivity growth of the sample corporations, I specify a simple regression model where the dependent variable is productivity. In contrast to decompositions, the regression model using annual data over the time period studied also includes information about the large number of plants appearing under the control of the corporations in some years, but not in the base or end year of the decomposition period. These are the plants established or acquired between the base and end year, but not kept until the end year.

The contribution of acquired, sold, new and closed plants in relation to continuing plants is analyzed using binary variables. Two kinds of dummy variables are defined. The first kind of dummy variables take the value of one in the year when a plant is acquired/sold/closed or established, and zero otherwise. The group of continuing plants to which these plants are compared consists of all other previously acquired and established plants. The other kind of dummy variables takes the value of one when a plant is acquired or established and during the following years, given that the plant is kept.[25] For plants that are sold or closed, the equivalent dummy variables take the value of one when a plant is sold or closed and during the years preceding the sell-off or closure. The first kind of dummy variables captures whether the acquired/sold/closed and new plants differed from the continuing plants at the time of acquisition/sell-off/closure or start-up. The other dummy variable captures whether the plants acquired (started) by the sample corporation differed from the continuing plants during the years after acquisition (start-up) and whether the sold (closed) plants differed from the other plants during the years preceding sell-off (closure).

growth was larger in the 1990s. The results are not reported here, but are available upon request.

[25]The acquired and new plants can be followed until 1998. I therefore define plants acquired or established in 1995 and 1996 as kept ones, if they are not sold or shut down before the end of 1998.

I use two measures of plant productivity: one relating plant labor productivity to the weighted average productivity of the corporation and one measuring a plant's labor productivity relative to its industry average productivity.[26] The first productivity measure controls for corporation-level variation in labor productivity, but not for industry-level variation. The second measure controls for industry-level variation by relating plant productivity to the average productivity of its industry. The five industry groups defined according to the OECD taxonomy are used to control for some industry-level variation in the specifications using my first productivity measure. Compared to the decompositions, the regression analysis thus provides additional information by controlling for industry-level differences in plant productivity.

Plant size can affect productivity. Generally, productivity is expected to be positively related to firm size. However, the positive effects of large size, such as economies of scale, can appear at the firm level rather than the plant level, and plant productivity can therefore be negatively related to plant size. In order to control for plant size, I add a size variable defined as the log of plant employment. The estimations are also computed with year dummies controlling for time-specific variation. The estimation method used allows for correlation of residuals within panel units (plants).[27]

Table 6 shows the results for the specification with the first kind of dummy variables. The results differ to some extent for the two measures of productivity. In terms of both productivity measures, the difference between acquired and continuing plants is not statistically significant at the time of acquisition. Unconditionally, without controlling for plant size, new plants are more productive than continuing plants at the time of start-up. In terms of the relative productivity measure, new plants were about 27 percent more productive than continuing plants. However, the result is only statistically significant at the ten-percent level and not significant when controlling for

[26] At the four-digit industry-level.

[27] The estimation method relaxes the assumption of independence of observations and requires the observations to be independent across panel units.

plant size, which suggests that the new plants did not differ significantly from continuing plants of equal size. The sold plants, on the other hand, were much less productive than the continuing plants in terms of both measures. The difference as compared to the continuing plants was about 15-19 percent, depending on the measure of productivity and whether we control for plant size. The closed plants were also less productive than the continuing plants when controlling for plant size.

[Table 6 here]

Table 7 shows the results for the specifications with the second kind of dummy variable. As seen in the table, the acquired plants kept by the corporations did not differ significantly from the continuing plants during the years following the acquisition. Sold plants were less productive than continuing plants of equal size during the years preceding the sell-off. The results are only conditionally statistically significant, that is after controlling for plant size. For the new plants, the results depend on the measure of productivity. In terms of both measures of productivity, new plants that corporations kept were unconditionally more productive than continuing plants thorough the period. However, the hypothesis of the coefficient being equal to zero cannot be rejected according to the t-test when productivity is measured relative to corporation average and when controlling for plant size. The results for the closed plants are not statistically significant.

[Table 7 here]

The results from the regression thus suggest that the plants acquired by the corporations did not differ from continuing plants in terms of productivity. This finding raises the question for what reasons the plants were acquired. Hakkala (2003) analyzed the acquisitions of the sample corporations and found that more than one third of the acquired plants were divested within three years. The results show that the corporations were more likely to divest those that were relatively less productive. An interpretation of the results is that the corporations acted efficiently, given that the acquisitions involved uncertainty about the matching outcome. Although the acquired plants did not to differ significantly from the continuing plants, they were not necessarily poorly performing. In fact, the comparison group of continuing plants was productive relative to its industries.

New plants were more productive than continuing plants at the time of start-up, which seems to be partly explained by their small size. The new plants that were kept remained more productive over time. Some of the contribution of new plants in the decompositions might be due to productivity growth of entrants subsequent to entry and might therefore partly be a within effect. Although new plants were much more productive than continuing plants, the effect of acquired plants on overall productivity growth was more important, since their share of total employment was larger (see Table A2).[28] Sold plants, on the other hand, were found to be significantly less productive than continuing plants at the time of sell-off. Furthermore, the plants that were sold showed lower productivity than continuing plants during the years preceding the sell-off, which suggests that divestitures were motivated by productivity considerations. A plausible explanation for the sell-offs is that corporations were downsizing their operations in industries with low productivity. However, the results were significant also in terms of productivity relative to industry average, thereby suggesting that the plants sold were also performing relatively poorly in their industries.

[28] F-tests were performed to test the equality of the coefficients on new and acquired plants. The tests cannot reject the hypothesis that coefficients were equal in estimations using productivity relative to industry. In estimations with productivity relative to corporation average, the equality hypothesis can be rejected at the10-percent level.

6 Conclusion

This study has examined the sources of productivity growth in multi-plant corporations. Although the analysis is largely descriptive, it can provide new important insights about organizational restructuring and the sources of productivity growth for multi-plant corporations. Using data for a sample of the largest manufacturing corporations in Sweden for the 1985-96 period and studying the sources of productivity growth at the level of the corporation, this study approaches the issue of productivity growth from a new perspective and extends both the micro-level productivity studies analyzing particular internal determinants of firm productivity growth and macro-level studies emphasizing the importance of external restructuring at the industry level.

It is found that, on average, one fourth of the jobs in the sample corporations were added or lost annually and almost half of the job flows was due to ownership changes of plants. These large job flows are shown to be associated with the overall productivity performance of the sample corporations. The decompositions of productivity growth suggest two conclusions. First, the results show that external restructuring contributes almost as much to long-term labor productivity growth of the multi-plant corporations as internal sources. Particularly important is the contribution of ownership changes of plants. Together, the internal and external restructuring accounted for more than half the total productivity growth in the sample corporations. This result suggests that the productivity of the sample corporations grew at least twice as fast as that of a single-plant firm with the same plant-level productivity growth.

Second, the relative importance of external and internal sources of productivity growth varies substantially with the business cycle at the corporation level. This finding is in line with the results of industry-level studies showing the within plant component to be large and positive in periods of robust productivity growth and negative in periods of modest productivity growth (Baily, Hulten and Campbell, 1992, Baily, Bartelsman and

Haltiwanger, 1996a and 1996b, and Haltiwanger, 1997). In times of lower productivity growth, the decompositions show that a large contribution to productivity growth stems from acquisitions and divestitures of plants. The external restructuring thus seems to compensate for low or even negative productivity growth within the continuing operations of the corporations. This may explain why multi-plant corporations were able to sustain higher productivity growth throughout the business cycle.

Furthermore, the regression analysis using relative measures of productivity shows that acquired plants did not differ from continuing plants at the time of acquisition or in the following years under the new ownership. I interpret the results to suggest that the sample corporations generated productivity growth through internal productivity improvements within continuing plants and by starting productive new plants rather than sourcing productivity growth through acquisitions of more productive plants from other firms. However, the sold plants showed to be significantly less productive than the continuing plants during the years preceding divestiture and at the time of sell-off. The evidence confirms that selloffs played an important role in a process of rationalizing where less productive plants were sold or closed down and replaced by start-ups of more productive new plants.

The sample corporations may not be representative for smaller multi-plant firms, but the results provide important insights into how larger corporations can sustain higher productivity growth than that of single-plant firms. By emphasizing the role of ownership changes, this study extends the findings of Haskel et al (2000) who found that an important contribution to overall productivity growth was due to multi-establishment firms closing down poorly performing plants and opening high productivity new ones. The role played by ownership changes may actually be explained by the characteristics of the sample corporations. Previous research shows that some industries characterized by the importance of intangible assets and high levels of multinational activity and concentration exhibit extensive and productive changes in control and rather less exit/entry turnover.[29] Nevertheless, there is corporation level heterogeneity within the sample. The finding that rationalization through sell-offs and closures seems to be associated with expanding corporations and corporations with high productivity growth rather than with downsizing corporations facing declining productivity sheds new light on the concept "creative destruction". Further work, however, is needed to analyze the sources of corporation heterogeneity and verify its implications on productivity growth.

[29] See e.g Baldwin and Gorecki (1990) and Baldwin and Caves (1991).

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A Appendix

A.1 Data appendix

The data set includes information on the manufacturing firms and plants that were under the control of the thirty sample corporations during the period of 1985-98. Four of the corporations only appear in part of the period. One corporation disappears as it merges with another corporation in the data, another appears as a new corporation and the third is established after a separation from one of the other corporations in the sample. Statistics Sweden has linked each plant to a firm, and each firm to a company group by using a corporation register. A corporate group can consist of firms and plants in several industries. All manufacturing plants with at least five employees are included. Every year, plants that are new or acquired are added to the data set and plants that are sold or divested are excluded from the data set. Information about the plant status before being added to or after being excluded from the data enables me to separate ownership changes from greenfield entry and closures. For an identifier appearing for the first time in the sample, this information shows whether it previously existed under other ownership or if it is a new plant. The new plants are assigned with information about the month and the year of start-up. For an identifier that disappears from the sample there is information showing whether the plant continues under other ownership or if it is closed down. Closed plants are assigned with information about the month and the year of closure.

Plants exiting one industry but continuing in another are regarded as continuing plants. Thus, entry and exit are universally defined, and not at the industry level. Firm-level changes in ownership of plants internal to a corporation are disregarded. These plants are defined as continuing plants within a corporation. There are cases where plants do not appear in the statistics before being added to the sample, but are not assigned with a start-up date either. These cases are defined as greenfield entry. There are also plants lacking information about the time of closure, but which do not continue after disappearing from the sample. These are defined as closures. An implication of this procedure is that some plants falling below the limit of five employees may be misleadingly regarded as non-existing. However, these cases are expected to be rare since Statistics Sweden has included plants that temporarily, during one or a few years, fell below the size limit.

There are cases when an establishment disappears from the data one year, but thereafter continues under the control of the same corporation as before. These plants are defined as continuing and data of employment and productivity are added by interpoleration.[30] This alternative is preferred to excluding the drop-outs or defining them as temporary changes in ownership.

[30]The values for year t are computed as the averages values for $t-1$ and $t+1$.

A.2 Tables

Table A1. Classification of industries according to OECD taxonomy.

Classification		
1	***Resource-intensive industries***	
		Manufacture of food, beverages and tobacco
		Manufacture of leather, except footwear and wearing apparel
		Manufacture of wood, wood and cork products, except furniture
		Manufacture of pulp, paper and paperboard
		Manufacture of miscellaneous products of petroleum and coal
		Petroleum refineries
		Manufacture of other non-metallic mineral products
		Non-ferrous metal basic industries
2	***Labour-intensive industries***	
		Manufacture of textiles
		Manufacture of wearing apparel, except footwear
		Manufacture of footwear except vulcanised or moulded rubber or plastic footwear
		Manufacture of furniture and fixtures, except primary metal
		Other Manufacturing Industries
		Manufacture of fabricated metal products, except machinery and equipment
3	***Scale-intensive industries***	
		Manufacture of paper, paper products, printing, publishing nec.
		Manufacture of industrial chemicals
		Manufacture of paints, varnishes and laquers
		Manufacture of soap and cleaning preparations, perfumes, cosmetics and other toilet preparations
		Manufacture of industrial chemicals
		Manufacture of rubber products
		Manufacture of plastic products not elsewhere classified
		Manufacture of glass and glass products
		Manufacture of pottery, china and earthenware
		Iron and steel basic industries
		Manufacture of transport equipment excluding 3845 (aircraft)
4	***Differentiated goods***	
		Manufacture of engines and turbines
		Manufacture of agricultural machinery and equipment
		Manufacture of metal and wood working machinery
		Manufacture of special industrial machinery and equipment except metal and wood working machinery
		Machinery and equipment except electrical nec.
		Manufacture of electrical industrial machinery and apparatus
		Manufacture of electrical appliances and housewares
		Manufacture of electrical apparatus and supplies nec.
		Manufacture of watches and clocks
5	***Science-based industries***	
		Manufacture of drugs and medicines
		Manufacture of chemical products not elsewhere classified
		Manufacture of office, computing and accounting machinery
		Manufacture of professional and scientific, and measuring and controlling equipment nec.
		Manufacture of photographic and optical goods
		Manufacture of aircraft
		Manufacture of radio, television and communication equipment and apparatus

Source: OECD (1987) and (1992). The taxonomy developed by OECD is adjusted by reclassifying manufacture of radio, television and communication equipment and apparatus and manufacture of office, computing and accounting machinery in differentiated goods industries as science-based industries. The changes are supported by Baldwin's (1994) discriminant analysis on Canadian manufacturing sector.

Table A2. Employment share and number of plants in different categories

	1985-90			1990-96			1985-96		
	Number of plants	Share of total empl	Plant size	Number of plants	Share of total empl	Plant size	Number of plants	Share of total empl	Plant size
Base year									
Continuing	312	0.599	479	273	0.560	512	197	0.472	598
Changing industry	46	0.051	274	53	0.077	363			
Sold	259	0.303	292	284	0.288	254	365	0.431	294
Closed	74	0.048	161	168	0.076	114	129	0.097	187
End year									
Continuing	312	0.637	508	273	0.693	497	197	0.649	625
Changing industry	46	0.052	282	53	0.088	325			
Acquired	338	0.259	191	140	0.152	187	224	0.237	200
New	72	0.051	176	40	0.067	329	66	0.115	330
Number of corporations	27			28			26		

Note: The number of corporations is the continuing ones during the period.

Table A3. Correlation table

Correlation between plant -level growth rates					
		(1)	(2)	(3)	(4)
Productivity (SV/L)	(1)	1.0000			
Productivity (VA/L)	(2)	0.8058	1.0000		
Sales value	(3)	0.7388	0.6430	1.0000	
Employment	(4)	0.0517	0.0943	0.5318	1.0000

Note: Observations are continuing plants during the 1985-96, (197 obs).

Table A4. Correlation table

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Employment growth	(1)	1.0000									
Sales value growth	(2)	0.9027	1.0000								
Productivity growth	(3)	0.6605	0.8145	1.0000							
Within	(4)	0.0452	0.0200	-0.1497	1.0000						
Between	(5)	0.1432	0.1064	0.1885	-0.2542	1.0000					
Covariance	(6)	-0.1144	-0.0679	-0.1168	0.2101	-0.9423	1.0000				
Acquired	(7)	-0.1427	-0.2009	-0.2242	0.1155	0.0844	-0.0861	1.0000			
Sold	(8)	0.2066	0.1868	0.3523	-0.6616	0.5259	-0.3725	-0.3693	1.0000		
New	(9)	-0.1896	-0.1400	-0.1584	-0.3233	-0.3849	0.14387	-0.2395	-0.3127	1.0000	
Closed	(10)	-0.0407	0.0308	0.1099	-0.7618	0.3503	-0.4044	-0.4567	0.5457	0.4572	1.0000

Note: Continuing corporations in 1985-96, (26 obs).

Table 2. Corporation level job flows

Year	Expansion	Contraction	Start-up	Closure	Acquisition	Divestiture	Gross Additions	Gross Losses	Gross Ownership	Turnover
	Percentage of Total Average Employment Year t-1									
	(1)	(2)	(3)	(4)	(5)	(6)	(1)+(3)+(5)	(2)+(4)+(6)	(5)+(6)	
1986	3.80	-2.23	0.11	-1.03	5.91	-6.48	9.83	-9.75	12.39	19.57
1987	4.14	-3.89	0.92	-1.15	6.81	-3.80	11.88	-8.83	10.61	20.71
1988	4.67	-3.66	0.40	-3.13	13.59	-7.25	18.66	-14.04	20.84	32.70
1989	3.36	-3.75	0.73	-0.90	2.43	-5.61	6.52	-10.26	8.04	16.78
1990	6.86	-6.38	3.39	-0.65	5.68	-13.54	15.92	-20.57	19.22	36.50
1991	4.35	-8.02	0.76	-1.46	5.60	-4.39	10.71	-13.87	9.99	24.58
1992	1.73	-9.45	1.90	-2.00	2.94	-3.78	6.57	-15.24	6.72	21.81
1993	3.37	-7.87	0.89	-1.57	4.49	-6.77	8.76	-16.20	11.26	24.96
1994	7.61	-4.14	0.37	-1.98	2.11	-7.98	10.09	-14.10	10.08	24.19
1995	9.24	-2.17	1.09	-1.26	2.51	-8.42	12.83	-11.86	10.93	24.69
1996	6.58	-5.35	0.98	-0.58	0.91	-6.00	8.47	-11.93	6.90	20.40
Average annual rate										
1986-96	5.07	-5.17	1.05	-1.43	4.82	-6.73	10.93	-13.33	11.54	24.26
1986-90	4.57	-3.98	1.11	-1.37	6.89	-7.33	12.56	-12.69	14.22	25.25
1990-93	4.08	-7.93	1.74	-1.42	4.68	-7.12	10.49	-16.47	11.80	26.96
1993-96	6.70	-4.88	0.84	-1.35	2.50	-7.29	10.04	-13.52	9.79	23.56
Pearson correlation between job flow and growth in manufacturing production										
1986-96	0.715	0.615	-0.185	-0.089	-0.277	-0.309	0.124	0.176	-0.024	-0.022

Note: Growth rate in manufacturing is computed from production index (IPI) provided by Statistics Sweden.

Table 3. Decomposition of corporation productivity growth

Labor Productivity Growth

Weights	Employment		Output		
Annual Growth Rate	6.36%		6.66%		Number of Plants
Decomposition Method	FHK	GR	FHK	GR	
Within (W)	0.445	0.491	0.212	0.488	197
Between (B)	0.043	0.045	-0.242	0.051	197
Covariance (Cov)	0.092		0.552		197
Acquired (A)	0.238	0.128	0.296	0.174	224
Sold (S)	0.025	0.177	0.054	0.161	365
New (N)	0.145	0.081	0.096	0.036	66
Closed (Cl)	0.012	0.078	0.032	0.089	129
Ownership Changes (A+S)	0.264	0.305	0.350	0.336	589
Internal Sources (W+B+Cov+Ch)	0.579	0.535	0.523	0.539	197
External Sources (A+S+N+Cl)	0.421	0.465	0.477	0.461	784

Note: Decompositions are computed for the corporations continuing through the period.

Table 4. Decomposition of corporation productivity growth for sub-periods

Labor Productivity Growth

Period	1985-90		1990-96	
Annual Growth Rate	2.0%		9.99%	
Decomposition Method	FHK	GR	FHK	GR
Within (W)	0.227	-0.076	0.538	0.595
Between (B)	0.549	0.271	0.070	0.121
Covariance (Cov)	-0.605		0.115	
Change of industry (Ch)	-0.006	-0.013	0.030	0.039
Acquired (A)	0.318	0.117	0.182	0.107
Sold (S)	0.357	0.570	0.012	0.065
New (N)	0.005	-0.030	0.061	0.033
Closed (Cl)	0.156	0.161	-0.008	0.040
Ownership Changes (A+S)	0.674	0.687	0.194	0.172
Internal Sources (W+B+Cov+Ch)	0.165	0.182	0.753	0.755
External Sources (A+S+N+Cl)	0.835	0.818	0.247	0.245

Note: Decompositions are computed for the corporations continuing through the period. The aggregated results are employment weighted.

Table 5. Decomposition of corporation productivity growth for sub-periods

Labor Productivity Growth				
Period	*1990-93*		*1993-96*	
Annual Growth Rate	*6.88%*		*13.2%*	
Decomposition Method	*FHK*	*GR*	*FHK*	*GR*
Within (W)	*0.549*	*0.534*	*0.665*	*0.749*
Between (B)	*0.119*	*0.098*	*0.166*	*0.252*
Covariance (Cov)	*-0.031*		*0.169*	
Change of industry (Ch)	*0.047*	*0.044*	*-0.015*	*-0.010*
Acquired (A)	*0.194*	*0.138*	*-0.001*	*-0.012*
Sold (S)	*0.049*	*0.124*	*-0.005*	*0.008*
New (N)	*0.071*	*0.040*	*0.034*	*0.009*
Closed (Cl)	*0.002*	*0.023*	*-0.012*	*0.004*
Ownership Changes (A+S)	*0.243*	*0.262*	*-0.007*	*-0.004*
Internal Sources (W+B+Cov+Ch)	*0.684*	*0.676*	*0.985*	*0.991*
External Sources (A+S+N+Cl)	*0.316*	*0.324*	*0.015*	*0.009*

Note: Decompositions are computed for the corporations continuing through the period. The aggregated results are employment weighted.

Table 6. Estimations of productivity level

	Level of Productivity					
	LP relative to industry			*LP relative to corporation*		
Acquired	*0.046*	*0.042*	*-0.012*	*0.020*	*0.002*	*-0.040*
	(0.049)	*(0.050)*	*(0.048)*	*(0.023)*	*(0.040)*	*(0.040)*
New	*0.277 **	*0.273 **	*0.191*	*0.208 ***	*0.224 ***	*0.157*
	(0.148)	*(0.149)*	*(0.145)*	*(0.100)*	*(0.101)*	*(0.101)*
Sold	*-0.146 ****	*-0.146 ****	*-0.168 ****	*-0.162 ****	*-0.172 ****	*-0.188 ****
	(0.026)	*(0.026)*	*(0.029)*	*(0.025)*	*(0.026)*	*(0.029)*
Closed	*-0.110*	*-0.116*	*-0.217 ****	*-0.104 ****	*-0.094*	*-0.175 ****
	(0.074)	*(0.076)*	*(0.070)*	*(0.023)*	*(0.067)*	*(0.065)*
Plant size			*-0.093 ****			*-0.069 ****
			(0.025)			*(0.023)*
Constant	*1.136 ****	*1.110 ****	*1.570 ****	*1.063 ****	*0.910 ****	*1.287 ****
	(0.020)	*(0.024)*	*(0.124)*	*(0.023)*	*(0.038)*	*(0.123)*
Year dummies	*no*	*yes*	*yes*	*no*	*yes*	*yes*
Industry dummies	*no*	*no*	*no*	*no*	*OECD*	*OECD*
Number of observations	*7633*	*7633*	*7633*	*7692*	*7692*	*7692*

Note: Standard errors in parentheses. *, **, *** significantly different from zero at the 1 percent, 5 percent and 10 percent level, respectively. Estimations allow for correlated residuals within panel units (plants). Standard errors are robust (Huber-White).

Table 7. Estimations of productivity level

	Level of Productivity					
	LP relative to industry			*LP relative to corporation*		
Acquired kept	0.079	0.091	-0.006	0.114	0.104	0.038
	(0.069)	(0.070)	(0.066)	(0.073)	(0.072)	(0.072)
New kept	0.317 **	0.338 **	0.238 *	0.202 *	0.237 **	0.165
	(0.142)	(0.143)	(0.138)	(0.105)	(0.104)	(0.106)
Sold	-0.055	-0.075 **	-0.136 ***	-0.029	-0.092 *	-0.134 **
	(0.037)	(0.038)	(0.043)	(0.046)	(0.048)	(0.055)
Closed	0.052	0.027	-0.107 *	0.080	0.024	-0.074
	(0.075)	(0.074)	(0.063)	(0.070)	(0.068)	(0.070)
Plant size			-0.092 ***			-0.064 ***
			(0.024)			(0.023)
Constant	1.118 ***	1.036 ***	1.531 ***	1.025 ***	0.841 ***	1.215 ***
	(0.027)	(0.033)	(0.124)	(0.032)	(0.046)	(0.137)
Year dummies	no	yes	yes	no	yes	yes
Industry dummies	no	no	no	no	OECD	OECD
Number of observations	7633	7633	7633	7692	7692	7692

Note: Standard errors in parentheses. *, **, *** significantly different from zero at the 1 percent, 5 percent and 10 percent level, respectively. Estimations allow for correlated residuals within panel units (plants). Standard errors are robust (Huber-White).

Chapter II

Corporate Acquisitions and Transfer of Firm-Specific Knowledge Capital*

Katariina Hakkala

Abstract

This paper investigates the role of knowledge capital in explaining productivity growth of plants acquired by large Swedish corporations. The empirical analysis finds that when targets were acquired by relatively more productive corporations, they experienced a positive growth in productivity relative to the industry average. The results suggest that productive buyers had the expertise or resources to improve the productivity of the targets. The effect of the acquirers' knowledge capital on the productivity growth of the acquired targets is estimated. R&D expenditures for the whole corporation are not found to have any effect. Segment specific measures of the acquirer's skill intensity are, however, positively related to the post-acquisition productivity growth of the target. I take this as evidence of transfer of segment specific knowledge capital from the acquirer to the target.

Keywords: acquisitions, R&D, firm-specific assets, productivity.

JEL classification: G34, D24

*I thank Fredrik Sjöholm, Karolina Ekholm, and Ari Kokko, seminar participants at IUI, FIEF, Nordic International Trade Seminars in Stockholm and Stockholm School of Economics for helpful comments. Financial support from Tore Browaldh's Foundation and Jacob Wallenberg's Foundation is gratefully acknowledged.

1 Introduction

The role of innovation and knowledge capital has become increasingly important in firm strategies of growth and survival. Firms invest in research and development (R&D) to generate new technologies and innovations that in turn can enhance their productivity and competitiveness. In addition to conducting R&D, many firms, particularly in industries where innovation is important, are engaged in mergers and acquisitions (M&As) to get access to the firm-specific knowledge capital of other firms. By merging with a firm with a unique knowledge capital, a firm may obtain assets improving competitiveness, which are thereby are essential for survival and growth. The importance of external sourcing of technology as a complementary or an alternative strategy for internal R&D has been emphasized in studies by e.g. Granstrand and Sjölander (1990), Arora and Gambardella (1994), Blonigen and Taylor (2000) and Cassiman and Veugelers (2000).

Despite the fact that several studies have found technology sourcing to be an important motive for M&As, the effects of knowledge capital on merging firms remain rather unexplored. The empirical literature provides plenty of evidence on the internal positive effects of knowledge capital on productivity of a firm. It also provides evidence of so-called spillover effects, that is, effects arising when firm-specific knowledge diffuses to other firms without a 'direct purchase'.[1] However, the effects of knowledge transfers in connection with M&As have not been studied in great detail. In this paper, I use data on acquisitions carried out by a sample of large Swedish manufacturing firms to analyze whether there is empirical evidence of transfers of knowledge capital in connection with these acquisitions.

Knowledge capital is typically a joint-input in the sense that knowledge generated by one unit can be shared by several other units within the same firm. This aspect of knowledge capital is particularly important in the case

[1] For overviews, see e.g. Mairesse and Sassenou (1991) and Griliches (1995).

of large multi-plant corporations that often concentrate their R&D activities to one or a few units, from which the new knowledge is then transferred to other production units within the corporation. In association with M&As, the joint-input characteristics imply that the knowledge capital of the entire acquiring corporation may become accessible to the acquired units.

Knowledge capital is often rather narrowly defined as the technological knowledge generated by R&D investments. In a broader sense, the knowledge capital of a firm may also include other kinds of expertise and intangible assets such as market specific "know-how", privileged access to financial capital, management skills or a valuable brand name. The common factor of the different types of knowledge capital is that firms with large endowments of such capital are expected to be relatively productive. When transfers of firms' knowledge occur, we thus expect these to be reflected by increases in the productivity of the receiving firm.

