Foreign Direct Investment, Host Country Characteristics, and Spillovers

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Foreign Direct Investment, Host Country Characteristics, and Spillovers

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THE ECONOMIC
RESEARCH INSTITUTE

A Dissertation for the
Doctor's Degree in Philosophy,
Stockholm School of Economics 1992

ISBN 91 - 7258 - 342 - 8

Key Words

Foreign Investment
Multinational Companies
Technology Transfer
Spillovers
Competition
Mexico

Graphic Systems AB, Stockholm 1992

Distributed by:
EFI, Stockholm School of Economics,
Box 6501, 113 83 Stockholm, Sweden.
Stockholm 1992

To be continued ... ?

PREFACE AND ACKNOWLEDGEMENTS

The available empirical evidence suggests that prefaces are the most carefully read parts of most dissertations. Friends and family seldom have the patience to labor through hundreds of pages of incomprehensible academic gibberish - unless, of course, they suffer from insomnia - but they may be eager to know where the author spent the last few years. Busy colleagues seldom have much spare time to spend on non-fiction that is irrelevant for their own research - besides, they may feel that they've already heard the punch lines at the department's seminars or around the coffee table - but they eagerly await the preface to find out what it says between the lines. The few friends and colleagues who work in the same field as the author have, in addition to the above, also been bored stiff by incomplete draft versions: their only meager reward may be found on the first few pages. The potential reader who doesn't know the author, finally, may wish to check if they recognize somebody who has read the manuscript before they decide whether to take the book seriously.

The preface is therefore the ideal place for summarizing the main findings and conclusions of any dissertation, and I will shortly return to an abstract, but I must first acknowledge my indebtedness to all the people who have taken part in the long process that has culminated in the completion of this book. However, my reasoning and my arguments have not always progressed linearly, and earlier (often remarkably incomplete) versions of this thesis have focussed on topics as disparate as *The Nationalism in Sibelius' Music, The Rybczynski Theorem, The Bucharest Principle, Mudharaba Financing, Islamic Capital Market Equilibria, Exchange Auctioning in Zambia, Thai Service Industries,* and *Politics as a Determinant of Finnish Growth and Convergence*. Elements of all these drafts remain in the final version, but none of the people mentioned below has had the opportunity to correct all of the fallacies, inconsistencies, and misunderstandings that I've picked up along the way. I alone am responsible for the errors and shortcomings that are left in spite of the efforts of colleagues, friends, and mentors.

The first in the long line of those to be thanked is my thesis advisor Magnus Blomström, who has made the greatest contribution to the present work. Not only has he provided many ideas, much of the data, and opportunities to meet interesting people, but he has also taken the time to read everything I've been able to come up with, and has managed to purge the thesis of much of the dead weight from earlier unsuccessful versions. I erased dos Santos and Sunkel, Amin, Abu Muslim, and Zambia, a lot of ifs, buts, and maybes, and almost all references to Bangkok's Pink Panther Club from the final version, and I think that the result is all the better for it. Jan-Erik Vahlne and Lennart Hjalmarsson, my other two thesis advisors, have read drafts of the manuscript, and their comments have contributed greatly to the presentation. In practice, Mario Zejan has also acted as an advisor, and his many comments and contributions have been very helpful. Furthermore, I would like to thank Mats Lundahl, who detected a grave error in a late version of the manuscript and suggested an elegant solution to the problem, for his loyal support and for offering me the opportunity to pursue my research at the Stockholm School of Economics.

Ronald Findlay read most of the manuscript, made sure that I interpreted him correctly, and offered very helpful suggestions on a multitude of matters. Robert Lipsey, Ed Wolff, and Mark Spiegel commented on early versions of some of the chapters, and their criticism proved to be quite useful. Lance Taylor took the time to discuss my scattered thoughts when they were still embryonic, and wisely suggested that some approaches might be less fruitful than others. Similarly, Renato Aguilar offered many valuable suggestions and comments on econometric and statistical techniques, which saved me from much stochastic searching in handbooks and textbooks. Sune Karlsson was also willing to discuss my statistical problems whenever my random walks took me to his doorway.

The seminars and more informal discussions at the Department of International Economics and Geography have yielded many constructive comments. In addition to

those who have already been thanked, I'm grateful to Thomas Andersson, Jonas Björnerstedt, Jan Bojö, Claes-Fredrik Claeson, Tore Ellingsen, Gun Eriksson, Lena Moritz, Per Ronnås, Örjan Sjöberg, Joakim Stymne, Stefan de Vylder, Zhang Gang, and the other participants for very useful comments and suggestions. I also appreciate their contributions to a very agreeable working environment. Udo Zander deserves thanks for providing some weighty reference material. The international economics seminars at Lund University have also earned a word of appreciation: the frank but well-meaning discussions of various colleagues' manuscripts left lasting impressions and provided many useful insights into scientific method and academic life.

Siv Andersson has drawn the figures and Bill Harris has cleansed the manuscript of the worst linguistic errors, thus improving both the form and content of the book. Carin Blomkvist and Lilian Öberg have made sure that everything has worked. Rune Castenäs has solved numerous practical problems, many of which I was not even aware of, and helped to secure the funds that kept me off the streets and allowed me to concentrate on research. Svenska Bankforskningsinstitutet and SAREC have generously financed the study.

Last but not least, many thanks are due to family and friends, for inspiration, support, and encouragement. My parents and brother might have wondered what I was doing - and above all why - but they never questioned my conclusions. In addition to their unfailing support, Eija and Taisia also accepted that I was only home during the weekends, although they complained about my elephant noises at five o'clock Monday mornings, when I was tramping around getting my things together before I rushed for the first train to Stockholm. Moreover, they took care of an unfairly large share of everything that just had to be done - I promise, one day I too will vacuum and take care of the laundry. I am also grateful to Thomas Andersson, Jan Bojö, Lena Ekelund, Anders Danielsson, Elias Kazarian, Rosemary Vargas-Lundius, and Mario Zejan, who provided great examples and had the good taste to include my name in their prefaces and forewords. Gratefully acknowledging the contributions of all these people, the story will henceforth be told by "us" rather than by "me" alone.

And now it is time to outline the main findings of this dissertation. Since the preface is already loquacious, we may save on words and turn to the cover of the book, where the main results are succinctly summarized. First, to have a potential for spillovers, we need technology. That's the paint - and some colors spill over in great blobs and others come in small drops. Then, we need a host country with firms that may absorb the spillovers. That's the paper - and paper quality has a great impact on how paint is absorbed and how colors spread. The paint can be spilled onto the paper in many ways - poured by the cup, sprayed on, or allowed trickle down a drop at a time - just as competition can be fierce or more subdued. Yet, whichever way we choose to act, we probably won't be able to spill the paint smoothly over the whole surface: it is even likely that there will be some white spots left, where nothing at all happens.

These are the main conclusions of this thesis, and for the appropriate illustration the author is indebted to Taisia Kuula, who immediately understood the message that the following chapters are trying to convey although she's only eight years old, and to Siv Andersson, who realized the concept with characteristic artistic skill.

Stockholm in March 1992
Ari Kokko

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CHAPTER I

INTRODUCTION:
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1.1 INTRODUCTION

The global stock of foreign direct investment (FDI) has grown rapidly over the past decades - from less than USD 70 billion in 1960 to more than USD 700 billion in the mid-1980s - and multinational corporations (MNCs) have come to control a major share of the world's production and trade of goods and services. The increasing multinationality of the world economy has been described in many different ways by numerous authors. For instance, Lall and Streeten (1977, p. 14) report that the short-term liquid assets controlled by multinational firms and banks headquartered in the U.S. were more than twice as large as those of all international monetary institutions in the world already in the early 1970s. Well over 10 000 parent MNCs had equity interest in at least 90 000 foreign affiliates by 1980, according to Stopford and Dunning (1983, p. 4). The United Nations Centre on Transnational Corporations (UNCTC, 1988, p. 16) estimates that the 600 largest industrial multinationals accounted for some 20 to 25 per cent of the value added from the production of goods in the world's market economies in the mid-1980s, and that between 80 and 90 per cent of the exports of the U.S. and the U.K. are associated with MNCs. The largest of these MNCs record yearly sales that are comparable to the aggregate output of entire countries like Norway, Ireland, Venezuela, or Pakistan, as noted by Jenkins (1987) and Buckley and Casson (1976).

It can be doubted whether all these statistics and comparisons are meaningful, but the quantitative importance of MNCs can hardly be questioned: hence the early conclusion of Lall and Streeten (1977, p. 11), that "any analysis of the present structure of international economic relationships which does not take [MNCs] into account, and, indeed, concentrate its attention on them, runs the gravest risk of being unrealistic and irrelevant."

It is therefore not surprising that FDI has received a tremendous amount of attention in both academic and political discussions, and the present study is a contribution to the ongoing debate. In the following chapters, we examine the technology imports of MNC affiliates and some aspects of the intra-industry spillovers of technology and productivity that may occur in host countries as a consequence of the entry and presence of foreign MNCs. With the term "spillover" we describe situations where the operations of foreign affiliates lead to improvements in the technology or productivity of domestic firms, and where the affiliates are not able to extract the full value of the gains - other authors have sometimes preferred to use the labels "external effects" or "involuntary technology diffusion" for the same phenomena. Technology is an important issue in the analysis of MNCs, because it constitutes one of the most important potential host country benefits of FDI. Spillovers are important because they make up the perhaps most important channels for the transfer of MNC technology to local firms in the host countries. In addition, spillovers are interesting because recent developments in growth theory have attributed great importance to externalities - e.g. spillovers of the kind we discuss here - in the process of economic growth and development.

We suggest in this book that spillovers are not only automatic consequences of the entry and presence of foreign firms, but also functions of various host country characteristics. This contrasts with earlier empirical studies, which have typically modelled spillovers as simply the impact of foreign presence on local productivity. The core of this volume is made up of four separate but closely related empirical studies focussing on various effects of the local environment on the behavior of MNC affiliates and on spillovers. More specifically, we analyze the determinants of MNC affiliates' technology imports, the impact of technology gaps and market characteristics on spillovers, and the simultaneous interactions between foreign and domestic firms. As a necessary background, we also provide a survey of existing theoretical and empirical studies of spillovers.

The purpose of this chapter is to outline the motives for the present study and to lay some cornerstones for the discussion and analysis in subsequent chapters. In Section 1.2, we note that earlier studies of spillovers in aggregate manufacturing have yielded conflicting results and policy conclusions. We suggest that the results appear contradictory because earlier authors have not taken into account that both the behavior of MNC affiliates and the incidence of spillovers may vary with the characteristics of host countries and industries. To support the hypothesis, we sketch the main arguments and findings of this study, and present some summary statistics to describe differences in the behavior of U.S. MNCs in 39 countries. In Section 1.3, we define some delimitations of the present study, and make some general comments with regard to data material and interpretation of statistical results. The issues taken up in this section are relevant for all of the following chapters, and are collected here to avoid repetition. Some alternative approaches and possible extensions of the study are also discussed.

1.2 EARLIER SPILLOVER STUDIES AND CROSS-COUNTRY DIFFERENCES IN MNC BEHAVIOR

Existing empirical studies differ in their estimates of the size and significance of spillovers. On the one hand, several studies of aggregate manufacturing suggest that spillovers are generally important. The earliest statistical tests - presented by Caves (1974), who examines Australian manufacturing in 1966, Globerman (1979), with data for Canadian manufacturing 1972, and Blomström and Persson (1983), who study Mexican manufacturing industries in 1970 - belong to this group. Although statistical models, variables, and data quality differ between the studies (the details are left to the survey in the next chapter), they all present evidence supporting the hypothesis that foreign presence has a positive impact on the labor productivity of local firms in the affiliates' industries.[1] A more recent contribution to the group is Blomström and Wolff (forthcoming), who analyze Mexican manufacturing in the period 1970-1975, and argue that spillovers have contributed to total factor productivity growth and led to a convergence of Mexican productivity toward U.S. levels. Likewise, in an analysis of the effects of U.S. direct investment on the manufacturing sectors of France, Germany, Japan, and the U.K., Nadiri (1991) finds that increases in the capital stock owned by U.S. firms appear to have significant positive effects on the host countries' productivity levels and productivity growth rates.

On the other hand, there are studies suggesting that spillovers are not important in general, or that they do not take place in all industries. For instance, Cantwell (1989) examines the responses of local firms to the emergence of U.S. multinationals in the European markets 1955-1975, and claims that the impact of FDI on domestic firms has not been beneficial in all industries. Technology spillovers have taken place mainly where local firms were initially relatively strong. Weak local firms have either been forced out of business, or confined to limited segments of the market that are neglected by the foreign MNCs. Haddad and Harrison (1991) examine data for Morocco during the period 1985-1989, and conclude that there are no spillovers, since they are unable to find any evidence of a positive effect of foreign presence on multi-factor productivity growth in local firms. (Yet, they observe that competition appears to push local firms toward best practice technologies in sectors with "low" or moderately advanced technology.)

Similarly, Aitken and Harrison (1991), using data for Venezuela between 1976 and 1989, conclude that there is no evidence of positive spillovers for a cross-section of manufacturing industries. (However, examining regional data for specific sectors, they find that large domestic firms located close to foreign firms tend to exhibit higher growth rates of multi-factor productivity, particularly in sectors like food products, textiles, and basic metals, where levels of technology are relatively low.)

There is also a corresponding uncertainty regarding policy prescriptions for host countries that aim to maximize the benefits from foreign direct investment. Judging from the early results, soliciting foreign investment and subsidizing foreign firms (e.g. by offering tax holidays or import duty exemptions) may be rational from the point of view of the host country. Foreign direct investment appears to be an important channel for the transfer of modern technology to local firms, but the amount of FDI may be sub-optimal in the absence of policy interventions because the spillover benefits are not internalized in the foreign firms' rates of return. The policy conclusions suggested by the latter studies are different. Cantwell's (1989) analysis implies that general subsidies to foreign investment - and attempts to benefit from MNCs in the development of new industries - are not likely to pay off. Instead, governments (particularly in small countries) should concentrate their efforts in areas where their firms are already competitive. Haddad and Harrison (1991) conclude that their analysis does not support special treatment of foreign investors. The same conclusion is implicit in Aitken and Harrison (1991), although the authors refrain from explicit policy recommendations (perhaps because of their slightly ambiguous results).

In this study, we will attempt to resolve some of the apparent contradictions between the existing spillover studies, and to reach some policy conclusions that are compatible with the divergent empirical findings. To this end, we will argue that spillovers are not automatic consequences of foreign investment, because the behavior of MNC affiliates - and the impact of FDI on the host country's local firms - is partly determined by various host country characteristics. Consequently, spillovers are likely to differ between locations, and modelling spillovers as merely the effect of an industry's foreign share on the productivity of domestic firms may yield misleading or incomplete results.

In Chapter II, we will suggest that spillovers can occur because MNC affiliates import and *demonstrate technologies* that are not well known in the host country, and because their operations (or mere presence) may *increase the level of competition* and force local firms to search for more efficient methods of production, and that the foreign share of an industry is not an ideal proxy for either of the two kinds of spillovers. Surveying the available studies of spillovers, we also conclude that there are both theoretical arguments and empirical evidence from case studies to suggest that spillovers differ between countries and industries, although the more aggregated statistical tests have not taken this into account.