Recently, Maksimovic and Phillips (2001) have analyzed the market for corporate assets and found that acquired plants increased their productivity when they were acquired by firms with a higher productivity than their own. Furthermore, they found that the acquisition of a more productive plant resulted in gains for the existing assets in the same industry and a decline in the productivity of the acquired plants. They interpreted these results to be consistent with buyers purchasing productive expertise that can be transferred to their existing assets.

This study builds on the results of Maksimovic and Phillips (2001) and takes the analysis one step further by examining whether there is evidence of the transferred productive expertise being knowledge capital. First, I examine whether there is evidence of transfers of productive ability in plants acquired by large Swedish manufacturing corporations. Second, I analyze whether the acquiring corporations' knowledge capital, proxied by measures of R&D and skilled labor, explain the post-acquisition productivity growth of the acquired assets. Knowledge capital is thus defined as an intangible asset consisting of accumulated technological "know-how", product and process innovations involving investments in R&D and inputs of skilled labor. In order to capture the joint-input characteristics of knowledge capital, I define the proxy variables at the corporation level rather than at the level of an acquiring affiliate firm. The sample studied consists of plants and firms acquired by the thirty largest Swedish manufacturing corporations during the 1986-96 period. These corporations represent approximately one fourth of total Swedish manufacturing employment and about 70 percent of the aggregate industrial R&D in 1999.[2]

The paper is organized as follows: the next section briefly discusses the related literature, Section 3 presents the empirical model and data, Section 4 presents and discusses the empirical results and Section 5 concludes.

2 Literature on Knowledge Transfers and Effects of M&As

Knowledge capital is an elusive concept that can be defined in a variety of ways. In the literature on technological progress, there is often a distinction between process and product innovations. Both types of innovations have the same effect in the sense of improving the firms' production possibility frontier. Process innovations imply an improvement through cost savings, whereas product innovations constitute an improvement by increasing the value of the products. For the purposes of this study, I broadly define knowledge capital as accumulated "know-how", product and process innovations and expertise involving investments in R&D and inputs of skilled labor.

In M&As, the firm-specific knowledge capital of the firms involved can be transferred from an acquirer to the target, vice versa or in both directions.

[2] Own calculations based on the data provided by Statistics Sweden. The three corporations with the largest R&D outlays stand for 51 percent of the total R&D outlays in the manufacturing sector in 1999.

When knowledge is transferred from the acquired to the acquirer, this is generally referred to as technology sourcing. The term relates to the idea that the motive for the M&As is to acquire superior knowledge possessed by the acquired firm. Studies by e.g. Arora and Gambardella (1990), Veugelers (1997) and Veugelers and Cassiman (2000) emphasize that firms with their own R&D programs may become involved in acquisitions to gain access to complementary external sources of technology. However, acquisitions of firms with a R&D program can also be a way of substituting for own investments in R&D. For instance, the technology management literature emphasizes the advantages of getting quick access to technological knowledge when the firm lacks competence in a new technology or market (Chatterji, 1996).

The actual motive for an acquisition may be an efficiency or productivity improvement where knowledge transfers play an important role. For instance, superior technology of the acquirer may replace old technology in the acquired firm which leads to improved productivity. In the economics and finance literature, several motives for M&As are associated with improvements in economic performance. Early theoretical work suggested that most mergers are an alternative to bankruptcy or a voluntary liquidation of the assets of failing firms (Dewey, 1961) or a means of trying to establish more efficient management in poorly run companies (Manne, 1965, Jensen and Ruback, 1983, Jensen, 1988). More recent literature emphasizes increases in market power as a motive for mergers. A merger leading to increased market power typically aims at achieving larger profits through price increases rather than improved economic efficiency. However, Jensen and Ruback (1983) find that the gains created by corporate takeovers do not appear to come from the creation of market power. It may, however, create efficiency gains. Horizontal mergers are often associated with a reduction in average costs achieved by increasing the scale of operations, while a vertical merger may lead to cost advantages by avoiding communication and bargaining costs (Arrow, 1975, Williamson, 1975).

Taking the motives for M&As as given, this paper focuses on the productivity gains that may arise through transfers of knowledge capital. There are few studies focussing on the case where the knowledge capital of the buyer is transferred to the acquired unit.[3] Most of the empirical literature analyzing gains of mergers aim at establishing either the existence or the absence of the gains.[4] Many studies have mainly relied either on a comparison of profitability or productivity before and after a change in ownership or used the so-called 'event-study' method to analyze the stock market reaction around the date of ownership change. These studies provide ambiguous evidence of the existence of gains. Empirical studies aiming directly at quantifying or explaining post-acquisition losses or gains are scarce. Röller, Stennek and Verboven (2000) point out that there are surprisingly few studies on the effect of mergers on productivity, price and market shares and that the evidence is contradictory and biased toward the U.S. Benfratello (2002) is among the few studies analyzing sources of gains from mergers in the manufacturing sector.[5] He investigates the impact of acquisitions on target firms' technical efficiency using data for 34 firms in the Italian pasta industry and finds that target firms experienced an increase in technical efficiency within a 6-year period after the acquisition.

A recent study analyzing corporate acquisitions and efficiency is Maksimovic and Phillips (2001). They found evidence that when firms with higher

[3]The literature on multinational enterprises recognizes knowledge transfers between domestic- and foreign located activities of a corporation (e.g. Dunning, 1979, Vernon, 1966, Mansfield and Romeo, 1980, Markusen, 1984 and Helpman, 1984). However, most empirical studies on foreign direct investments do not distinguish between greenfield investments and acquisitions. In the business literature the issue of knowledge transfers in acquisitions has been addressed in case studies, see e.g. Bresman, Birkinshaw and Nobel (1999).

[4]See for instance, Ravenscraft and Scherer (1987), Lichtenberg and Siegel (1992), Matsusaka (1993), McGuckin and Nguyen (1995), Baldwin (1993) and Maksimovic and Phillips (2001) for individual studies and Röller, Stennek and Verboven (2000) for an overview.

[5]Most of the studies analyzing the sources of the gains have focused on post-merger cost efficiency in the banking industry. See e.g. Berger and Humphrey (1992), Vander Vennet (1996), Peristiani (1997) and Lang and Welzel (2000).

productivity purchased assets with lower productivity, the acquired assets increased in productivity and the other way round.[6] They also found that buyer's existing assets in an industry showed a significant increase in productivity when more productive plants were acquired in the same industry. They interpreted the pattern of gains to be consistent with a buyer purchasing expertise or productive ability that can be transferred to the existing assets.[7] They did not, however, analyze what kind of expertise or productivity capability was transferred from efficient buyers to targets or from efficient targets to acquirers to generate the efficiency gains.

This study builds on the results of Maksimovic and Phillips (2001) and takes the analysis one step further by examining whether transferred productive ability can be captured by proxy variables of knowledge capital. Given the ambiguous evidence for gains of mergers, it is important to go beyond the analysis by examining what explains the gains when they exist. We have reason to believe that productivity gains to be generated by transfers of knowledge capital, since knowledge capital is assumed to be positively related to the productive capacity of a firm. The knowledge capital of a firm may include different kinds of expertise and assets such as market-specific "know-how", greater access to finance capital, management skills or a valuable brand name. These assets are more or less intangible and therefore it is rather difficult to measure them empirically. However, an important part of firms' knowledge capital can be argued to involve investments in R&D and inputs of skilled labor. Therefore, I construct proxy variables using data for R&D and labor and examine whether they can capture the effect of buyers' knowledge capital on the productivity of the acquired targets.

An important concept associated with knowledge transfers is the notion

[6] They analyze the change in productivity between the year prior to the merger and the end of the second year after the transaction in a large sample of partial and whole-firm asset acquisitions.

[7] For one category of transactions, full-firm acquisitions by buyers with lower productivity than that of the assets purchased, they found a significant decrease in overall firm-level productivity.

of 'absorptive capacity' introduced by Cohen and Levinthal (1989). This concept stresses the importance of prior knowledge capital to effectively absorb new knowledge. It is initially used in association with the spillover effects through which the know-how of an inventing firm becomes accessible to another without a "direct purchase".[8] It may also be relevant in connection with M&As, since the efficiency effects of technology diffusion depend on the characteristics of the receiving party. However, it is unclear how the efficiency effects are related to the prior knowledge capital of the buyer and the target. It may be argued that a firm with a large amount of knowledge capital prior to a merger is likely to benefit more from a merger with a firm with superior technology, since it has a larger 'absorptive capacity'. On the other hand, the effects may be small if the technologies of the two merging firms are close substitutes or of little relevance for each other's production. Hence, efficiency effects may either diminish or increase in prior R&D when both merging firms have extensive R&D programs. In the empirical analysis, I use proxy variables for both the acquirers' and the targets' knowledge capital in order to capture the importance of prior knowledge capital for 'absorbing' knowledge transfers.

3 The Empirical Model

In the empirical analysis, I first investigate whether there is evidence of productive capacity being transferred from the acquiring corporations to the acquired units. Thereafter, I analyze whether the buying corporations' knowledge capital, proxied by measures of R&D and skill intensity, explain productivity gains in the acquired targets. Analyzing the effects accruing to the acquiring corporations is not within the scope of the study. An analysis of these effects would require that the impact of an acquired target on the productivity of an acquiring corporation could be isolated from several other

[8] See Griliches (1992) for an overview of the literature on R&D spillovers.

factors affecting productivity growth in a larger corporation.[9]

3.1 Post-Acquisition Productivity Growth and Knowledge Capital

In the empirical analysis, my main proxy for the buyer's knowledge capital is R&D. In general, R&D is expected to affect firm productivity either by generating new products or improving production technology. The former indirectly affects productivity through demand and the latter more directly through the firm's production technology. I depart from a production function approach to describe the relationship between the R&D assets of the buyer and post-acquisition plant productivity growth. Plant output is assumed to be generated by a log linear Cobb-Douglas production function,

$$\log Y_i = \alpha(t) + \beta\left(\log X\right)_i + \gamma_a\left(\log K_a\right)_i + \gamma_b\left(\log K_b\right)_i + u \qquad (1)$$

where i denotes the plant, a the target, b the acquiring corporation, Y is a measure of gross output, X a vector of inputs, such as labor, equipment, energy and materials, and K a measure of cumulated knowledge capital. $\alpha(t)$ represents other factors which affect output and change systematically over time and u reflects other unsystematic fluctuations in output. Denoting log form variables in equation (1) by lower case letters, and taking first differences gives,[10]

$$\Delta y_{it} = \alpha + \beta\Delta x_{it} + \gamma_a\Delta\left(k_a\right)_{it} + \gamma_b\Delta\left(k_b\right)_{it} + \Delta u_{it} \qquad (2)$$

[9]For instance, McGuckin and Nguyen (1994) study the performance of acquiring firms before and after acquisitions for the period 1977-87. They suggest that productivity aggregated to the firm level hides important information on the productivity of each of the firm's components, and post-acquisition performance at the firm level is likely to be subject to aggregation bias.

[10]Versions of this formulation have been estimated e.g. by Link (1981) and Griliches (1986).

Since data on knowledge stocks is not available and the construction of reliable knowledge stocks from flow data is associated with difficulties, the production function is transformed to enable the use of data on R&D expenditures. The terms containing k_a and k_b are rewritten in the following way

$$\gamma_s \Delta k_s = \left(\frac{\partial Y}{\partial K_s}\frac{K_s}{Y}\right)\Delta k_s \approx \left(\frac{\partial Y}{\partial K_s}\frac{K_s}{Y}\right)\left(\frac{\Delta K_s}{K_s}\right) \approx \left(\frac{\partial Y}{\partial K_s}\frac{R_s}{Y}\right) \equiv \phi\left(\frac{R_s}{Y}\right)$$

where R is measured as R&D expenditures and ϕ is the rate of return. This formulation follows that of Griliches (1980). Replacing stocks with flow measures, equation (2) can be rewritten as:

$$\Delta y_{it} = \alpha + \beta \Delta x_{it} + \phi_a \left(\frac{R_a}{Y}\right)_{it} + \phi_b \left(\frac{R_b}{Y}\right)_{it} + \Delta \eta_{it} \tag{3}$$

where η_{it} is the new random error term.

As previously discussed, the effect of the acquiring corporation's knowledge capital on target efficiency may depend on the level of 'absorptive capacity' of the target. A knowledge-intensive target may be more effective in absorbing new knowledge. However, at the same time, the positive effects may decrease when the technological knowledge of the acquirer and the target overlap to a large extent. An interaction variable of the acquiring corporation's and the target plants's knowledge capital is defined to capture possible substitution and complementary effects of knowledge capital. Including the interaction term to equation (2) gives us:

$$\Delta y_{it} = \alpha + \beta \Delta x_{it} + \phi_a \left(\frac{R_a}{Y}\right)_{it} + \phi_b \left(\frac{R_b}{Y}\right)_{it} + \psi_{ab} \left(\frac{R_a}{Y} * \frac{R_b}{Y}\right)_{it} + \Delta \eta_{it} \tag{4}$$

When the estimate of ψ_{ab} is tested to be significantly different from zero, ϕ_a and ϕ_b do not have a meaningful interpretation without simultaneously considering the interaction term. When ϕ_b is positive and ψ_{ab} is negative, the marginal effect of the acquirer's knowledge capital decreases in the level of 'absorptive capacity' of the acquired plant. We expect $\phi_a, \phi_b > 0$, but we do not have any prior belief regard to the sign of ψ_{ab}, i.e. whether the marginal effect is decreasing, increasing or constant.

3.2 Variables in the Empirical Model

In econometric studies attempting to estimate the rate of return on firm level knowledge capital, the Cobb-Douglas equation expressing growth in output is often simplified by being rewritten in terms of growth in labor productivity and by assuming constant returns to scale with respect to labor and physical capital in the production function. Or, sometimes studies are based on measures of total factor productivity (TFP). Theoretically, TFP is an appropriate measure of productivity, because it takes into account all inputs, not only labor. In practice, the estimation of labor productivity often gives better accuracy than TFP, because estimating the value of capital stocks often implies a large error. This paper will be based on labor productivity, because the data for capital investments required to compute TFP are not available at the plant-level. In all estimations, labor productivity is measured as the sales value of output per employee. Changes in capital stocks and other inputs are controlled for by using data for various types of inputs.

Measuring real labor productivity involves several problems. One problem is that productivity comparisons over time and across industries are largely dependent on the prices required to estimate the plants' real output. Furthermore, labor productivity measures do not neutralize differences in capital intensity. Some of the problems with real labor productivity measures can be avoided by using a relative measure. A relative productivity measure allows for inter-temporal and inter-industry comparisons since it does not depend on an output deflator and can correct for the problem of price dispersion among plants across industries. The relative labor productivity measure (RLP) is defined as:

$$RLP_{plant} = \frac{LP_{plant}}{LP_{industry}} \tag{5}$$

where the labor productivity of an acquired plant is related to the average labor productivity of its four-digit industry.[11] In addition to correcting some deficiencies in the real labor productivity measure, the relative productivity measure controls for industry-specific heterogeneity. Rewriting equation (4) in terms of growth in labor productivity gives:

$$\Delta(y-l)_{it} = \alpha+\beta\Delta(x-l)_{it}+\phi_a\left(\frac{R_a}{Y}\right)_{it}+\phi_b\left(\frac{R_b}{Y}\right)_{it}+\psi_{ab}\left(\frac{R_a}{Y}*\frac{R_b}{Y}\right)_{it}+\Delta\eta_{it} \tag{6}$$

Changes in capital intensity in vector X in equation (2), $\Delta(c-l)$, are proxied by a variable defined as changes in energy costs to employee.[12] Capital intensity is measured in relative costs to be consistent with the relative productivity measure (plant costs per employee relative to average industry costs per employee at the four-digit industry level). A variable for growth in relative materials costs per employee is included to control for changes in other inputs corresponding to the X vector in equation (2). In the empirical estimation, growth in labor productivity and inputs are computed as average annual growth rates.

Empirical implementation involves the construction of lag structures. In general, R&D investments produce results with a certain time lag and the application of results in production will involve further delay.[13] This study

[11]The use of the measure was originally suggested by Christensen, Cummings and Jorgensen (1981) and has been used in several plant-level studies on productivity, e.g. McGuckin and Ngueyn (1995).

[12]Data to compute capital stocks is not available at the plant level. Energy outlays are generally believed to proxy capital stocks. To investigate the relevance of this proxy, energy costs are correlated with the book value of capital assets (machinery, buildings and land) for affliate firms in the sample and at the four-digit level of manufacturing industries in 1985-96. The correlation is 0.74 (7100 obs) at the firm level and 0.89 at the industry level. This evidence suggests that energy outlays may proxy capital stocks.

[13]Branch (1974) finds that the effet of R&D on productivity peaked after two years.

focuses on rather immediate effects of the acquirer's existing knowledge capital on target productivity induced by the merger. On basis of previous studies, the length of available time series and the particular issue of this study, a lag length of three years is chosen.[14] Choosing a longer period can obscure the impact of technology transfers if investments in R&D undertaken after the acquisition affect target plant productivity.[15] Target productivity growth is measured between year one and three, because data to compute the initial productivity of plants in the year before the change in ownership are not available. However, the time gap between a change in ownership and the observation of plant characteristics is always less than one year.[16]

Acquirers' R&D expenditures are measured at the corporation level of the Sweden-based operations.[17] Using corporation level R&D assumes knowledge capital to be a joint-input at the corporation level. R&D expenditures are measured in year $t-1$, to avoid including investments of the target plant in year t. Since data on the output of the acquired plants is not available before the year of acquisition, the intensity measure is computed as

$$\frac{(R_b)_{it-1}}{(Y)_{it-1}} \approx \frac{(R_b)_{it-1}}{(Y_b)_{it-1}} * \frac{(Y_b)_{it}}{(Y_a)_{it}}$$

where Y_a is target plant output and Y_b is corporation level output. Output

Griliches (1979) recommends, on the basis of case study evidence, a lag structure peaking after three to five years and then rapidly declining.

[14]Sensitivity of the results for the chosen time period will be analyzed by using one year longer and shorter time periods. Lichtenberg and Siegel (1992) found that plants changing owners realized the largest increase in TFP growth during the first three years after a change in ownership. Their findings support the choice of a three-year period.

[15]A longer lag in R&D outlays before an acquisition is to be preferred given that the R&D results transferred to the target are generated with a time lag. However, the construction of longer lags would imply that acquisitions at the beginning of the data series must be excluded.

[16]Measuring initial target productivity at the end of the year of the change in ownership implies that some immediate change in plant productivity is not captured.

[17]Statistics Sweden can provide data for R&D outlays at the corporation level every second year. Data is collected for firms with a minimum of 50 employees. These data are used to interpolerate R&D outlays for the missing years.

is measured in terms of sales value to match the corresponding measure for labor productivity.[18] The inconsistency involved with respect to the timing of relating growth rates of labor productivity over a period of years to the level of R&D intensity at the beginning of the period is of little importance in practice, if the ratio is relatively stable. To test the robustness of the results, I also use an average of R&D intensity the year before and after the change in ownership.[19]

For the empirical implementation of the model, R&D statistics are not available for the acquired plants. Therefore, wage costs for skilled labor are chosen to proxy target plant R.[20] This proxy is assumed to be sufficiently accurate for the purpose of estimating the 'absorptive capacity' of the plants. Skilled labor is defined as employees with a certain educational level. Three different categories of employees are considered: tertiary education, tertiary education in natural sciences, and a minimum of 3-year tertiary education in natural sciences. The wage costs for the different categories of employees are related to the output of the plant. The three measures of skill intensity are likely to capture somewhat different kinds of 'absorptive capacity'. The share of employees with a university degree in natural sciences is expected to be a more specific measure of the knowledge capital intensity of production than the share including employees even with other categories of tertiary education.

Due to the limitations set by data and the chosen methods, the results should be interpreted with caution. In particular, the meaning of the estimated rate as the rate of return on R&D is ambiguous. In studies on firm

[18]Mairesse and Sassenou (1991) point out that in principle the choice between value added and sales value should match the corresponding choice involved in the measurement of productivity, but in most studies, these choices have been shown to have little effect on the final result.

[19]For even years, the computed average equals the interpolerated value and for uneven years it is computed as an average of the interpolarated values the year before and after.

[20]Data from OECD countries indicate that on average about 50% of firms' R&D expenditures are related to labor costs, 14% to capital costs and the rest to other current costs (OECD, 1994).

level rates of return, the estimated results have varied widely and are far from comparable due to differences in methods and data. However, most of the studies confirm that there is a positive relationship between productivity and R&D.[21] Considering the difficulties in estimating returns within a firm, the problems are likely to be more severe when estimating the effect of one firm's R&D on the productivity of another. The situation is further complicated by the fact that most R&D in our sample is carried out by conglomerates, perhaps conducting R&D in several industries. On the one hand, it is important to consider knowledge capital as a joint input at the corporation level but, on the other hand, only part of the total knowledge capital in diversified conglomerates may be relevant for a certain industry. The possibilities to take this aspect into consideration are limited when using R&D measures. I therefore choose to use measures of skill intensity as alternative proxy variables that can capture the "effective fraction" of knowledge capital, an issue that I return to below. Accepting the limitations set by the data implies that the estimations in this paper should be regarded as an attempt at establishing whether a relationship between knowledge capital of the acquiring corporation, proxied with measures of R&D and skilled labor, and a target exists, rather than an attempt at providing more precise estimates of the magnitudes of the effects.

3.3 Data

The data set is based on a sample of large Swedish corporations. More specifically, the corporations in the sample are the thirty largest multinational manufacturing company groups with headquarters in Sweden in 1990.[22] The corporations studied represent approximately 30 percent of total Swedish manufacturing employment.[23] Statistics Sweden have constructed the data

[21] For a review, see Mairesse and Sassenou (1991).

[22] Some of the corporations included in the sample have moved their headquarters from Sweden after 1990, but they still are key employers in Sweden.

[23] Their share in production varied from 30 to 35% during the same period.

set from their databases on industrial and financial statistics, and it includes information on all manufacturing plants controlled by these thirty corporations during the period of 1985-98.[24]

In the resulting unbalanced panel, the yearly number of plants varies between about 600 and 700. During the period 1986-96, 718 manufacturing plants were acquired by the thirty corporations. The majority of these plants became single-plant affiliate firms (423 firms), while the remaining plants became part of acquired multi-plant affiliate firms (76 firms) or were integrated into existing multi-plant firms (25 firms).[25] The data set includes plant-level information on output, employment, value-added, intermediate inputs, wages, industry code variables and also information on the identification and ownership status at the plant, firm and corporation levels.[26] Some variables, such as investments and R&D, are available only at the firm level. R&D outlays at the corporation level include outlays of non-manufacturing firms. Identification codes of plants and firms in combination with information from a firm registrer are used for categorizing changes in ownership.[27] The data have been carefully cleaned for the empirical analysis. All ownership changes of plants where both the buying and the selling firm are owned by the same corporation are excluded, since these are associated with internal restructuring. During the period studied, there were also three mergers involving entire corporations or at least, all Swedish operations of a corporation in the sample. These mergers were not included in the studied sample of acquisitions, since this study focuses on acquisitions of plants and firms by corporations rather than mergers between large corporations.[28]

The sample consists of 411 plants that the thirty corporations acquired

[24] All manufacturing plants with at least five employees are included.

[25] The average number of plants acquired as a multi-plant firm is 3.04 and median 2.

[26] Industries are classified at the five-digit level of the Swedish industrial classification (SNI69 and SNI92), which roughly matches the European Union standard, NACE Rev.1.

[27] Each plant receives a unique identity code at the time of entry, and normally keeps the same identity through its life span. For a more detailed description, see Hakkala (2003a).

[28] In total, 27 observations were excluded due to mergers between corporations.

during the period of 1986-96 and kept at least until the end of the third year.[29] Table 1 reports the mean values of the initial average relative productivity (RLP) and the mean rates of growth in relative and real labor productivity and plant employment.[30] The acquired plants were, on average, 6.4 percent more productive than the industry average, which suggests that the plants in the sample were competitive. The annual average rate of growth in relative productivity was 0.5 percent. However, a closer examination of the productivity levels of acquired plants shows that more than half of the plants were actually less productive than the industry average (227 of the 411 acquired plants). The two groups of plants also differ in terms of productivity growth, the relative productivity of the initially less productive plants grew by an annual 4.7 percent, while the initially more productive plants experienced a negative growth in relative productivity at the annual rate of 4.7 percent. The growth rate in the number of employees is close to zero which may indicate that improvements in target plants' productivity were a result of an increase in the value of output rather than redundancies.

[Table 1 here]

4 Empirical Results

Before estimating the effects of knowledge capital on target efficiency, we first analyze if the gains in relative productivity of the acquired plants depend on the productivity of the acquiring corporations. Efficient buyers are expected to have expertise or resources that can improve the efficiency of acquired assets, while inefficient buyers, who primarily acquire assets to increase the value of their existing assets, are not expected to have a positive impact on the

[29] 454 acquired plants are observed at the end of the third year. Data for all variables exists for 421 plants. Ten plants are excluded as extreme outliers after analyzing values of leverage points and residuals. Six of the ten plants have relative productivity larger than 4.

[30] Plants with a value of relative productivity higher than five were excluded as outliers.

efficiency of the acquired assets. To examine these possibilities, the growth rate in the relative productivity of the acquired plants is regressed on the difference between the relative productivity of the acquiring corporation and the acquired plant. The relative productivity of the acquiring corporations is computed as a weighted relative productivity the year before the acquisition, where employment shares of plants are used as weights. The productivity of the acquired plants is expected to increase when acquired by corporations with a higher relative productivity. However, less productive corporations may have no impact or even a negative impact on the growth in the relative productivity of the acquired plants. An interaction variable, suggested by Maksimovic and Phillips (2001), is used to capture these differences. A dummy variable equal to one when the acquired plant is more productive than the acquiring corporation is interacted with the difference between buyer and target productivity. The variable allows the slope coefficient to change when acquired plants are more productive than their acquirers. Variables for growth in relative capital costs per employee, material costs per employee and time dummies are included.[31]

In Table 2, columns 1 and 2 show the results for OLS and columns 3 and 4 for the fixed effects regression estimations allowing for corporation-specific effects.[32] The results show that a plant's relative productivity increases when the acquiring corporation is more productive than the plant. However, when the plants are purchased by corporations with lower relative productivity, the relative productivity of the acquired plants falls. The finding is in line with the results obtained by Maksimovic and Phillips (2001). In absolute terms, the negative effect of less productive acquirers (0.163-0.140=0.023) is much smaller than the positive effect of more productive acquirers (0.163), thereby suggesting that the effect of corporations transferring productivity

[31]Summary statistics and correlation tables for the variables are shown in Appendix.

[32]The fixed error components are tested be statistically different from zero at the 10 percent's level by a F-test. Ramsey's RESET test on the OLS regressions indicates that the model is not misspecified.

to the assets may be more important than the decline in productivity of the acquired assets.[33]

[Table 2 here]

Next, I use the main regression model to analyze if the gains in target plants' productivity growth can be explained by buyers' knowledge capital proxied with R&D. I estimate equation (6) with and without the interaction variable and include the initial relative productivity of the acquired plants and time dummies as control variables.[34] Wald tests between the different specifications indicate that the interaction variable can be excluded. Therefore, results are reported only for the estimations without this variable. Ramsey's RESET test on the OLS regressions indicates that the model is not misspecified.[35] Columns 1-3 in Table 3 report results for the OLS and columns 4-6 results for the fixed effects regression estimations allowing for corporation-specific effects.[36] As seen from Table 3, the estimator of $\frac{Rb}{Y}$ (R&D) has a negative sign and is close to zero.[37] My priors about the effect of acquirers' knowledge capital are not confirmed. The knowledge capital of the acquirer, proxied with R&D, does not have any statistically significant

[33]We cannot exclude the possibility that the results reflect convergence to mean productivity. However, the convergence to mean -hypothesis does not provide an explanation why plants with lower productivity experience positive growth in relative productivity and the ones with higher productivity negative growth.

[34]The initial relative productivity is included to control for the convergence to mean productivity. Time dummies are included to capture the time-specific variation in the pooled sample.

[35]The hypothesis that time dummies are jointly equal to zero cannot be rejected by a Wald test. The hypothesis that the model is misspecified can be rejected at a higher level of significance when time dummies are included according the RESET test. Estimations with time dummies yield almost the same results as in Table 3 and are available upon request.

[36]The fixed error components are tested be statistically different from zero at the 10 percent's level by a F-test.

[37]The results in column 1, for instance, indicate that a standardized increase in R&D (about 61.5) decreases the growth rate in relative productivity by about 0.7 percentage points.

impact on the growth in relative productivity of the targets.[38] However, the estimators of the different proxies for target plants' knowledge capital have positive signs and are tested to be statistically different from zero at the 10% level or lower using a one sided t-test. The result suggests that knowledge-capital intensive plants experienced a higher growth in relative productivity. For the largest effect, the skill intensity variable was measured as the share of employees with tertiary education in natural sciences.

An interpretation problem involved with the $\frac{R_b}{Y}$ variable is that R&D expenditures of the acquiring corporations can be several times larger than the output of a target. Defined as in equation (6), this implies that the variable can take on much larger values than the usual R&D intensity measures that vary between zero and one. It is therefore uncertain what is actually captured by this measure. For instance, it may partly capture size differences between an acquirer and a target. To investigate the sensitivity of the results to the definition of the variable, I use an alternative intensity measure defined as corporate R&D to sales in $t-1$, $\frac{Rb}{Yb}$, and use this variable to replace $\frac{R_b}{Y}$ in equation (6). As seen in Table 4, the results for the variable of interest, the knowledge capital of the acquiring corporation, do not differ significantly from the previous results. The coefficient is positive but the hypothesis that the estimator of acquirers' knowledge capital is equal to zero cannot be rejected according a t-test.

[Tables 3 and 4 here]

Another problem involved in the estimation is that the sample studied may be subject to a selection bias. Hakkala (2003b) found that the corporations in the sample divested more than one third of the total number of acquired plants within three years after the acquisition. The incidence of divestiture was found to be dependent on the acquiring corporation's R&D

[38]For robustness, I also use a measure of average R&D intensity the year before and after the ownership change. The results are not significantly different from those presented in Table 3.

intensity, the target plant's relative productivity and size, the size rank of the business segment within the acquiring corporation and the technological distance of the acquiring corporation and the acquired plant.[39] The technological distance is defined as the ratio of an acquired plant's skill intensity relative to that of the acquiring corporation when the plant is less skill intensive than the corporation, and as an inverse of the ratio when the plant is more skill intensive than the corporation.[40] These results suggest that the sample is not randomly selected, but was influenced by the R&D intensity of the acquirers among other factors. Thus, it is possible that the productivity growth of the observed plants may be upward biased. To analyze whether the results are affected by the occurrence of a selection bias, Heckman's selection model is applied. Variables included in the selection equation are believed to determine whether a plant is observed at the end of the third year after the acquisition.

I include the variables mentioned above in the selection equation and estimate my primary model by using Heckman's maximum likelihood estimation model.[41] I include time dummies in the selection equation, but not in the underlying model to be estimated. The time dummies are tested to be jointly different from zero by a Wald test at the one percent's level of statistical significance. Results in Table 5 show that the magnitude and sign of coefficients are not affected by the hypothesized selection bias. The likelihood-ratio test statistics that compares the joint likelihood of an independent probit model for the selection equation and a regression model on the observed plants' productivity growth are reported at the bottom of Table 5. The χ^2 test statistic justifies the Heckman selection equation. Altogether, the Heckman

[39] Segments were defined at the three-digit level of industries and ranked by size.

[40] Skill intensity is defined as the share of employees with a tertiary education in natural sciences of the total number of employees.

[41] The target plant's relative productivity is measured in the initial year. The selection equation is estimated separately as the probit model. The probit model predicts 70 percent of the observations correctly, which suggests the selection equation being correctly specified.

estimations suggest that the results are not sensitive to a selection bias.

[Table 5 here]

4.1 Robustness

The result that R&D measures do not capture the effect of knowledge capital transfers may indicate at least two things; that the positive effects of acquirers' knowledge capital take more than three years to materialize or that the knowledge capital of acquiring corporations is important, but that R&D intensity is not a good proxy for overall knowledge capital. These two possible explanations are analyzed below.

The three-year period was chosen to capture the expected one-time effect of the increased accessibility of acquirers' knowledge capital on the acquired targets. In a longer period, the dynamic effects of a merger, such as increasing investments in R&D, may become dominant and identifying one-time effects may therefore be difficult. To analyze the sensitivity, the period was both shortened and extended by one year.[42] The results were found to be robust for both estimations with respect to the R&D variable.[43]

Another reason why my priors are not confirmed might be that the measure of the buyer's knowledge capital at the corporation level is too general and does not capture the contribution of knowledge capital relevant for the acquired plant. As already mentioned, conglomerate firms may have production in several business segments, where knowledge capital in one industry has little or no effect on production in another industry.[44] The plants can thus be expected to utilize different kinds of knowledge from the acquirer depending on the technological distance between the target and the opera-

[42] Extending the period by one year implies that acquisitions made in 1996 disappear from the sample.

[43] The results are not reported in detail, but are available from the author.

[44] The problem is generally dicussed in connection with industry and firm-level R&D spillovers, see e.g. Griliches (1992).

tions of the acquiring corporation. To estimate the effect of the knowledge capital that is most useful for the target, a measure of the "effective" fraction of R&D is required. When R&D is concentrated in research units, all input measures involve the problem that investments are not ear-marked to any specific segment. It is thus difficult to find relevant weights that capture technological distance empirically.[45] A preferred alternative might be to use an output measure, such as patents for products and technology, that can be allocated to a segment. However, that kind of data are not available for this study.

Instead of weighting R&D with some arbitrary weights, data for skilled labor can be used to construct an alternative proxy for knowledge capital. Skill intensity, defined as the share of skilled labor in total employment, can be computed within industry segments of a corporation to proxy the knowledge capital assumed to benefit the target most. In some respect, skill intensity can be argued to be a more general proxy of knowledge capital than the R&D measures. In addition to measuring the share of employees involved in R&D activities and the application of R&D results, the skill intensity measures capture the extent of "previous experience" of the buyer within a business segment. The corporations are expected to employ relatively more skilled labor in the segments where they have experience than in the segments more peripheral to the core competence of the corporation. An extreme case is new segments, where corporations are assumed to have no previous experience and the share of skilled labor is zero.

Skill intensity should not be defined at too narrow an industry level since knowledge capital is expected to be a joint-input, at least in related industries. I choose to measure skill intensity within business segments defined

[45] See Griliches (1992) for a discussion on the issue in connection with studies for intra-industry spillovers. Examples of used weights are Brown and Conrad (1967) who derived "closeness" measures from the input-output table, and Terleckyj (1974) who used capital and intermediate input expenses as matrix weights.

at the three-digit level industry level within a corporation.[46] The segment-specific skill intensity is computed as a weighted average with plant employment shares as weights.[47] Skill intensity is measured as the share of employees at the following educational levels: tertiary education, tertiary education in natural sciences and a minimum of 3-year tertiary education in natural sciences. The plant-level skill intensity measures are computed the same way, that is, as the ratio of the number of skilled employees to total number of employees.

[Table 6 here]

Table 6 shows that using segment-specific skill intensity as a proxy for knowledge capital yields results supporting our priors.[48] The regressions are estimated both with and without the target plant skill intensity variable, since the buyer's segment skill intensity and the target plant skill intensity are correlated.[49] The coefficient for the acquiring corporations' knowledge capital is positive and statistically significant. The coefficients of the segment skill variable are larger in the estimations excluding the target-plant skill intensity. The results indicate that an increase of one standard deviation (about 0.100) in Skill (tertiary education, column 1), raises the growth rate in relative productivity by about 2.4 percentage points.[50] An equivalent standardized increase (about 0.045) in Skill (3-year tertiary education in natural sciences, column 5), implies an increase in the growth rate of about 2.2 percentage points.

The results confirm the significant positive impact of the acquirers' knowledge capital on the productivity of the acquired plants. However, the effect

[46] According to the Swedish industry classification (SNI69 and SNI92).

[47] Segment skill intensity is computed the same year as the plant is acquired, excluding the acquired plant. New segments have skill intensity equal to zero.

[48] The interaction variable between acquirer and target skill intensity was not significant and could be excluded. The results are not reported.

[49] For a correlation table see the Appendix.

[50] The fixed effect estimation results yield an increase of about 3.5 percentage points.

is only captured by the segment-level measures of knowledge capital. The marginal effect is largest for the skill intensity expected to be more closely associated with the R&D intensity of production, that is, the share of employees with a minimum of three years of tertiary education in natural sciences. Estimators of the skill intensity of target plants are positive but not statistically significant. However, the positive correlation between the buyer's segment skill intensity and target-plant skill intensity suggests that together these variables may explain growth in relative productivity of the acquired plants and that the 'absorptive capacity' of the acquired plant is important.[51]

Although skill intensity may be a more general proxy of knowledge capital than R&D measures, the differences in the results do not seem to be explained simply by the differences in the two measures.[52] A plausible explanation is that the corporation level measures of knowledge capital are too general and therefore, cannot capture the effect of knowledge transfers. It is possible that I would have received similar results by using an R&D measure if data indicating the final industry destination of R&D expenditures had been available.

In this study, I have considered only the knowledge capital involving investments in R&D activities and inputs of skilled labor. The productive capability of a corporation can also reflect other kinds of expertise and intangible assets. A corporation can be more successful in improving the productivity of a target because it has better access to financial capital, better management, economies of scale and sales organization or a valuable brand name, among other things. For instance, it has been argued that capital-raising is much cheaper for large than small firms. Consequently, a smaller firm acquired by a large firm is likely to benefit from the larger enterprise's

[51] Wald tests between the different specifications indicate that the coefficients on the target-plant skill intensity and the buyer's segment skill intensity are jointly different from zero.

[52] The models were also estimated with a corporation level skill intensity variable found to be statistically insignificant.

lower capital cost. Ravenscraft and Scherer (1987) find evidence that this may be one of the most compelling advantages of mergers. The empirical results bring some evidence that increasing capital investments are of importance. In my estimations, the proxy for growth in capital intensity is positive and significant.

5 Conclusion

This paper has explored the role of knowledge capital in the acquisitions of plants by large Swedish corporations. I provide new evidence that help us understand why some mergers generate gains while others do not. The empirical results suggest that within three years after acquisition, there are productivity gains for the targets acquired by more productive corporations. When the buyer is less productive than the target, the effects on the target plant's relative productivity might be negative. These results are in line with the hypothesis that there are efficient buyers with the expertise or resources to improve assets and inefficient buyers acquiring assets primarily to increase the value of their existing assets. Similar results were obtained by Maksimovic and Phillips (2001). In the case of targets that were more productive than their acquirers, the decline in relative productivity may suggest that technology sourcing was relevant. If these plants were primarily acquired to gain access to their valuable knowledge assets, the positive effects of knowledge transfers were more likely to accrue to the acquirers.

It is further analyzed whether the transferred expertise hypothesized to improve the productivity of the acquired targets can be captured by proxy variables of knowledge capital. The results of the estimations suggest that the knowledge capital of the acquiring corporations, measured in terms of R&D, does not explain growth in the relative productivity of the acquired plants in the sample. The results are robust to different estimation techniques and measures of R&D intensity. However, when the knowledge capital of the acquirer is measured as segment specific skill intensity, I find evidence of knowledge transfers. The segment specific proxies of the acquirers' knowledge capital are tested to be statistically significant and positively related to the growth in relative productivity of the targets. Furthermore, the acquired plants' skill intensity is found to be positively related to their growth in relative productivity but the effect is not statistically significant. However, the buyer's segment skill intensity and target-plant skill intensity are positively correlated, which may indicate that the 'absorptive capacity' of the acquired plant is of importance.

A plausible explanation why the skill intensity measures turn out to be statistically significant and positive while the R&D measures do not, is that corporation level R&D is too aggregated as s measure. The corporation-level proxy of knowledge capital was initially chosen because knowledge capital is typically regarded as a joint-input shared by several production units within the same corporation. However, more specific measures are required to capture the impact of the "effective" fraction of the acquirer's knowledge capital. In particular, large diversified corporations may have several operations where knowledge capital in one industry may be of limited use for operations in another. Maksimovic and Phillips (2002) find there to be an inverse relation between the rank of a segment and its efficiency, and that the equally ranked segments of larger firms tend to be more efficient than those of smaller firms. This suggests that the productive capacity has an industry-specific component, but that there are large corporations whose organizational talent is portable across several industries to some extent. The finding that targets experienced positive growth in relative productivity when acquired by more productive corporations suggests that also more general corporation-level capabilities might be transferred.

Altogether, this study goes beyond the analysis on gains from mergers by investigating the factors that may explain the gains. It does leave some questions unsolved. First, it analyzes the short-run effects of mergers and focuses on the rather immediate effect of the acquirers' existing knowledge capital on target productivity. In the long run, mergers may have an impact on new investments in knowledge capital that generate synergies and dynamic effects of mergers. However, the positive effects of mergers may also turn out to be temporary and lead to divestitures in the medium/long term. To investigate this issue, longer spans of panel data than those available here are required. Second, this study is limited to investigating the gains from the transfers of the knowledge capital involving investments in R&D activities and inputs of skilled labor. The productive capability of a corporation can naturally reflect other kinds of expertise and intangible assets. Furthermore, it is possible that the increases in target productivity are to some extent explained by changes in market power alongside knowledge transfers. Hence, an extension of this study would be to take into consideration other factors explaining the productive capacity transferred to the acquired targets.

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Appendix

Table A1. Summary Statistics

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
Initial RLP	*418*	*1.0643*	*.5403*	*.1797*	*3.8044*
Corporation RLP	*418*	*1.0708*	*.1611*	*.5623*	*1.4223*
R&Dj/Yi	*416*	*18.9993*	*61.5237*	*0*	*728.9092*
R&Dj/Yj	*416*	*.0544*	*.0519*	*.0022*	*.3452*
Growth in REL	*418*	*.0679*	*.4976*	*-.9382*	*6.8316*
Growth in RML	*418*	*.0430*	*.3545*	*-.9459*	*2.4125*
(Wi Te)/Yi	*413*	*.0382*	*.1033*	*0*	*1.7412*
(Wi TeNS) /Yi	*413*	*.0271*	*.0791*	*0*	*1.3318*
(Wi TeNS3)/Yi	*413*	*.0147*	*.0685*	*0*	*1.2191*
(Li Te)/Li	*413*	*.1115*	*.1310*	*0*	*.875*
(Li TeNS)/Li	*413*	*.0796*	*.1065*	*0*	*.75*
(Li TeNS3)/Li	*413*	*.0278*	*.0631*	*0*	*.5556*
Segment (Lj Te)/Lj	*413*	*.0893*	*.1000*	*0*	*.6230*
Segment (Lj TeNS)/Lj	*413*	*.0632*	*.0769*	*0*	*.5660*
Segment (Lj TeNS3)/Lj	*413*	*.0268*	*.0447*	*0*	*.4117*

Note: RLP (relative labor productivity), R&Dj (corporation R&D), REL (relative energy costs per employee), RML (relative material costs per employee), Wi (plant wage costs), Yi (plant sales value), Te (employees with tertiary education), TeNS (employees with tertiary education in natural sciences) and TeNS3 (employees with a minimum of 3-year tertiary education in natural sciences).

Table A2. Correlation Table

		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)
Initial RLP	(a)	1.0000														
Corporation RLP	(b)	0.0993	1.0000													
R&Dj/Yi	(c)	-0.1102	0.1313	1.0000												
R&Dj/Yj	(d)	-0.0011	0.1100	0.1902	1.0000											
Growth in REL	(e)	-0.1268	-0.0726	0.0055	0.0679	1.0000										
Growth in RML	(f)	-0.1622	0.0286	0.0214	-0.0005	0.1590	1.0000									
(Wi Te)/Yi	(g)	-0.1891	-0.0255	0.0986	0.1506	0.1409	0.0543	1.0000								
(Wi TeNS) /Yi	(h)	-0.1671	-0.0236	0.1015	0.1521	0.1489	0.0415	0.9737	1.0000							
(Wi TeNS3)/Yi	(i)	-0.1540	-0.0301	0.0434	0.1158	0.1246	0.0227	0.9614	0.9789	1.0000						
(Li Te)/Li	(j)	0.0595	-0.0429	0.1406	0.2492	0.1261	0.0247	0.6646	0.6505	0.5608	1.0000					
(Li TeNS)/Li	(k)	0.0797	-0.0296	0.1512	0.2666	0.1419	0.0060	0.5775	0.6328	0.5248	0.9353	1.0000				
(Li TeNS3)/Li	(l)	-0.0604	-0.0493	0.0295	0.2299	0.1517	-0.0221	0.7011	0.7405	0.7211	0.8066	0.8152	1.0000			
Segment (Lj Te)/Lj	(m)	0.0586	0.0642	0.1486	0.3334	0.1145	-0.0276	0.2270	0.2615	0.2120	0.4075	0.4402	0.3783	1.0000		
Segment (Lj TeNS)/Lj	(n)	0.0653	0.0849	0.1695	0.3474	0.0769	-0.0204	0.1973	0.2329	0.1790	0.3908	0.4338	0.3633	0.9700	1.0000	
Segment (Lj TeNS3)/Lj	(o)	0.0495	0.0732	0.1517	0.3696	0.0700	-0.0373	0.2134	0.2486	0.2049	0.4224	0.4598	0.4168	0.9206	0.9442	1.0000

Note: 411 obs. RLP (relative labor productivity), R&Dj (corporation R&D), REL (relative energy costs per employee), RML (relative material costs per employee), Wi (plant wage costs), Yi (plant sales value), Te (employees with tertiary education), TeNS (employees with tertiary education in natural sciences) and TeNS3 (employees with a minimum of 3-year tertiary education in natural sciences).

Table 1. Descriptive statistics of target plants

	All plants	Plants with initial RLP<1	Plants with initial RLP>=1	t-test for difference in means between (2) and (3), p-value
	(1)	(2)	(3)	(4)
Initial relative labor productivity (RLP)	1.064	0.703	1.508	0.000 ***
Growth rate in RLP	0.005	0.047	-0.047	0.000 ***
Growth rate in real labor productivity	0.036	0.073	-0.009	0.000 ***
Growth rate in employment	0.009	-0.006	0.027	0.037 **
Number of observations	411	227	184	

Note: Initial RPL is measure in the end of year one under the new ownership. *, **, *** significantly different from zero at the 1 percent, 5 percent and 10 percent level, respectively. T-test assumes equal variances.

Table 2. Transferred productivity

	Dependent variable: Growth rate in RPL between t and t+2			
	OLS		Fixed Effects	
	(1)	(2)	(3)	(4)
Difference in RLP: acquiring corporation(t-1)-acquired plant(t)	0.068 ***	0.163 ***	0.060 ***	0.161 ***
	(0.014)	(0.049)	(0.014)	(0.037)
Difference in RLP *Dummy variable for negative difference in RLP		-0.140 **		-0.146 ***
		(0.062)		(0.049)
Growth rate in RCL, energy costs	0.132 ***	0.131 ***	0.133 ***	0.130 ***
	(0.041)	(0.040)	(0.020)	(0.020)
Growth rate in RCL, material costs	0.247 ***	0.243 ***	0.256 ***	0.251 ***
	(0.048)	(0.047)	(0.021)	(0.021)
Constant	-0.036	-0.060 **	-0.026	-0.044 **
	(0.026)	(0.028)	(0.042)	(0.042)
Number of observations	411	411	411	411
R-squared	0.423	0.436	0.439	0.453
F-test	<1%	<1%	<1%	<1%

Note: *, **, *** significantly different from zero at the 1 percent, 5 percent and 10 percent level, respectively. Standard errors in parentheses. Standard errors are robust (Huber-White) in the OLS estimations. Year dummies are included in all estimations. The fixed error components are tested to be statistically different from zero at the 10 percent's level.

Table 3. Results for the estimation of productivity growth in target plants

	Dependent variable: Growth rate in RPL between t and t+2					
	OLS			Fixed Effects		
	(1)	(2)	(3)	(4)	(5)	(6)
	Skill: tertiary education	Skill: tertiary education in natural sciences	Skill: = 3-year tertiary education in natural sciences	Skill: tertiary education	Skill: tertiary education in natural sciences	Skill: = 3-year tertiary education in natural sciences
Initial plant RLP	-0.071 ***	-0.071 ***	-0.072 ***	-0.061 ***	-0.061 ***	-0.063 ***
	(0.013)	(0.013)	(0.013)	(0.015)	(0.015)	(0.015)
R&D	-1.15E-04	-1.19E-04	-9.88E-05	-2.01E-04	-2.04E-04	-1.86E-04
	(8.96E-05)	(8.6E-05)	(8.8E-05)	(1.26E-04)	(1.26E-04)	(1.27E-04)
Skill	0.196 *	0.280 *	0.265	0.183 **	0.263 ***	0.235 **
	(0.110)	(0.165)	(0.162)	(0.074)	(0.096)	(0.109)
Growth rate in RCL, energy costs	0.123 ***	0.121 ***	0.123 ***	0.125 ***	0.124 ***	0.126 ***
	(0.038)	(0.038)	(0.038)	(0.020)	(0.020)	(0.020)
Growth rate in RCL, material costs	0.246 ***	0.247 ***	0.247 ***	0.255 ***	0.255 ***	0.255 ***
	(0.048)	(0.048)	(0.048)	(0.021)	(0.021)	(0.021)
Constant	0.042	0.043	0.047	0.040	0.040	0.045
	(0.029)	(0.028)	(0.028)	(0.045)	(0.045)	(0.045)
Number of observations	411	411	411	411	411	411
R-squared	0.442	0.444	0.440	0.457	0.459	0.455
F-test	<1%	<1%	<1%	<1%	<1%	<1%

Note: *, **, *** significantly different from zero at the 1 percent, 5 percent and 10 percent level, respectively. Standard errors in parentheses. Standard errors are robust (Huber-White) in the OLS estimations. Year dummies are included in all estimations. Wald tests indicated that the interaction variables (Skill*R&D) could be excluded. The fixed error components are tested to be statistically different from zero at the 10 percent's level.

Table 4. Results for the estimation of productivity growth in target plants with corporation R&D intensity

Dependent variable: Growth rate in RPL between t and t+2

	OLS			Fixed Effects		
	(1)	(2)	(3)	(4)	(5)	(6)
	Skill: tertiary education	Skill: tertiary education in natural sciences	Skill: = 3-year tertiary education in natural sciences	Skill: tertiary education	Skill: tertiary education in natural sciences	Skill: = 3-year tertiary education in natural sciences
Initial plant RLP	-0.069 ***	-0.070 ***	-0.071 ***	-0.057 ***	-0.057 ***	-0.059 ***
	(0.014)	(0.013)	(0.014)	(0.014)	(0.015)	(0.015)
R&D, corporation intensity	0.009	0.004	0.023	0.556	0.544	0.549
	(0.169)	(0.171)	(0.170)	(0.580)	(0.579)	(0.581)
Skill	0.191 *	0.273 *	0.262	0.172 **	0.248 ***	0.226 **
	(0.109)	(0.164)	(0.163)	(0.074)	(0.096)	(0.110)
Growth rate in RCL, energy costs	0.123 ***	0.122 ***	0.123 ***	0.130 ***	0.129 ***	0.131 ***
	(0.038)	(0.037)	(0.038)	(0.020)	(0.020)	(0.021)
Growth rate in RCL, material costs	0.246 ***	0.247 ***	0.247 ***	0.259 ***	0.259 ***	0.259 ***
	(0.048)	(0.048)	(0.048)	(0.021)	(0.021)	(0.021)
Constant	0.034	0.034	0.040	0.009	0.009	0.015
	(0.028)	(0.028)	(0.028)	(0.048)	(0.047)	(0.047)
Number of observations	411	411	411	411	411	411
R-squared	0.440	0.443	0.439	0.454	0.456	0.453
F-test	<1%	<1%	<1%	<1%	<1%	<1%

Note: *, **, *** significantly different from zero at the 1 percent, 5 percent and 10 percent level, respectively. Standard errors in parentheses. Standard errors are robust (Huber-White) in the OLS estimations. Year dummies are included in all estimations. Wald tests indicated that the interaction variables (Skill*R&D) could be excluded. The fixed error components are tested to be statistically different from zero at the 10 percent's level.

Table 5. Results for the Heckman estimation of productivity growth in target plants

Dependent variable: Growth rate in RPL between t and t+2

	(1)		(2)		(3)	
	Skill: tertiary education		Skill: tertiary education in natural sciences		Skill: = 3-year tertiary education in natural sciences	
Initial plant RLP	-0.069	***	-0.069	***	-0.070	***
	(0.013)		(0.013)		(0.013)	
R&D	-9.73E-05		-1.02E-04		-7.84E-05	
	(8.4E-05)		(8.09E-05)		(8.35E-05)	
Skill	0.208	*	0.293	*	0.288	*
	(0.108)		(0.162)		(0.165)	
Growth rate in RCL, energy costs	0.125	***	0.123	***	0.125	***
	(0.038)		(0.037)		(0.038)	
Growth rate in RCL, material costs	0.247	***	0.248	***	0.248	***
	(0.049)		(0.049)		(0.049)	
Constant	0.073	***	0.074	**	0.077	**
	(0.018)		(0.018)		(0.018)	
Selection equation						
Plant size	0.166	***	0.163	***	0.156	***
	(0.034)		(0.033)		(0.035)	
Initial plant RLP	0.217	***	0.213	***	0.209	***
	(0.062)		(0.063)		(0.062)	
R&D, corporation intensity	4.545	***	4.545	***	4.422	***
	(0.791)		(0.790)		(0.789)	
Technology distance	0.254	***	0.285	***	0.290	***
	(0.130)		(0.121)		(0.125)	
Segment rank	-0.078	***	-0.076	***	-0.078	***
	(0.016)		(0.016)		(0.016)	
Constant	-0.461	**	-0.462	**	-0.332	***
	(0.219)		(0.219)		(0.226)	
Number of observations	663		663		663	
Number of censored observations	248		252		252	
Number of uncensored observations	411		411		411	
LL	-142.37		-141.26		-142.87	
Wald chi2	99.26	***	103.92	***	99.27	***
Wald test of independent equations	5.97	**	6.45	**	5.43	**

Note: *, **, *** significantly different from zero at the 1 percent, 5 percent and 10 percent level, respectively. Robust standard errors (Huber-White) in parentheses. Wald tests indicated that the interaction variables (Skill*R&D) could be excluded. Year dummies are included in the selection equation in all estimations.

Table 6. Results for the estimation of productivity growth in target plants with segment skill intensity

	Dependent variable: Growth rate in RPL between t and t+2											
	OLS						Fixed Effecs					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Skill: tertiary education		Skill: tertiary education in natural sciences		Skill: = 3-year tertiary education in natural sciences		Skill: tertiary education		Skill: tertiary education in natural sciences		Skill: = 3-year tertiary education in natural sciences	
Initial plant RLP	-0.081 ***	-0.082 ***	-0.084 ***	-0.083 ***	-0.081 ***	-0.082 ***	-0.069 ***	-0.069 ***	-0.071 ***	-0.070 ***	-0.069 ***	-0.070 ***
	(0.015)	(0.015)	(0.016)	(0.015)	(0.014)	(0.015)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Segment-specific skill share (corporation)	0.243 ***	0.287 ***	0.237 **	0.313 ***	0.503 ***	0.564 ***	0.347 ***	0.384 ***	0.404 ***	0.458 ***	0.684 ***	0.721 ***
	(0.092)	(0.102)	(0.116)	(0.113)	(0.191)	(0.195)	(0.099)	(0.095)	(0.134)	(0.129)	(0.223)	(0.212)
Skill share (plant)	0.083		0.126		0.103		0.078		0.111		0.072	
	(0.083)		(0.126)		(0.253)		(0.066)		(0.082)		(0.134)	
Growth rate in RCL, energy costs	0.073 **	0.074 **	0.075 **	0.077 **	0.075 **	0.076 **	0.090 ***	0.091 ***	0.091 ***	0.093 ***	0.092 ***	0.092 ***
	(0.031)	(0.032)	(0.031)	(0.033)	(0.031)	(0.033)	(0.015)	(0.015)	(0.016)	(0.015)	(0.016)	(0.016)
Growth rate in RCL, material costs	0.258 ***	0.259 ***	0.256 ***	0.257 ***	0.259 ***	0.258 ***	0.269 ***	0.270 ***	0.269 ***	0.268 ***	0.269 ***	0.269 ***
	(0.048)	(0.048)	(0.048)	(0.048)	(0.049)	(0.048)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
Constant	0.023	0.024	0.031	0.031	0.043	0.042	-0.006	-0.003	0.003	0.004	0.025	0.026
	(0.029)	(0.029)	(0.028)	(0.029)	(0.028)	(0.028)	(0.046)	(0.046)	(0.046)	(0.046)	(0.045)	(0.045)
Number of observations	413	413	413	413	413	413	413	413	413	413	413	413
R-squared	0.437	0.434	0.432	0.429	0.432	0.431	0.461	0.459	0.456	0.453	0.452	0.452
F-test	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%

Note: *, **, *** significantly different from zero at the 1 percent, 5 percent and 10 percent level, respectively. Standard errors in parentheses. Standard errors are robust (Huber-White) in the OLS estimations. Year dummies are included in all estimations. Wald tests indicated that the interaction variables (Skill (plant)*Skill (corporation)) could be excluded. The fixed error components are tested to be statistically different from zero at the 5 percent's level.