Various host country characteristics are likely to influence the affiliates' technology imports and the potential for spillovers from demonstration, as Chapters III and IV suggest. Chapter III analyzes U.S. manufacturing affiliates in 33 host countries in 1982, and Chapter IV looks at foreign firms in 144 Mexican manufacturing industries in 1975. The results show that the technology imports (and productivity levels) of affiliates seem to be positively related to the skill level of the host country's labor force and the degree of competition from local firms, but negatively related to the existence of technology transfer and performance requirements.

Chapter V examines whether the size of the technology gap between affiliates and local firms influences observed spillovers, as hypothesized by e.g. Findlay (1978), Wang and Blomström (1992), and Cantwell (1989), or if other host country characteristics are more important. The focus is on 216 Mexican manufacturing industries 1970. We find that large technology gaps between foreign and local firms may sometimes act as obstacles to spillovers, but that the industries where spillovers are least likely are those where technology differences are aggravated by market conditions that limit competition.

Market characteristics and the responses of local firms also play an important role in deciding the impact of MNC presence on market rivalry and on the spillovers that take place because of competition. Chapter VI discusses the competitive interactions between affiliates and local firms in 156 Mexican manufacturing industries 1970: the results suggest that the productivities of affiliates and local firms are simultaneously determined, and that spillovers from competition may be endogenous results of the behavior of local firms. If local firms are able to absorb spillovers and become more competitive. e.g. because they devote resources to imitate MNC technologies, they force the affiliates to import more technology in order to remain competitive, which creates a potential for further spillovers.

Taken together, the findings of this book suggest that spillovers may be relatively important or insignificant depending on factors that influence the economic environment in the host country, such as the economy's technological capability, the character of FDI regulations, the amount of local investment, and the level of competition. These factors may reconcile the seemingly contradictory conclusions of earlier spillover studies, and explain why Cantwell (1989), Haddad and Harrison (1991), and Aitken and Harrison (1991) find spillovers in some industries but not in all. Moreover, an important share of spillovers appear to be endogenous functions of the behavior of local firms, which suggests that there may be two kinds of possible "equilibria" between foreign and local firms. One kind - a "virtuous circle" - occurs in industries where local firms are able to absorb spillovers, where they compete with the foreign firms, and where the affiliates are forced to import new technology continuously, in order to retain their competitive advantages and market shares; another is found in industries where spillovers are small, competition is limited, and MNC affiliates can afford to defer costly imports of technology. However, the present study stops short of a detailed analysis of what determines whether a country will be caught in a "virtuous" rather than a "vicious" circle: this is left as a challenge for future research.

To put the results into a wider context, it can be noted that recent theoretical models of economic growth also attach great importance to externalities and suggest that technical progress and growth are endogenous phenomena. For instance, Romer (1986) assumes that spillovers from learning-by-doing lead to increasing returns and sustained growth, while Lucas (1988) focusses on human capital externalities in a similar set-up. Romer (1990) constructs a model of endogenous technological change with monopolistic competition, knowledge spillovers, and innovation that is motivated by market incentives. Grossman and Helpman (1991a, 1991b, 1991c) present several models of endogenous growth, trade, and international technology diffusion, where results are determined by spillovers and competition between Northern innovators and Southern imitators.[2] All of these models contain elements that are compatible with our results.

A major policy conclusion from this book is that host countries may be able to influence the size and significance of spillovers from FDI. From the policy perspective, it is important to note that the affiliates' technological efforts may be more important than their market share in determining the potential for spillovers. Consequently, policies should not only be aimed at attracting new foreign investment. It is also possible that efforts to improve the host country's technical skills and the competitiveness of local firms (and to reduce barriers to entry and other factors that limit competition in the affiliates' industries) are viable alternatives to traditional policies that focus on affiliates, such as strict technology transfer and performance requirements. However, country and industry characteristics are also likely to influence the efficiency of policies - for instance, support to the least developed domestic firms may create few externalities. Yet, our view is less deterministic than that of Cantwell (1989), who implies that only industries where local firms have historically been competitive will benefit from positive spillovers from FDI: technology differences alone do not appear to be insurmountable obstacles to spillovers, and the experience of the Asian NICs seems to show that it is possible to benefit from FDI in building new industries.

These arguments and conclusions will not be examined in any closer detail in this introductory chapter, but Table 1.1 below presents some summary statistics to illustrate differences in the behavior of U.S. MNCs in 39 host countries, and to suggest that the potential for spillovers varies between countries.

TABLE 1.1 Differences in the Behavior of U.S. MNCs in 39 Host Countries 1982.

COUNTRY	(1) LABOR ('000)	(2) SALES/ LABOR ('000 USD)	(3) Major indus- tries	(4) PRD^{aff}/PRD^{par}	(5) PRD^{aff}/PRD^{dom}	(6) LICENSE/ LABOR (USD)
Developed Countries						
Australia	118.4	102.9	f	1.00	1.47	830
Austria	12.8	.	g	.	.	700
Belgium	86.8	101.9	e	1.07	.	1130
Canada	454.6	117.1	g,f	1.19	1.22	910
Denmark	7.4	87.7	e,a	0.92	1.31	950
France	208.6	92.6	d,g	0.98	1.33	1760
Greece	6.0	83.8	f,b	0.84	1.53	500
Ireland	31.7	100.7	g	1.09	1.64	190
Italy	131.1	76.6	d,e	0.82	1.14	1690
Japan	47.5	123.8	d,b	1.26	1.36	5330
Luxembourg	7.0	63.4	g	0.71	0.90	140
Netherlands	69.3	160.1	g,b,a	1.58	1.42	2800
New Zealand	10.1	79.8	f	0.76	1.57	500
Norway	5.2	90.6	e,g	0.98	1.08	770
Portugal	14.3	42.4	e	0.44	1.70	1050
Spain	92.3	67.4	e,f	0.69	1.19	660
Sweden	15.8	124.6	d	1.42	1.72	3350
Switzerland	14.7	121.7	g	1.31	.	1090
United Kingdom	516.0	78.6	g,f	0.80	1.35	930
Turkey	2.6	46.2	e	0.50	1.15	0
West Germany	404.2	94.2	f	0.97	1.29	1160

continued...

TABLE 1.1 *Differences in the Behavior of U.S. MNCs in 39 Host Countries 1982. continued...*

COUNTRY	(1) LABOR ('000)	(2) SALES/ LABOR ('000 USD)	(3) Major indus-tries	(4) PRD^{aff}/PRD^{par}	(5) PRD^{aff}/PRD^{dom}	(6) LICENSE/ LABOR (USD)
Developing Asia						
Hong Kong	22.6	50.2	e	0.60	2.30	400
India	22.4	22.7	e,b	0.24	1.52	40
Indonesia	16.2	29.9	e,g	0.33	2.25	310
Malaysia	48.2	33.6	e	0.42	1.08	100
Philippines	66.4	25.3	a	0.25	1.38	150
Singapore	31.8	59.0	e	0.72	0.93	660
South Korea	12.0	34.5	e	0.42	1.01	80
Thailand	11.3	46.1	e	0.52	.	350
Taiwan	49.6	30.2	e	0.37	.	180
Latin America						
Argentina	56.8	56.7	g,b,a	0.55	.	510
Brazil	305.6	55.8	g,b,f	0.56	1.51	50
Chile	6.0	63.8	c,g,b	0.62	0.88	170
Colombia	26.9	68.6	g,b	0.66	1.98	40
Ecuador	4.6	39.3	a,b	0.35	1.12	220
Mexico	227.8	41.4	e,g	0.42	.	280
Panama	2.5	69.2	g	0.66	1.43	1600
Peru	5.6	57.1	b	0.54	1.41	180
Venezuela	43.1	112.5	g,a	1.09	1.39	70

Legend:
a - Food and kindred products
b - Chemicals and allied products
c - Primary and fabricated metals
d - Machinery, except electrical
e - Electric and electronic equipment
f - Transportation equipment
g - Other manufacturing

Sources:
U.S. Department of Commerce (1985) and Industrial Statistics Yearbook, various issues.

Column (1) shows the employment of U.S. majority-owned foreign affiliates (MOFAs) in each host country. Column (2) is the average gross sales-labor ratio of U.S. affiliates, which is a very rough proxy for the average technology level of affiliates: presumably, technically more advanced affiliates exhibit higher labor productivity. Column (3) shows which industry groups account for the largest share of the affiliates' employment. Column (4) is the sales-labor ratio from column (2) divided by the sales-labor ratio of

U.S. parents.[3] This is a rough measure of how much of the available technology the affiliates have imported. Column (5) is the sales-labor ratio from column (2) divided by the gross output-employment ratio of the host country's manufacturing industry (excluding U.S. MOFAs). It proxies the productivity and technology gap between the average U.S. affiliate and the average domestic (i.e. non-U.S.) firm in the host country. Column (6), the affiliates' average payments of royalties and license fees per employee to the U.S., reflects some of the affiliates' technology imports.

The data in the first three columns illustrate some rather obvious differences between countries: that amounts of FDI vary between host countries, that there are large differences in the productivities of affiliates operating in different countries, and that the industry distribution of affiliates differs between host countries. The last three columns are more interesting for our specific purposes, since they may say something about the potential for spillovers. Column (4) suggests that some affiliates have chosen technologies that are probably close to best practice, while others have a large unexploited potential to draw upon. Column (5) implies that the size of the technology gap between affiliates and local firms varies much, and the figures in column (6) show that there are large differences in the affiliates' continuous imports of technology. A technology gap is probably necessary in order to create a potential for spillovers that are related to demonstration, as noted above, and the potential for further spillovers may increase with the amount of new technology that flows to the affiliates. This potential seems to vary greatly between countries.

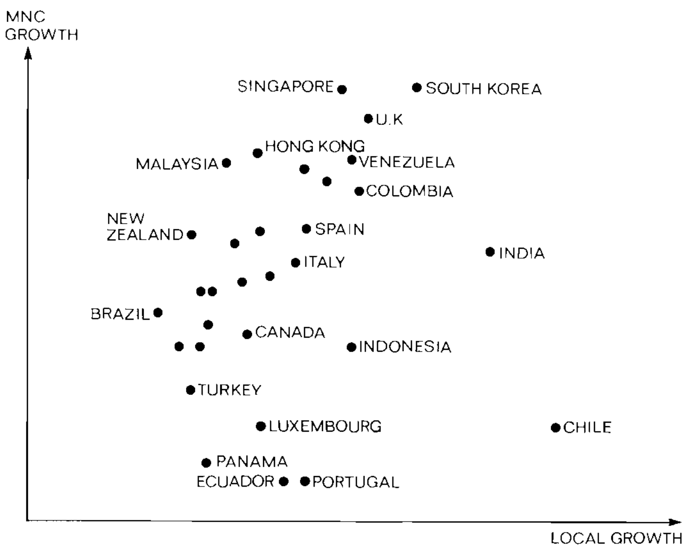
Are the differences illustrated by the table arbitrary or systematic? The central argument of this thesis is that the behavior of MNC affiliates is related to the characteristics of the host countries, and the relationship is obvious in some cases. For instance, amounts of foreign investment vary according to the attractiveness of countries and industries as locations for FDI.[4] The technology and productivity levels of affiliates also vary between locations in a (partly) predictable manner. Affiliates operating in less developed countries typically use technologies with lower capital-intensity and lower labor productivity than affiliates in more developed countries.

It is less obvious what the link between host country characteristics and the size of the technology gap is, or what determines the affiliates' continuous imports of technology. We will not make any in-depth analysis of the possible determinants of technology gaps and technology payments in this chapter - as noted, Chapters III and IV will try to explain some determinants of technology imports of MNC affiliates - but it is useful to present some more summary data to illuminate some of the underlying relationships.

Figure 1.1 plots the cumulative growth rate of the U.S. affiliates' sales-labor ratio between 1977 and 1982 (measured in current USD) against the growth rate of the local firms' gross output-labor ratios (in current USD) during the same period.

The measures used in the figure are imperfect proxies for the rates of the productivity growth and technical progress that have taken place in affiliates and local firms in the countries. The amounts of intermediary inputs are not constant, exchange rates have changed, capacity utilization varies between countries, and so forth.

FIGURE 1.1 *Cumulative Growth Rates of Sales and Gross Output in Majority-Owned U.S. Affiliates and Local Firms 1977-1982.*



Sources:
Calculated from U.S. Department of Commerce (1981,1985) and *Industrial Statistics Yearbook*, various issues.

Yet, the picture provides a rough - but suggestive - illustration of a pattern in the MNC affiliates' behavior: there seems to be a clear positive correlation between the growth rates of MNCs and the growth rates of local firms.

This pattern can be interpreted in at least two ways. The correlation occurs if the growth rates of both foreign and local firms are influenced by various host country characteristics, such as levels of education, local demand, infrastructure, the institutional and legal framework, trade policies, and so forth. Alternatively, it is possible that foreign and local firms influence each other more directly, by competing for customers, market shares, and profits. Both these explanations imply that the differences in MNC behavior are not entirely random. In fact, even some of the outliers seem to fit into the explanations: they are countries where political and macroeconomic problems may have forced the MNCs to be particularly cautious (Chile) or countries where market forces have been curtailed by economic policies (e.g. India, Indonesia, and Ecuador).[5]

Thus, our summary data show that MNC behavior differs between host countries, and that there are probably some differences in the potential for spillovers from FDI. The data also suggest that the variation in MNC behavior may be caused by differences in host country characteristics or by the competition from local firms. Hence, this brief look at data already suggests that it may be possible to bridge some of the gaps between the contending and apparently conflicting results from earlier spillover studies by explicitly introducing host country characteristics into the analysis of spillovers.

1.3 SOME DELIMITATIONS OF THE STUDY AND NOTES ON DATA AND STATISTICAL RESULTS

Some of the delimitations of the present study must be noted explicitly. We concentrate our attention on the impact of host country characteristics on MNC behavior and spillovers, but it is also likely that the characteristics of the multinational corporation and the specific technology (and possibly also the MNC's home country) influence technology transfer and spillovers. We will not examine these issues in detail, but they need to be included in a more comprehensive analysis of technology diffusion through

MNCs. We have also restricted the empirical analysis to middle and high-income countries that have reached above some minimum level of development. The conclusions of this thesis may therefore not be applicable to countries that are significantly less developed than those in our sample - local firms in the least developed countries may be unable to respond to MNC entry, or may lack the technical skills needed to benefit from any MNC technology.

In addition, we avoid addressing several important questions. We will not look at the MNC's decision to establish foreign production. Throughout the book, we are concerned with the behavior of already existing MNC affiliates, but it should be noted that much research analyzes the determinants of FDI (and host country policy often aims to attract more FDI and new MNCs to the country). It is conceivable that some of the policies that are useful to make the incumbent MNC operate in a manner that optimizes spillovers and technology flows to the host country are contradictory to policies that attract new MNCs: in practice, it is therefore necessary to weigh the benefits from the policies suggested by this study against the possible costs in terms of foregone FDI. Similarly, we will not attempt to make any welfare assessment of FDI, and many other factors apart from technology and productivity are important in a more comprehensive assessment of costs and benefits.

The conclusions of the following chapters - except those that emerge from the literature survey in Chapter II - are largely drawn from statistical tests of theoretical hypotheses, and there are many possible sources of errors in the analysis. Some comments on data and interpretation of statistical results are therefore warranted.

Firstly, technology, competition, and the other variables that appear in the theoretical hypotheses are abstract concepts, without direct empirical counterparts at the level of aggregation of this study. In most cases, it has therefore been necessary to use indirect proxies for the variables. This makes up an important caveat: the empirical results are to be treated with caution even where we find significant relations between the variables used in the statistical tests. In many cases, we have decided to use several alternative proxies for the same variable, in order to avoid drawing conclusions from spurious correlations between imperfect empirical measures, but the admonition still applies. In this context, it should also be noted that statistical test can not prove causality even if the empirical measures are perfect: at best, we can examine whether the data are compatible with the theoretical hypotheses we discuss.

Another warning refers to data quality. The data we use are aggregated to country or industry levels, which introduces considerable uncertainty. For instance, it is not certain that the country is the proper unit of analysis if there are large regional differences. In this respect, it would be interesting to examine the metropolitan Mexico City region separately from the rest of the country, but we only have data for the entire nation. At an international level, it is possible that regions like the Ruhr belt are sometimes more meaningful units than Belgium, Luxembourg, and Germany separately, but we are limited by the availability of data. Similarly, the classification of firms into industries is to some extent arbitrary, and several entirely separate products are often included in the same industry classes, even at relatively low levels of aggregation. As we will see in Chapters IV, V, and VI, this is a likely problem in our Mexican data, although the Mexican four-digit classification covers 230 manufacturing industries.

Some comments on alternative approaches and possible extensions are also in order. In the present study, we employ cross-country data for U.S. foreign affiliates in aggregate manufacturing 1982, and Mexican data for 230 four-digit manufacturing industries in 1970 and 1975 to examine international and inter-industry differences in MNC affiliates' technology imports and spillovers. The choice of method and level of aggregation is due to two factors. Firstly, we have decided to follow closely in the tradition of earlier spillover studies, and secondly, data limitations have precluded several of the other possible approaches. This allows us to examine the impact of country and industry characteristics, and offers some scope for generalization, but only at a cost: aggregation across industries and countries is not always appropriate, and conceals many details and differences between individual firms and regions, as noted above.

Some alternatives are obvious. Case studies of specific industries and firms, possibly over time, would avoid the aggregation problems, allow a more detailed analysis of the market environment - in particular, the level of competition - and produce a more refined description of the interactions between foreign and local firms. Yet, this is perhaps a complementary rather than an alternative approach, because it is difficult to generalize from case studies. Another possible extension of the present study would be to focus on time-series data: it is likely that spillovers do not occur instantaneously, but little is known about the time lags. A more detailed cross-country analysis of some particular, suitably defined industry would make it possible to exclude some of the effects of technology characteristics on observed spillovers, and to focus more closely on the impact of host country characteristics.[6] Finally, we have already mentioned the need for more detailed analyses of the endogenous element of spillovers, and the need to include technology, firm, and home country characteristics in more comprehensive studies of technology diffusion through MNCs - some further notes about unresolved questions and additional topics for research will be made later.

Despite the many delimitations and shortcomings of the present study, it is hoped that the following chapters provide some insights into the processes that determine the size and significance of spillovers.

1.4 NOTES

1. Some related conclusions are provided by Katz (1969), for Argentine manufacturing, and Chen (1983), for Hong Kong, although their statistical tests are less comprehensive, as will be seen in Chapter II.

2. Grossman and Helpman (1991d) summarize several additional models of trade, innovation, and growth.

3. The denominator (PRD^{par}) is the sales-labor ratio that would have been exhibited by U.S. parents 1982 if the relative employment shares of the seven industry groups shown below had been identical to those of the affiliates in the host country. The actual distribution of the 10,267,000 U.S. employees of the parent MNCs, and their average sales per employee and industry group (in USD) are given below:

	LABOR	SALES/ LABOR
Food and kindred products	975,000	114,710
Chemicals and allied products	1,355,900	124,190
Primary and fabricated metals	951,400	102,630
Machinery, except electrical	1,443,400	79,260
Electric and electronic equipment	1,601,700	77,890
Transportation equipment	1,649,700	108,890
Other manufacturing	2,290,400	84,630

4. See e.g. Dunning (1977) for a discussion of locational advantages as determinants of foreign direct investment.

5. It is also possible that the low development levels of e.g. India, Indonesia, and Ecuador explain why they appear to be outliers. Low development may be an obstacle both to spillovers and competition between local firms and affiliates, and we have therefore excluded the least developed countries from the discussion in this study, as will be noted more explicitly in the last section.

6. Although the statistical tests in Chapters IV, V, and VI are based on data from Mexican manufacturing, we do not focus on the characteristics of Mexico, but rather on differences between industries. A brief summary of FDI in Mexico is provided by Peres Nuñez (1989), and more detailed descriptions of the Mexican economy are given by e.g. King (1970), Reynolds (1970), and Montavon (1979).

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CHAPTER II

SPILLOVERS FROM FOREIGN DIRECT INVESTMENT:
A Survey of Theoretical and Empirical Findings

2.1 INTRODUCTION

Technology is a central issue in the analysis of foreign direct investment and multinational corporations, for at least two well-known reasons. Firstly, technology is essential for the MNCs, because it is one of the proprietary assets that allow firms to become multinational and establish affiliates in foreign markets. Secondly, technology is a major determinant of the host countries' benefits of foreign investment: the opportunity to get access to modern technology may even be the main reason for many countries to accept or seek foreign direct investment.

This study looks at technology and FDI from a host country perspective. More specifically, we examine technology or productivity spillovers from FDI, which have been identified as the most important channels for the diffusion of MNC technology to host countries. As noted in the introductory chapter, spillovers are events where the entry or presence of MNC affiliates lead to improvements in the technology or productivity of local host country firms, and where the MNC "cannot capture all quasi-rents due to its productive activities, or to the removal of distortions [caused] by the subsidiary's competitive pressure" (Caves, 1974, p. 176). The purpose of this chapter is to discuss and survey the literature and existing evidence on spillovers, as a necessary background to the analysis in the following chapters.

To put the topic into perspective, we begin by briefly looking at the role of MNCs in the international transfer and diffusion of technology in Section 2.2. The distinction between these two concepts may be noted already here: with *technology transfer* we refer to deliberate dissemination of MNC technology, whereas *technology diffusion* can also take place without the conscious participation of the MNC, through spillovers of various types. Section 2.3 turns to discuss why spillovers are likely to be important channels for the international diffusion of technology, and what shape they may take. Some of the theoretical works analyzing spillovers are reviewed in Section 2.4, and Section 2.5 surveys a large number of related empirical studies. In the course of the survey, an attempt is made to identify some areas where established (empirical) wisdom is weak or limited. Section 2.6 briefly reiterates these possible topics for further research, and outlines the content and purpose of the following chapters.

2.2 MNCs IN THE INTERNATIONAL TECHNOLOGY MARKET

It is well known that MNCs undertake a major part of the world's private research and development (R&D) efforts and produce, own, and control most of the world's advanced technology. It is also known that the multinationals' R&D and technology is heavily concentrated to a few home countries, unlike MNC investment, production, and employment that are more widely spread across both industrialized and developing economies.

A few summary statistics can demonstrate this clustering of technology production. Over four fifths of the global stock of FDI originates from the half dozen home countries that dominate the world's research and technology: the U.S., the U.K., Japan, Germany, Switzerland, and the Netherlands. On average, about a third of the total sales and the total employment of the MNCs based in these countries were accounted for by their foreign affiliates in the early 1980s.[1] However, only some six per cent of the R&D expenditures of e.g. U.S. manufacturing MNCs in 1982 were undertaken in their majority-owned affiliates, and more than half of these six per cent were recorded by the affiliates located in the U.K. and West Germany.[2] Detailed data on the R&D

expenditures of the MNCs based in the other five countries are not available, but the pattern is likely to be similar and it is not very controversial to conclude that foreign MNCs are the most important sources of modern technology for most economies.[3]

But although we know that MNCs produce and own the bulk of the world's modern technology, it is not obvious exactly how MNC technology spreads across international borders and what role MNCs play in the process. One reason, of course, is that "technology" is an inherently abstract concept, and therefore difficult to observe and evaluate. For present purposes, we interpret it broadly as "the perishable resource comprising knowledge, skills, and the means for using and controlling factors of production for producing... delivering... and maintaining goods and services" (Robock, 1980, p. 2), which includes both product, process, and distribution technology, as well as management skills. It can also be separated into "hardware" that is made up of machines, tools, and other physical objects, and "software" that is captured in manuals, people, or organizations, and is necessary to operate plants and machines.[4] None of the available measures of technology and technology production -such as R&D expenditures, numbers of new patents, payments for licenses and royalties, stocks of capital equipment, and so forth - cover more than a part of this.

Another reason is that technology is diffused in many different ways. MNC technology can spread to new users through formal market transactions - transfers - or through informal, non-market mediated channels that may be voluntary or involuntary. For each alternative, the role of MNCs can be either active or passive. Table 2.1 below shows some of the possible modes of international technology diffusion, grouped according to the type of transaction and role of the MNC. Foreign direct investment is another potential channel of technology transfer, but we have not included it explicitly in the table: what distinguishes FDI from sales of equipment or licenses to outsiders (or even joint ventures) is that the MNC has chosen to retain the control and ownership of its proprietary technologies within the corporation.

It is an open question which of the transfer modes mentioned in the table is the most important, because it is difficult to compare the technology content of the different transactions, and because there are no comprehensive data available to measure the magnitude of the informal transfers.

TABLE 2.1 International Diffusion of Technology: Type of Transaction and Role of MNCs.

Type of Transaction	Role of MNCs: ACTIVE	Role of MNCs: PASSIVE
FORMAL	joint ventures licensing	goods trade
INFORMAL	linkages	trade journals, scientific exchange

Source:
Adapted from Fransman (1985).

However, there are some data on formal transactions, and they are useful in outlining some of the quantitative dimensions, although the figures are neither complete nor extremely accurate. For instance, the industrialized countries imported USD 310 billion worth of machinery and transport equipment in 1980, whereas their yearly payments for technology and technical and management services in the early 1980s only amounted to approximately USD 10 billion. Concurrently, the developing countries' imports of machinery and transport equipment from developed countries reached USD 129 billion, and their payments of royalties, fees, and remuneration for technical services totalled about USD 2.5 billion.[5] There are no data on the overall importance of joint ventures, but it can, for comparison, be noted that the industrialized countries' inward stock of foreign investment was estimated at approximately USD 401 billion in 1983, while the corresponding figure for developing countries was USD 138 billion (UNCTC, 1988, p. 25).[6]

There are also some data available to describe the extent of MNC participation in licensing and goods trade. These data are interesting because they confirm that MNCs are the main sources of these types of technology, but also because they indirectly introduce foreign direct investment into the picture. MNCs control technology supplies by virtue of their ownership of proprietary technologies, but they also account for a significant share of the demand, via their foreign affiliates.

This is most apparent for the transfers of "disembodied" technology that are captured by data on trade in royalties, licenses, and patent rights. Over 80 per cent of the registered payments to the United States for technology sales during the 1970-1985 period were made by foreign affiliates of U.S. firms (Grosse, 1989). More than 90 per cent of the technology payments from developing countries to Germany in the early 1980s, and over 60 percent of the payments to Japan, originated from their own foreign affiliates (UNCTC, 1988, p. 177).

The intra-firm character of the technology transfers that take place through trade in capital equipment and other products is less apparent, but still distinguishable. What we known about MNC involvement from statistics on goods trade is that between 70 and 80 per cent of the goods exports of both the U.S. and the U.K. - the main suppliers of embodied technology together with Japan and Germany - are accounted for by MNCs (UNCTC, 1988, p. 90). Moreover, a significant share of the exports and imports of the major home countries (between one fifth and one third overall, and more for complex and technologically sophisticated goods that supposedly embody more technology) flow between MNC parents and affiliates (UNCTC, 1988, p. 91). A very important part of all formal technology transfers are, therefore, closely tied to FDI.

As already mentioned, there are no comprehensive data on the informal modes of technology diffusion, but it seems that FDI plays an important role also there. For instance, linkage effects can take place between firms in different countries, like when exporters learn from the feedback they receive from their multinational customers abroad (Fransman, 1985), but are perhaps stronger when they arise between local firms and MNC affiliates operating in the same country (as will be seen in the ensuing discussion of spillovers). Similarly, many informal transfers where MNCs have a passive role - those that come about as a result of any kind of personal contact with people who know about MNC technologies - are obviously facilitated by the presence of foreign affiliates. Of course, there are also transfer types that may be entirely independent from FDI. Exports from the MNC's home country may be sufficient to prompt reverse engineering - the practice of taking apart and analyzing products, to learn about the technologies embodied in them - which is often recognized as one of the main sources of involuntary technology dissemination (Zander, 1991, Chapter 5).[7] Other informal transfers, through academic contacts, technical publications, and education abroad can also occur irrespective of the presence of foreign affiliates.

Thus, although FDI was not included explicitly in Table 2.1, it nevertheless seems that much of the international dissemination of technology is connected to foreign direct investment. A large share of both license sales and sales of technologically advanced products are directed to MNC affiliates, and FDI therefore seems to be more important for the geographical spread of technologies than sales of technology to unrelated parties. In addition, many informal contacts are easier and more important when MNC affiliates are present in the market than when contacts have to be made across international borders. Keeping this in mind, it is not surprising that FDI is probably the transfer mode that has received the most attention (see e.g. Enos, 1989).

However, there are important questions related to the role of FDI as a source of technology for host countries. From the point of view of the host, it is not clear what the actual technological benefits of FDI are and how they come about. A distinguishing characteristic of direct investment, as has already been noted, is that the control and ownership of the technologies used by the affiliates stay in the MNCs' possession. Is there any significant diffusion of technology to new users or is the affiliate able to protect its technology from spreading to outsiders? And if technology is diffused from the MNC affiliates, does it spread through the market or informally, and are the multinationals active or passive in this process? Obviously, it is not trivial to pinpoint the correct position of foreign direct investment in Table 2.1.

2.3 SPILLOVERS AS A SOURCE OF TECHNOLOGY DIFFUSION

In the debate on the role of MNCs in international technology transfer, it has sometimes been suggested that the most significant channels for the dissemination of modern, advanced technology are external effects or "spillovers" from foreign direct investment, rather than formal technology transfer arrangements (Blomström, 1989; see also Stoneman, 1983). It is argued that when firms establish affiliates abroad and become multinational, they are distinguished from the already established firms in the host country for two reasons. One is that they bring with them some amount of the proprietary technology that constitutes their firm-specific advantage and allows them to compete successfully with local firms who have superior knowledge of local markets, consumer preferences, and business practices. Another reason is that the entry of the MNC affiliate disturbs the existing equilibrium in the market and forces local firms to take action to protect their market shares and profits. Both these changes are likely to cause various types of spillovers that lead to productivity increases in local firms.