Chapter III
Why Do Corporations Divest Recently Acquired Assets?*

Katariina Hakkala

Abstract

Acquisitions ending in divestitures are often viewed as evidence of failed firm strategies. This paper regards divestitures of acquired corporate assets as a consequence of experiments. Corporations search for new business opportunities well matching their organizational capabilities, learn the value of a match and decide whether to keep or divest the target. The empirical analysis uses plant-level data to examine asset acquisitions of large Swedish corporations. I find plant performance, the buyer's organizational capabilities and the relation between the buyer's expertise and that of the target to determine the likelihood of a divestiture. The results are interpreted as consistent with the view that acquisitions involving a higher degree of experimentation were more likely to end in separations.

Keywords: acquisitions and divestitures, uncertainty, firm-specific assets

JEL classification: G34, D81, L21

*I thank Karolina Ekholm, Chloé Le Coq, Ari Kokko, Fredrik Sjöholm and Jens Josephson, seminar participants at IUI, FIEF and the Stockholm School of Economics for helpful suggestions. Financial support from Tore Browaldh's Foundation and Jacob Wallenberg's Foundation is gratefully acknowledged.

1 Introduction

The market for corporate assets is large and has been rapidly expanding over the past decades. Worldwide the total number of mergers and acquisitions grew at an annual 42 percent between 1980 and 1999 according to estimates by UNCTAD (2000). In addition to M&As between companies, there is a large market for corporate assets where large corporations buy and sell entire firms or parts of firms.[1]

While there exists a large literature discussing the causes and consequences of mergers between firms, less is known about acquisitions and sales of corporate assets. The increasing availability of plant-level data containing information about ownership changes has opened up new possibilities to study corporate asset acquisitions including purchases of individual plants. Corporate asset acquisitions differ from mergers between firms in many respects and therefore there is reason to focus on the corporate asset market separately.

This paper studies corporate asset acquisitions and in particular, addresses the issue of divestitures. Several studies on firm-level data have found that acquisitions often end in divestitures. The agency theory suggests that corporate managers being the agents of shareholders is fraught with conflicting interests and that managers have incentives to cause their firms to grow beyond their optimal size (Jensen, 1986). The theory thus suggests that many M&As, particularly acquisitions in unrelated industries of conglomerate firms, are undertaken by managers wishing to build empires (Baumol, 1959, Mueller, 1969 and 1993) and entrench themselves (Shleifer and Vishny, 1989) rather than promote efficiency and maximize the value of shareholders' assets. Due to the dubious motives of managers, many acquisitions are assumed to be *ex ante* inefficient and end in divestitures. The high rates of divestitures have been interpreted as evidence consistent with

[1] Maksimovic and Phillips (2001) find that almost 4 percent of the large manufacturing plants in the US changed ownership between 1974-92.

the agency theory.

More recent literature challenges this conventional view by arguing that acquisitions end in divestitures for a variety of reasons and should not necessarily be regarded as ex ante failures (Weston, 1989, Kaplan and Weishbach, 1992). Matsusaka (2001) views diversifying acquisitions as experiments undertaken by firms to find new business opportunities matching their capabilities.[2] According to this view, the future value of an experiment cannot be perfectly foreseen and therefore, some acquisitions are likely to turn out to be poor and end in divestitures. In this sense divestitures can be regarded as a consequence of successful experiments: the firm learned the value of its organizational capabilities in the target activities.

This paper aims at investigating whether the idea that asset acquisitions can be regarded as experiments is supported by empirical evidence. The framework for experimental acquisitions suggested by this paper is based on Matsusaka's (2001) model, where firms maximize their revenue and each period choose between the strategies of specialization, diversification through acquisition or liquidation of a previous match. In the framework of this paper, corporations have one core business and can make experimental acquisitions of additional assets both in related and unrelated industries. All acquisitions are assumed to involve uncertainty about the matching outcome. After acquisition corporations learn the value of their capabilities in the target activities and decide whether to keep or divest the target.

The empirical analysis of the paper uses data for asset acquisitions made by the thirty largest manufacturing corporations in Sweden during the period of 1986-96. It is found that 37 percent of the plants acquired by the corporations were divested, that is, sold or closed down, within three years after the acquisition. I use information on plant performance, the buyer's organizational capabilities and the relation between the buyers' expertise and that of the target to assess how the degree of experimentation is related to

[2] see also Klein and Klein (2001).

the likelihood of an acquisition to end in a divestiture. The time dimension is important for exploring the importance of the experimentation hypothesis. It can be argued that acquisitions that turn out to be poor matches are likely to end in separations relatively soon, when the value of the match between an acquirer and a target is revealed. The empirical analysis therefore examines divestitures occurring within a few years after acquisition.

The paper is structured as follows: the next section discusses related literature, Section 3 presents the theoretical framework for the analysis, Section 4 presents the empirical model, Section 5 presents and discusses the empirical results and Section 6 concludes the paper.

2 Related Literature

Much of the theoretical literature on M&As has focused on the strategic motives and competitive consequences of M&As. In this literature, mergers are motivated by strategic considerations, such as the ambition to achieve market dominance, block another merger or eliminate a competitor. The strategic motives of M&As are important when the parties involved in a merger represent a proportionally large share of an industry. Many asset acquisitions and sales have, however, little, if any, impact on the market structure of the industry.[3] Diversifying acquisitions are not generally perceived to have same anti-competitive consequences as horizontal mergers. Even horizontal mergers may be argued to have a limited impact on the competitive structure of an industry when they involve small targets.

The finance literature provides several insights on corporate acquisitions involving other than competitive motives.[4] The agency theory suggests that managers may have incentives to cause their firms to grow beyond an optimal size (Jensen, 1986). According to this view, many M&As, particularly

[3]Jensen and Ruback (1983), for instance, find that the gains created by corporate takeovers do not appear to be due to the creation of market power.

[4]For a more comprehensive survey see Jensen and Ruback (1983).

acquisitions in unrelated industries of conglomerate firms, are undertaken by managers pursuing their own interests rather than maximizing shareholders' value. Managers' motives for acquiring may be to build empires (Baumol, 1959, Mueller, 1969 and 1993) and entrench themselves (Shleifer and Vishny, 1989). Due to the dubious motives of managers these acquisitions are assumed to be *ex ante* inefficient and end in divestitures. Roll (1986) proposes that managers are infected by hubris, that is, they systematically overestimate their own ability to run the acquired assets, which explains why many acquisitions end in divestitures.

The post-merger inefficiency and the high frequency of divestitures following upon acquisitions, particularly diversifying ones, are regarded as evidence of agency problems. Supportive empirical evidence is provided by Ravenscraft and Scherer (1987, 1991), Porter (1987), Kaplan and Weisbach (1992) and others studying the US conglomerate merger waves of the 1960s and 1970s and find that unrelated acquisitions brought no long-term gains to the firms that diversified[5] and that the acquired assets were often resold later on.[6] The evidence that the stock market reacts negatively to diversifying acquisitions is also interpreted as support for the agency theory (Morck, Shleifer and Vishny, 1990, Lang and Stulz, 1994 and Berger and Ofek, 1995). In the 1980s a wave of divestitures led to an increasing focus on core activities in many large firms, which was interpreted as further evidence of the inefficiency of the earlier diversifying acquisitions.

While the agency theory is very appropriate for describing some acquisitions, it does not provide a full understanding of the observed corporate asset

[5]An exception is Kaplan's and Weisbach's (1992) study which finds that acquired assets were often divested, although diversifying acquisitions increased the combined value of the target and acquirer.

[6]Ravenscraft and Scherer (1987) estimate that 33% of the acquisitions in the 1960s and 1970s were later divested and Porter (1987) finds that over 50% of the acquisitions in "new" or unrelated industries were later divested, Kaplan and Weisbach (1992) find that 43.9% of the large acquisitions completed between 1971 and 1982 had been divested by 1989 and Baldwin (1993) finds that of the firms that enter an industry by merger 15 % exit within two years and 58 % by the end of nine years.

acquisitions and divestitures. The view that managers are buying growth to increase their own power is inconsistent with acquired assets being resold soon after their acquisition. For instance, Shleifer and Vishny (1989) argue that a manager acquiring assets to entrench herself wants to divest a division only when another manager can run it better or when it is destroying shareholder value without producing any entrenchment benefits.

More recent literature challenges this conventional view by arguing that acquisitions end in divestitures for a variety of reasons, such as changes in corporate strategies, the regulatory environment and economic conditions (Weston, 1989). Maksimovic and Phillips (2002) study corporate asset sales in general, without making any distinction between acquired and non-acquired assets. They construct a model considering conglomerate investments to be consistent with an efficient resource allocation within a conglomerate firm even when they are seemingly inefficient. In their model firms grow and become large in industries where they have a competitive advantage. As a firm's returns to further growth within an industry diminish, the firm moves into other industries. Firms sell assets in their less productive divisions when these divisions receive positive shocks or when firms' more productive divisions receive positive shocks.[7] Maksimovic and Phillips (2001) test their model empirically and show evidence of acquisitions and divestitures being consistent with profit-maximization, although their results cannot reject the existence of agency motives for some acquisitions.[8]

Another view on corporate acquisitions and divestitures is presented by Matsusaka (2001).[9] He regards diversifying corporate acquisitions as experiments undertaken by firms to find new business opportunities matching their

[7]The opportunity cost of the assets may be higher for a firm either because other firms in the industry can better use the assets, or because the selling firm has better prospects in other industries.

[8]For a sub-set of conglomerate firms that are broken-up growth decisions are not found to be consistent with optimizing behavior. However, there is no evidence of these firms significantly subsidizing the growth of inefficient segments.

[9]See also Klein and Klein (2001).

existing capabilities.[10] Matsusaka (2001) develops a model where diversification is a search process and firms search for business opportunities maximizing their revenue. In each period, firms choose between the strategies of specialization in the current business, diversification through the acquisition of a new business or the liquidation of current business and the acquisition of a new business. Once a firm has found a good match, it divests its current business and specializes in the new one. In contrast to Maksimovic's and Phillips's model where there is no uncertainty about the realized productivity of a firm's investments, firms in Matsusaka's model have imperfect information about how well their capabilities are matched with other activities. The only way firms can learn about the value of their organizational capabilities in new activities is to test them in an activity during one period. After learning the value of the acquisitions, firms divest the activities that turned out to be poor matches. In this sense, divestitures can be regarded as a consequence of successful experiments: firms have learned that the activity was not a good match with their existing capabilities. The experimental hypothesis thus assumes profit-maximization but also incorporates uncertainty. It can therefore be regarded as a complementary explanation why some acquisitions end in divestitures.

In Matsusaka's model all acquisitions are diversifying, but firms remain diversified only until they decide to specialize in one activity. If acquisitions in both related and unrelated industries were to involve uncertainty, the experimentation hypothesis might be argued to be relevant for both kind of acquisitions. Whether diversification is an optimal strategy may depend on the circumstances. For instance, Maksimovic and Phillips (2002) find evidence of firms diversifying in times of low demand in their main industry.

[10] Matching models have also been applied to studies on corporate asset markets also by Lichtenberg and Siegel (1992) who motivate their empirical analysis of ownership changes by a matching theory and Hall (1987) who develops a matching model where acquisitions occur when the assets of the acquiring firm and target create synergy gains yielding a sufficiently large return.

When the prospects in their main industry improve significantly, they become focused and divest assets in periphery segments.

The empirical literature on sales of plants and divisions is small. Maksimovic and Phillips (2002), Alexander et al. (1984), Jain (1985), Hite et al. (1987) and John and Ofek (1995) are among the few studies having analyzed asset sales.[11] The study by Schlingemann, Stulz and Walking (2002) examines the sales of divisions. However, these studies look at divestitures in general and do not specifically focus on sales of previously acquired assets. Studies by Kaplan and Weisbach (1992), Ravenscraft and Scherer (1987, 1991), and Porter (1987) focus on divestitures following upon acquisitions, but their data only consists of lines of business or firms.[12] Kaplan and Weisbach (1992) analyze divestitures succeeding large acquisitions and present some supportive evidence of managerial motives. Evidence by Porter (1987) and Kaplan and Weisbach (1992) show that diversifying acquisitions are more likely to end in divestitures. They take this as evidence of acquisitions, in particular diversifying ones, being induced by agency problems. None of these studies has, however, focused on the divestitures of previously acquired assets at the plant level.

3 Framework for Analyzing Corporate Acquisitions and Divestitures

The analytical framework of this paper regards corporate acquisitions as experiments. The major difference to Matsusaka's model is that firms can make asset acquisitions both in related and unrelated industries, while they

[11] Maksimovic and Phillips (2002) use data for plants and measure performance in terms of productivity. The other studies are so called event studies analyzing stock-market reactions to sell-off announcements with the exception of John and Ofek (1995) who also analyze post-acquisition operating performance.

[12] Ravenscraft and Scherer (1987) use lines of business data with 261 manufacturing and 14 nonmanufacturing industry categories.

keep their core business activity. Matsusaka's model can thus be interpreted as a description of long-run firm strategies when firms may shift their core business activity to another, while this paper describes firm strategies in the short-run when the core business activity remains unchanged.

In this framework, corporations search for investments maximizing the value of their organizational capabilities. For all acquisitions, the expected value of the match is random due to imperfect information about the value of the organization capabilities in new investments. The decision to acquire an asset, the market interaction between a buyer and a seller leading to the acquisition of an asset and its price are taken as given. For instance, acquisitions can be preceded by a bidding process where a corporation with the highest expected value of the match makes a bid exceeding the evaluation of any other bidder and the reservation price set by the seller of the target.[13]

Each corporation has unique organizational capabilities, T, that could be anything from intangible assets such as management skills to more tangible ones such as access to financial capital, a sales organization, brand names, patents and blue-prints of products and technologies. It is assumed that a fixed part of the aggregate organizational capability, $t < T$, can be allocated to new investments without incurring any additional cost for the core business.[14]

The productivity of the organizational capability varies across firms and industries. The productivity of organizational capabilities in a certain business activity is given by $\theta_i \in [0, 1]$, which is referred to as the quality of a match between the corporation's organizational capabilities and an activity. To capture the idea that corporations have imperfect information

[13]The framework does not make any specific assumptions about the strategic interaction between actors in an industry. In situations where acquisitions involve firms or parts of firms representing a smaller share of an industry or where the buyer is a conglomerate firm with its main operations in another industry, strategic interaction can be assumed to be of no importance for the acquisitions.

[14]Managers never allocate more than t to new investments, since too little T devoted to their core business would jeopardize the productivity of the core business and their jobs. However, allocating all T into the core business is assumed to yield lower expected profits than dividing it between the core and a new business activity.

about which new firms and businesses their organizational capabilities are best matched with, θ_i is assumed to be a random variable for each activity i. The only way corporations can learn about the value of their organizational capabilities in new activities is to test them in an activity during one period.

The total profit of a corporation is a sum of the profits in the core and new business activities

$$\Pi = \pi_c(t_c, \theta_c) + \pi_e(t_e, \theta_e)$$

where π_c is the profit function for the core activity, $t_c = T - t_e$ the organizational capacity allocated to the core business and θ_c the productivity of the core business, π_e the profit function for the new activity, $t_e = T - t_c$ the organizational capacity allocated to that activity and θ_e the matching quality of an acquired asset.[15]

A corporation that makes an acquisition is assumed to act as follows: the corporation acquires a target, allocates t_e to the target, hires inputs for productive activities and at the end of the period learns the realization of the match. Based on the realization of the match, the corporation decides whether to keep the target or divest it. The uncertainty of the matching outcome until the end of the period essentially drives the results of the model. The uncertainty can arise both from the buyer's as well as the target's characteristics and may concern whether the buyer's organizational capacity can be successfully transferred to the target. Information about the target may also be insufficient or even incorrect at the time of acquisition. The actual outcome of matching is not revealed until after a take-over.

Corporations are assumed to know the true distribution of matching outcomes. A corporation with a certain productivity in its core business, expects new investments in related industries to turn out to be as productive on average. The distribution of the matching quality parameter in related industries (r) is thus a cumulative conditional distribution function of θ_r given θ_c, given

[15] Corporations can acquire only one additional activity at a time.

by $F(\theta_r|\theta_c)$, with the expected value of $E(\theta_r|\theta_c) = \theta_c$.

The productivity of the core business, θ_c, does not affect the expectations of matching outcomes in unrelated industries (u). The cumulative distribution function of the matching quality parameter in unrelated industries is thus unconditional, $G(\theta_u)$. The unconditional distribution of θ_u reflects that corporations do not know if and how the productivity of their capabilities in the core business affects the matching outcomes in unrelated industries.

Corporations live forever, discount the future at δ, search for revenue generating investments and maximize value. At the beginning of a period the value of an optimal strategy is $v(\theta_c, \theta_e)$, where θ_c is the productivity of the core business and θ_e the quality of the best match so far for an experimental activity. In each period a corporation makes a choice between the following actions: i) keeping the previously acquired activity, ii) divestiture of the previously acquired activity and acquisition of a new activity in industries related to the core business iii) divestiture of the previously acquired activity and acquisition of a new activity in industries unrelated to the core business.

If the corporation decides to keep a previously acquired activity, its value is given by

$$\alpha(\theta_{c,}\theta_e) = \pi_c(t_c, \theta_c) + \pi_e(t_e, \theta_e) + \delta v(\theta_c, \theta_e) \tag{1}$$

where $e = \{r, u\}$. If the corporation continues to operate its core business while divesting the previously acquired activity and experimenting in a new activity in a related industry, its value is

$$\beta_r(\theta_{c,}\theta_r) = \pi_c(t_c, \theta_c) + \pi_r(t_e, \overline{\theta_r}) + \delta v(\theta_{c,}\theta_r) \int_0^{\overline{\theta}_r} dF(\theta'_r|\theta_c) + \delta \int_{\overline{\theta}_r}^1 v(\theta_{c,}\theta'_r) dF(\theta'_r|\theta_c) \tag{2}$$

and if it continues to operate its core business while divesting the previously acquired activity and experimenting in a new activity within an unrelated industry, its value is

$$\beta_u(\theta_c,\theta_u) = \pi_c(t_c,\theta_c)+\pi_u(t_e,\overline{\theta_u})+\delta v(\theta_c,\theta_u)\int_0^{\overline{\theta}_u} dG(\theta'_u)+\delta\int_{\overline{\theta}_u}^1 v(\theta_c,\theta'_u)dG(\theta'_u) \quad (3)$$

where $\overline{\theta_r} = \int_0^1 \theta_r dF(\theta_r|\theta_c)$ and $\overline{\theta_u} = \int_0^1 \theta_u dG(\theta_u)$. The first and second terms in equations (2) and (3) represent profits from the core business and the new business activity in the current period. The last two terms are the discounted expected value of the firm in the next period. The third term is the discounted expected value of the corporation if the new match is worse than the expected value of the acquisition. This is the case when the corporation divests the acquired business in the next period and draws a new match in the next period. The fourth term is the discounted expected value of the corporation if the acquired business is at least as good as the expected value of a new match. In this case the corporation keeps the activity in the next period.

The choice between the two kind of acquisitions is determined by the productivity of the core business and the expected value of matching outcomes in the two types of industries. A corporation with $\theta_c > \overline{\theta_u}$ chooses an acquisition in related industries, since $E(\theta_r|\theta_c) > E(\theta_u)$ for $\theta_c > \overline{\theta_u}$, while the opposite applies to a corporation with $\theta_c < \overline{\theta_u}$:

$$\begin{aligned} \beta_r &\succsim \beta_u \quad for \quad \theta_c \geq \overline{\theta_u} \\ \beta_u &\succ \beta_r \quad for \quad \theta_c < \overline{\theta_u} \end{aligned}$$

Thus, diversifying acquisitions appear as a value maximizing strategy only for corporations with $\theta_c \leq \overline{\theta_u}$. In other words, this means that corporations with relatively poor productivity in their core business become involved in diversifying acquisitions.

At the beginning of each period, the value of an acquisition from the previous period is revealed and the corporation must decide whether to keep it or divest it and acquire a new target. The choice is dependent on the realized matching parameter. For values of $\theta_r^{'} > \theta_c$ and $\theta_u^{'} > \overline{\theta}_u$ there is no longer any incentive to continue searching and the corporation decides to keep what it has and make no more experiments. The following holds:

$$\begin{aligned} \alpha &\succsim \beta_r \quad for \quad \theta_r^{'} \geq \theta_c \\ \alpha &\succsim \beta_u \quad for \quad \theta_u^{'} \geq \overline{\theta}_u \end{aligned}$$

because keeping an activity yields a higher profit than continuing to experiment: $\pi_r(t_e, \theta_r^{'}) \geq \pi_r(t_e, \theta_c)$ for $\theta_r^{'} \geq \theta_c$ and $\pi_u(t_e, \theta_u^{'}) \geq \pi_u(t_e, \overline{\theta_u})$ for $\theta_u^{'} \geq \overline{\theta}_u$.

The corporation's value is then

$$\begin{aligned} v(\theta_c, \theta_r) &= \max[\alpha(\theta_{c,}\theta_r), \beta_r(\theta_{c,}\theta_r)] \text{ for } \theta_c \geq \overline{\theta_u} \\ v(\theta_c, \theta_u) &= \max[\alpha(\theta_{c,}\theta_u), \beta_u(\theta_{c,}\theta_u)] \text{ for } \theta_c < \overline{\theta_u} \end{aligned}$$

An implicit assumption of the framework is that in each industry there may be two kind of buyers; corporations with a relatively productive core business activity in the industry and those with a relatively less productive core business in another industry.

The framework has some restrictive features requiring comments. First, corporations with a relatively high productivity in their core business only make acquisitions in related industries and, second, keeping an acquired activity becomes a static strategy once a corporation has drawn a "good" match. Both these restrictions can be seen as consistent with short-run scenarios. The feature that diversification is an optimal strategy when corporations' core business has relatively low productivity is in line with the model of Maksimovic and Phillips (2002) and the empirical evidence they present. In their model, specialization is optimal if the firm is much more productive in one industry than in the other and diversification is optimal if the productivity levels are similar. In the long run, the productivity of the core business cannot be assumed to remain constant. When the productivity of the core business changes, corporations may get an incentive to make new acquisitions and keeping an activity never becomes a static strategy. Since this paper focuses on short-run firm strategies, the productivity of the core business activity can be assumed to remain constant.

I have simplified the framework by assuming that t which is allocated to the experimental activity is a fixed share of T and that the probability of divestiture is equal for acquisitions in related and unrelated industries. If corporations differ from each other in terms of total organization capabilities, they will have different preconditions to allocate a part to a new activity. For instance, corporations investing large amounts in R&D are expected to have more competitive organizational capabilities. R&D results, like many other organizational capabilities, are in general described as assets that can be shared by several units of a corporation at a low cost. It is therefore hypothesized that corporations with "larger" organizational capabilities are able to allocate more organizational capabilities to the target and are therefore more likely to get a "good" match. Furthermore, if organizational capabilities are industry-specific to some extent,[16] corporations acquiring assets in their core industry may thus be more likely to get a "good" match than corporations with their core business in another industry. The likelihood of divestiture can then be expected to be higher for a corporation buying assets in an industry unrelated to its core business. These features will be analyzed empirically.

[16] Maksimovic and Phillips (2002) find that larger segments of conglomerate firms have higher average productivity than smaller segments, which they interpreted as consistent with the view that organizational talent has an industry-specific component.

4 Empirical Analysis

In the empirical work, I depart from the analytical framework to examine to what extent corporate asset acquisitions and divestitures are consistent with the experimental hypothesis. More specifically, I aim at examining the following conclusions:

i) *An acquired asset matching poorly with the organizational capabilities of the buyer is divested when the value of the match is revealed.*

ii) *The likelihood of divestiture is decreasing in the organizational capabilities of the buyer.*

iii) *The probability of a divestiture is larger for acquisitions in unrelated industries because organizational capabilities are industry-specific to some extent and buyers are expected to have more expertise in their core business.*

The first conclusion follows directly from the framework. The empirical analysis attempts to identify a poor match by using measures of target productivity relative to its industry average or the productivity of the core business of the buying corporation. The second conclusion proposes that the probability of getting a "good" match is dependent on the total T. The third conclusion proposes that not only the "amount" of organizational capabilities but also their relevance for the acquired target affect the likelihood of getting a "good" match. Corporations with productive organizational capabilities are thus hypothesized to be more successful with new investments in related industries than in industries where they lack previous experience.

The framework for experimental investments does not make any distinct difference between asset acquisitions involving the whole firm with several plants and transactions involving only one or some plants. In fact, a "good" match can occur between parts of an acquired multi-plant firm and the acquiring corporation. In some cases, corporations may not be able to acquire only the parts of a firm they believe to maximize their revenue. In the presence of such market imperfections, one explanation why corporations divest some plants is rationalization. The empirical analysis cannot necessarily detect this type of divestitures as the decision of divestitures might still be based on the same factors as that of experimental acquisitions. However, if the rationalization hypothesis is relevant, I expect the likelihood of divestitures to be explained by the initial plant productivity among the plants of acquired multi-plant firms, indicating that corporations optimally divest the parts performing poorly from the start. To explore the relevance of the rationalization hypothesis, I investigate differences between the acquired single- and multi-plant firms as regards the relationship between the likelihood of divestiture and initial plant performance. Furthermore, my empirical tests cannot completely reject the existence of agency motives. However, we can question the view that opportunistic behavior lead agents to misallocate resources, if divestitures taking place rather soon after a change of ownership are shown to be consistent with efficiency considerations.

4.1 Data and Measures

The data set is a sample of large Swedish corporations. More specifically, the corporations in the sample are the thirty largest multinational company groups with their headquarters in Sweden in 1990.[17] The studied corporations represent approximately a quarter of total employment in Swedish manufacturing, and a share which remained almost constant during the period of study.[18] Statistics Sweden have constructed the data set from their databases on industrial and financial statistics, and it includes information on all manufacturing plants owned by the thirty corporations during the period 1985-98.[19] An advantage of this data set, as opposed to data originating from

[17] Some of the corporations included in the sample have moved their headquarters from Sweden after 1990, but are still key employers in Sweden.

[18] Their share in production varied from 30 to 35% during the same period.

[19] All manufacturing plants with at least five employees are included.

stock market data, is that it allows me to study partial acquisitions where a corporation acquires one or several plants, rather than an entire firm.

In the resulting unbalanced panel, the yearly number of plants varies between about 600 and 700. The data set includes plant-level information on output, employment, value-added, intermediate inputs, wages, industry code variables and information about corporate ownership of plants and firms. Some variables, such as investments and R&D, are available only at the firm level.[20] Identification codes of plants and firms in combination with information from a firm register are used for categorizing plant closures, start-ups and ownership changes. The data is described more in detail in Hakkala (2003).