Generally, spillovers are said to take place when the MNCs cannot reap all the productivity or efficiency benefits that follow in the host country's local firms as a result of the entry or presence of MNC affiliates. The simplest example of a spillover is perhaps the case where a local firm improves its productivity by copying some technology used by MNC affiliates operating in the local market. Another kind of spillover occurs if the entry of an affiliate leads to more severe competition in the host economy, so that local firms are forced to use existing technology and resources more efficiently; a third type of spillover effect takes place if the competition forces local firms to search for new, more efficient technologies. These effects may take place either in the foreign affiliate's own industry or in other industries, among the affiliate's suppliers or customers.

Thus, the term "spillover" has a broader meaning than "imitation" or even "technology diffusion" (although technology is at the center of the concept) and it should perhaps primarily be associated to productivity - hence the use of the interchangeable terms *productivity spillover* and *technology spillover.*[8] We will return in a while to discuss more concretely what form spillovers may take and what their consequences are, but we will first look at why they are likely to be significant channels of technology diffusion (apart from what we already know - i.e. that the stock of foreign investment is large and that much of the formally transferred technology ends up in MNC affiliates.)

A first reason to suspect that spillovers are important is that the technologies used by MNC affiliates may not be available in the market. Abstracting from the fact that several means of extracting technology rents may occur simultaneously in reality, we can assume that the MNC has three alternative ways to exploit its technological advantages internationally. The MNC can produce for export in the home country, it can sell its technology to foreigners, or it can establish an affiliate abroad and control foreign production directly.[9]

However, markets for technology are typically imperfect, which makes the transactions costs for sales of technology to outsiders high (Buckley and Casson, 1976; Caves, 1982; Teece, 1981). For instance, it is difficult to judge the value of any specific technology and agree about prices and licensing costs that are acceptable to both parties. The potential licensee needs detailed information about the technology to determine how valuable it is, but his incentives to pay that price are low *ex post*, when he is already in possession of the information (which is often identical to the technology itself). Consequently, MNCs often prefer direct investment before licensing, and the preference for FDI may be particularly strong when the newest and most profitable technologies (or those that are very close to the MNCs principal line of business) are exploited. A technology that is exploited through FDI will probably not be licensed to the local competitors in the host country - the local firms' only chances to gain access to the technology may lie in reverse engineering or hiring of former MNC employees with special skills, or some other type of spillover. This reason for the importance of spillovers may be most valid for the more developed host countries and industries, because the technical skills required to imitate the newest and most profitable technologies are typically very high.

Some empirical evidence in support of this argument is provided by Mansfield and Romeo (1980), who study the dissemination of 26 U.S. technologies and conclude that transfers to affiliates tend to be of a later vintage than technologies sold to outsiders. The average age of their sample of technologies at the time of their first transfer to affiliates in developed countries was 5.8 years (9.8 years for affiliates in developing countries) whereas the corresponding figure for outside licensing and joint ventures was 13.1 years.[10] Behrman and Wallender (1976) and McFetridge (1987) also find that the transfer lags tend to be shorter for intra-firm transfers. Moreover, Davidson and McFetridge (1985) conclude that technologies that are close to the MNC's main line of business are more likely to be transferred to affiliates than licensed to outsiders.

Another reason why spillovers may be significant is that direct contact with users appears to be a principal factor explaining technology diffusion (see e.g. Gomulka, 1990 and Gottinger, 1987). Before a new process or product innovation is widely spread on the market, potential adopters have limited information about the costs and benefits of the innovation and may therefore associate it with a high degree of risk. As they come in contact with users, information also becomes available, risk decreases, and the likelihood of imitation or adoption of the innovation increases. In this way, the entry of foreign affiliates may demonstrate the existence and profitability of new products and processes, and encourage local firms to adopt some of them: the processes may even be repeated every time innovations are transferred from the MNC parent to the affiliate. This is an argument for spillovers even when access to new technology is not restricted by proprietary factors, because information about foreign technology is generally more expensive for local firms than for MNC affiliates. In addition, it can be assumed that "contagion" effects are more important for less developed host countries, where indigenous skills and information are in shorter supply.[11]

Mansfield and Romeo (1980) present indirect evidence also for this argument. They claim that the export of technologies from parents to U.S. affiliates abroad speeded up the emergence of competing products or processes in the host countries by an average of 2.5 years in about a third of their cases. In addition, they report that more than half of the managers of a sample of British firms believed that they had introduced some products and processes earlier as a consequence of transfers of technology to U.S. affiliates operating in the United Kingdom. More evidence will be presented later, in the survey of empirical studies of spillovers.

Some of the neo-classical theories of foreign direct investment (see e.g. Caves, 1971, 1982) provide a third reason to expect positive external effects from MNC entry. The typical features of MNCs - scale economies, high initial capital requirements, intensive advertizing, and, not least, advanced technology - are also industry characteristics that signal high barriers to entry, high concentration, and perhaps some inefficiency that follows from low levels of competition. Entry by new domestic firms into such industries in potential host countries is likely to be difficult; MNCs, on the other hand, are both likely to enter just those industries and be well equipped to overcome the entry barriers. They can coordinate their international operations and concentrate specific processes to few locations if scale economies are important entry barriers. If the barriers are made up of high capital costs, they can seek financing on international markets. Barriers related to product-differentiation and technology, finally, are not likely to stop a multinational, since these features often characterize the MNCs themselves.

The entry of MNCs into this kind of monopolistic industry is likely to increase the level of competition and force existing firms to become more efficient. Foreign entry may, of course, also lead to a fall in the number of firms in the industry if the least efficient local companies are forced out of business. This raises the fear that foreign MNCs may outcompete all local firms and establish monopolies that are even worse than the domestic oligopolies they replace: in addition to restricting competition, there is a risk that MNC monopolies may also repatriate profits and avoid taxation through transfer pricing. However, Caves (1971) argues that the general outcome is that competition becomes more fierce, because the MNC affiliates' strategies typically stir up the established patterns of "gentlemanly competition". Hence, Caves (1971, p. 15) holds that:

> whatever the market structure that results from the influence of direct investment, it can be argued that entry by a foreign subsidiary is likely to produce more active rivalrous behaviour and improvement in market performance than would a domestic entry at the same initial scale.

A related argument is that the resulting increase in competition may be more effective in inducing technological change and productivity improvements than profit incentives, since:

> threats of deterioration or actual deterioration from some previous state are more powerful attention-focussing devices than are vague possibilities for improvements. (Rosenberg, 1976, p. 124.)

We will come back to the empirical evidence related to the effects of foreign presence on industry structure and competition in Section 2.5 below, but note already here that it is not very conclusive. In particular, it seems difficult to determine *ex ante* whether the possible increase in competition is most beneficial for less developed countries and industries, where the initial distortions and potential improvements may be larger, or in developed countries, where local firms may be better suited to respond competitively to MNC entry.

2.4 SPILLOVERS IN THE THEORETICAL LITERATURE

2.4.1 Early Contributions: Identifying Spillovers

The earliest discussions of spillovers in the theoretical literature on FDI date back to the early 1960s. The first author to systematically include technology spillovers (or external effects) among the possible consequences of FDI is MacDougall (1960), who analyzes the general welfare effects of foreign investment. Corden (1967), looking at the effects of FDI on optimum tariff policy, and Caves (1971), examining the industrial pattern and welfare effects of FDI, are other early contributions to the spillover literature. The common aim of these studies is to identify the various costs and benefits of FDI, and technology spillovers are discussed together with several other indirect effects that influence the welfare assessment, such as those arising from the impact of FDI on government revenue, tax policies, terms of trade, and the balance of payments. The fact that spillovers are taken into account is generally motivated by evidence from empirical studies rather than by comprehensive theoretical arguments - the detailed theoretical models analyzing spillovers did not appear until the late 1970s.

A few of the empirical works that have inspired the early theoretical analyses and provided evidence to confirm the existence of various types of spillovers (as will be seen in Section 2.5) are Balasubramanyam (1973), Brash (1966), Deane (1970), Dunning (1958), Forsyth (1972), Gabriel (1967), Rosenbluth (1970), and Safarian (1966). In summary, these studies call attention to some very concrete channels for spillovers. It is pointed out that foreign MNCs may:

- contribute to efficiency by breaking supply bottlenecks (but that the effect may become less important as the technology of the host country advances),
- introduce new know-how by demonstrating new technologies and training workers who later take employment in local firms,
- either break down monopolies and stimulate competition and efficiency or create a more monopolistic industry structure, depending on the strength and responses of the local firms,
- transfer techniques for inventory and quality control and standardization to their local suppliers and distribution channels, and,
- force local firms to increase their managerial efforts, or to adopt some of the marketing techniques used by MNCs.

Although this diverse list gives some clues about the broad range of various spillover effects, the taxonomy suggested by Caves (1974) may provide a more lucid illustration. He classifies possible spillover externalities into three categories, depending on the impact on local firms. Firstly, Caves argues that MNCs may improve *allocative efficiency* by entering into industries with high entry barriers and reducing monopolistic distortions. Secondly, the entry of MNCs may induce higher *technical efficiency* if the increased competitive pressure or some demonstration effect spurs local firms to more efficient use of existing resources. Thirdly, MNC presence may lead to increases in the rate of *technology transfer and diffusion*, because of competition, continuous imitation, or other reasons. Most practical cases of MNC entry and presence probably contain elements of all three effects.

For present purposes, however, we will apply a somewhat different taxonomy. We distinguish between effects on local productivity and technology that are primarily results of *demonstration, imitation, and contagion* and effects that are mainly caused by *competition* (although these are also likely to coincide). The reason is that we will be concerned with why spillovers occur and how they can be influenced, and we suggest that the determinants of these two kinds of spillovers are fundamentally different. Demonstration and contagion effects occur because of differences in technology and information between MNC affiliates and local firms, whereas competition depends on market characteristics and interactions between foreign and local firms. Another difference is that contagion is related to the extent of foreign presence and may operate in a relatively predictable manner - the higher the market share of MNCs, the more likely it is that local firms will come in contact with them - whereas competition may have less to do with market shares: the strongest competitive challenge to local firms may well come from foreign affiliates that have recently entered the host country and still operate at a small scale, but are trying to capture a larger share of the market.

2.4.2 Spillovers in Theoretical Models

More recent theoretical studies of spillovers differ from the earlier ones on several points. The newer analyses take the existence of various types of spillovers for granted, and aim to analyze the determinants and consequences of spillovers for host (and home) countries in theoretical partial equilibrium models, without any ambitions to reach normative welfare conclusions of the kind attempted by the earlier authors.

The earliest models in this tradition seem to be Findlay (1978a) and Koizumi and Kopecky (1977). Findlay constructs a simple dynamic model with foreign direct investment and technology transfer from an "advanced" developed economy to a "backward" developing country, and examines some steady-state characteristics, such as the size of the technology gap between the countries and the share of foreign capital. The model is discussed further in Chapter V, and it may be sufficient to note some brief points here.

The rate of technological diffusion (or spillovers, as we have defined them) to the backward country is described as a combination of two related effects. On the one hand, Findlay (1978a, p. 2) refers to Gerschenkron (1962) and Veblen (1912), who hypothesize that the rate of technological convergence may be higher "the greater the backlog of available opportunities to exploit." Thus, diffusion may be faster when the technology gap between the home country and the host country is larger.

On the other hand, it is assumed that technology spreads most easily when there is contact between those who already use a technology and those who are to adopt it, in analogy to the spread of a disease. This contagion effect implies that diffusion is faster the higher the MNCs' share of the backward country's capital stock. Changes in some exogenous parameters - the rate of progress in the advanced country, the tax rate on the MNCs' profits, the educational level of the host country, and the host country's savings propensity - may affect the gap or the foreign share, and thereby also the incidence of spillovers, but both the gap and the foreign share are assumed to be independent of the decisions and actions taken by local firms.

Koizumi and Kopecky (1977) also analyze effects of foreign direct investment on growth, but in the framework of a model of long-term international capital movements. They assume that the private marginal return on domestic and foreign capital is equal, but that the technology embodied in foreign capital, through its public good nature, generates an additional benefit to society: the extent of this spillover is related to the foreign ownership of a country's capital stock, as in Findlay's model.

An implication of their analysis is, they argue, that some of the conclusions of standard models of international capital movements have to be modified. In the traditional model, the "steady-state capital-labor ratio is determined solely by the characteristics of the production function and the exogenous world interest rate" (Koizumi and Kopecky, 1977, p. 53), and international capital movements occur when the domestic funds exceed or fall short of the amount necessary to reach that ratio. Exogenous changes in the domestic savings propensity have an impact only on the international net debt in steady-state. In the model with spillovers, however, the capital-labor ratio depends on the foreign share of capital. Spillovers from foreign capital raise the social marginal product of capital above the world interest rate, which stimulates domestic capital accumulation and leads to a higher capital-labor ratio.

In terms of our taxonomy of spillovers, it appears that both Findlay's convergence and contagion effects and the spillovers in Koizumi and Kopecky's model belong to the group with demonstration and imitation, i.e. technology differences between MNCs and locals are the main determinants of spillovers. Spillovers related to competition are not explicitly included, although Findlay (1978a, p. 5) notes that contact with MNCs can induce local firms to "try harder" and that "the visible example of a high standard can inspire those with a lower level of achievement to perform better." Moreover, spillovers are assumed to be "automatic", in the sense that they depend only on exogenous factors, and not on the behavior and decisions of affiliates and local firms.

The most recent models have progressed towards making spillovers endogenous, and have also included the level of competition among the determinants. Das (1987) observes that spillovers make up a cost for the MNC affiliate, since the benefits gained by local firms sooner or later translate into increasing competition. He then proceeds to examine the optimal behavior of the MNC when these costs are recognized. Assuming that spillovers are directly related to the quantity of MNC output, Das shows that the output price charged by the MNC is higher when spillovers take place. An increase in the price charged by the MNC reduces profit in the short term (because the price increase leads to a fall in the volume of output from an initially optimal level), but this loss is more than outweighed by the gains that come about in the long run. The reduction in the MNC's output means that fewer spillovers will materialize, and that the competitiveness of local firms will increase at a slower rate than if prices had remained unchanged.

Das also concludes that imports of additional technology are always profitable for the multinational, in spite of spillovers. However, technology transfer is assumed to be costless, and will only lead to a fall in the unit cost of production of the affiliate. The conclusion seems, therefore, trivial.[12] The merit of the model lies instead in its recognition of the fact that MNC affiliates are aware of spillovers, and that this has some effect on their behavior: yet, the behavior of local firms is still not taken into account explicitly.[13]

Wang and Blomström (1992) extend this reasoning by noting that technology transfer is costly, and that local firms are also aware of spillovers. Accordingly, they treat spillovers as an endogenous phenomenon resulting from the strategic interaction between MNC affiliates and local firms. Their model is also discussed in some detail elsewhere in this study (Chapter VI), and we will therefore be brief here. In essence, they model a differential game involving an MNC affiliate and a local firm, where both solve their individual dynamic optimization problems subject to the other firm's actions. The MNC's objective is to choose, for each time period, how much to invest in imports of new technology, and the local firm's objective is to decide how much to invest in learning to imitate MNC technology, given that both know the other party's decisions, and that:

a) a larger technology gap gives the MNC affiliate's products a "quality advantage" that translates into a "quasi-rent", whereas the profit of the local firm is negatively related to the size of the technology gap,

b) technology transfer is costly, and newer and more complex technologies are more expensive to transfer,

c) the technology gap between the firms grows as new technology is imported, but diminishes as a result of the local firm's learning efforts, and,

d) some spillovers that are proportional to the size of the technology gap always take place irrespective of the local firm's active learning efforts, as discussed by Findlay (1978a).

The differential game is solved by defining the steady-state equilibrium conditions for each party's optimal control problem, subject to the other's decisions, and then finding the combination of technology import and learning decisions that fulfills the conditions for a unique, locally stable steady-state Nash equilibrium: such an equilibrium is shown to exist.

The most interesting conclusion of the model is that the total amount of spillovers of MNC technology is not exogenously fixed (although some spillovers may occur automatically). Instead, both the MNC affiliate and the local firm are able to influence the extent of spillovers through their investment decisions. The more the MNC invests in new technology, the higher the spillovers, *ceteris paribus*, because they are related to the size of the technology gap; the more the local firm invests in learning, the more MNC technology it is able to absorb through spillovers. In addition, there is also a multiplicative second order effect, since an improvement in local technology (e.g. as a result of spillovers) will reduce the technology gap, cut into the MNC affiliate's quasi-rent, and force it to import new technology (part of which may also spill over) in order to restore its profitability and market shares. Analogously, an increase in the technology gap may force local firms to spend more resources on learning.[14]

To summarize this brief review of theoretical models, we may repeat the hypotheses regarding the determinants of spillovers. In Findlay (1978a), Koizumi and Kopecky (1977), and Das (1987), spillovers are made possible by differences in the technological levels of local firms and MNCs, and their size or extent is determined by the size of the technology gap or the foreign share of the industry. These characteristics, in turn, are influenced by various exogenous parameters, such as the rate of technological progress in the advanced country, tax rates on MNC profits, the educational level of the host country, the host country's savings propensity, and so forth. However, neither the local firms' nor the affiliates' behavior is assumed to influence spillovers.

By contrast, Wang and Blomström (1992) argue that both local firms and affiliates may influence the incidence of spillovers. The size of the technology gap is a determinant of the size of spillovers, as in Findlay's model, but both local firms and affiliates have some impact on it - local firms may spend resources to learn to imitate the technologies used by MNC affiliates, which reduces the gap, and affiliates may spend resources on importing innovations from the home country, which expands the gap. Consequently, in addition to the "automatic" spillover effects, there is also a second type of "discrete" effect that is spurred by the investment decisions of local firms and affiliates. The impact is cumulative, because the actions taken by one party force the opponent to respond: this translates into a third kind of effect that depends on the degree of competition between foreign and local firms. In terms of our classification, it is obvious that the automatic spillovers belong to the demonstration-imitation-contagion group (because they depend on technology differences) whereas the two latter effects fit into the competition group (since they are determined by the market environment and the interactions between local and foreign firms).

2.5 EMPIRICAL EVIDENCE

In this section, we will survey some empirical studies of FDI, technology, and spillovers, with a dual purpose. The survey aims to provide an overall picture of the significance of spillovers, but also seeks to indicate some areas where empirical knowledge is weak or limited. To summarize the wealth of evidence from the many heterogeneous sources, we will structure the survey according to the taxonomy suggested in the previous section: evidence related to demonstration and contagion-type effects is taken up first, and studies of the effects of competition are discussed thereafter.

However, there is only little direct evidence of spillovers, and it is difficult to generalize from the few detailed case studies that are available. Hence, we will also examine some circumstantial evidence. For instance, there are not enough case studies of demonstration and contagion to unambiguously show that these effects are generally significant, and we will therefore complement the picture by discussing the technology differences between MNC affiliates and local firms. Several of the theoretical models noted above have identified the technology gap as a determinant of spillovers, and it is obvious that some kind of technology differences are necessary to create a potential for spillovers from demonstration and imitation. Similarly, there is only limited explicit evidence of competition-type spillovers, and it is necessary to examine the relation between MNC entry and presence and market structure in the host country.

Regarding the demonstration-contagion effects, we will look at three separate (but related) issues. These deal with demonstration and the technology choices of MNCs, spillovers from the linkages between MNCs and their local suppliers and customers, and spillovers from the training of MNC affiliates' local employees. The fourth sub-section examines competition and related effects. The last part of the survey focusses on the few available statistical tests of spillovers in aggregate manufacturing.

2.5.1 Demonstration Effects and the Technology Choices of MNC Affiliates

Although few and far between, there are some case studies where demonstration and contagion effects of FDI are discussed explicitly. Tilton (1971), in a study of the semiconductor industry, points at the importance of new MNCs in introducing U.S. innovations to the European countries. Lake (1979), also examining the semiconductor industry, argues that affiliates of U.S. MNCs have been more active than local firms in the diffusion of new technology in Great Britain. As already mentioned, Mansfield and Romeo (1980) show that the technologies transferred to affiliates are younger than those sold to outsiders, and that there are cases where the affiliates' technology imports have induced local competitors to imitate their behavior. Riedel (1975), referring to his own earlier studies, claims more explicitly that horizontal demonstration effects from the operations of MNCs were an important force behind the development of the manufacturing export sector in Hong Kong in the 1960s. In a similar vein, Swan (1973) suggests that multinationals are important not only for the diffusion of the specific technologies they use, but more generally because they strengthen international communications channels, which makes demonstration across international borders possible.

Some of the cases that are referred to in the subsection on competition below also include elements of demonstration-imitation-contagion. However, the evidence from the case studies is not sufficient to prove that simple demonstration and contagion effects are typically significant, because only some industries and countries have been examined. To complement these findings, we will briefly examine the technology choices of MNC affiliates: there is a potential for intra-industry spillovers from demonstration, imitation, and contagion only if affiliates use technologies that are more advanced than those employed by the average local firm.

We have noted earlier that MNCs dominate global technology production, and that technology is one of the competitive advantages that allow firms to become multinational and to operate plants in foreign countries where local competitors have the benefit of better market knowledge. This means that MNC affiliates generally have the option to use advanced technologies. However, technology transfer is costly, even within MNCs (see Teece, 1976), so affiliates may try to minimize the technology imports from their parents, just as they minimize other costs. The MNCs may also be competitive for reasons other than technology, e.g. protected brand names, scale economies, or access to capital markets. It is therefore not clear whether there is typically a significant technology gap.

Comparisons of Factor Proportions

There is a multitude of studies comparing the technological level of MNCs affiliates and local firms in developing countries - studies for industrialized economies are less common - but the empirical evidence is far from clear-cut, as shown in surveys by e.g. Jenkins (1991), Lall (1978), Newfarmer (1985), and White (1979).

Looking first at comparisons of local and foreign firms' factor-intensities across specific industries or the entire manufacturing sector, it is difficult to discern any distinct patterns.[15] On the one hand, there are countries like India (Agarwal, 1976), Indonesia (Wells, 1973), Brazil (Morley and Smith, 1977a; Tyler, 1978), Mexico (Blomström, 1989), and other Latin American countries (Meller and Mizala, 1982; Sosin and Fairchild, 1984) where MNC affiliates in manufacturing appear to use more capital-intensive (and more advanced) technologies than local firms. On the other hand, there are also studies for Hong Kong (Chen, 1983a), Korea (Cohen, 1973, 1975), Malaysia (Chee, 1980), Singapore (Cohen, 1975), Taiwan (Riedel, 1975), and Thailand (Lecraw, 1977) where the authors have not been able to establish any significant differences in overall factor proportions. There is also evidence of industries in Hong Kong (Chen, 1983a), Ghana (Forsyth and Solomon, 1977), Kenya (Pack, 1974), and Taiwan (Chen, 1983a) where local firms seem to be more capital-intensive.[16]

Comparisons based on matched pairs of firms, where the main difference between the firms is nationality of ownership, also come up with mixed results. Most of these studies suggest that the differences in the factor intensities of affiliates and local firms are small or negligible. This is the finding in studies of Brazil by Morley and Smith (1977b), Costa Rica by Willmore (1976), the Philippines and Mexico by Mason (1973), and South Korea by Chung and Lee (1980). Yet, the most detailed of the matched-pair studies - by Willmore (1986), who compares 282 pairs of local firms and affiliates in Brazilian manufacturing - concludes that the affiliates were significantly more capital-intensive.

There are several possible explanations for the confusing results. In the cross-section analyses, the most obvious reason is probably that some, but not all, authors have taken into account differences in industry, firm size, and other factors apart from foreign ownership that affect factor-intensity. It is obvious that the more of these factors that are taken into account in the comparisons, the less likely it is that foreign ownership *per se* will make any difference. For instance, in a simple comparison of factor proportions, Sosin and Fairchild (1984) find that foreign firms in Latin America are more capital-intensive: taking size into account, they conclude that there is no significant difference. Similarly, the more precise the "matching" of pairs in the latter kind of comparisons, the harder it is to find any differences between the firms.

Chen (1983b) argues that product and host country factors are responsible for most of the conflicting findings, and that these should be included in an eclectic explanation of the relative factor proportions of foreign and local firms. More specifically, he means that the capital-intensity of MNC operations varies according to the type of goods that are produced. The manufacturing of newer products is likely to use capital-intensive technologies, whereas older, standardized products may be produced with lower capital-labor ratios. This has an impact on comparisons of aggregate factor proportions if the MNCs' product mix differs between host countries that are otherwise comparable. For instance, the exports products of many less developed countries (LDCs) are manufactured with relatively standardized and labor-intensive technology. Developing countries that host mainly export-oriented foreign affiliates are therefore likely to exhibit smaller technology gaps between affiliates and local firms than countries where affiliates substitute for imports. In addition, Chen argues that the differences in factor proportions are smaller in the more developed host countries, because the local factor prices ratios are closer to those in the MNCs' home countries (so that only small adaptations of MNC technology are necessary), and because local firms may have the capability to adopt techniques similar to those of the affiliates. A similar argument is also proposed by Findlay (1978b), as will be discussed in Chapter III. The data from the comparisons seem to be consistent with these hypotheses: many of the cases where the factor proportions of foreign and local firms do not differ significantly are either more developed or more export-oriented than the others.

Courtney and Leipziger (1975) also focus on factor substitution when they try to explain the ambiguous results from factor proportions comparisons. Estimating production functions for 1484 affiliates of U.S. MNCs (787 in Europe and 697 in LDCs) in 1970, they distinguish between *ex ante* factor substitution, meaning choices of plant design, and *ex post* substitution, referring to the way plants are actually used. They find no statistically significant differences between the capital-intensities of *ex ante* technologies transferred to developing and industrialized countries. This means that the technologies flowing to less developed countries are relatively advanced and that there should be scope for demonstration effects at least in these countries. However, *ex post*, firms seem to respond to the lower relative labor costs in developing countries and operate their LDC plants with significantly lower capital-intensity, which makes their technology - as estimated from the factor proportions - appear similar to that of local competitors.[17]

Helleiner (1975), reporting on a study of 1400 firms in Israel, Colombia, the Philippines, and Malaysia, comes to similar conclusions: when *ex post* capital-labor substitution takes place, MNCs use their capital so much more intensively than local firms that their *ex ante* higher capital-intensity is offset. Therefore, there is reason to believe that MNC affiliates do use more advanced technology than the average local firms, although the direct factor-intensity comparisons may not reveal the differences.

Another possible reason for the widely disparate results from the comparisons is that there are differences in market structure and competition between host countries and industries. Technology transfer and adaptation of advanced technology to host country conditions is costly, as noted earlier, and the MNC affiliate is likely to adjust its technology imports to the level that is necessary to maintain acceptable profits, given the competition. However, there are no comprehensive empirical studies of the affiliates' technology imports, and it is unclear what the effects of a competitive host country climate are. On the one hand, Wells (1973) argues that lack of competition allows MNCs to operate inappropriately capital intensive technologies in less developed host countries. On the other hand, direct competition or threats of entry from local firms may force affiliates to import technology continuously, to maintain their competitive advantages.

Comparisons of Productivity and Efficiency

There are fewer explicit comparisons of labor productivity, but the ones that are available generally present a clearer picture. Typically, the affiliates' labor productivity is found to be higher than that of local firms, in developed as well as developing countries (Parry, 1980, pp. 110-112), although the conclusion may appear trivial, because "companies do not become multinational unless they are good at something" (Caves, 1982, p. 223).[18] The problem is that higher productivity may not always reflect superior technology, but rather market power or other characteristics that do not make up a base for contagion-related spillovers.

However, the studies that have examined the causes for the MNCs' higher labor productivity imply that some type of superior technology is often the reason, although it might not be reflected by higher capital-labor ratios. For instance, Agarwal (1979) estimates that on average, foreign manufacturing firms in India in 1969 had 65 per cent higher labor productivity than local firms, although they were only 16 per cent more capital-intensive. Most of the difference was attributed to more efficient use of production inputs (capacity utilization, management), rather than to choice of equipment or machine technology. The underlying advantage in management technology can, of course, provide an example for local firms.[19] Tyler (1978) believes that greater elasticities of substitution and returns to scale were the important dynamic advantages of foreign firms in Brazil in the early 1970s. These assets are also partly related to the organization of production and to management practices, and may therefore spill over.

Regarding overall "efficiency" comparisons of foreign and local firms, Lall (1978) argues that there is no firm basis to reach any definite conclusions: the evidence from the LDC studies he surveys indicates that affiliates have higher labor productivities than local firms, but not necessarily higher capital productivities. Caves (1982, pp. 222) also concludes that it is difficult to generalize about the overall efficiency of MNCs, since host country policy (e.g. tariffs) may lure them into markets where they operate with inappropriate technology and at suboptimal scale.[20]

Summarizing this discussion of technology differences and potential demonstration effects, it appears that *ex ante* technology choices of MNC affiliates are generally somewhat more advanced than those used by local firms. Comparison of factor proportions may not reveal these differences, because *ex post* factor substitution may have brought down the capital intensities observed in the affiliates.[21] This seems to support the hypothesis that some sort of demonstration effect is usually possible: not only are advanced technologies introduced to host countries, but the affiliates also provide examples of what type of *ex post* adaption is possible.[22]

It has also been suggested that the size of the technology gap differs systematically between host countries, depending on the characteristics of the MNCs' products, the technical capability of the host countries, and possibly also the level of competition facing the affiliate. Yet, there are no detailed analyses of what determines the technology imports (or *ex ante* technology choices) of MNC affiliates and encourages them to create a large potential for spillovers.[23]

2.5.2 *Backward and Forward Linkages*

Some of the spillovers that may occur when the MNC has a technology or information advantage operate via the linkages between the foreign affiliate and its local suppliers and customers. Borrowing a definition from Lall (1980, p. 204), we will use the term "linkage" here to denote "direct relationships established by firms in complementary activities which are external to 'pure' market transactions."[24] The spillovers occur when local firms benefit from the MNC affiliate's superior knowledge of product or process technologies or markets, without incurring a cost that exhausts the whole gain from the improvement. However, the existence of linkages does not prove that there are spillovers, but the two are probably closely related. Even if the MNC affiliate charges for the support it provides to their local suppliers and distributors, it is not always able to extract the full value of the resulting productivity increases.