The data has been carefully cleaned for the empirical analysis. All ownership changes of plants where both the buying and the selling firm are owned by the same corporation are excluded, since these are associated with internal restructuring. During the period studied, there were also three mergers involving entire corporations or at least, all Swedish operations of the corporations. These mergers were not included in the studied sample of acquisitions, since the study focuses on take-overs of plants and firms by corporations rather than mergers between large corporations.[21]

Productivity, the performance measure used in this paper, can be measured either as a ratio of plant output to all its inputs (total factor productivity, TFP) or as a ratio of output to a single input such as labor (labor productivity). Theoretically, TFP is a more appropriate measure of productivity because it takes into account all inputs, not only labor. In practice, the estimation of labor productivity often gives better accuracy than TFP, because estimating the value of capital stocks often implies a large error. One shortcoming of labor productivity compared to TFP is that it fails to capture changes in factor intensities that may be the result of adoption of new tech-

[20]Data for R&D outlays is collected by Statictics Sweden for firms with a minimum of 50 employees every second year. R&D outlays for even years are computed by interpoleration.

[21]27 plants involved in these mergers were excluded from the analysis.

nology or changes in factor prices. For example, productivity growth could be overestimated in one sector due to a shift to labor-saving and more capital intensive technology. Another problem with labor productivity is that average labor productivity may be procyclical as has been found in empirical studies.[22]

A relative labor productivity measure relating plant productivity to its industry productivity avoids some problems associated with real labor productivity. The relative productivity measure allows for inter-temporal and inter-industry comparisons because it does not depend on an output deflator and is able to correct for the problem of price dispersion among plants across industries. The relative productivity measure (RLP) is defined as:

$$RLP_{plant} = \frac{LP_{plant}}{LP_{industry}} \tag{4}$$

where the labor productivity of an acquired plant, measured as the sales value of output per employee,[23] is related to the average labor productivity of its four-digit industry. It should be noted that some deficiencies in labor productivity, such as plant-specific changes in capital intensity, are not corrected by the relative measure. If a plant shifts to use more capital intensive production technology than another then labor productivity may be higher (status quo) even if total factor productivity might be the same.

4.2 Variable Selection

To empirically investigate the experimentation hypothesis, I focus on the determinants of divestitures taking place shortly after acquisitions. The ac-

[22] See Baily, Bartensman and Haltiwanger (1996).

[23] Value added is a preferred measure of output in studies at the aggregate level, because output used as an input by another industry is netted out and problems of double-counting are avoided. At finer levels of analysis, gross output may be a more preferred measure since it does not require data for inputs and is therefore likely to contain less severe measurement errors.

quisitions made by the corporations in different years are pooled to a sample and followed for a number of years.[24] An advantage of this approach is that all plants are followed for equally long periods after acquisition. Three years is chosen as the main cut-off point for the analysis and the dependent variable is defined as a binary variable taking the value of one if a plant is divested within the three years and zero otherwise.[25] It may be argued that three years is not a long enough period for the gains of mergers to be realized. However, the choice is based on the assumption that it is a sufficiently long time to observe how well the acquired target matches with the organizational capabilities of the buyer.

The theoretical framework for experimental corporate acquisitions proposes the incidence of divestiture to depend on the matching outcome and the benchmark for a "good" match set by the buyer. The empirical analysis evaluates how the likelihood of divestiture is dependent on different relative measures of target performance, as the benchmark values of target performance affecting the decision of divestiture are unknown. The following measures are used: plant productivity in relation to its industry average; average weighted productivity in the main segment or segments of the corporation; and the average weighted productivity of all other operations of the corporation.[26] Relative productivity is measured for the year before the divestiture for the divested plants and as an average of the productivities in the first and third year for other plants. Dummy variables taking the value of one if the relative productivity measure is smaller than one, and zero otherwise are used to investigate if the decision of divestiture is dependent on a bench-

[24]Since the main interest in the analysis is not the lenght of time elapsesing from a change in ownership to divestiture, the use of estimation methods for duration data is not motivated.

[25]Divestitures comprise both sell-offs and closures. The sensitivity of the results for the chosen cut-off point will be analyzed by prolonging the period to four and five years.

[26]Plant shares of sales are used as a weights. The main segment is defined as the three-digit industry group with at least 25% of the total sales of the corporation. All segments with at least 10% of total sales are defined as main segments in corporations that do not have a single segment with at least 25% of the total sales.

mark as suggested in the framework. The relative productivity measures are expected to be negatively related to the probability of divestiture, indicating that poor matches are divested. It is also analyzed how growth in plant productivity is related to the likelihood of divestiture.

The second conclusion from the framework I aim at exploring is that a buying corporation with "larger" organizational capabilities is less likely to divest. The organizational capabilities or managerial talent are, at least partly, viewed as intangible assets generated over time by a process of learning-by-doing and therefore rather difficult to quantify empirically. However, I expect well managed corporations with organizational talents to be relatively more productive and use corporation productivity as a proxy for organizational capabilities.[27] In a broader sense, organizational capability can consist of more tangible assets such as technological innovations and brand names. Morck and Yeung (1998) provide some evidence of investments in R&D and advertising leading to the creation of organizational capabilities. I use the acquiring corporation's R&D intensity as another proxy for organizational capabilities.[28] The corporations investing more in R&D are expected to have superior organizational capabilities or a productive capacity influencing the probability of getting a "good" match.

The usefulness of expertise measured in terms of R&D may differ for plants in different industries. A concept associated with transfers of technological knowledge is the notion of 'absorptive capacity' introduced by Cohen and Levinthal (1989). The concept stresses the importance of prior knowledge capital to effectively absorb new knowledge. To capture the importance of absorptive capacity, I also include a variable to proxy the technological distance between an acquiring corporation and the acquired plant. The tech-

[27]Corporation productivity is computed as a weighted average relative to the productivity year before acquisition, with plant sales shares as weights. The corporation productivity measure is used only in the specifications where plant productivity is related to industry productivity.

[28]R&D intensity is defined as the ratio between R&D investments and sales the year before the acquisition.

nology level is proxied by skill intensity. More specifically, I use the share of employees with a tertiary education in natural sciences to measure skill intensity.[29] The corporation-level skill intensity is computed as a weighted average of plants' skill intensities. The technological distance is defined as the ratio of an acquired plant's skill intensity relative to that of the acquiring corporation when the plant is less skill intensive than the corporation, and as an inverse of the ratio when the plant is more skill intensive than the corporation.[30] Plants with lower skill intensity are expected to have a limited absorptive capacity to receive technological knowledge proxied by the buyer's R&D intensity. I expect the likelihood of divestiture to increase the more an acquiring corporation and an acquired plant differ in technological terms (and the smaller the value of the technological distance proxy).

The third conclusion from the framework is that diversifying acquisitions imply a higher degree of experimentation with organizational capabilities. Corporations are assumed to have a higher ability and be more productive in their core segments and are thus more likely to get a "good" match in these industries.[31] To assess if diversifying acquisitions are more likely to be divested, the acquiring corporation's operations are defined as business segments according to a three-digit industry classification and ranked according to the segment share.[32] A rank variable, which takes a larger value the smaller the segment, is expected to be positively related to the likelihood of divestiture indicating that the likelihood of getting a "good" match is higher in the relatively larger segments of the corporations.

Additional variables for plant size and industry demand are included to

[29] Using the share of employees with any tertiary education would more probably include administrative staff and thus be a less accurate measure of technological skills.

[30] Data is missing for 18 plants, and I therefore estimate the model with and without the proxy variable for technological distance.

[31] Maksimovic and Phillips (2002) define segments at the three-digit industry level and rank them according to the sales share within a firm, where the segment with the largest share is ranked first. They find the rank of a segment to be inversely related to its efficiency, which indicates that corporations have a higher ability in their larger segments.

[32] According to the Swedish industry classification (SNI69 and SNI92).

control for other factors that can influence the incidence of divestitures. The size of the target can be argued to be either positively or negatively related to the likelihood of divestitures. Klein and Klein (2001) argue that less is known about small firms and that there is more uncertainty about their characteristics, but that there is more to learn about large firms that are engaged in more activities. On the other hand, it can be argued that larger targets involve a larger acquisition cost and a larger absolute risk and buyers are likely to be more prudent when investing in larger targets. Since the unit of analysis is plants generally not engaged in several activities, acquisitions of smaller targets are expected to involve a higher degree of experimentation and are more frequently divested.

Economic conditions have been found to affect the incidence of asset sales in general. For instance, Maksimovic and Phillips (2001) find that plants and segments are more likely to be sold when aggregate industrial production is high. To control for the business cycle effect on divestitures, a variable measuring growth in industrial production during the post-acquisition period is included.[33] This variable is computed as the growth rate the year before divestiture for the divested plants and the average annual growth rate during the first three years for other acquired plants. Year dummies are also included to control for other unknown time dependent factors that can affect the incidence of divestitures.

5 Empirical Results

Before proceding to explore the relevance of the experimental hypothesis, I will first describe the acquired plants.

[33] Growth is measured by the index for industrial production (IPI) provided by Statistics Sweden.

	Definition
RLP_industry	Plant labor productivity relative to average industry labor productivity
RLP_industry dummy	Dummy variable equal to one if RLP_industry<1, zero otherwise
RLP_corporation	Plant labor productivity relative to average labor productivity of other plants of the acquiring corporation
RLP_corporation dummy	Dummy variable equal to one if RLP_corporation<1, zero otherwise
RLP_main_segment	Plant labor productivity relative to average labor productivity of main segment or segments of the acquiring corporation
RLP_main_segment dummy	Dummy variable equal to one if RLP_main_segment<1, zero otherwise
R&D	R&D to sales of the acquiring corporation, year before acquisition
Corporation RLP	Weighted average corporation labor productivity year before acquisition
Technology distance	Plant skill intensity (S_{pl}) relative to corporation skill intensity (S_c) when $S_{pl}<S_c$, an inverse of S_{pl}/S_c otherwise, first year
Segment rank	Rank of the acquired plant's segment within the acquiring corporation according to sales share (the largest segment =1)
Plant size	Log of number of employees of the acquired plant
Industry growth	Growth rate in manufacturing production

Table 1: Definitions of Variables

5.1 Acquired Plants

During the period studied of 1986-96, 718 manufacturing plants were acquired by the corporations in the sample.[34] The majority of these plants were single-plant affiliate firms in the acquiring corporation (423 firms), while the remaining plants were part of acquired multi-plant affiliate firms (76 firms) or were added to existing multi-plant firms (25 firms).[35] Within three years after acquisition, 37 percent of the acquired plants were divested, that is, sold or closed down.[36]

Table 1 reports the average relative productivity at the end of the year of acquisition for all acquired plants and the plants that were divested or kept three years or longer.[37] On average, the acquired plants exhibited high productivity relative to their industry averages at the year of acquisition. The acquired plants were 4.6 percent more productive than the average for their industries, which suggests that corporations acquired relatively competitive plants.[38] However, a closer examination of the productivity levels of acquired plants shows that more than half the plants actually had productivity levels below their industry averages.[39] The plants that were kept at least three years (449 plants) exceed their industry average by, on average, 7.0 percent at the time of the acquisition. However, differences in the initial productivity of the kept and divested plants are not statistically significant according to a t-test for the equality of means.

[34] An additional 61 acquired non-manufacturing plants that were part of manufacturing firms were excluded from the analysis. Industry-level data are not available for these plants.

[35] The average and median number of plants acquired as a multi-plant firm is 3.04, and 2 respectively.

[36] 84 plants were closed down.

[37] Seven plants with a value of relative productivity higher than five were excluded as extreme outliers. Two plants dropped out due to missing data.

[38] Similar results were obtained by McGuckin and Nguyen (1995), Matsusaka (1993) and Ravenscraft and Scherer (1987), who found acquired plants to perform better on average than their industries.

[39] The 409 relatively less productive plants had an average relative productivity of 0.68 (st dev 0.21) while the relatively productive ones had 1.56 (st dev 0.56).

[Table 1 here]

To examine in which type of segments plants were acquired, I aggregate corporation sales at the three-digit level of industries and define segments in the following way:[40] (1) main segment of single-segment corporation (a single three-digit industry group with a sales share of at least 95% of the total corporation sales); (2) main segment of a multi-segment corporation (a three-digit industry group with a sales share of at least 25% of the total corporation sales) or a large segment of a multi-segment corporation without main segments (a three-digit industry group with a sales share between 10% and 25% of the total corporation sales); (3) a complementary segment of a single- or multi-segment corporation (segments not categorized in (1) or (2)); (4) a new segment.

Table 2 shows the shares of plants acquired in the different types of segments and the shares of divested plants in each category. Divestitures were more common in new and more peripheral segments. The share of divested plants is highest in new segments where corporations are assumed to be less experienced. The differences in the divestiture rates are consistent with the hypothesis that diversifying acquisitions are more likely to be divested.

[Table 2 here]

5.2 Incidence of Divestiture

The econometric estimation uses probit regressions for panel data with random corporation-specific error components.[41] The results of the estimations

[40] Segments are defined according to the sales shares in the year before acquisition.

[41] The random effects model is chosen instead of the fixed effects model (logit), since the differences between corporations cannot be viewed as parametric shifts in the regression function with confidence. An advantage of the random effects model is that the loss degrees of freedom can be avoided by assuming random error components.

are presented in Table 3. The high Chi-squared of the various models indicates the high joint explanatory power of the independent variables in all regressions. The model predicts about 74 percent of the observations correctly, which is suggestive of fit.[42] Year dummies are tested to be jointly different from zero by Wald tests. The panel-level variance component is tested to be different from zero by a likelihood ratio test comparing the pooled estimator with the panel estimator. Using estimation methods for panel-data is therefore motivated.[43]

[Table 3 here]

According to the results, a corporation's decision to divest a plant is influenced by the plant's relative productivity. The probability of divestiture declines, the more productive are the plants relative to the average of their industries. This is indicated by the statistically significant negative coefficient for the variable measuring relative plant productivity. It seems that the industry average productivity works as a benchmark for the decision to divest. The dummy variable indicating whether a plant is less or more productive than its industry is negatively related to the incidence of divestiture and statistically significant.

The variables measuring plant productivity relative to that of the main segments and all other plants of the corporation are also statistically significant and negatively related to the likelihood of divestiture. Plant productivity in relation to the productivity of all other plants of the corporation seems to be a less important factor for explaining the incidence of divestiture. The

[42] Classification as a divestiture occurs when the model's probability prediction exceeds the prior probability based upon the frequencies of divested and non-divested plants in the sample.

[43] Estimations are also computed using the probit method, allowing for correlated residuals within panel units. The results are qualitatively the same as in Table 3, but are not reported here. The main difference is that the coefficients for R&D and technological distance become smaller. Guilkey and Murphy (1993) have shown that ignoring random effects and performing a standard probit analysis can lead to very missleading inference since the coefficient standard errors are badly biased.

results for the continuous variables of plants' relative productivity are thus consistent with corporations divesting plants performing relatively poorly, as compared to the other operations of the acquiring corporation. The dummy variables indicating whether a plant is less or more productive than the main segments or other plants of the corporation are not statistically significant. The result suggests that the decision to divest is not explained by a plant being strictly less or more productive than the acquirer's main segments or all other plants.

Organizational capabilities measured in terms of the R&D intensity of the acquiring corporation have a significant impact on the matching outcomes. The corporations with higher R&D intensity are less inclined to divest the acquired targets. Corporation level productivity, which is the other variable proxying buyers' organizational capabilities, is negatively related to the likelihood of divestiture, but is not statistically significant. The results are consistent with the hypothesis that corporations investing more in organizational capabilities are more likely to get a "good" match. Corporation level productivity does not capture these organizational capabilities, however.

Rather interesting is that not only the R&D intensity of the buyer but also the technological distance between a target and an acquiring corporation is of importance, as indicated by the negative and statistically significant coefficient of the technological distance variable. The coefficient is larger in absolute terms and statistically more significant when the plant size variable, correlated with the technological distance variable, is excluded. The more the acquiring corporation and the acquired target differ in terms of skill intensities, the more likely is their match to end in a separation.

The segment rank is another variable proxying the expertise of the buyer in the segment of the target. The likelihood of divestiture is positively and significantly related to the segment rank within the corporation: plants acquired in relatively smaller segments are more likely to be divested. The effect is highly significant. Given that corporations are more experienced in relatively larger segments, the result implies that acquisitions in industries where corporations are less experienced are more likely to be divested.[44]

These findings are made holding plant size and industry growth constant. The incidence of divestiture decreases in the size of a target plant, which is consistent with the view that acquisitions of small plants involve uncertainty or experimentation to a larger extent. The coefficient of the variable measuring growth in aggregate manufacturing production is large and very significant, thereby suggesting that the business cycle within the manufacturing sector significantly affects the incidence of divestiture. The negative coefficient implies the likelihood of divestiture to increase in times of weaker growth in aggregate manufacturing production.

5.3 Robustness

To ensure that the results are not sensitive to the chosen length of period during which the plants are observed after acquisition, the period is extended by one year and the regressions are re-estimated.[45] The dependent variable now takes the value of one if a plant is divested within four years after acquisition and zero otherwise. The results are shown in Table 4 and are qualitatively the same as in Table 3. The only important difference is that the coefficients for variables proxying matching quality are larger and more significant. Thus, the results seem robust to smaller changes in period length.[46] The sensitivity of the results to the chosen estimation method is also examined using the random effects logit model. The results, which are not reported here, are found to be very similar to those reported in Table 3.

[44] The sales share of a segment and the real sales of a segment are used as alternative proxies, but tested to be statistically insignificant.

[45] To be able to follow the acquired plants for four years, the plants acquired in 1996 are excluded from the sample. The corporation productivity variable found to be statistically insignificant in the previous estimations is also excluded.

[46] The results are found to be robust even when the cut-off point is five years, including 641 plants acquired during the 1986-94 period.

[Table 4 here]

As already mentioned, an alternative explanation why corporations divest parts of acquired multi-plant firms is their desire to rationalize. To explore the relevance of the rationalization hypothesis, relative productivity at the end of the initial year is used as an explanatory variable and regression models are estimated separately for plants acquired as singles and plants acquired as part of multi-plant firms.[47] In addition to the main dependent variable, I also define an alternative dependent variable taking the value of one if a plant is divested during the second year and zero otherwise.[48] This variable is used to capture the determinants of divestitures that took place during the second year after acquisition when divestitures due to rationalization are expected to be more likely. If the initial productivity is found to be significant and negative for the plants acquired together with other plants, we may suspect these plants to have been divested for rationalization reasons.

Table 5 shows the estimation results for the two sub-samples. The results in columns 1 and 2 suggest that there are some differences between the two groups of plants that were divested during the second year. The initial relative productivity is negative and statistically significant for plants of multi-plant firms but not for single-plant firms. Segment rank has opposite signs for the two groups of plants. The positive sign implies divestitures of single-plant firms to be more likely in relatively smaller segments, while the negative sign indicates divestitures of plants of multi-plant firms to be more likely in relatively larger segments. The segment rank variable is statistically significant only for single-plant firms. The differences in the coefficients for initial productivity and segment rank are tested to be statistically significant

[47]It would be preferable to measure productivity before acquisition but these data are not available. The time lag between an acquisition and the observation of productivity is always less than a year, however.

[48]During the second year, 20.7 percent of the single-plant firms and 19.0 percent of the plants of multi-plant firms were divested. During the first three years, the share of divested single-plant firms and plants of multi-plant firms was 38.2 and 34.0 percent, respectively.

by interacting all variables with a multi-plant dummy in a regression for the whole sample. However, the test results in column 6 show that there are no statistically significant differences for plants divested within three years (columns 4 and 5). These results are interpreted to indicate that rationalization rather than poor matching may have been the reason for the divestitures of plants belonging to multi-plant firms during the second year after acquisition.

[Table 5 here]

The above results raise the question of whether the initial productivity or changes in productivity explain the divestitures that took place during the third year. The agency theory suggests that acquisitions undertaken by managers maximizing their own benefit lead to divestitures due to value destruction. Value destruction may be caused by poor management or lack of expertise in industries where acquisitions are made. To investigate whether the incidence of divestitures is explained by growth in target productivity, I estimate a model where matching quality is measured in terms of the growth rate in real and relative productivity.[49] The productivity growth rates can be computed for the plants kept at least until the end of the second year. I estimate the model also with initial relative productivity and relative productivity in the year before acquisition for this group of plants. The results in columns (1) and (2) show that the likelihood of divestiture is explained by the relative productivity in the year before acquisition rather than the initial productivity of the acquired plants. As can be seen from columns (3) and (4) in Table 6, however, the productivity growth variables are not significant. All other variables are statistically significant and have the expected signs.

[49]Industry-specific price deflators are used to compute real sales value. A majority of deflators are assigned at the three-digit level of the Swedish standard for industry classification (SNI69 and SNI92). Some industries with an important share of the total manufacturing production are given deflators at a more disaggregate level, while industries with smaller shares have deflators at the two-digit level.

The results do not provide evidence that the plants were divested due to productivity losses succeeding the acquisition, nor do they indicate that a "good" match implies an improvement in plant productivity.[50]

[Table 6 here]

5.4 Economic Significance

The economic significance of the previous regression models is analyzed in Table 7. Column 1 in Table 7 shows how the predicted probability of divestiture is affected by varying the variables measuring matching quality, holding all other variables at their sample means. The probability of an acquired plant being divested at the median level of relative productivity is 33.9 percent, whereas the corresponding probability for a plant with productivity at the level of the 10th percentile is 37.5 percent and at the 90th percentile 27.3 percent. The predicted probabilities are approximately equal for the different measures of plant productivity. An increase in median relative productivity by one standard deviation (from 0.92 to 1.48) and holding all other variables at their mean implies that the likelihood of divestiture decreases by 4.6 percentage points. Columns 2 and 3 show how the probability varies with the R&D intensity of the buyer and the technological distance between the buyer and the target. The predicted probabilities are very sensitive to variations in these variables, particularly to variations in the R&D intensity of the buyer. An increase in R&D intensity by one standard deviation at the median level of 4.3 (to 9.4) implies that the probability of a divestiture decreases by 9.5 percentage points.[51]

[Table 7 here]

[50] The growth rate in real and relative plant productivity is not found to be statistically significant for the extended four- and five-year periods either.

[51] A prediction with probit estimators assuming correlated residuals within panel units yields that the probability of divestiture increases by 8.2 percent.

5.5 Discussion

The empirical results show that corporations divested poorly performing assets. However, the divestitures were not explained by declining plant productivity. The decision to acquire and the interaction between a buyer and a seller that sets the price of the target were taken as given in the analysis. However, acquisitions are likely to be preceded by a selection process where the price affects the choice of the target and the buyer's expectations of target productivity. Well performing assets are priced higher and the scope for making a profit by improving the performance may be more limited compared to assets poorly matched with their present owners. Since well performing assets are unlikely to be bargains, corporations may be more cautious when acquiring assets commanding a relatively high price and therefore acquire in the industries they know best. This hypothesized selection process is a plausible explanation why relative productivity is negatively related to the incidence of divestiture, but not growth in productivity. The well performing assets are not expected to improve performance after the change in ownership like the poorly performing ones. An interpretation of the results is that the corporations divested the acquired assets when they found themselves unable to improve their prospects of or run them efficiently.

This explanation is, however, not the only one consistent with the results presented in this paper. I also find some evidence suggesting that rationalization among plants of multi-plant firms may be reason for some divestitures. During the second year after the ownership change, the corporations divested parts of the multi-plant firms that were initially performing poorly in their industries. This finding suggests that these assets may have been acquired due to some market imperfection, that is, the corporations could not choose to acquire only the plants they desired and thus rapidly resold or closed down those they had no intention to keep.

The result that corporations divest relatively less productive plants is consistent with the findings of Maksimovic and Phillips (2001). They find that multi-divisional firms are likely to sell less productive divisions as the prospects in their other industries improve and interpret the results to support the conclusion that assets change hands as their owners discover that they are not competitive in running these assets. The finding that divestitures are not preceded by decline in productivity challenges the view of Ravenscraft and Scherer (1987), Porter (1987) and Morck, Shleifer and Vishny (1990) which suggests that most acquisitions have managerial motives and are therefore *ex ante* inefficient, destroy value and end in divestitures. An important difference is that this study uses plant-level data and focuses on the short-run perspective. My analysis does not exclude the possibility of value destruction leading to divestitures being realized in the medium/long term. Nor do I exclude the possibility that managers were infected by hubris and therefore overestimated their ability to run the acquired assets as is argued by Roll (1986).

The framework of this paper suggested that targets are better matched with buyers with organizational capabilities, such as technological expertise. This conclusion is supported by the finding that the R&D intensity of the acquiring corporation has a rather large and negative impact on the likelihood of divestiture. There is ample previous empirical evidence that show R&D investments and productivity to be closely related, which suggests that corporations with higher R&D intensity may have a productive capacity that can be transferred to targets to improve their productivity. This productive capacity is not captured by the average relative productivity of the buying corporation, however. A plausible explanation is that average productivity at the corporation level is too broad a measure of the organizational capabilities, particularly in diversified firms which may consist of relatively productive main segments and less productive peripheral segments.

Another conclusion from the framework was that not only the total organizational capacities but also the relevance of the expertise of the buyer is for the target influence the prospects of a "good" match. Organizational capabilities have been found to be industry specific to some extent,[52] and diversifying acquisitions are therefore expected to imply larger uncertainty about the outcome. In the empirical work, I used two variables for proxying the relatedness of the buyer and the target. The technological distance variable capturing the similarity of the entire corporation and the target, was found to be significant. The more similar the buyer and the target in terms of skill intensity, the more likely the match was to hold. The result suggests that insufficient absorptive capacity may explain why some acquisitions end in divestitures. Another interpretation is that a good match may occur also among buyers and targets that have low skill intensity, as long as their technological levels are similar, while technologically advanced targets are less likely to become "good" matches if their buyers lack technological knowledge.

The segment rank was the other variable proxying the relevance of the organizational capabilities of the buyer for the target. In line with previous findings of Maksimovic and Phillips (2002) and Schlingemann et al. (2002), the probability of an asset sale was found to be higher in a segment ranked as more distant to the largest segment of the corporation. Smaller segments are assumed to be more distant to the core expertise of the buyer. Corporations are therefore expected to be more likely to find their expertise to be insufficient to efficiently run assets in more peripheral segments. For instance, Baldwin (1993) argues that diversifying merger process should be regarded as a substitute for entry by plant creation. It is thus one of the ways that firms enter new industries and all of these imply experimentation and bear considerable risk of failure.

[52]Maksimovic and Phillips (2002) find a strong negative relation between the rank of the segment and its productivity, which they interpreted as consistent with conglomerates being larger in the segment where they have a comparative advantage.

6 Conclusions

This paper has empirically explored the hypothesis that corporations acquire plants to experiment with their organization capabilities and divest if they find their organizational capabilities to be poorly matched with the targets. It makes a contribution to the literature on corporate assets acquisition by analyzing divestitures at the plant-level rather than at the firm-level. Previous studies have found that acquired firms are often divested. The high rates of divestitures observed in several studies have been interpreted as evidence of acquisitions, particularly diversifying ones, being ex ante inefficient and destroying value. Using plant-level data including both partial and whole firm asset acquisitions of larger corporations and viewing post-acquisition performance from a short-run perspective this paper can present evidence of divestitures of plants depending on efficiency considerations, but not being explained by productivity losses in the post-acquisition period.

I find that within three years after acquisition, the corporations had disposed of 37 percent of the acquired plants. The results show that plants that were relatively less productive in their industries and in relation to the core businesses of the buyer were more likely to be divested. While I do not have a precise benchmark for the optimal level of matching quality, the fact that the likelihood of divestiture is sensitive to the plant's productivity relative to its industry is consistent with corporations searching for matches optimizing resource allocation. These results are obtained while controlling for growth in aggregate manufacturing production and size of the plant. Growth in real or relative labor productivity is not found to explain the probability of divestiture. There is thus no evidence of value destruction in terms of declining productivity leading to divestitures, which would support the agency theory. However, this study focuses on the short run perspective, and cannot exclude the possibility of agency problems motivating acquisitions that were divested later after acquisition. Furthermore, the initial relative productivity is found to explain the likelihood of divestiture of plants belonging to multi-plant firms during the second year after acquisition. I interpret this evidence to indicate that rationalization rather than poor matching may have been a reason for these divestitures.