Unlike spillovers from demonstration or outright imitation, these effects may take place between firms in different industries, and the underlying information asymmetries may therefore not be observed through comparisons of factor intensities or technologies. We will begin by examining some evidence of backward linkages, which arise from the affiliate's relationships with suppliers, and thereafter look at forward linkages, i.e. effects on customers.

Backward Linkages

Lall (1980), in a study of Indian truck manufacturers, identifies some of the "complementary activities" that may create spillovers through backward linkages. Although the study is not exclusively interested in foreign affiliates (one of the firms is a joint venture), it is useful also here. In summary, his arguments imply that MNCs may contribute to spillovers as they:

- help prospective suppliers (domestic as well as foreign) to set up production facilities,

- provide technical assistance or information to raise the quality of suppliers' products or to facilitate innovations,
- provide or assist in purchasing of raw materials and intermediaries,
- provide training and help in management and organization, and,
- assist suppliers to diversify by finding additional customers.[25]

In addition to these linkages-spillovers that occur as a result of cooperation between affiliates and local firms, it is also possible that there are effects that occur as suppliers are forced to meet the higher standards of quality, reliability, and speed of delivery of the MNCs. For instance, Brash (1966), in a study of the impact made by General Motors on its Australian local suppliers, emphasizes the importance of the MNC's stricter quality control, which also had an impact on the suppliers' other operations. Katz (1969, p. 154) reports that foreign MNCs operating in Argentina "forced their domestic suppliers to adopt productive processes and techniques used by the suppliers of their main firms in their country of origin." Similarly, Watanabe (1983a) notes complaints from small local producers in the Philippines about the large foreign firms' tough requirements on both product characteristics and prices: in developing countries, in particular, this alone may have an effect on what technologies are used, and perhaps also on the general competitive climate. However, there is very little additional evidence on such "forced linkage effects", so the following discussion is limited to the Lall-type linkages. There are plenty of very detailed case studies relating to these and the results appear to be fairly similar. With the exception of Lall's study, we will therefore not go into the details, and only emphasize some of the distinguishing results.

Lall (1980) looks specifically at two Indian truck manufacturers (one MNC and one joint venture) and finds significant backward linkages in both cases. Domestic content is extremely high - probably over 90 per cent - and both firms have extensive supplier networks, with 500 and 339 independent suppliers, respectively. It should be noted that these characteristics already distinguish the Indian experience from others, since an extreme import substitution policy makes India a virtually closed economy. This complicates general welfare judgments, and Lall also chooses not to evaluate whether the local suppliers were efficient in international terms. Nevertheless, he presents evidence for all the types of linkages mentioned above, except those related to financial matters and raw material procurement. In particular, the truck manufacturers had been active in the establishment of supplier firms: of the 36 sampled supplier firms, 16 had been launched by the principals.

For the technical linkages, there were large variations depending on the size of the supplier and technical similarity between the supplier and the principal company. *Low technical linkages*, meaning quality control and communication of information about input specifications, were found for all types of suppliers, but quality control was more important in contacts with small subcontractors. *Medium technical linkages*, including joint development of component designs and more comprehensive technical assistance, were most important for large suppliers of complex products with technology similar to that of the truck firms. In many cases, there was direct collaboration between the technical departments of the firms, and also some signs of flows of know-how from larger suppliers to the principal; for smaller suppliers, however, the flows were of the opposite direction. *High technical linkages* also occurred in some cases where research and development work was undertaken to create entirely new designs that would fit the capabilities of the suppliers.

Summarizing his findings, Lall maintains that technologically dissimilar suppliers gain mainly from having assured markets and information about the future plans of their customers. Technologically similar large suppliers have additional strong benefits from technical linkages. Technologically similar small suppliers may face a certain trade-off between benefits and cost, since the dependence on the large buyer translates into a weak bargaining position in pricing decisions; yet, on balance, the benefits are likely to dominate. Another detailed empirical study where similar linkage effects are noted is presented by Behrman and Wallender (1976), who examine the operations of General Motors, ITT, and Pfizer in several host countries. In particular, they emphasize the ongoing character of the contacts and information flows between MNCs and their local suppliers.

The generality of Lall's conclusions is challenged by Hill (1982), who examines the Philippine appliance and motor cycle industries. His results show inter-firm linkages that are significantly weaker than in the Indian truck industry, and he attributes this to a combination of different factors. Most importantly, more liberal import policies reduce local content, the small size of the market makes much production economically inviable, and the assembler character of the principal firms makes them incapable of offering technical assistance to suppliers.

Watanabe (1983a) outlines a somewhat more positive picture in a study of the Philippine automobile industry. He mentions various types of linkages, including establishment of supplier firms and direct technical linkages, but notes also that the average local content ratio of his five automobile parts producers is significantly lower than that found for India, at approximately 30 per cent in 1978.[26] The findings for the Mexican manufacturing industry in Watanabe (1983b) are similar, with the exception that large foreign-controlled supplier firms and sub-subcontracting exist in Mexico, but are not observed in the other cases. UNCTC (1981) reports that the local content ratio in the Peruvian automotive industry was also around 30 per cent in the late 1970s, but significantly lower in the Moroccan car industry: in both cases, low and medium technical linkages were observed, but at correspondingly much smaller scale than in India.[27]

Thus, the degree of local content seems to be one of the determinants of backward linkages, Reuber *et al.* (1973), in a comprehensive survey of MNC affiliates in developing countries, note that over a third of the total value of goods and services purchased 1970 by all affiliates included in their survey were provided by local firms. However, there were systematic differences in local purchases depending on the affiliates' market orientation, the parent's nationality, and the host country. Local-market oriented affiliates purchased more from local firms than did export-oriented affiliates (perhaps because import licenses are easier to obtain for exporters); European MNCs relied more on local firms than U.S. or Japanese firms (perhaps because they are generally older and have already built up local supplier networks); and affiliates in Latin America and India purchased more local inputs than affiliates in the Far East (probably because of differences in local content requirements). In addition to these factors, it seems that the technical capability of potential local suppliers must be important to take into account. Furthermore, Reuber *et al.* suggest that the share of local inputs is likely to increase notably over time, also for export-oriented affiliates.

Similarly, McAleese and McDonald (1978), who study Irish manufacturing 1952-74, show that local purchases of inputs tend to increase as the MNC affiliates mature. Several factors contribute to the gradual development of linkages: further production processing stages are added over time, the autonomous growth of the manufacturing sector brings up new suppliers, and some MNC take deliberate action to attract and develop local suppliers.

This last point is noted in numerous other studies. Dunning (1958), one of the earliest contributions, maintains that foreign firms are generally engaged in the training of local suppliers. In addition to the comprehensive evidence on local content, Reuber *et al.* (1973) argue that MNCs actively support the establishment of independent local suppliers. Lim and Pang (1982) also underscore this in their study of the Singapore electronics industry: they point specifically at the role of MNCs in suggesting entrepreneurial possibilities and assisting in the establishment of supplier firms, and their "willingness to bear the initial costs of encouraging and patronizing local suppliers, who in the long run would be cost-competitive" (p. 591). What distinguishes their study is, firstly, that it is concerned with export-oriented MNCs whereas most others look at import-competing industries, and secondly, that they show how the development of linkages in Singapore was relatively rapid during the late 1970s while most other studies seem to suggest a much slower process.[28]

Some contrasting results are presented by Aitken and Harrison (1991), who examine Venezuelan manufacturing between 1976 and 1989, and conclude that the effect of foreign investment on the productivity of upstream local firms is generally negative. They assert that foreign firms divert demand for domestic inputs to imported inputs, which means that the local supplier firms are not able to benefit from potential economies of scale. Their results differ from most other findings in this respect - perhaps because they not only cover the local firms who actually supply inputs to the foreign affiliates, and because they do not take into account the increase in local content that seems to take place over time - and emphasize the need for more research where the connection between spillovers and linkages is examined explicitly.

Forward Linkages

There is much less evidence of forward than backward linkages. Only a minority of the firms studied by Reuber *et al.* (1973) claimed to have contributed significantly to the development of local distributors and sales organizations. However, McAleese and McDonald (1978) report that forward linkages in the Irish economy grew in much the same way as backward linkages. In particular, they assert that many MNCs commenced operations with heavy export-orientation, but that the importance of the home market has increased over time. It is unclear how representative this finding is, since few other authors have studied the question.

Blomström (1991) discusses forward linkages in closer detail, and emphasizes the growing technical complexity in many industries. On the one hand, this could mean that only MNCs can afford the necessary R&D to develop and manufacture these products; on the other hand, industrial application of e.g. computer-based automation and information technologies might require expertise from the manufacturers. This, he argues, would contribute to increasing the role of MNC-customer contacts, especially in the smaller countries. One of the few empirical works touching upon the issue is the study by Aitken and Harrison (1991) noted above. They conclude that spillovers from forward linkages seem to be important in most industries - in fact, they argue that the downstream effects of foreign investment are generally more beneficial than the upstream effects.

Summarizing, there is much evidence of the existence and potential of backward linkages, and a suspicion about the growing importance of forward linkages as well. Some of the host country characteristics that may influence the extent of linkages - and spillovers - are market size, local content regulations, and the size and technological capability of local firms. Moreover, linkages are likely to increase over time, as the skill level of local entrepreneurs grows, new suppliers are identified, and local content increases. This constitutes circumstantial evidence for spillovers, but it must also be mentioned that there are few studies where the connection between linkages and spillovers is explicit.

2.5.3 Training of Local Employees in MNC Affiliates

The transfer of technology from MNC parents to affiliates is not only embodied in machinery, equipment, patent rights, and expatriate managers and technicians, but is also realized through the training of the affiliates' local employees. This training affects most levels of employees, from simple manufacturing operatives through supervisors to technically advanced professionals and top-level managers. Types of training range from on-the-job training to seminars and more formal schooling to overseas education, perhaps at the parent company, depending on the skills needed. Although higher positions are often initially reserved for expatriates, the local share typically increases over time. The various skills gained while working for an affiliate may spill over as the employees move to other firms, or set up their own businesses.

The evidence on spillovers from the MNC affiliates' training of local employees is less complete than that on backward linkages, and comes mainly from developing country studies. Considering that the public education systems in developing countries are relatively weaker, it is also possible that spillovers from training are relatively more important there. However, there is scattered evidence of effects in the industrialized countries, and then perhaps mainly regarding management skills. It is possible, for instance, that the inter-firm mobility of managers has contributed to spread specific management practices from Japan to the US and Europe, and, in earlier times, from the US to Europe (Caves, 1982, p. 233). Moreover, casual observation suggests that the mobility of employees from MNCs in the computer and software industries contributes to spillovers, both within the industry and elsewhere. These cases are also closely related to demonstration and competition effects, but there are no detailed studies available.[29]

Studies in developing countries have recorded spillovers of both technical and management skills. For instance, Gerschenberg (1987) examines MNCs and the training and spread of managerial skills in Kenya. From detailed career data for 72 top and middle level managers in 41 manufacturing firms, he concludes that MNCs offer more training of various sorts to their managers than private local firms do, although not more than joint ventures or public firms. Managers also move from MNCs to other firms and contribute to the diffusion of know-how. Of the managers in private local and public firms who had training from elsewhere, the majority had received it while working for MNCs - joint ventures, on the other hand, seemed to recruit mainly from public firms. Yet, mobility seemed to be lower for managers employed by MNCs than for managers in local firms. This is not surprising remembering the common finding that MNCs pay more for their labor than what local firms do, even taking skill levels into account: in fact, it is not unreasonable to hypothesize that the fear of a "brain-drain" to local firms is one of the reasons behind the higher wages in MNCs.

Katz (1987) agrees that host countries may receive important spillovers this way, and points out that managers of locally owned firms in Latin America often started their careers and were trained in MNC affiliates. Likewise, Yoshihara (1988) underlines the importance of training in foreign companies (and overseas education) for Chinese-owned firms in South-East Asia.

Chen (1983a), in a study of technology transfer to Hong Kong, chooses to emphasize training of operatives. In three out of four sampled industries, the MNCs' incidence of undertaking training and their training expenditures were significantly (several times) higher than those for local firms. Consequently, he concludes that "the major contribution of foreign firms in Hong Kong manufacturing is not so much the production of new techniques and products but the training of workers at various levels" (p. 61). Behrman and Wallender (1976) recognize spillovers of both managerial and technical skills. In particular, they note that several of the MNC affiliates' subcontractors had been established by former employees. Hill (1982) also identifies similar cases in the Philippine appliance and motor cycle industries, but argues that they were insignificant. Nevertheless, 12 out of 20 assembler firms had some subcontractors that were established by former employees.

Another factor in the dissemination of technology and human capital skills is related to the R&D efforts undertaken by the MNC affiliates. Here, we will only hint at some of the results in a very extensive research field. Firstly, MNCs do undertake R&D in their host countries, although it is strongly concentrated to the home countries. The affiliates' research efforts could be important, and should be compared with the R&D efforts of local firms, rather than with the parents' total R&D. Doing so, Fairchild and Sosin (1986) conclude that foreign firms in Latin America exhibit more internal local R&D activity than is generally presumed, and that their total expenditures on research are very similar to those of domestic firms. In addition, they have access to the aggregate know-how base of the parent and related affiliates, and sometimes also to the parent's R&D facilities. The affiliates' R&D may therefore be more efficient than that of local firms. Not much is known, however, about what type of R&D is done in affiliates - presumably, much is adaptation of products and processes - and even less is known about the mobility of R&D personnel or the effects on the host country's technological capability. (See further Lall, 1985, Chapter 7.)

Judging from the aggregate evidence on spillovers from the training of MNC personnel, there seems to be a definite accumulation of human capital skills in the MNCs' employee stock. Some of these skills can be appropriated by local firms when employees move to new jobs, but how much is an open question. The fact that most studies deal with the spread of management skills suggests that they are less firm-specific than technical skills, and can more easily be used in other contexts: the empirical evidence, however, is too limited for any more definite conclusions.

2.5.4 Effects on Competition and Industry Structure

It has been claimed that MNC entry raises the level of competition in the host country's industry and puts pressure on local firms, who are forced to introduce new technologies or improve their efficiency in some other manner, in order to avoid losing market shares or going out of business. The general increase in productivity that follows is considered to be a major spillover effect of FDI. Some authors have hypothesized that the most important influences of MNCs on local firms operate this way (Blomström, 1986a), and some reasons to expect important effects from competition were noted already in Section 2.3 above: most importantly, MNCs are likely to enter into industries where potential local challengers are discouraged by high barriers to entry and where competition between existing local firms may therefore be limited.