This paper finds that plants acquired by corporations with a higher R&D intensity were less likely to be divested. The average productivity of the buying corporation, as an alternative proxy of organizational capabilities, is not found to explain the incidence of divestitures. However, the results indicate that the more different the acquiring corporation and the acquired target were in terms of technology levels, the more likely was the match to end in a separation. The pattern is consistent with the hypothesis of corporations with larger organizational capabilities, proxied by R&D, being more likely to get a good match, but that an insufficient absorptive capacity may explain why some acquisitions end in divestitures. Furthermore, the probability of divestiture was higher in segments ranked as more distant to the largest segment of a corporation. This evidence is consistent with the view that diversifying acquisitions are more likely to end in divestitures because they involve more uncertainty about how well the organizational capabilities of the buyer match targets in industries where corporations are assumed to be less experienced. In this sense, diversifying acquisitions may be regarded one of the ways that firms enter new industries and all of these imply experimentation.

This study sheds new light on the reasons why corporations divest recently acquired assets. However, it leaves several questions unanswered. For instance, future research should examine resold assets during a longer period than one transfer of ownership to answer the following questions: Do the resold assets become better matched with their new owners? Or do they continue changing hands until they are closed down? Furthermore, for policy making reasons it might be important to analyze the long-term implications of corporate assets acquisitions. Are there any efficiency gains realized among the plants the corporations choose to keep and what explains the gains? Or is a "good" match indicated by other factors such as gains to the other plants of the acquiring corporation?

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Appendix

Table A1. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
RLP_industry	709	1.0347	.5578	.0601	3.9747
RLP_corporation	709	.8230	.5216	.0527	5.1449
RLP_main_segment	709	.7895	.5104	.0465	4.7119
Initial RLP_industry	709	1.0463	.5920	.0678	4.4179
Growth in RLP_industry	565	.0191	.3080	-.7008	3.3637
Growth in real productivity	565	.0569	.3526	-.6066	3.5292
R&D	707	.0515	.0515	0	.3453
Corporation_RLP	709	1.2206	.2221	.5556	2.2908
Plant size	709	4.2992	1.3116	1.6094	7.7736
Technological distance	691	.4338	.3167	0	.9999
Segment rank	709	3.0818	2.6546	1	17
Industry growth	709	.0176	.0343	-.052	.1188

Note: See Table 1 for definitions of variables.

Table A2. Correlation Table

		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
RLP_industry	(a)	1.0000									
RLP_corporation	(b)	0.7516	1.0000								
RLP_main_segment	(c)	0.7229	0.9635	1.0000							
Initial RLP_industry	(d)	0.9130	0.6704	0.6336	1.0000						
R&D	(e)	-0.0389	-0.0601	-0.0357	-0.0243	1.0000					
Corporation_RLP	(f)	0.0436	-0.1941	-0.2193	0.0545	0.0392	1.0000				
Plant size	(g)	-0.1058	-0.0473	-0.0424	-0.1056	0.0553	-0.0369	1.0000			
Technological distance	(h)	0.0367	0.0207	0.0007	0.0226	-0.0381	-0.0316	0.3301	1.0000		
Segment rank	(i)	0.0159	-0.1361	-0.1353	0.0215	-0.0361	0.0662	-0.1620	-0.0709	1.0000	
Industry growth	(j)	-0.0189	-0.0321	-0.0438	-0.0412	0.0791	-0.0295	0.0274	0.0655	0.1885	1.0000

Note: Number of observations 707 except for Technological distance (689 obs).

Table 1. Relative productivity of acquired plants

	Relative Productivity			
	Obs	*Mean*	*Median*	*Std. Dev.*
All acquired	*709*	*1.046*	*0.916*	*0.59*
Divested during the second year	*144*	*0.950*	*0.817*	*0.61*
Divested during the third year	*116*	*1.069*	*0.865*	*0.63*
Divested within three years (1)	*260*	*1.005*	*0.848*	*0.62*
Kept three years or longer (2)	*449*	*1.070*	*0.952*	*0.58*

Note: t-statistic for the equality of mean initial productivity of the divested (1) and the kept plants (2) is 1.48 (assuming equal variances), which is not statistically significant.

Table 2. Divested plants by segment type

	Share of plants in total number of acquired plants	*Share of Divested Plants*
	%	%
(1) *Main segment of a single-segment corporation*	*5.50*	*20.51*
(2) *Main segment of a multi-segment corporation*	*28.07*	*28.64*
(3) *Complementary segment of a multi- or single-segment corporation*	*33.99*	*39.00*
(4) *New segment*	*32.44*	*43.91*
All plants	*100*	*36.67*

Note: For definitions of segments see Section 5.1.

Table 3. Estimation results of the main model

Dependent Variable: Divestiture

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
RLP industry	-0.226 **	-0.226 **	-0.252 **	-0.223 **					
	(0.100)	(0.100)	(0.105)	(0.104)					
RLP industry dummy					-0.260 **				
					(0.116)				
RLP corporation						-0.191 *			
						(0.112)			
RLP corporation dummy							-0.070		
							(0.131)		
RLP main segment								-0.250 **	
								(0.116)	
RLP main segment dummy									-0.117
									(0.132)
R&D	-5.311 ***	-5.339 ***	-5.533 ***	-5.649 ***	-5.421 ***	-5.463 ***	-5.438 ***	-5.464 ***	-5.431 ***
	(1.789)	(1.793)	(1.797)	(1.688)	(1.782)	(1.780)	(1.795)	(1.753)	(1.780)
Corporation RLP		0.047							
		(0.350)							
Technology distance			-0.317 *	-0.553 ***					
			(0.188)	(0.178)					
Segment rank	0.062 ***	0.062 ***	0.063 ***	0.072 ***	0.061 ***	0.058 ***	0.061 ***	0.057 ***	0.060 ***
	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)
Plant size	-0.253 ***	-0.253 ***	-0.191 ***		-0.250 ***	-0.248 ***	-0.244 ***	-0.248 ***	-0.245 ***
	(0.047)	(0.047)	(0.050)		(0.047)	(0.047)	(0.046)	(0.047)	(0.046)
Industry growth	-12.527 ***	-12.500 ***	-12.131 ***	-12.056 ***	-12.589 ***	-12.596 ***	-12.618 ***	-12.519 ***	-12.561 ***
	(2.991)	(2.998)	(3.034)	(3.000)	(2.995)	(2.986)	(2.987)	(2.983)	(2.987)
Constant	0.736 *	0.687	0.674	0.046	0.615	0.655	0.484	0.714 *	0.511
	(0.400)	(0.544)	(0.406)	(0.363)	(0.383)	(0.393)	(0.380)	(0.391)	(0.380)
Number of Obs	707	707	689	689	707	707	707	707	707
Wald chi2 Statistic	125.85 ***	125.75 ***	120.10 ***	111.55 ***	125.70 ***	124.59 ***	122.72 ***	126.10 ***	123.17 ***
LL	-372.85	-372.85	-361.03	-368.53	-372.89	-373.92	-375.28	-373.03	-375.03
Rho	0.135	0.136	0.126	0.099	0.137	0.141	0.138	0.139	0.138
Likelihood Ratio Test of Rho	0.000 ***	0.000 ***	0.000 ***	0.000 ***	0.000 ***	0.000 ***	0.000 ***	0.000 ***	0.000 ***
Percent Correctly Predicted	72.7	72.9	74.0	74.0	74.5	73.3	73.6	73.6	74.1

Note: Standard errors in parenthesis.*, **, *** significantly different from zero at the 1 percent, 5 percent and 10 percent level, respectively. Rho is the proportion of the total variance contributed by the panel-level variance component. Classification as a divestiture occurs when the model's probability prediction exceeds the prior probability based upon the frequencies of divested and non-divested plants in the sample. Year dummies are included in all regressions.

Table 4. Robustness check: estimation results of longer period (divestiture within four years)

Dependent Variable: Divestiture				
	(1)	*(2)*	*(3)*	*(4)*
RLP industry	*-0.359 ****	*-0.373 ****	*-0.333 ****	
	(0.103)	*(0.108)*	*(0.106)*	
RLP industry dummy				*-0.432 ****
				(0.116)
R&D	*-5.340 ****	*-5.232 ****	*-5.188 ****	*-5.400 ****
	(1.795)	*(1.750)*	*(1.646)*	*(1.818)*
Technology distance		*-0.458 ***	*-0.638 ***	
		(0.193)	*(0.184)*	
Segment rank	*0.084 ****	*0.087 ****	*0.098 ****	*0.081 ****
	(0.024)	*(0.024)*	*(0.024)*	*(3.421)*
Plant size	*-0.242 ****	*-0.187 ****		*-0.245 ****
	(0.047)	*(0.049)*		*(0.047)*
Industry growth	*-10.236 ****	*-9.840 ****	*-9.813 ****	*-10.493 ****
	(3.413)	*(3.467)*	*(3.400)*	*(3.422)*
Constant	*2.202 ****	*2.084 ****	*1.280 ****	*1.948 ****
	(0.505)	*(0.462)*	*(0.398)*	*(0.449)*
Number of Obs	*679*	*661*	*661*	*679*
Wald chi2 Statistic	*116.28 ****	*116.48 ****	*109.91 ****	*117.80 ****
LL	*-380.62*	*-367.80*	*-375.19*	*-379.62*
Rho	*0.175*	*0.156*	*0.122*	*0.172*
Likelihood Ratio Test of Rho	*0.000 ****	*0.000 ****	*0.000 ****	*0.000 ****
Percent Correctly Predicted	*63.9*	*66.0*	*66.7*	*64.5*

Note: Standard errors in parenthesis.*, **, *** significantly different from zero at the 1 percent, 5 percent and 10 percent level, respectively. Rho is the proportion of the total variance contributed by the panel-level variance component. Classification as a divestiture occurs when the model's probability prediction exceeds the prior probability based upon the frequencies of divested and non-divested plants in the sample. Year dummies are included in all regressions.

Table 5. Robustness check: estimation results for plants of single- and multi-plant firms

	Dependent Variable					
	Divestiture during the second year			*Divestiture during the second or the third year*		
	Plants of single-plant firms	*Plants of multi-plant firms*	*Test for Significant Difference*	*Plants of single-plant firms*	*Plants of multi-plant firms*	*Test for Significant Difference*
	(1)	(2)	(3)	(4)	(5)	(6)
RLP industry initial	-0.033	-0.633 ***		-0.131	-0.265	
	(0.131)	(0.228)	(0.255) ***	(0.122)	(0.172)	(0.204)
R&D	-1.707	-0.324		-2.530	-6.966 **	
	(2.371)	(2.715)	(2.709)	(2.289)	(2.817)	(2.581)
Segment rank	0.069 ***	-0.120		0.074 ***	-0.002	
	(0.027)	(0.073)	(0.072) **	(0.026)	(0.066)	(0.059)
Plant size	-0.223 ***	-0.152 *		-0.250 ***	-0.282 ***	
	(0.069)	(0.091)	(0.105)	(0.062)	(0.088)	(0.094)
Industry growth	-8.508 ***	-19.699 ***		-12.663 ***	-13.380 ***	
	(3.557)	(4.681)	(5.469)	(4.032)	(5.297)	(6.353)
Constant	0.041 *	1.481 **		0.027 *	1.498 **	
	(0.570)	(0.787)	(0.874)	(0.535)	(0.713)	(0.773)
Number of Obs	411	296		411	296	
Wald chi2 Statistic	36.02 ***	41.02 ***		59.23 ***	69.59 ***	
LL	-188.80	-103.05		-228.90	-129.80	
Rho	0.171	0.232		0.178	0.230	
Likelihood Ratio Test of Rho	0.010 ***	0.045 **		0.000 ***	0.000 ***	
Percent Correctly Predicted	79.6	87.8		68.9	79.7	

Note: Standard errors in parenthesis.*, **, *** significantly different from zero at the 1 percent, 5 percent and 10 percent level, respectively. Rho is the proportion of the total variance contributed by the panel-level variance component Classification as a divestiture occurs when the model's probability prediction exceeds the prior probability based upon the frequencies of divested and non-divested plants in the sample. Year dummies are included in all regressions.

Table 6. Robustness check: estimation results with productivity growth variable

Dependent Variable: Divestiture

	(1)		(2)		(3)		(4)	
Initial RPL industry	-0.179							
	(0.126)							
RPL industry			-0.282	**				
			(0.135)					
Growth rate in RLP industry					-0.033			
					(0.229)			
Growth rate in real LP							0.128	
							(0.199)	
R&D	-7.544	***	-7.726	***	-7.471	***	-7.548	***
	(2.638)		(2.666)		(2.625)		(2.633)	
Segment rank	0.072	**	0.070	**	0.074	**	0.074	**
	(0.029)		(0.029)		(0.029)		(0.029)	
Plant size	-0.294	***	-0.230	***	-0.276	***	-0.280	***
	(0.065)		(0.065)		(0.063)		(0.064)	
Industry growth	-11.552	*	-11.859	*	-11.762	*	-11.194	*
	(-6.356)		(6.363)		(6.370)		(6.392)	
Constant	0.117		0.300		-0.106		-0.159	
	(0.623)		(0.635)		(0.603)		(0.605)	
Number of Obs	563		563		563		563	
Wald chi2 Statistic	80.24	***	81.32	***	79.45	***	79.31	***
LL	-222.32		-221.12		-223.35		-223.15	
Rho	0.120		0.119		0.117		0.120	
Likelihood Ratio Test of Rho	0.000	***	0.000	***	0.000	***	0.000	***
Percent Correctly Predicted	83.5		83.5		83.7		83.5	

Note: Standard errors in parenthesis.*, **, *** significantly different from zero at the 1 percent, 5 percent and 10 percent level, respectively. Rho is the proportion of the total variance contributed by the panel-level variance component. Classification as a divestiture occurs when the model's probability prediction exceeds the prior probability based upon the frequencies of divested and non-divested plants in the sample. Year dummies are included in all regressions.

Table 7. Predicted Probabilities

Probability of divestiture

	Median Level	Marginal Effect at Median Level	10th Percentile	90th Percentile
All acquisitions				
Varying RLP industry[1]	33.9	0.76	37.5	27.3
Varying RLP main segment[1]	34.1	0.61	37.5	28.3
Varying RLP corporation[1]	33.9	0.49	36.4	29.3
Varying R&D[2]	34.6	0.83	41.8	26.3
Varying technological distance[3]	31.7	0.51	37.0	27.1

Note: All other variables are held at their sample means. The marginal effect is a ten percent change in the measure.
1) Computed for the specification without technological distance variable. 2) Computed for the specification with PLP industry and without technological distance variable. 3) Computed for the specification with PLP industry and plant size.

Chapter IV

Location of R&D and High-Tech Production by Vertically Integrated Multinationals*

Karolina Ekholm and Katariina Hakkala

Abstract

We develop a two-country model where firms make separate choices about the location of R&D and high-tech production. There are two agglomeration forces: knowledge spillovers associated with R&D and backward och forward linkages associated with high-tech production. The latter tend to attract production to the larger country. We show that for weak knowledge spillovers, the smaller economy tends to specialize in R&D for intermediate levels of trade cost. For intermediate levels of knowledge spillovers, we find that there are multiple equilibria in the sense that both concentration of R&D activities in the small country and dispersion of R&D activities are possible outcomes. Specialization in R&D activities does not necessarily lead to welfare gains even if R&D is associated with relatively strong spillovers.

Keywords: monopolistic competition, R&D, high-tech production, agglomeration economies

JEL classification: F12, F23

*We thank Jim Markusen and seminar participants at the Department of Economics, University of Colorado at Boulder, and at the CEPR Conference on FDI and the Multinational Corporation in Hydra, Greece, for helpful suggestions. Financial support from Jan Wallander's and Tom Hedelius' Foundation is gratefully acknowledged.

1 Introduction

The increased globalization of the economy has generated concerns about the location of industries, especially those where firms seem to be able to shift around production on a global scale. For policy-makers, these concerns are primarily related to the potential loss of jobs from a relocation of industries and its effect on unemployment. However, as has been emphasized in the recent literature on trade and location, there are also concerns about potential welfare losses from a relocation of activities generating positive externalities (e.g. Krugman, 1991). In particular, the location of high tech industries characterized by the importance of research and development (R&D) for generating new and improved products, may be of importance for national welfare. Since the available empirical evidence suggests that R&D activities generate positive spillovers that are geographically limited in scope (e.g. Griliches, 1992 and Jaffe et al., 1993), regions that are successful in attracting R&D activities may improve their welfare.

In most economic models, R&D is simply assumed to be located with the rest of the firm's activities. An implication of this assumption is that countries with a comparative advantage in knowledge creation would also have a comparative advantage in high-tech production.[1] Figure 1 shows a plot diagram of R&D expenditures in relation to GDP, and the share of high-tech goods in total exports relative to their world-market share of exports for a number of industrialized countries. As predicted by standard theory, there is a positive correlation between these two variables (the solid line shows the fitted line from an OLS regression). However, there are some interesting

[1]Notable exceptions in this respect are papers analyzing vertically integrated multinational firms, meaning firms loctaing different stages of their production process in different countries. Helpman (1984) developed a model where firms operating under monopolistic competition could choose to locate their headquarters separately from their production plants. In a recent paper by Markusen (1997), the same possibility arises in a more general model where firms may be either vertically or horizontally integrated and where trade costs create advantages from locating production in the proximity to consumers.

outliers. For instance, Sweden, which is the country with the highest ratio between R&D expenditures and GDP, does not belong to the countries with the highest share of high-tech goods in their exports. On the opposite side, Ireland has the highest share of high-tech goods in their exports, but does not belong to the countries with the highest ratio between R&D expenditures and GDP. A common feature of these two economies is the important role of multinational enterprises (MNEs); Sweden being the home country of several large MNEs and Ireland being the host country of many MNEs originating in the US and Japan, as well as other European countries. Since a large part of total R&D is carried out by MNEs, an immediately obvious potential explanation for these two outliers is that they reflect the tendency of MNEs to concentrate their R&D activities in their home countries while producing R&D intensive goods elsewhere.[2] Traditionally, R&D activities seem to have been strongly concentrated in the parent firm, implying that R&D has primarily taken place in the home country. This tendency is often taken to be the main explanation why certain small countries, such as Sweden, with large R&D expenditures in relation to GDP do not export high-tech goods to the extent motivated by their R&D expenditures. More recently, R&D activities seem to have become more dispersed in the sense of a larger share taking place outside the firms's home countries.

The apparent geographical separation between R&D and production activities suggests that an appropriate analysis of the location choice of high-tech firms should allow for such a separation. In this paper, we develop a two-country model where firms may choose to locate their R&D activities and their production plants in separate countries. Furthermore, we allow for two different sources of agglomeration economies: knowledge spillovers associated with R&D activities and backward and forward linkages associated with the production of final goods. The backward and forward linkages arise from the combination of increasing returns to scale in production and

[2]This explanation for the case of Sweden is discussed in Hansson and Lundberg (1995).

transaction costs associated with cross-border trade. They make it beneficial for firms to locate their production of final goods in the larger market.[3] This aspect of the model is similar to recent models within the so-called "new economic geography" (see Fujita, Krugman and Venables, 1999).

Our model thus involves two different mechanisms creating incentives for the concentration of activities. However, counteracting these two centripetal forces is the effect on the return to scarce factors when R&D activities and the production of high-tech goods compete for resources. We assume that both these activities use inputs of skilled labor. The outcome in terms of the firms' location choices then depends on the interplay between the advantages of concentrating activities in order to benefit from externalities and the disadvantages of locating skill-intensive activities where skilled labor is relatively expensive.

In the paper, we focus on the location of high-tech production from a small-country perspective and assume an asymmetry between countries in terms of their sizes. We analyze how the location choices of high-tech firms are affected by the strength of pure externalities generated by R&D activities and the strength of "pecuniary" externalities generated by linkages, thereby being able to address issues related to the ambition of many small, industrialized countries of attracting high-tech production. The analysis is related to work by Markusen (1997, 2002), which shows that a small country may end up headquartering vertically integrated multinationals with production in the larger country when the smaller country is relatively skill-abundant and trade costs relatively low. A crucial difference between this analysis and that by Markusen, however, is that agglomeration economies may not only affect the location of production activities, but also that of non-production activities.

[3] The backward linkage is related to the increase in demand arising when a firm moves its production to a certain region, while the forward linkage is related to the decrease in wage costs when nominal wages fall to compensate for falling consumer prices due to reduced imports (Krugman, 1991, Fujita et al., 1999, Chapter 5).

The rest of the paper is organized as follows: In section 2, we discuss related literature on the location of high-tech industries. Section 3 presents and discusses the model, while section 4 analyzes the location choice by high-tech firms. Finally, section 5 concludes.

2 Related Literature

In an early paper, Krugman (1980) showed that the combination of increasing returns to scale and transaction costs associated with cross-border trade may generate a so-called home-market effect; a tendency for large countries to host a disproportionately large share of production. The presence of scale economies generates an incentive for firms to concentrate production in one single location and, by locating production in a large market, firms get better access to consumers. This home-market effect serves as the basis for more recent theorizing within the so-called new economic geography framework (see Fujita et al., 1999).

In related work, multinational enterprises (MNEs) have been incorporated in trade-theoretic models by adding the assumption that there exist joint inputs such as management, marketing and R&D which create multi-plant economies of scale (e.g. Markusen 1984, Horstmann and Markusen, 1992, Brainard 1993, Markusen and Venables, 2000). In these models, the location choices of MNEs crucially depend on the trade-off between the benefits from concentrating production in one location and those stemming from locating in proximity to the consumers, thereby avoiding trade costs. The MNEs arising in these models can be characterized as horizontal in the sense of producing the same final good in more than one country. However, MNEs may also be vertical in the sense of carrying out different stages of the production process in different countries. Vertical MNEs were analyzed by Helpman (1984) using a trade model with monopolistic competition, but without any trade costs. In Helpman's analysis, a skilled-labor abundant country may end up being the net exporter of headquarter services because skill-intensive headquarters activities tend to be located there.

More recently, Markusen (1997, 2002) has developed a model incorporating horizontal as well as vertical MNEs. As in the analysis by Helpman (1984), vertical MNEs arise when there are advantages in fragmenting the production process into skill-intensive headquarter activities and less skill-intensive production of the final good. However, in Markusen's analysis, the equilibrium production structure is not only determined by differences in factor proportions but also by the level of trade costs. This is important since it may be especially advantageous to locate final-goods production in the large country when trade costs create benefits from producing in proximity to the consumer.

Neither of these papers allow for the possibility that skill-intensive headquarters activities generate externalities. In the presence of such externalities, e.g., knowledge spillovers from R&D activities, the location of headquarters might be important from a welfare point of view. Knowledge spillovers may arise because firms learn from each other, for example through co-operation, by reverse-engineering each others' products or as a consequence of the turnover of highly specialized labor. Several studies have found evidence of such knowledge spillovers (e.g. Jaffe et al., 1993, Acs et al., 1992, 1994, Feldman, 1994, and Audretsch and Feldman, 1996).

In our model, we assume knowledge spillovers generated by R&D activities to be national in scope. If they were global in scope, there would be no advantages of having local R&D activities. In fact, if technological knowledge very easily diffuses across countries, it may even be beneficial to free-ride on the rest of the world by cutting back investments in R&D. However, the fact that R&D activities tend to be geographically concentrated suggests that the knowledge spillovers may be geographically limited in scope. For instance, Feldman and Audretsch (1996) find that, controlling for the degree of geographical concentration of production, innovative activity tends to cluster more in industries where knowledge spillovers play a decisive role. Moreover, Jaffe et al. (1993) provide direct evidence of geographically limited knowledge spillovers from R&D activities.[4]

Our model adds knowledge spillovers associated with R&D activities to an analysis of the location choice of firms. The firms are potentially vertical MNEs in the sense that they may choose to geographically separate their R&D activities from their production of final goods. Because we allow firms to choose to locate their R&D activities in proximity to other R&D labs in order to benefit from knowledge spillovers, the analysis is related to the literature on technology sourcing and so-called "centres of excellence". It has been argued that MNEs locate R&D in "centres of excellence" in order to source the available technology (Kogut and Chang, 1991, Neven and Siotis, 1996). This type of technological externality may interact with a home-market effect in a mutually reinforcing way. However, at the same time, if final production and R&D activities draw on the same type of resources, as is reasonable to expect when it comes to high-tech production, it may also be the case that the concentration of one type of activity raises the prices of these resources so much that the other type of activity will be located elsewhere.[5] It is the interaction between these forces that is the focus of the present analysis.

3 The Model

We assume a two-country, two-factor and two-good model to analyze the location choice by firms operating in a high-tech industry. There are two countries, Home (H) and Foreign (F), two factors of production, skilled

[4]See also work by Keller (2002).

[5]A somewhat related analysis can be found in Ekholm and Torstensson (1997), where the possibility of expanding high-tech production by means of production and R&D subsidies is analyzed assuming that both R&D and the production of high-tech goods require inputs of skilled labor.

labor (S) and unskilled labor (L), and two final goods, a homogeneous good, Y, produced with constant returns to scale in a perfectly competitive sector and a differentiated high-tech good, X, produced with economies of scale and sold in markets characterized by monopolistic competition. The supply of skilled and unskilled labor is given. Both factors of production are perfectly mobile between sectors but completely immobile between countries. The technology for producing the homogeneous good, Y, is linear and one unit of L produces one unit of Y. Production of X requires inputs of firm-specific knowledge (R), produced by R&D labs that may be located in a different country than production. Firms choosing to produce R and X in the same country become national enterprises, while firms choosing to separate R&D from production become multinational enterprises with a vertical production structure. We use n to superscript variables associated with national firms and m to superscript variables associated with multinational firms.

3.1 Technology

R&D labs produce an input transferrable across national borders but not tradable in the sense that it can be sold at arm's length to any firm. R is assumed to be directly supplied to the production plant within the same firm. A motivation for this assumption is that asymmetric information and incomplete contracting may create strong incentives to internalize R&D within the firm. However, at the same time, we assume the firms to be unable to completely internalize the benefits from their R&D. We assume the firm-specific knowledge produced by individual firms to spill over to all firms conducting R&D in the same country. More specifically, we assume the cost of inventing additional varieties in terms of inputs of skilled labor to decrease with the amount of R&D conducted in the country. The production function of a representative R&D lab is specified as follows:

$$R_{ij} = \frac{1}{\rho^g} S_{Rij}(1 + \delta \overline{R_j}), \quad \overline{R}_j = \left(\sum_{h \neq i} R_{hj} \right), \quad g = n, m, \tag{1}$$

where R_{ij} is the amount of R&D produced by firm i in country j, the sum $\overline{R}_j$ is aggregate R&D conducted in country j, and S_{Rij} the amount of skilled labor employed by firm i to carry out R&D in country j. Parameter $\rho^g \geq 1$ denotes a cost for geographically separating the production of R and X.[6] We assume that $\rho^n = 1$ and $\rho^m > 1$, which implies that there is no additional cost incurred by national firms, only by multinational firms.

The production function specified in (1) has the property of augmenting the productivity of skilled labor in a constant proportion to the number of firms conducting R&D in the country. We have thus assumed that the R&D spillovers obtained from an additional firm conducting R&D in the country is independent of the initial size of the R&D sector. Alternative assumptions could be made, i.e., increasing or decreasing productivity spillovers in the R&D sector. However, since we have no information about the specific nature of R&D spillovers, we have simply chosen to model them as being constant.

A cost-minimizing firm chooses S_{Ri}, taking the level of $\overline{R}$ as given, in order to produce the technological knowledge required to produce a variety of the high-tech product. That is, we assume that the firm takes potential knowledge spillovers into account in its location decision. For a firm to enter the market with a new variety, it must generate one unit of R. This implies the following demand for skilled labor stemming from an R&D lab located in country j:

$$S_{Rij}\left(n_j^n, n_k^m \mid R_i = 1\right) = \rho^g \left(1 - \delta + \delta(n_j^n + n_k^m)\right)^{-1} \tag{2}$$

where n_j^n is the number of national enterprises in country j and n_k^m the num-

[6]Our specification in (1) implies that transferring R from one country to another involves an "iceberg" type of cost so that $\rho \geq 1$ units must be shipped from the R&D lab for one unit of R to arrive at the production plant located abroad.

ber of multinational enterprises conducting R&D in country j and producing in country k (note that country subscripts denote the country where the firm locates its production plant). A firm deciding to conduct its R&D in the country with a larger total number of R&D labs needs to use a smaller amount of skilled labor in order to produce its own single unit of R.

The high-tech firms then employ unskilled labor (L) and skilled labor (S) to produce their final products. There are fixed costs in production, creating an incentive for concentrating final production to one country. More specifically, we assume the following cost function of a representative high-tech firm producing in region j:

$$c\left(w_{Sj}, w_{Lj}, X_{ij} \mid R_i = 1\right) = w_{Sj}^{\alpha} w_{Lj}^{1-\alpha}(\beta + \gamma X_{ij}) \tag{3}$$

where w_{Sj} and w_{Lj} are the returns to skilled and unskilled labor, respectively, X_{ij} is the level of output of the representative firm i, $\alpha \in [0, 1]$, and β and γ are positive constants.

3.2 Preferences

In modelling consumer preferences, we use the Dixit-Stiglitz specification of preferences for variety (Dixit and Stiglitz, 1977). A representative consumer has the following utility function:

$$U = (C_X)^{\mu} (C_Y)^{1-\mu}, \qquad C_X = \sum_{i=1}^{n^w} \left(c_i^{1-\frac{1}{\sigma}}\right)^{\sigma/(\sigma-1)}, \tag{4}$$

where C_X is a subutility function capturing utility derived from the consumption of different varieties of high-tech goods; c_i denotes the consumption of each available variety, $\mu \in [0, 1]$, and $n^w = n^n + n^m$ is the total number of varieties produced.[7]

[7] Following e.g. Neary (2001), we assume a finite number of varieties instead of defining the subutility function C_X over a continuum of varieties. This requires a sufficiently large number of firms for us to be able to approximate the elasticity of demand by σ (see

It is well-known that a two-stage budgeting procedure generates the following expression for demand for an individual variety i (see e.g. Fujita et al., 1999, section 4.1):

$$c_i = \frac{p_i^{-\sigma}\mu E}{P^{1-\sigma}}, \tag{5}$$

where $P \equiv \left(\sum_{j \neq i} p_j^{1-\sigma}\right)^{\frac{1}{1-\sigma}}$ is a CES price index of manufacturing products and E total expenditures.

Letting Y be numeraire, we get the following demand for Y:

$$C_Y = (1-\mu)\, E. \tag{6}$$

3.3 Profit Maximization of Firms

With symmetric firms operating in the two countries, H and F, the price index in a region j reduces to:

$$P_j = \left[\sum_g n_j^g (p_j)^{1-\sigma} + \sum_g n_k^g (\tau p_k)^{1-\sigma}\right]^{1/(1-\sigma)}, \; j = H, F, \; k = H, F, \; j \neq k, \; g = \tag{7}$$

where n_j^g is the number of high-tech producing firms in country j (superscript g denotes national or multinational). Trade in X is assumed to involve an iceberg type of transaction cost denoted by $\tau \geq 1$ (for one unit to arrive, τ units must be shipped).

First-order conditions for profit maximizing by a firm producing in country j are given by:

$$p_j\left(1 - \frac{1}{\sigma}\right) = \gamma w_{Sj}^{\alpha} w_{Lj}^{1-\alpha} \tag{8}$$

Helpman and Krugman, 1985, Chapter 6).

where σ is the price elasticity of demand. Free entry and exit and a continuous number of firms imply that in equilibrium, all active firms make zero profits. At the same time, these assumptions imply that a type of firm that is not active in equilibrium, must make negative profits. This means that we have the following complementary slackness condition:

$$\Pi_j^g \leq 0 \qquad n_j^g \geq 0 \qquad \text{and} \qquad \Pi_j^g n_j^g = 0. \tag{9}$$

Given the pricing condition (8), the profits of a national enterprise in country j are:

$$\Pi_j^n = (p_j - \gamma w_{Sj}^{\alpha} w_{Lj}^{1-\alpha})(X_{jj} + \tau X_{jk}) - w_{Sj}^{\alpha} w_{Lj}^{1-\alpha}\beta - w_{Sj}\left(1 - \delta + \delta(n_j^n + n_k^m)\right)^{-1}, \tag{10}$$

where the first subscript of X_{jj} denotes the location of the production plant and the second the market where the final good is sold. The second term in (10) represents the fixed costs in production and the third term the cost of producing one unit of R. Profits of a multinational enterprise locating production in country j but R&D in country k are given by:

$$\Pi_j^m = (p_j - \gamma w_{Sj}^{\alpha} w_{Lj}^{1-\alpha})(X_{jj} + \tau X_{jk}) - w_{Sj}^{\alpha} w_{Lj}^{1-\alpha}\beta - w_{Sk}\rho\left(1 - \delta + \delta(n_k^n + n_j^m)\right)^{-1}.$$

3.4 Equilibrium

The equilibrium conditions used to solve the model are first-order conditions, zero profit conditions (in complementary slackness form) and conditions for the clearing of factor and goods markets. To solve for the equilibrium, we use the following system of equations for $j = H, F$, $k = H, F$, $j \neq k$

$$P_j = \left[\left(n_j^n + n_j^m\right) p_j^{1-\sigma} + \left(n_k^n + n_k^m\right)(p_k\tau)^{1-\sigma}\right]^{1/(1-\sigma)} \tag{P_j}$$

$$E_j = (w_{Sj} S_j + w_{Lj} L_j) \tag{E_j}$$

$$X_{jj} = \frac{p_j^{-\sigma} \mu E_j}{P_j^{1-\sigma}} \tag{X_{jj}}$$

$$X_{jk} = \frac{(p_j \tau)^{-\sigma} \mu E_k}{P_k^{1-\sigma}} \tag{X_{jk}}$$

$$\gamma \left(w_{Sj}^{\alpha} w_{Lj}^{1-\alpha} \right) = p_j \left(1 - \frac{1}{\sigma} \right) \tag{p_j}$$

$$w_{Sj} \left(1 - \delta + \delta (n_j^n + n_k^m) \right)^{-1} + \left(w_{Sj}^{\alpha} w_{Lj}^{1-\alpha} \right) \left(\gamma \left(X_{jj} + \tau X_{jk} \right) + \beta \right) \geq p_j \left(X_{jj} + \tau X_{jk} \right) \tag{n_j^n}$$

$$w_{Sk} \left(1 - \delta + \delta (n_k^n + n_j^m) \right)^{-1} \rho + \left(w_{Sj}^{\alpha} w_{Lj}^{1-\alpha} \right) \left(\gamma \left(X_{jj} + \tau X_{jk} \right) + \beta \right) \geq p_j \left(X_{jj} + \tau X_{jk} \tag{n_j^m}$$

$$L_j = \left(n_j^n + n_j^m \right) (1 - \alpha) \left(\frac{w_{Sj}}{w_{Lj}} \right)^{\alpha} \left(\gamma \left(X_{jj} + \tau X_{jk} \right) + \beta \right) + Y_j \tag{w_{Lj}}$$

$$\begin{aligned} S_j \quad &= \quad \left(n_j^n + n_k^m \rho \right) \left(1 - \delta + \delta (n_j^n + n_k^m) \right)^{-1} \\ &\quad + \alpha \left(\frac{w_{Lj}}{w_{Sj}} \right)^{1-\alpha} \left(n_j^n + n_j^m \right) \left(\gamma \left(X_{jj} + \tau X_{jk} \right) + \beta \right) \end{aligned} \tag{w_{Sj}}$$

$$w_{Lj} \geq 1. \tag{Y_j}$$

The associated variables are given in parenthesis after each equilibrium condition. In total, this is a system of 20 equations solving for the 20 unknowns P_H, P_F, n_H^n, n_F^n, n_H^m, n_F^m, p_H, p_F, E_H, E_F, w_{SH}, w_{SF}, w_{LH}, w_{LF}, X_{HH}, X_{HF}, X_{FF}, X_{FH}, Y_H, and Y_F.

4 Analysis

In this model, the combination of increasing returns to scale and trade costs creates a home-market effect leading to a tendency for the larger country to attract the final production of the differentiated good. As in new economic-geography models with intersectorally mobile, but regionally immobile, factors, the advantages of locating increasing returns to scale production in the larger market are strongest for intermediate levels of trade costs.[8]

Because of the tendency for the final goods production of X to become concentrated in the large country, the small country may end up having an advantage in producing R&D. That is, it may be cheaper to produce R&D in the small country because skilled labor is relatively expensive in the large country where most of the skill-intensive high-tech production takes place. However, it may still be the case that R&D becomes concentrated in the large country, since there are agglomeration economies working in the R&D sector as well.

4.1 Stability of equilibria with only national firms

To begin with, note that in equilibrium, there will never be multinational firms originating in both countries. If there are incentives for firms producing in country j to conduct R&D in country k, there cannot simultaneously be incentives for firms producing in country k to conduct R&D in country j.[9]

Suppose we start from a situation with only national firms. Assuming H

[8]See e.g. Krugman and Venables (1995), and Venables (1996).

[9]Formally, if firms producing in H have incentives to locate R&D in F, the following condition must hold:

to be a smaller economy than F (i.e., H has less endowments of S and L than F), conducting R&D in F will require smaller inputs of skilled workers because the technological externality is larger. This means that there may be incentives for firms producing in H to become multinationals by instead locating their R&D activities in F. However, in order for a situation with only national firms to be an equilibrium, there cannot be any such incentives. This means that the costs of producing one unit of R must be at least as high in F as in H, which requires that the following condition holds:

$$\frac{w_{SH}}{w_{SF}} \frac{(1-\delta+\delta n_F^n)}{(1-\delta+\delta n_H^n)} \leq \rho. \tag{11}$$

If the condition in (11) is satisfied, the reduction in production costs stemming from stronger spillovers and possibly a lower return to skilled labor in the large country is not sufficient to compensate for the additional costs arising from a geographical separation between R&D and production. There are three factors affecting whether (11) holds: the relative return to skilled labor in the two countries, the relative number of firms and the strength of R&D externalities as captured by δ. If follows directly from (11) that the higher the return to skilled labor in H relative to F and the larger the number of firms in F relative to H, the higher the value of the left-hand side of the condition in (11) and the less likely it is to be satisfied. It is also clear that as long as $n_F^n > n_H^n$, a higher value of δ will increase the value of the left-hand

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$$\frac{w_{SH}}{w_{SF}} \geq \rho\varphi,$$

where $\varphi \equiv (1-\delta+\delta(n_H^n+n_F^m)) \,/\, (1-\delta+\delta(n_F^n+n_H^m))$. If firms producing in F have incentives to locate R&D in H, the following condition holds:

$$\frac{w_{SH}}{w_{SF}} \leq \frac{\varphi}{\rho}.$$

Since $1/\rho < \rho$, both conditions cannot hold simultaneously.

side of (11).[10] It follows from this that whether firms producing in the small country have incentives to locate R&D in the large country depends on the difference in size between the countries, the strength of R&D externalities and the relative return to skilled labor. While differences in size and the strength of R&D externalities are given by parameters of the model, the relative return to skilled labor is endogenously determined and, in particular, affected by the level of trade costs.

Assume that both countries produce Y so that $w_{LH} = w_{LF} = 1$ and that there are only national firms operating in the high-tech sector. Using the zero-profit condition for national firms in H in the factor-market clearing condition for skilled workers, we get the following equilibrium condition:

$$S_H = n_H^n \left[\xi_H (1 + \alpha (\sigma - 1)) + \alpha \beta \sigma w_{SH}^{\alpha - 1} \right], \tag{12}$$

where $\xi_H \equiv (1 - \delta + \delta n_H^n)^{-1}$.[11]

This condition gives us the combinations of n_H^n and w_{SH} for which the demand for skilled labor equals the fixed supply. It is shown in Figure 2 as the upward sloping broken curve.[12]. The curve is upward sloping since a larger number of high-tech firms leads to a larger demand for skilled labor and therefore a higher return to skilled labor. The level of δ affects the location of this curve so that a higher level of δ shifts the curve downwards (i.e. reduces the demand for skilled labor for a given number of firms).

{Figure 2: Goods and factor-market clearing with national firms only}

[10] We will assume that the parameter δ can take values between zero and one.

[11] See the Appendix for the derivation of the condition.

[12] The following parameter values have been used to plot the curve: $S_H = 20$, $\delta = 0.05$, $\alpha = 0.5$, $\beta = 0.1$, $\mu = 0.7$, and $\sigma = 7.5$.

In order to find the equilibrium value of n_H^n and w_{SH}, we need to ensure that goods markets clear as well. Combining the zero-profit condition with supply equals demand for a representative national firm producing in Home gives us the following equilibrium condition:[13]

$$\frac{\sigma w_{SH}^{\alpha\sigma}\left[w_{SH}^{1-\alpha}\xi_H+\beta\right]}{\mu} = \frac{(w_{SH}S_H+L_H)}{\left[n_H^n w_{SH}^{\alpha(1-\sigma)}+n_F^n\left(w_{SF}^{\alpha}\tau\right)^{1-\sigma}\right]} + \frac{\tau^{1-\sigma}(w_{SF}S_F+L_F)}{\left[n_F^n w_{SF}^{\alpha(1-\sigma)}+n_H^n\left(w_{SH}^{\alpha}\tau\right)^{1-\sigma}\right]} \quad (13)$$

This condition gives us the combinations of n_H^n and w_{SH} for which supply equals demand in the market for high-tech goods for a given number of firms and return to skilled workers in Foreign. As is evident from (13), this condition is affected by the level of trade costs. In Figure 2, there are three curves plotting this condition: one for free trade ($\tau = 1.0$), one for an intermediate level of trade costs ($\tau = 1.25$) and one for a high level of trade costs ($\tau = 2.0$).[14] The location of the curves differs depending on the level of τ.

When the home-market effect is strong, i.e. the trade cost is at an intermediate level, the return to skilled labor consistent with goods market clearing is lower for a given number of firms compared to when it is weak, i.e. the trade cost is either low or high.[15] This implies that for low and high levels of trade costs, the equilibrium price of skilled workers may be sufficiently high in Home as compared to Foreign for high-tech firms producing

[13]See the Appendix for the derivation of the condition.

[14]The following values of the additional parameters have been used: $\delta = 0.05$, $\alpha = 0.5$, $\beta = 0.1$, $\mu = 0.7$, $\sigma = 7.5$, $\gamma = 1$, $S_H = 20$, $L_H = 20$, $S_F = 40$, $L_F = 40, n_F^n = 12.79$, and $w_{SF} = 0.65$. The values of n_F^n and w_{SF} have been chosen so as to be consistent with a free trade equilibrium.

[15]This is true at least when δ is sufficiently low and the given number of firms is close to the equilibrium value. For relatively high levels of δ, however, increases in τ lead to successive downward shifts of the goods market clearing curve.

in Home to want to shift the location of their R&D activities to Foreign. For intermediate levels of trade costs, on the other hand, it is less likely that the firms will have incentives to shift the location of R&D, since the equilibrium price of skilled workers is lower. In Figure 2, the return to skilled labor in Foreign has been set to 0.65, which is the equilibrium value generated by the full model in free trade. This means that for the parameter values chosen, the return to skilled labor will actually be lower in Home than in Foreign for all three levels of trade costs (this is true for all cases where $\delta > 0$). For high-tech firms considering moving their R&D activities to the larger country, there is thus a trade-off: the amount of skilled workers they must employ will be smaller but the wage they must pay will be higher. If the technological externality is relatively small so that the former effect is weak, it may even be the case that high-tech firms producing in Foreign have incentives to move their R&D labs to the smaller country in order to take advantage of the lower costs of hiring skilled workers. If this were the case, the small country would become specialized in conducting R&D while a substantial part of actual high-tech production would take place in the large country.

4.2 Numerical Simulations

The previous section showed that for given production costs and number of firms in Foreign, there may be incentives to locate R&D in Home. Whereas the analysis shows the possibility of an equlibrium where Home is specialized in R&D activities, it does not establish that such an equilibrium will occur when wages and number of firms in Foreign are allowed to be determined endogenously. In order to solve the full model, however, we have to rely on numerical simulations.[16] Different equilibria are characterized by the different types of firms that are active (national firms located in H and F will be denoted by n_H and n_F, respectively, whereas multinational firms producing

[16]In the simulations discussed below we have used the follwing parameter values: $\mu = 0.9$, $\alpha = 0.5$, $\beta = 0.1, \gamma = 1$, $\sigma = 7.5$, $\rho = 1.1$, $S_H = 20$, $L_H = 20$, $S_F = 80$ and $L_F = 80$.

high-tech goods in H and F will be denoted by m_H, and m_F), by the pattern of specialization and the concentration of R&D activities in each of the two countries. We are mainly interested in the two parameters δ and τ, one capturing the strength of R&D externalities and the other the strength of the home-market effect (although not in a monotonic way). That is, we solve the model for different values of parameters δ and τ. With weak R&D externalities, there are weak incentives for firms to concentrate R&D activities in one of the countries. Close to free trade and autarky, the home-market effect is weak and therefore, there are only weak incentives for firms to concentrate their production activities in the large country. However, at the intermediate levels of trade costs, the home-market effect is relatively strong, which implies that firms have an incentive to locate the production of high-tech goods in the large country.

4.2.1 Location of Production and R&D

We first analyze a benchmark case with no externalities in the R&D sector, that is $\delta = 0$. This case corresponds to one of the cases analyzed by Markusen (1997), namely that countries of different size have identical relative factor endowments and trade costs are moderately high. Figure 3 shows Home's share of the total number of R&D labs and its share of total high-tech production. At free trade and high levels of trade costs, Home's share of total R&D and total high-tech production is proportional to its relative size, thereby implying that there is no specialization in either high-tech production or R&D and only national firms are active. However, at intermediate level of trade costs, the home-market effect is relatively strong, inducing a relatively large share of firms to locate their high-tech production in the large country (F). As was clear from Figure 2, this implies that the price of skilled labor tends to increase, creating a factor market reason for high-tech firms to locate R&D activities in the small country (H). Hence, for intermediate levels of trade costs, there are, in equilibrium, multinational firms producing high-tech goods in the large country, while carrying out R&D in the small country. Within this range of trade costs, the large country specializes in the production of high-tech goods, while the small country specializes in R&D.[17]

{Figure 3: Benchmark case with no R&D externalities}

Another benchmark case is one where there are R&D externalities, but no trade costs. In this case, the R&D externalities create incentives for firms to locate their R&D activities in the same country. Figures 4 and 5 show that for levels of δ close to zero, both R&D activities and production activities are spread out between the countries in proportion to their size. However, beyond a certain threshold level of δ, R&D activities tend to become concentrated in one of the countries. For the distribution of overall resources assumed in Figure 4, activities agglomerate in either of the regions beyond this threshold level, although we cannot determine in which. With larger size differences, however, a concentration of R&D activities in the large country would be the only stable equilibrium for relatively low levels of δ, since in that case, the amount of skilled labor available in the small country would not be sufficient to support the entire R&D sector. There is also an unstable equilibrium where R&D activities are conducted in both countries. It is unstable in the sense of a small perturbation of the equilibrium creating incentives for firms of different types to exit and enter, so that we end up in one of the equilibria with total concentration of R&D activities.[18]

{Figure 4: Home's share of R&D activities in a benchmark case with free

[17]With the size differences chosen in Figure 2, both countries produce the high-tech good for all levels of τ. However, with larger size differences between Home and Foreign, high-tech production may become completely concentrated in the large country.

[18]The issue of stability has been analyzed by examining whether the total costs for conducting R&D would increase or decrease for a firm moving its R&D activities from one country to another, keeping the location of production fixed.

trade}

{Figure 5: Home's share of high-tech production in the benchmark case with free trade}

In order to analyze how R&D externalities and agglomeration economies created by a home-market effect interact in determining the location structure, we look at cases where we either keep the degree of R&D externalities fixed, varying the level of trade costs, or *vice versa*. First, we choose a relative country size that does not prevent a concentration of R&D activities in the smaller country due to a resource restriction. Figure 6 shows a case where we keep R&D externalities at a constant level; a relatively low one in this particular case ($\delta = 0.01$). The R&D externalities create incentives for firms to locate their R&D activities in the same country at the same time as they have an incentive to locate production in the large country for intermediate levels of trade costs. As seen in Figure 6, at relatively low levels of trade costs, we get an agglomeration of R&D in either the large or the small country. In addition, there is an unstable equilibrium, marked by a dashed line, where R&D activities are spread between the countries. For a range of intermediate trade costs where the home-market effect is particularly strong, a concentration of R&D activities in the large country is not possible, however. In this case, both agglomeration of R&D in the small country and dispersion of R&D are stable equilibria. For relatively high trade costs, both countries will be engaged in producing high-tech products since high-tech firms are mainly producing for their domestic market. In this situation, both high-tech production and R&D are spread and there is no agglomeration of either high-tech activity.

{Figure 6: Case with moderate R&D externalities}

In Figures 7 and 8, we have assumed stronger R&D externalities ($\delta = 0.2$). As is clear from these figures, agglomeration of R&D is the outcome for all levels of τ. Once more, we cannot determine whether R&D becomes concentrated in the large or the small country, and there is an unstable equilibrium where R&D activities are spread between the countries. Irrespective of whether R&D concentrates in H or F, however, there is a tendency for F to specialize in high-tech production for intermediate levels of τ because of the home-market effect (see Figure 8).

{Figure 7: Home's share of R&D for relatively strong R&D externalities}

{Figure 8: Home's share of high-tech production for relatively strong R&D externalities}

Figure 9 shows Home's share of R&D activities in the case where we keep trade costs fixed at a level where the home-market effect is especially strong and let the parameter δ vary. From Figure 3, we know that we should find an equilibrium where the small country specializes in R&D activities and the large country in high-tech production for low levels of δ. This is also what we find in Figure 9. For high levels of δ, we find an agglomeration of R&D activities in either country and an unstable equilibrium with R&D activities spread out, just as would be expected from Figure 7. Within a certain range of δ, however, we now have a case of multiple equilibria in the sense of both concentration and dispersion of R&D being possible. R&D may be concentrated in the small country or may become spread out to both countries. However, it cannot become concentrated in the large country because the home-market effect creates a tendency for high-tech production to be located in the large country, which puts upward pressure on the return to skilled labor there. Only if R&D spillovers are sufficiently strong, the advantages of locating R&D in proximity to other R&D labs in the large country outweigh the disadvantage of incurring higher costs for inputs of skilled labor.

{Figure 9: Home's share of R&D for strong home-market effect}

{Figure 10: Home's share of high-tech production for strong home-market effect}

From Figure 10, which shows Home's share of high-tech production, we see that for a sufficiently high level of δ, the small country may produce high-tech goods even when R&D activities are completely concentrated there. The reason is that high levels of δ are associated with relatively low demand for skilled labor from the R&D sector. This means that the return to skilled labor in the smaller country becomes sufficiently low for some firms to find it profitable to produce high-tech goods in the smaller market.

4.2.2 Product Variation and Welfare

The Dixit-Stiglitz specification of preferences implies that a higher degree of product variation reduces the price index and the cost of attaining a given level of utility. Welfare thus increases in the number of varieties produced. The price index is also affected by the level of trade costs; both directly and through the effect on the share of imported goods. Due to the effect of the share of imports on the price index, the per capita utility tends to be higher in the large country (except in the limiting case where trade is completely costless). This effect may be even stronger when there are R&D externalities if R&D agglomerates in the small country, since the share of imports of high-tech goods from the large country will then be even higher.

The effect on welfare can be assessed by calculating per-capita utility according to the following expression:

$$u_j = \frac{\mu^{\mu}(1-\mu)^{(1-\mu)}(w_{Sj} + w_{Lj})}{P_j^{\mu}}. \tag{14}$$

In order to assess the welfare implications, we first analyze the degree of product variation associated with different equilibria. When there are no R&D externalities at all, the number of produced varieties only varies marginally with changes in trade costs. The degree of product variation is highest in free trade and autarky and lowest for intermediate levels of trade costs where the resources spent on shipping the high-tech good reduce the resources available for developing varieties. However, when there are R&D externalities, the degree of product variation will depend on the location of R&D activities. Product variation tends to be larger when R&D is agglomerated than when it is dispersed and it is larger when it is agglomerated in the large country than when it is agglomerated in the small economy. However, as shown in Figure 11, it is possible that the degree of product variation is higher when R&D agglomerates in the smaller country. This occurs when R&D externalities are relatively strong ($\delta = 0.2$) and trade costs are such that the home-market effect is strong. In this case, there are especially strong incentives for firms to locate their production of high-tech goods in the large country, leading resources to be freed up in the small country to conduct more R&D. More R&D leads to more varieties, and therefore the degree of product variation is the highest in such a situation.

{Figure 11: The degree of product variation for relatively strong R&D spillovers}

Now, we use equation (14) to analyze the level of per-capita utility in both countries in the different equilibria. Figure 12 shows the case where there are relatively strong spillovers ($\delta = 0.2$). Naturally, welfare is at a generally higher level as compared to the case without spillovers. Furthermore, irrespective of where R&D ends up being concentrated, Foreign's welfare is higher than Home's for all levels of τ but the free trade level. However, whether the welfare of a particular country is higher in one type of equilibrium as compared to another depends crucially on the level of trade costs. As shown by the location of the curves in Figure 12, for relatively low levels of τ, welfare is the lowest in Home and the highest in Foreign when R&D activities are concentrated in Home. For relatively high levels of τ, on the other hand, it is the other way around, welfare is the highest in Home and the lowest in Foreign when R&D activities are concentrated in Home.

The concentration of R&D activities in one country frees up resources for high-tech production in the other country, thereby leading to a relatively low import share and lower consumer prices. The country that carries out all the R&D activities, on the other hand, suffers from being able to produce less domestic varieties of the high-tech good, thereby having a relatively high import share and high consumer prices. Thus, in this setting, becoming specialized in R&D activities is not necessarily associated with welfare gains. As shown in Figure 12, a country suffers a welfare loss from being specialized in R&D activities for low and intermediate levels of trade costs.[19]

At the same time, the concentration of R&D activities in one country puts upward pressure on the return to skilled labor in that country. Apart from having a positive effect on income, this also makes it more costly to separate R&D activities from production, since these costs are incurred in terms of skilled labor. When the home-market effect is relatively strong, this effect is outweighed by the strong incentives for producing high-tech goods

[19]The exception to this is at the free trade level, where the country hosting an agglomeration of R&D will have a higher return to skilled labor. In this case, there will co-existence of national firms and multinational firms with R&D activities in one country. Since the fixed costs for conducting R&D are higher for the multinational firms than for the national firms (because of the separation cost ρ), the costs associated with plant production must be lower for the multinationals in order for the zero profit conditions for both types of firms to be satisfied. This implies that the return to skilled labor in the country where the multinational firms carry out their plant production has to be lower than in the country where they carry out their R&D. As is evident from Figure 12, however, the difference in per-capita utility is very small.

in the larger Foreign for firms with R&D activities in Home. However, when the home-market effect is relatively weak, as it is for high trade costs, the higher costs associated with the multinational strategy changes the composition of high-tech production so that relatively more production takes place in Home and relatively less in Foreign. The consequence of this is lower consumer prices in Home and higher in Foreign, which is why, for higher levels of τ, Home's welfare tends to be higher and Foreign's lower when R&D is concentrated in Home.[20]

{Figure 12: Welfare for relatively strong R&D spillovers}

The result that specialization in R&D may be associated with a welfare loss is worth emphasizing. This welfare loss occurs even though the externality associated with R&D activities has been assumed to be purely national in scope in the sense of one firm's R&D activities only affecting other firms with R&D located in the same country. It is the interaction with the pecuniary externality stemming from backward and forward linkages that generates this result. Since there are two activities generating externalities at the same time as they are competing for resources, the outcome in terms of welfare depends on the relative strength of welfare improving effects generated by the two types of externalities. Part of the benefit from R&D spillovers is global since they generate increased product variety, benefitting both countries. The effect that is purely national is to raise wages of skilled labor in the country where R&D concentrates. This then has to be weighed against the effect on

[20]We have also analyzed the welfare implications of different equilibria at moderate R&D externalities ($\delta = 0.01$). Product variation is then smaller when R&D concentrates in Home (as it only does for low/intermediate trade costs). However, Home's per-capita utility is the highest in the equilibrium in which R&D is concentrated in Home for relatively low trade costs. In this equilibrium, there is only one type of firm: multinational firms producing in Foreign and conducting R&D in Home. The positive effect of an upward pressure on wages for skilled labor in Home from the concentration of R&D activities outweigh the negative effect on the price index from having to import all varieties. At higher trade costs, however, the latter effect dominate and Home's welfare is higher when R&D activities are dispersed.

consumer prices stemming from producing a smaller share of the high-tech products domestically. Depending on the strength of R&D spillovers and the level of trade costs, Home may either lose or gain from becoming specialized in R&D activities.