Some case studies at the firm and industry level are available to describe the effects of the competition from MNCs on local firms. For instance, Langdon (1981), in a study of FDI in the Kenyan soap industry, reports that the entry of foreign MNCs also introduced mechanized production, and local firms found themselves unable to sell handmade soap in the urban markets. Instead, they were forced to introduce mechanized techniques to stay in business. Similarly, foreign entry into the Kenyan footwear industry led to increased competition and changes in the production techniques of local firms.[30] In the Brazilian textile industry, the establishment of an affiliate by a foreign firm brought in synthetic fibers: the consequent stagnation of demand for cotton textiles led to the disappearance of some local firms, and forced others to seek joint ventures with foreign firms in order to get access to competitive technology (Evans, 1979).

The reason for reporting these examples under the label "effects of competition" is that the changes in the local firms' behavior were apparently triggered by events in the market place, rather than by the demonstration of new technologies alone. However, demonstration is an important feature also here. Summarizing a comparison of MNC and local technologies, Jenkins (1990, p. 213) notes that:

> ...over time, where foreign and local firms are in competition with each other, producing similar products, on the same scale and for the same market, there is a tendency for local firms to adopt similar production techniques to those of the TNCs. Indeed this is part of a general survival strategy, whereby in order to compete successfully with the TNCs local capital attempts to imitate the behavior of the TNCs.

In practice, it is difficult to distinguish between the two effects, and the most valuable information from case studies may therefore be related to how local firms respond to increased competition in the short run, before imitation takes place. The immediate local reaction may be to merely enforce stricter or more cost-conscious management and motivate employees to work harder, in order to reduce slack or improve X-efficiency. It is possible that this seemingly simple response may make a more substantial contribution to productivity than improvements in resource allocation (see Lebenstein, 1966, 1980). Bergsman (1974), on the basis of a study of industry in six developing countries, argues that X-efficiency is several times as important as allocative efficiency in increasing GNP in these countries. Also Pack (1974), in a study of LDC manufacturing industries, and Page (1980), referring to evidence for three manufacturing industries in Ghana, suggest that factors related to X-efficiency - mainly management and capacity utilization - are more important than changes in resource allocation (via changes in relative factor prices) to improve performance (see also White, 1976).

The potential productivity improvements from these types of reactions are probably larger in the less developed countries than elsewhere, simply because the initial inefficiencies are often larger. On the other hand, local firms in the less developed countries may be too weak to mount a competitive response to foreign entry, whereas the locals in industrialized host countries can often be expected to reply competitively. Various defensive corporate agreements, such as amalgamations among local firms or cooperative ventures with other foreign firms, may improve the local firms' competitiveness, even in developing countries (Lall, 1979; Evans, 1977), but there are no direct cross-country comparisons available, and there are not enough case studies for more comprehensive conclusions. Exactly what the reaction is - and how important the spillover benefits are - is likely to depend on the initial conditions in the market, and how much of an impact MNC entry makes on concentration and competition.

This leads us to take a look at the studies of FDI and industry structure in host countries. The aggregate evidence, unfortunately, is not very much clearer than that on factor proportions reviewed earlier. One central problem here is the question whether MNC entry and presence explain industry structure, or whether industry structure determines if MNCs will enter or not. This is an important question, since we have argued that one of the reasons to expect spillovers is the improvement in efficiency and resource allocation that may follow from MNC entry into monopolistic host country industries. Another problem is noted by Lall (1978, p. 227), in a survey of some of the studies of MNCs and market structure in LDCs. He argues that there is some confusion regarding effects that are endemic to MNCs and those that are only speeded up by MNC presence:

> It is not clear to what extent TNCs have contributed *independently* to concentration ... as distinct from simply embodying or transmitting changes caused by technological, marketing, financial, or organizational developments.

Few authors have been able to make a proper distinction between these two effects, but it may not be a crucial issue in the present context. What matters is the impact made by MNCs, and not the question of whether it is caused by foreign ownership or some other of the MNCs' characteristics. Yet another (perhaps even more important) complication is that there is no simple relationship between competition and efficiency, on the one hand, and concentration, on the other hand. This will warrant some further comments later.

Moving to the empirical findings, it is clear that the overwhelming majority of studies are able to establish a positive correlation between foreign entry and presence and seller concentration in host country industries. For industrialized countries, this pattern is found e.g. for the U.K. (Dunning, 1958, Fishwick, 1981), France and Germany (Fishwick, 1981), Canada (Rosenbluth, 1970; Caves *et al.*, 1980), Australia (Parry, 1978), and New Zealand (Deane, 1970). For developing countries, there are studies for Mexico (Blomström, 1986b), Brazil (Newfarmer and Mueller, 1975, Newfarmer and Marsh, 1981), Guatemala (Willmore, 1976), Malaysia (Lall, 1979), and other countries (Lecraw, 1983) that show the same results.[31] The only notable exceptions seem to be Japan, for inward as well as outward investment, and outward investment from developing countries (Lecraw, 1983).[32]

The causal links are more difficult to establish. One finding is that the correlation disappears once other determinants of concentration are taken into account, and that MNCs do not cause concentration but are drawn to concentrated industries: this is suggested to be the case for FDI in the United Kingdom (Fishwick, 1981; Globerman, 1979b). Similarly, Rosenbluth (1970) points to the fact that affiliates are relatively large firms, and that this, rather than foreign ownership, explains much of their investment pattern. Other authors are more explicit. Gorecki (1976), also in a study of Canadian manufacturing, argues more directly that new MNCs enter into relatively more concentrated industries than new local firms. Knickerbocker (1976) shows that entries by MNCs into the U.S. market in the 1960s were negatively correlated with changes in concentration (i.e. higher numbers of foreign entries led to lower concentration): the same pattern was supposedly true for Canada, Italy, France, and West Germany as well. Commenting on these and other studies, Caves (1982, p. 101) concludes that "the absence of a positive relationship is comforting," at least for industrialized countries.

It has also been suggested that the international rivalry among MNCs is an explanation for why foreign entry might not increase concentration. Knickerbocker (1973) seems be one of the first authors to note that the pattern of foreign investment depends on the oligopolistic rivalry in home country markets. Investigating the establishment of manufacturing affiliates by 187 U.S. MNCs during the years 1948-1967, he found that home market concentration significantly increased the likelihood that several MNCs would simultaneously enter particular host country industries. Flowers (1976) also establishes a relationship between seller concentration in home countries (Canada and Europe) and entry concentration for FDI flowing into the United States.

This clustering of MNC entry is apparently strongest in moderately concentrated industries. According to Flowers, oligopolistic reaction seems to be most likely when the four-firm concentration ratio in the home country is lower than 70 per cent; Yu and Ito (1988) argue that it is most common when the home industries have between three and ten or twelve firms with approximately equal market power. For a concrete example, Evans (1977) refers to what he calls a "miniature replica" effect in the pharmaceutical industry. There, levels of concentration are relatively low and numerous MNCs are often crowded in one and the same host country, including LDCs such as Argentina, Brazil, and Mexico.

Yu and Ito (1988) have demonstrated that these effects are significant even when other host country and firm related factors explaining entry are taken into account. Thus, they conclude that FDI in these industries is not likely to cause very concentrated host country market structures. They also suggest that oligopolistic reaction should be examined with respect to firms from different countries. Sölvell (1987), in a detailed study of international competition in electrical industries (low-voltage apparatus and switchgear, and home appliances) does this: his findings are consistent with the other studies, but they outline a more complex picture where oligopolistic rivalry in some markets is coupled with weaker competition and market sharing in others.[33] In this context, it should be noted that most of the studies listed above look at effects of MNC entry, and it is possible that the concentration-reducing impact does not hold for already established affiliates, who may instead be interested in building barriers to entry.

Regarding the LDC studies, most authors have not been able to - or have even tried to - determine whether the high degrees of concentration in the industries where foreign affiliates are present have been caused by MNCs or whether MNCs have just been attracted to these industries by good profit opportunities. Two (seemingly contradictory) exceptions are Evans (1977), who claims that MNCs tended to reduce concentration in the oligopolistic Brazilian pharmaceutical industry, and Newfarmer (1979), who argues for the opposite effect - caused by interlocking directorates, collusion, cross-subsidization, and other "oligopolistic tactics" - in the Brazilian electrical equipment industry.[34]

Lall (1978) hypothesizes that it is plausible that MNCs speed up the natural concentration process in LDCs, or that the weakness of local competitors allows MNCs to achieve a higher degree of market dominance than in developed countries. Lall (1979) proceeds to argue that the level of concentration probably falls in the short run following MNC entry, as the affiliate adds to the number of firms in the industry, but that this may be reversed in the long run. The MNCs may buy out local firms or force them out of business, their success may force local firms to fusions and amalgamations, or they may be more skilled as lobbyists than others, thus adding to entry barriers and protection. Looking at the effects of MNCs on concentration in 46 Malaysian industries, he asserts that the presence of foreign firms on balance increased concentration. This was brought about both by the MNCs' impact on general industry characteristics - such as higher initial capital requirements, capital intensity, and advertizing intensity - and by some apparently independent effect of foreign presence, perhaps related to "predatory" conduct, changes in technology and marketing practices, or gains of policy concessions from the government. Thus, the evidence seems to suggest that there is a larger risk that MNCs crowd out local firms in LDCs than in developed countries.[35] However, Lall is unwilling to make any normative conclusions about whether or not the increase in concentration is desirable for industrial efficiency and technical change.

The assumption implicit in much of the discussion above is that competition improves efficiency and welfare, but there are cases where it must not necessarily be that way. Firstly, economies of scale are important determinants of industrial productivity. To the extent that foreign entry increases concentration in relatively small national industries - particularly those where some type of imperfections have initially influenced market structure - resource allocation and efficiency may well improve from the increase in average firm size. Whether this effect is stronger than that from the presumably reduced competition depends on market characteristics and trade policy. For instance, a fall in the number of competitors from thirty to twenty must not necessarily harm the competitive environment, but a reduction from three to two certainly will. Similarly, increased concentration is likely to have more harmful effects in protected industries than in import-competing or export-oriented industries.[36]

In fact, free trade and imports may well be good substitutes for large numbers of domestic competitors: Scandinavian, and particularly Swedish, industrial policies have for a long time built on this assertion (Hjalmarsson, 1991), although the competition between the few remaining large firms has also been important (Porter, 1990; Sölvell, Zander, and Porter, 1991). The conclusion by Chen (1983a, p. 90) from his study of Hong Kong manufacturing, where all industries are either export-oriented or import-competing, is consistent with these arguments:

> There are indications that the presence of foreign investment in an industry may have the effect of eliminating wasteful competition ... [without introducing] ... damaging monopolistic elements into the industry.

Secondly, focussing more closely on technology, there is the classic "Schumpeterian Dilemma" of weighing the static allocative efficiency of competitive markets against the supposed dynamic efficiency of monopolistic and oligopolistic firms. The rate of technical progress can perhaps be higher in concentrated markets, since firms there have internally generated profits to use for R&D, and are generally larger and more able to enjoy economies of scale in R&D. It is also possible that market structure has some impact on what the R&D efforts aim to achieve.

In fact, empirical studies seem to show that market structure affects both the rate and type of technical progress. Looking at the overall rate of technical change, Kamien and Schwartz (1982) summarize a survey of research in industrialized countries by concluding that neither perfect competition nor perfect monopoly, but rather mildly oligopolistic markets, are most conducive to technical progress. Moreover, Katz (1984) and Teitel (1984) in studies of Latin America, and Lall (1980) for India, show that technical change in industries with limited competition largely aims to overcome supply bottlenecks, e.g. by substituting imported raw materials and components, while change in more competitive industries is characterized by cost-reducing and quality-improving innovations. In these cases, however, limited competition is intimately tied to import-substitution rather than concentration, although there is a certain overlap.

Summarizing the evidence on the relation between MNC entry and presence and competition, most of the case studies we have noted illustrate instances where competition has increased. MNC entry has forced local firms to improve resource allocation, and often also to upgrade technology. Looking at the effects on industry structure, it seems that MNCs enter mainly into industries where barriers to entry and concentration are relatively high, and initially add to the number of firms in the market. In the long run, MNCs may contribute to some increase in concentration, but efficiency may still benefit, particularly if initial distortions had preserved inefficient producers and if protection does not guarantee an easy life also for the MNC affiliate. Most of the evidence, however, is related to MNC entry rather than to MNC presence - the dynamic aspects of MNCs and competition in host country markets are not well researched. Moreover, much of the evidence refers to effects in developed countries, and it is not possible to disregard the risk that MNC entry into developing countries replaces local production and forces local firms out of business, rather than forcing them to become more efficient. An additional point to be noted is that existing studies have almost exclusively looked at effects of competition from MNCs on local firms. It is likely that the behavior of the host country's local firms is an important determinant of the type and intensity of competition, but there are no empirical studies of the competitive interactions between affiliates and local firms and consequences of this for spillovers.

2.5.5 Statistical Testing of Spillovers

Although the empirical evidence of spillovers from the studies reviewed above is quite comprehensive, there are only few direct analyses and tests of the existence and significance of spillovers at more aggregated levels, presumably because of measurement problems and lack of suitable data.[37] In addition, most of the available studies focus on intra-industry effects. An early exception is Katz (1969), who notes that the inflow of foreign capital into the Argentine manufacturing sector in the 1950s had a significant impact on the technologies used by local firms. He asserts that the technical progress did not only take place in the MNCs' own industries but also in other sectors, because the foreign affiliates forced domestic firms to modernize, "by imposing on them minimum standards of quality, delivery dates, prices, etc. in their supplies of parts and raw materials" (Katz, 1969, p. 154).

The earliest analyses of intra-industry spillovers include studies for Australia by Caves (1974), for Canada by Globerman (1979a), and for Mexico by Blomström and Persson (1983).[38] These authors attempt to test the existence of spillovers by measuring the effect of foreign presence - expressed in terms of the foreign share of each industry's employment or value added - on labor productivity (*viz.* value added per worker) in local firms. The hypothesis is that spillovers are present if foreign presence has a significant positive impact on local firms' labor productivities. We will outline their statistical models here, since our own estimations in later chapters follow closely in the same tradition.

Caves (1974) estimates value added per worker for 22 Australian industries in 1966 as a function of value added per worker in foreign affiliates, the employment share of foreign affiliates in 1962, and proxies for several other factors that are expected to affect labor productivity. These are labor quality (measured as payroll per worker in local firms over payroll per worker in the United States), cost of capital (capital rentals per worker in local firms over capital rentals per worker in the US), scale of firms (employment in Australian industry over employment in US industry) and competition from imports (imports over output for each industry). The results support the hypothesis that spillovers are present, since the foreign share of industry is found to have a significant positive effect on the labor productivity of local firms. Moreover, R^2 is markedly high, all variables have the expected signs, and all except the scale effect and import competition proxy are statistically significant.[39]

Globerman (1979a) examines data for 60 Canadian manufacturing industries in 1972. He estimates the same dependent variable as Caves, but employs a more direct production function approach: the explanatory variables aim to take into account different factors that may influence labor productivity, including the foreign share of the industry. Globerman uses the capital-labor ratio of foreign affiliates to capture basic technology characteristics, which is the main difference compared to Caves' study, where value added per worker in the affiliates is used: Caves' measure is also likely to capture market characteristics that influence product prices. Data on wages per worker in the affiliates and the share of male employees with third level education are used as alternative measures of each industry's labor quality, and there are three alternative measures of foreign presence - the ratio between affiliates' and domestic firms' value added, a binary variable that separates industries with more than 50% of value added produced in foreign affiliates from the others, and the ratio between value added of affiliates and employment of domestic firms. The measure for plant-scale economies is also more accurate than that used by Caves, with average plant size related to minimum efficient scale plants in the US. The results are consistent with the spillover hypothesis, although the explanatory power of the model falls by almost a third compared with Caves' results: capital-intensity, labor quality, scale economies, and foreign presence all seem to have significant positive impacts on local productivity.