4.2.3 Relative Size

The relative size of countries may affect the results obtained above. In particular, an important issue is how the strength of the home market is affected as countries become more symmetric in size. Above, we showed that for moderate R&D externalities and the level of trade costs creating a strong home-market effect, R&D activities can only be concentrated in the small country. When R&D externalities are stronger or trade costs are lower, however, a concentration of R&D activities in the large country becomes possible. This suggests that externalities in the R&D sector can partly offset the home-market effect. However, Figure 8 showed that even when strong R&D externalities are involved, the larger country tends to specialize in the production of high-tech goods, which makes it possible to find an equilibrium where a small country conducts all R&D.

In order to analyze how the location pattern is affected by changes in relative size, we solve the model by varying Home's share of a fixed total supply of S and L and keeping the level of trade costs and externalities constant. Figure 13 shows the case with a strong home-market effect ($\tau = 1.2$) and moderate externalities ($\delta = 0.01$). We find the same type of equilibria as shown in Figure 6. Within an interval where Home's share of overall resources is between around 0.2 and 0.4, there are three equilibria: one in which the share of R&D activities is equal to relative country size, one in which R&D tends to concentrate in the smaller country, and one (unstable) in which R&D activities are spread out disproportionately between the countries. When Home's share of overall resources is lower than 0.2, we find that the only stable equilibrium is the first one; the one in which the share of R&D

activities corresponds to relative country size. Within this interval, Home is not sufficiently large to host all R&D activities and therefore, there will not be a concentration of R&D activities, although there are incentives to locate R&D in the smaller country. When Home's share of overall resources is higher than 0.4, we find an additional equilibrium in which Home's share of R&D activities is small. Throughout the range in which Home's relative size is above 0.2, an equilibrium with R&D concentrated in Home is a stable equilibrium.[21] Thus, in order for such an equilibrium to be possible, Home cannot be too small in relation to the rest of the world.

{Figure 13: Relative country size and equilibria with moderate externalities}

5 Conclusions

This paper has analyzed location choice by firms operating in a high-tech sector on the assumption that there are two sources of agglomeration economies: knowledge spillovers from R&D activities and backward and forward linkages between workers and firms. These two sources generate agglomeration economies affecting the choice of locating R&D differently from the choice of locating high-tech production. The pecuniary externality in the form of linkages creates incentives for high-tech firms to concentrate production in the larger economy, while the technological externality creates incentives for firms to locate R&D labs in proximity to other R&D labs. Because skilled labor is assumed to be used in both production and R&D, the tendency for production activities to concentrate in the large country, thereby putting upward pressure on the return to skilled labor, implies that at the same time,

[21]In the case with strong externalities ($\delta = 0.2$), a concentration of R&D activities can occur in Home at a relative country size equal to around 0.1. For a higher share, the equilibria are the same as in Figure 7.

there may be advantages associated with locating R&D in the small economy. When trade costs are such that the pecuniary externality is particularly strong while the technological externality is not too weak and not too strong, we get multiple equilibria: in one equilibrium, R&D activities are completely concentrated in the smaller economy and in another, they are spread out between countries. With strong R&D spillovers, R&D becomes concentrated in either country.

We also compare different outcomes with respect to the degree of product variation and welfare. The most beneficial case for the large country from a welfare point of view may be when R&D is concentrated in the small country. In this case, resources are freed up for the production of high-tech goods in the large country. Because the consumer price index increases with the share of imported products, this means that real income tends to be higher than when these resources are spent conducting R&D. For the small country, it may for similar reasons be beneficial to have R&D activities concentrated in the large country. Being specialized in R&D activities tends to draw resources from the production of high-tech products and with a larger import share, consumer prices tend to be higher. The opposing effect is an upward pressure on wages of skilled labor, which leads to higher incomes and to the multinational strategy to become more costly, thereby inducing more domestic production. However, when R&D externalities are relatively strong, this effect is only sufficiently strong to outweigh the negative effect on consumer prices for relatively high trade costs. In this analysis, it is thus not necessarily welfare improving for a country to specialize in R&D activities, even though these activities are associated with externalities that are national rather than global in scope.

The possibility of having R&D concentrated in a small country fits in well with the observation that small, skill-labor abundant countries such as Sweden and Finland are among those with the highest R&D expenditures as a share of their GDP, but not necessarily among those most specialized in high-tech production. In particular in the case of Sweden, it seems clear that the focus on R&D activities is related to Sweden being the home country of many MNEs operating in the high-tech sector and conducting R&D at home, but carrying out a substantial part of their actual production in the large OECD economies.

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A Appendix

Derivation of equilibrium condition (12)

Assume that both countries produce Y so that $w_{Lj} = w_{Lk} = 1$ and only national firms are operating. For country j, supply equals demand for skilled labor when:

$$S_j = n_j^n \left[\left(1 - \delta + \delta n_j^n\right)^{-1} + \alpha \left(w_{Sj}\right)^{\alpha - 1} \left(\gamma \left(X_{jj} + \tau X_{jk}\right) + \beta\right) \right]. \tag{15}$$

The equilibrium price of a differentiated good is given by the first-order condition for profit maximization, which for a good produced in j can be written as:

$$p_j = \frac{\sigma \gamma w_{Sj}^{\alpha}}{\sigma - 1}. \tag{16}$$

Subtracting marginal costs for both sides gives us:

$$p_j - \gamma w_{Sj}^{\alpha} = \frac{\gamma w_{Sj}^{\alpha}}{\sigma - 1}. \tag{17}$$

Using this in the expression for total profits of a national firm yields:

$$\Pi_j^n = \frac{\gamma w_{Sj}^{\alpha} \left(X_{jj} + \tau X_{jk}\right)}{\sigma - 1} - w_{Sj} \left(1 - \delta + \delta n_j^n\right)^{-1} - \beta w_{Sj}^{\alpha}. \tag{18}$$

Setting profits to zero yields:

$$\frac{\gamma w_{Sj}^{\alpha} \left(X_{jj} + \tau X_{jk}\right)}{\sigma - 1} = w_{Sj} \left(1 - \delta + \delta n_j^n\right)^{-1} + \beta w_{Sj}^{\alpha}. \tag{19}$$

Solving for $X_{jj} + \tau X_{jk}$ gives us:

$$X_{jj} + \tau X_{jk} = \frac{\sigma - 1}{\gamma} \left[w_{Sj}^{1-\alpha} \left(1 - \delta + \delta n_j^n\right)^{-1} + \beta \right]. \tag{20}$$

Substituting $X_{jj} + \tau X_{jk}$ in (15) for the right-hand side of (20) gives us:

$$S_j = n_j^n \left[\left(1 - \delta + \delta n_j^n\right)^{-1} + \alpha \left(w_{Sj}\right)^{\alpha-1} \left[(\sigma - 1) \left[w_{Sj}^{1-\alpha} \left(1 - \delta + \delta n_j^n\right)^{-1} + \beta \right] + \beta \right] \right]. \tag{21}$$

Simplifying this expression yields:

$$S_j = n_j^n \left[\left(1 - \delta + \delta n_j^n\right)^{-1} \left(1 + \alpha \left(\sigma - 1\right)\right) + \alpha\beta\sigma \left(w_{Sj}\right)^{\alpha-1} \right], \tag{22}$$

which corresponds to expression (12).

Derivation of equilibrium condition (13)

Assume once more that both countries produce Y so that $w_{Lj} = w_{Lk} = 1$ and that only national firms are operating. The condition that supply equals demand for a differentiated good produced in country j is given by:

$$X_{jj} + \tau X_{jk} = \mu p_j^{-\sigma} \left[\frac{E_j}{P_j^{1-\sigma}} + \frac{\tau^{1-\sigma} E_k}{P_k^{1-\sigma}} \right]. \tag{23}$$

Substituting p_j in (23) for the equilibrium price in (16) gives us:

$$X_{jj} + \tau X_{jk} = \mu \left(\frac{\sigma \gamma w_{Sj}^{\alpha}}{\sigma - 1} \right)^{-\sigma} \left[\frac{E_j}{P_j^{1-\sigma}} + \frac{\tau^{1-\sigma} E_k}{P_k^{1-\sigma}} \right], \tag{24}$$

which can be rewritten as:

$$X_{jj} + \tau X_{jk} = \frac{\mu}{w_{Sj}^{\alpha\sigma}} \left(\frac{\sigma - 1}{\sigma \gamma} \right)^{\sigma} \left[\frac{E_j}{P_j^{1-\sigma}} + \frac{\tau^{1-\sigma} E_k}{P_k^{1-\sigma}} \right] \tag{25}$$

Substituting the left-hand side of (25) for $X_{jj} + \tau X_{jk}$ given by the zero profit condition in (20), gives us:

$$\frac{\sigma - 1}{\gamma} \left[w_{Sj}^{1-\alpha} \left(1 - \delta + \delta n_j^n\right)^{-1} + \beta \right] = \frac{\mu}{w_{Sj}^{\alpha\sigma}} \left(\frac{\sigma - 1}{\sigma \gamma} \right)^{\sigma} \left[\frac{E_j}{P_j^{1-\sigma}} + \frac{\tau^{1-\sigma} E_k}{P_k^{1-\sigma}} \right], \tag{26}$$

which can be rewritten as:

$$\frac{(\sigma-1)^{1-\sigma}\sigma^{\sigma}\gamma^{\sigma-1}}{\mu}w_{Sj}^{\alpha\sigma}\left[w_{Sj}^{1-\alpha}\left(1-\delta+\delta n_j^n\right)^{-1}+\beta\right]=\left[\frac{E_j}{P_j^{1-\sigma}}+\frac{\tau^{1-\sigma}E_k}{P_k^{1-\sigma}}\right]. \tag{27}$$

Using the expression for the equilibrium price in (16), we get the following expression for the CES price index in country j:

$$P_j^{1-\sigma}=\left(\frac{\sigma\gamma}{\sigma-1}\right)^{1-\sigma}\left[n_j^n\left(w_{Sj}^{\alpha}\right)^{1-\sigma}+n_k^n\left(w_{Sk}^{\alpha}\tau\right)^{1-\sigma}\right]. \tag{28}$$

Noting that E_j is given by $w_{Sj}S_j+L_j$ and using the expression for the CES price index above, gives us the following equilibrium condition for country j:

$$\frac{\sigma w_{Sj}^{\alpha\sigma}}{\mu}\left[w_{Sj}^{1-\alpha}\left(1-\delta+\delta n_j^n\right)^{-1}+\beta\right]=$$
$$\frac{(w_{Sj}S_j+L_j)}{\left[n_j^n\left(w_{Sj}^{\alpha}\right)^{1-\sigma}+n_k^n\left(w_{Sk}^{\alpha}\tau\right)^{1-\sigma}\right]}+\frac{\tau^{1-\sigma}(w_{Sk}S_k+L_k)}{\left[n_k^n\left(w_{Sk}^{\alpha}\right)^{1-\sigma}+n_j^n\left(w_{Sj}^{\alpha}\tau\right)^{1-\sigma}\right]}, \tag{29}$$

corresponding to condition (13) in the text.

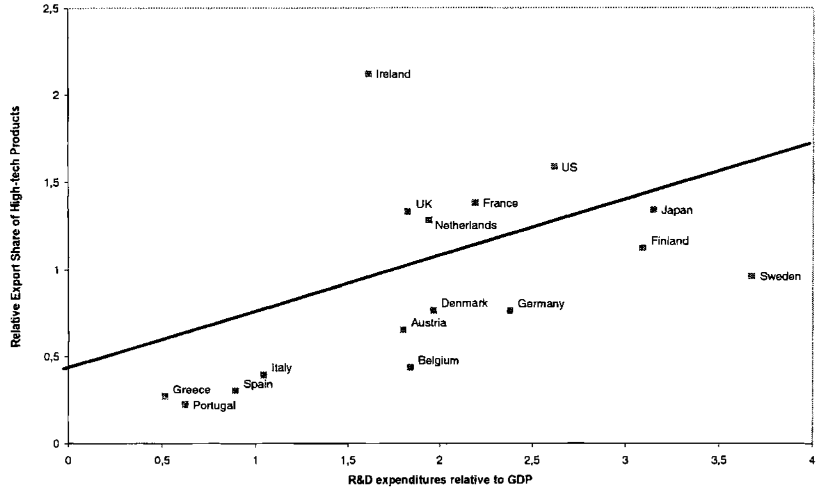

Figure 1: R&D expenditures and exports of high-tech products. (Sources: IFS (world market shares of exports), EU (export shares of high-tech goods) and IMD (R&D)).

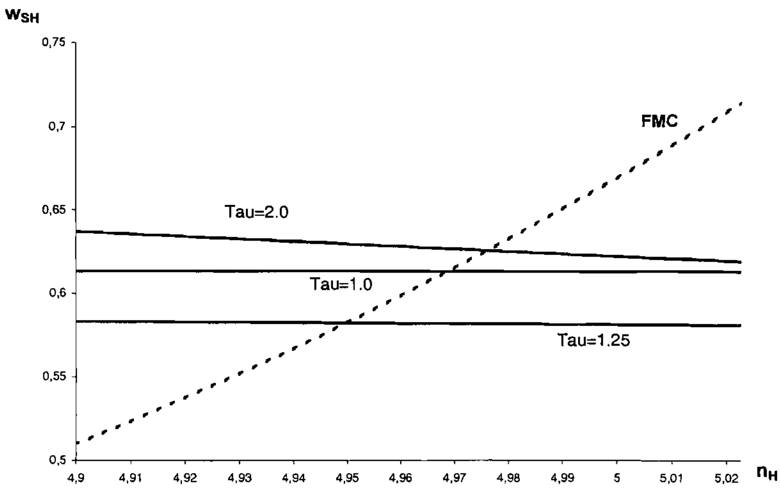

Figure 2: Goods and factor market clearing with national firms only.

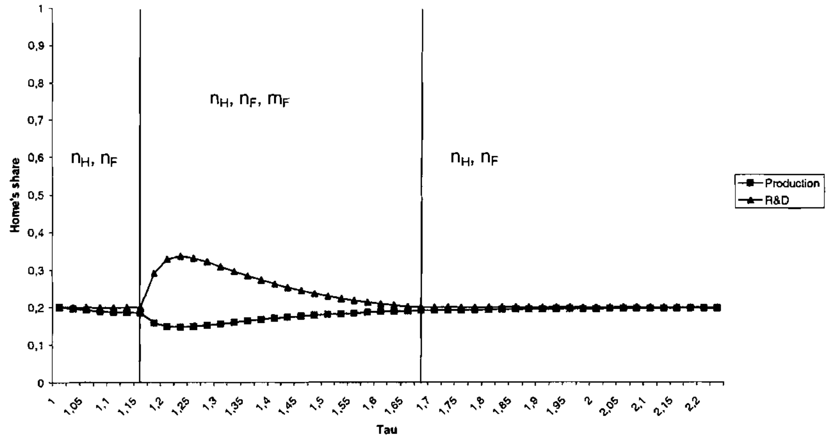

Figure 3: Benchmark case with no R&D externalities.

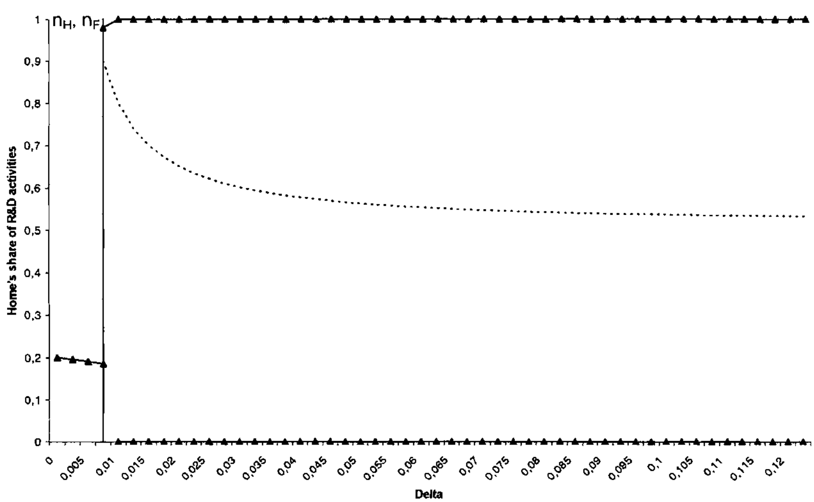

Figure 4: Home's share of R&D activities in a benchmark case with free trade.

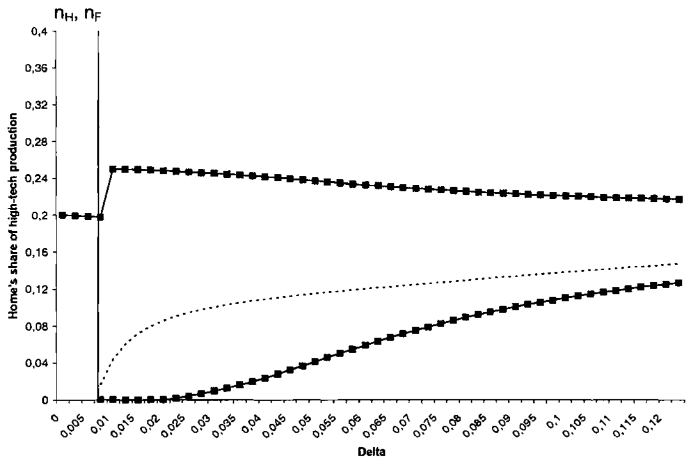

Figure 5: Home's share of high-tech production in a benchmark case with free trade.

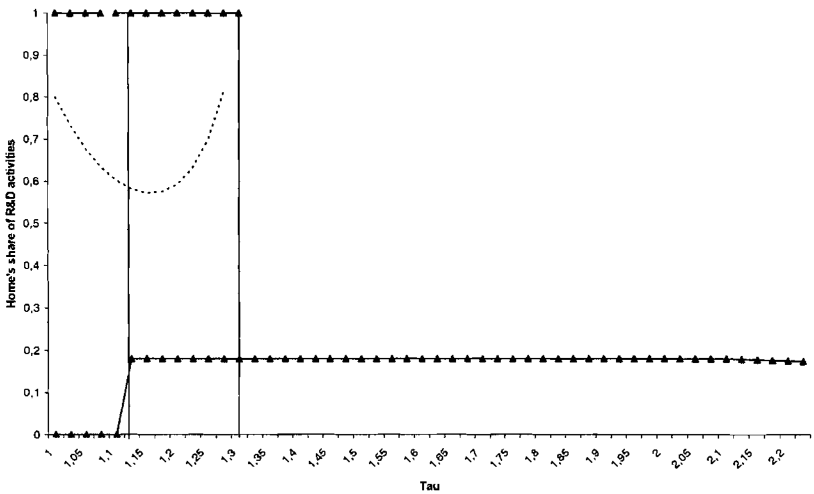

Figure 6: Home's share of R&D activities for moderate R&D externalities ($\delta = 0.01$).

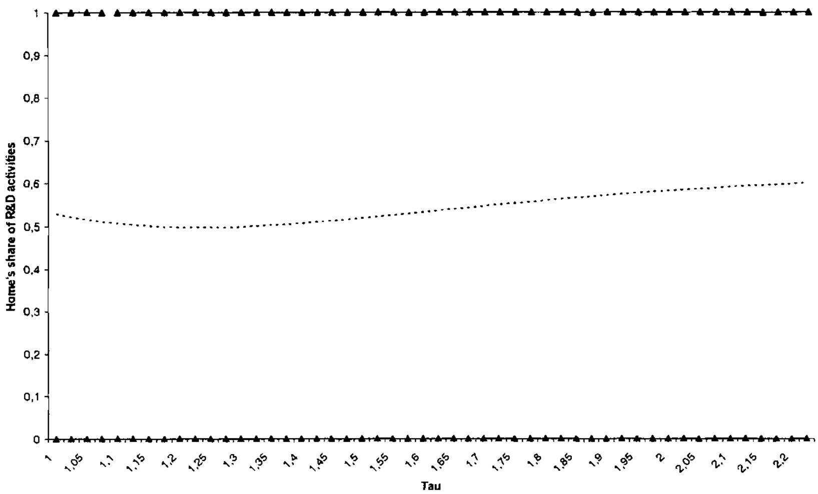

Figure 7: Home's share of R&D for relatively strong R&D externalities ($\delta = 0.2$).

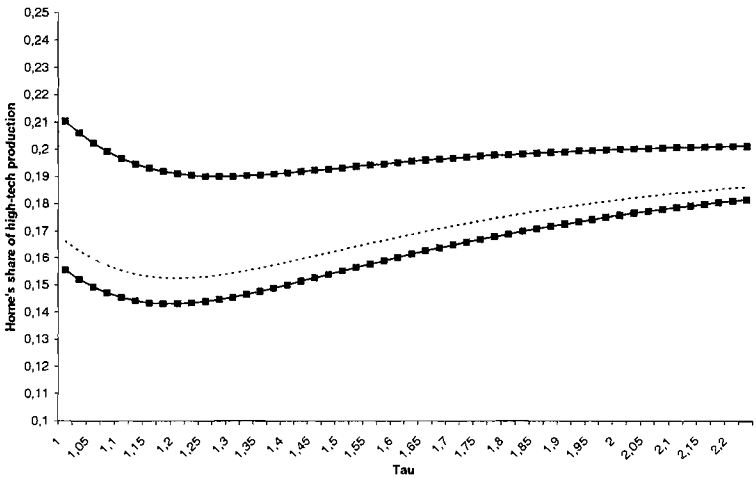

Figure 8: Home's share of high-tech production for relatively strong R&D externalities ($\delta = 0.2$).

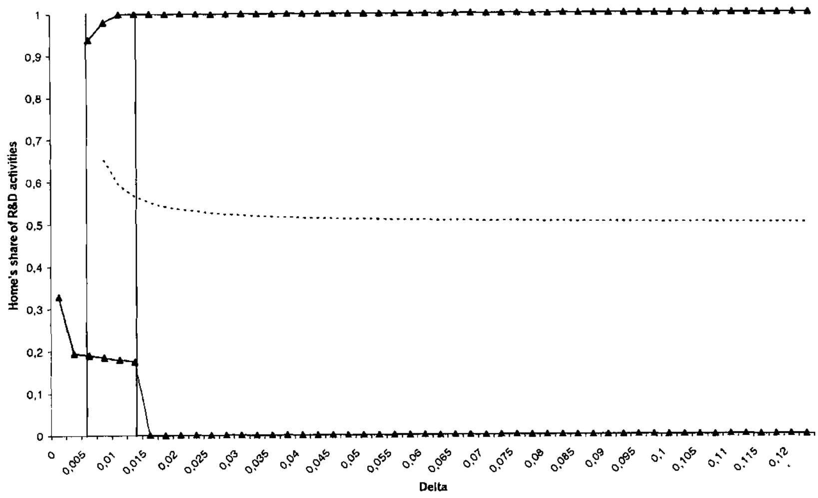

Figure 9: Home's share of R&D for a strong home-market effect ($\tau = 1.2$).

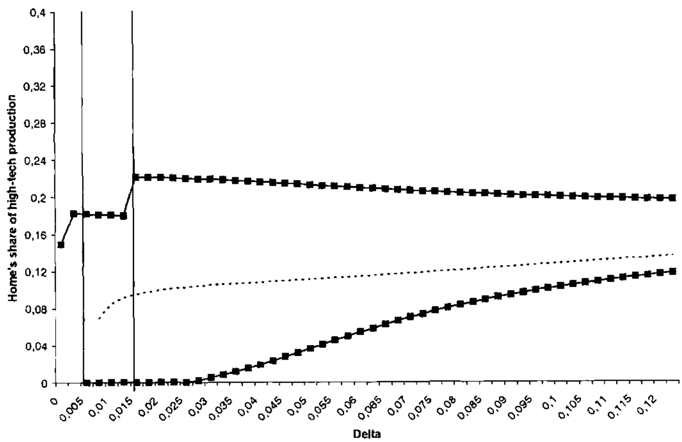

Figure 10: Home's share of high-tech production for a strong home-market effect ($\tau = 1.2$).

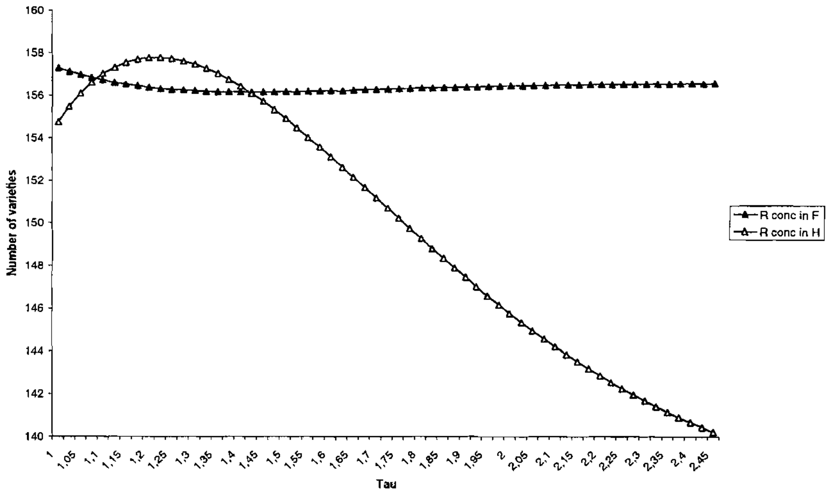

Figure 11: The degree of product variation for relatively strong R&D externalities ($\delta = 0.2$).

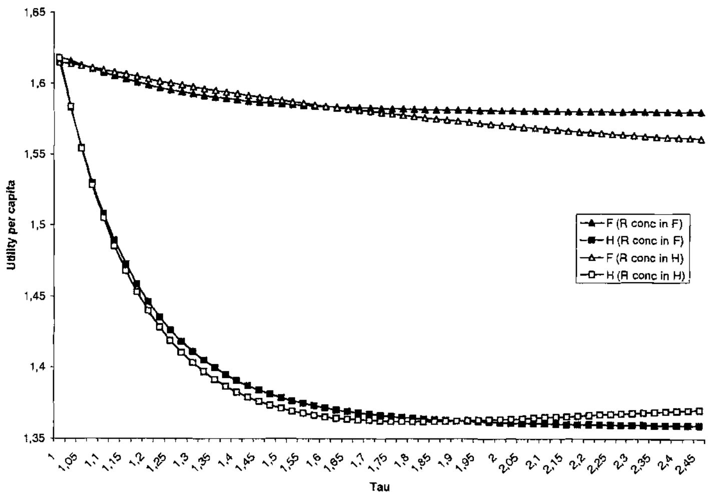

Figure 12: Welfare in the case with strong R&D externalities ($\delta = 0.2$).

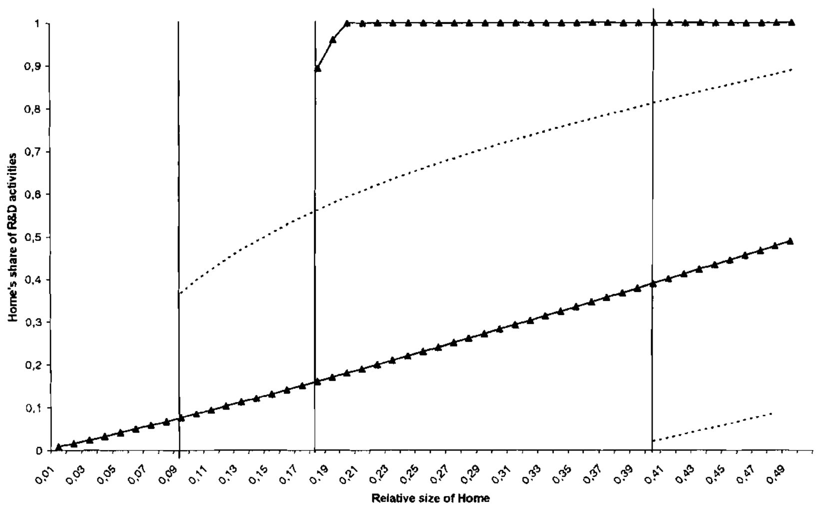

Figure 13: Relative country size and equilibria with moderate externalities.

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