Blomström and Persson (1983) base their statistical tests on data for 215 Mexican manufacturing industries in 1970. Like Globerman, they estimate a primitive production function for local firms, but use the capital-labor ratio of *local* firms to capture industry effects (rather than the *affiliates'* capital intensity). This is an important difference, because it implies that the local firms' capital-labor ratio is exogenously determined, which in turn means that the estimate of spillovers may be biased downwards. In Globerman's tests, it is possible to capture the increase in local labor productivity that occurs if higher foreign presence prompts local firms to choose a technology with higher capital-intensity: in Blomström and Persson's test, this is not recorded as a spillover. Concentration is proxied by a Herfindahl index, and the minimum efficient scale measure is based on the largest plant size in each Mexican industry. Blomström and Persson also employ an alternative proxy for labor quality, namely the ratio of white-collar to blue-collar workers in each industry. The most notable result is that the effect of foreign presence appears to be more significant than in the other studies, in spite of the more conservative model. The effects of capital-intensity and labor quality are also highly significant, whereas concentration and scale do not appear to have any statistically significant effects.

Some more recent studies also present results that are consistent with these early analyses. Blomström and Wolff (forthcoming) ask whether the spillovers in the Mexican manufacturing sector were large enough to help Mexican firms converge toward U.S. productivity levels during the period 1970-1975. Their answer is affirmative: foreign presence seems to have a significant positive impact on the rates of growth of local productivity. Nadiri (1991b), in a study of the impact of U.S. direct investment in plant and equipment on the manufacturing sectors in France, Germany, Japan, and the U.K. between 1968 and 1988, comes to similar conclusions. Increases in the capital stock owned by U.S. MNCs seem to stimulate new domestic investment in plant and equipment, and it appears that there is also a positive impact of FDI on the growth of total factor productivity in the host countries' manufacturing sectors. However, there is reason to be cautious in the interpretation of the results because of the high level of aggregation of the data.

It is impossible to tell whether the effects in the studies mentioned above are results of contagion or competition, since the spillover effect is defined simply as the impact of the foreign share on the productivity of local firms. Blomström (1986a) examines the impact of foreign presence on "structural efficiency" in Mexican manufacturing industries 1975 - industries where the average firm is closer to best practice technology are taken to be more efficient - in order to say something about the nature of spillovers. He finds that foreign presence and producer concentration have statistically significant positive effects on structural efficiency, but that the structure of industries experiencing high rates of technical progress is less efficient. By contrast, market growth does not seem to have any significant impact on the firms' average deviation from best practice technology. The positive effect of foreign presence is consistent with the results regarding spillovers presented above.

However, looking more closely at the determinants of *changes* in best practice technology between 1970 and 1975, Blomström is unable to find any significant impact of foreign entry. There is no impact of foreign entry on the technical progress taking place in the least productive firms in each sector either, but a significant effect on the changes in each industry's average productivity. The interpretation of these findings is that new foreign entries into Mexico did not seem to speed up the transfer of any particular technologies, but that the increase in competitive pressure forced local firms to approach best practice technologies. More specifically, Blomström hypothesizes that Mexican industries may have a dual structure, where most firms belong to a "modern" sector that is affected by competition from foreign affiliates, but that the least productive firms in each industry belong to a "traditional" sector where technologies are not affected by foreign investment.

There are also some recent spillover studies suggesting that the effects of foreign presence vary between industries, and that they are not always beneficial for local firms. An example is Cantwell (1989), who investigates the responses of local firms to the increase in competition caused by the entry of U.S. MNCs into European markets between 1955 and 1975, and argues that positive technology spillovers did not occur in all industries. His analysis differs notably from the other studies discussed in this section - he does not focus on productivity, but rather on changes in the market shares of foreign and local firms - but his conclusions are interesting. He asserts that "the technological capacity of indigenous firms ... was the major factor in determining the success of the European corporate response" (p. 86) to the U.S. challenge, and that the size of the national market was an additional determinant. More specifically, Cantwell suggests that the entry of U.S. affiliates provided a highly beneficial competitive spur in the industries where local firms had some traditional technological strength, whereas local firms in other industries - especially in countries where markets were too small to allow both kinds of firms to operate at efficient scale - were forced out of business or pushed to market segments that were ignored by the foreign MNCs.

Also Haddad and Harrison (1991), in a test of the spillover hypothesis for Moroccan manufacturing during the period 1985-1989, conclude that spillovers do not take place in all industrial sectors. Unlike the authors mentioned previously in this section, they focus on firm level data for several years, and estimate the effect of foreign presence on, firstly, the deviation between firm level multi-factor productivity and the sector's best practice technology, and secondly, the rate of growth of local productivity. Like Blomström (1986a), they find that foreign presence lowers the average dispersion of a sector's productivity, but they also observe that the effect is more significant in sectors with simpler technology. This is interpreted to mean that foreign presence forces local firms to become more productive in sectors where best practice technology lies within their capability, but that there are no significant transfers of modern technology. Haddad and Harrison argue that there are no signs of spillovers: obviously, their definition of concept is narrower than the one used in this study. Furthermore, they find no significant effects of foreign presence on the rate of productivity growth of local firms, and interpret this as additional support to the conclusion that technology spillovers do not occur.[40]

Aitken and Harrison (1991) use plant-level data for Venezuelan manufacturing between 1976 and 1989 to test the impact of foreign presence on total factor productivity growth. They conclude that domestic firms exhibited higher productivity in sectors with a larger foreign share, but argue that it may be wrong to conclude that spillovers have taken place if MNC affiliates systematically locate in the more productive sectors.[41] In addition, they are also able to perform some more detailed tests of regional differences in spillovers. Examining the geographical dispersion of foreign investment, they suggest that the positive impact of FDI accrued mainly to the domestic firms located close to the MNC affiliates. However, effects seemed to vary between industries. Aitken and Harrison (1991) is also one of the few studies, apart from Katz (1969), where inter-industry spillovers from foreign investment are discussed explicitly. As noted earlier, they assert that forward linkages generally brought positive spillover effects, but that backward linkages appeared to be less beneficial because of the foreign firms' high import propensities (although there were differences between industrial sectors).

Summarizing the results from the statistical tests of spillovers, it can be noted that the conclusions from the early studies appear straightforward. Caves (1974), Globerman (1979a), and Blomström and Persson (1983) all find that foreign presence has a consistently positive impact on the productivity of local firms in manufacturing industries. Their conclusions are challenged by more recent contributions, which present evidence to suggest that spillovers vary between industries (or argue that spillovers do not take place at all). The technological strength of local firms seems to be positively related to the emergence of spillovers according to Cantwell (1989), whereas Haddad and Harrison's (1991) results indicate that complex MNC technologies may make spillovers less likely. Harrison and Aitken (1991) show that geographical proximity to foreign firms probably increases the likelihood that domestic firms will benefit from spillovers. Blomström (1986a) hypothesizes that some segments of domestic industries may belong to "traditional" sectors that remain unaffected by both foreign technology and foreign competition. Yet, only Cantwell (1989) draws the explicit conclusions that host country characteristics may determine the strength of spillovers.

It is also noteworthy that existing studies treat spillovers as an exogenous effect of foreign presence. In essence, they only examine the impact of the foreign market share on local productivity (or productivity growth), which is what Findlay (1978a) identifies as the contagion effect. As discussed in the overview of theoretical results, there are several other hypotheses regarding the determinants of spillovers. For instance, Findlay (1978a) and Wang and Blomström (1992) argue that the size of the technology gap between foreign and local firms may be positively related to the amount of spillovers - only Cantwell (1989) considers the possibility (and reaches the opposite conclusion). Furthermore, spillovers related to competition may not be captured very well by the existing studies, since the foreign share is not likely to be a good proxy for the competitive climate. Wang and Blomström also argue that investment in learning allows local firms to absorb more spillovers, and that competition may cause a cumulative process where spillovers narrow the technology gap and force the affiliate to import new technology, which in turn makes room for new spillovers, and so forth. Neither the active learning efforts of local firms, nor the possible endogeneity of the competition-related spillovers have been taken into account in any of the available studies of spillovers in aggregate manufacturing.

2.6 TOPICS FOR FURTHER RESEARCH

Comparing the hypotheses from theoretical studies of spillovers with the available empirical evidence - particularly that from the studies of aggregate manufacturing - it is obvious that there are notable gaps in what is known or even researched. Most importantly, theoretical models have highlighted several factors that are hypothesized to determine the incidence of spillovers, but empirical studies have only examined some of these. Spillovers that are related to demonstration-imitation-contagion have been researched, but there are no comprehensive studies of what determines the potential for this sort of spillover, i.e. the MNC affiliates' technology imports. There are few studies of how the size of the technology gap or other technology characteristics influence spillovers. It is also unclear what role the local firms' active learning efforts to absorb spillovers play in practice. In particular, there is very little explicit empirical evidence related to the overall effects of competition between MNC affiliates and local firms.

The purpose of the present study is to examine if and how spillovers vary depending on host country characteristics, and whether spillovers from FDI can be influenced by the host country. The following chapters will therefore address some of the unanswered questions mentioned above. Chapter III looks at the technology imports of U.S. MNCs in 33 host countries. The technology imports of MNC affiliates determine what the *potential* for spillovers is. The purpose of the chapter is to examine what determines the affiliates' technology imports and whether the MNCs' import decisions can be influenced by the host country. Anticipating some of the results, it can be noted that competition from local firms seems to be one of the explanatory factors, which is consistent with a hypothesis suggested by Wang and Blomström (1992): local investment narrows the technology gap and forces the foreign firm to import new technology in order to keep its competitive advantage. The skill level of the labor force is also found to be positively correlated with technology imports, whereas various performance and technology transfer requirements imposed by the host countries are negatively related to technology transfer.

Chapter IV is an extension of the analysis. While Chapter III examines some host country characteristics that influence the technology imports of U.S. affiliates, this chapter turns to analyze some industry-level determinants of the technology imports of foreign firms in the Mexican manufacturing sector 1975. This adds to the findings of the preceding chapter in several ways. Firstly, data quality is better and the number of observations is significantly larger, which allows us to interpret the results more confidently. Secondly, many factors related to the development levels of the host countries may influence the results in Chapter III, but these variables are not likely to have much impact on the variation between industries in one host country. Thirdly, the foreign firms in Mexican manufacturing include affiliates of MNCs from many different countries (although the U.S. is the dominant foreign investor), whereas Chapter III examines only U.S. affiliates. This permits somewhat more general conclusions regarding the behavior of MNC affiliates. The results stress the importance of competition from local firms and the skill level of the labor force as determinants of the affiliates' technology imports.

Chapter V examines the nature of spillovers, to explore whether the technology gap between local firms and MNC affiliates or some other technology characteristics are important determinants of the size and significance of spillovers. Using data from 1970 for 216 Mexican manufacturing industries, we examine spillovers in several sub-sectors of manufacturing with different characteristics. The findings suggest that spillovers are relatively independent of the features of aggregate technology, but are more sensitive to market characteristics. Spillovers are observed in industries with small as well as large technology gaps, but not in the group of industries where markets are characterized by high foreign shares and large technology gaps together, i.e. where some type of "enclaves" or dual markets are likely. To explain these findings, it is suggested that spillovers are perhaps not monotonously increasing functions of foreign presence, and that they may be relatively unimportant in industries where local and foreign firms are not in direct competition with each other.

Chapter VI, finally, argues that statistical tests of spillovers should take into account both the demonstration-imitation-contagion effects that are determined by technology differences and foreign shares, and the effects that are caused by the competition between local firms and MNC affiliates. Consequently, the data on Mexican manufacturing from Chapter V is used to estimate the labor productivities of local and foreign firms in a simultaneous model. The reason to use a simultaneous model is the "cumulative" character of the competition-related effects: an unusually productive affiliate (or local firm) poses a threat to the local firm (affiliate) and forces it to become more productive, which in turn has some repercussions on the affiliate (local firm), and so forth. The hypothesis is that spillovers from competition are important if the productivity of foreign firms has an independent impact on local firms even when other determinants - including the foreign share of industry - are accounted for.

The results imply that there are important interactions between foreign and local firms, and both the (exogenous) foreign share of industry and the (endogenous) productivity of the foreign firms appear to have significant positive effects on local firms. However, this result holds only when the industries that were identified as "enclaves" in Chapter V, are excluded.

In summary, the following chapters present some evidence to suggest that the host country can influence MNC behavior, and that technology or productivity spillovers are largely endogenous phenomena. This also implies that some of the major benefits of FDI are endogenous, which appears to be an important insight, both for the academic debate on FDI and for policy makers in host countries.

2.7 NOTES

1. The foreign shares of Japanese MNCs' employment and sales are lower than the averages, while the figures for the Netherlands and Switzerland are markedly higher, see UNCTC (1988), pp. 35-36, 212.

2. Calculated from U.S. Department of Commerce (1985), Tables III.H.1 and III.Q.1. The share of R&D in the German and British affiliates is disproportionately large even if we take into account that they represent a large share of all U.S. foreign direct investment.

3. However, there is a wide debate in the literature about the appropriateness of technology, and it has been argued - e.g. by Pavitt (1971) - that the "key" technologies for less developed countries are not concentrated in the hands of MNCs. For a more recent discussion, see Stewart (1987).

4. Many other definitions of technology can be found in the literature. See e.g. Dosi (1984), Gomulka (1990), Zander (1991).

5. The statistics on imports of machinery and transport equipment are from the *1987 International Trade Statistics Yearbook*, Special Table: B, and the data on technology

payments are from UNCTC (1985), p. 119 and Marton (1986), p. 14.

6. Some authors argue, in spite of the lack of more comprehensive evidence, that goods trade is the main channel of technology transfer for most countries. See e.g. Gomulka (1990), p. 161 and Kaplinsky (1990), p. 21.

7. One of the few comprehensive quantitative assessments of the importance of imitation and reverse engineering is de Melto *et al.* (1980). They report that half of a sample of 280 significant innovations commercialized in Canada between 1960 and 1979 could be characterized as "imitations", and that more than half of these resulted from reverse engineering. Mansfield, Schwartz, and Wagner (1981) find that 60 per cent of the patented innovations in their sample were imitated within 4 years. Kim and Kim (1985) also present evidence of imitation and informal technology transfers in 42 South Korean firms. We will not examine these studies in detail because they do not focus on foreign investment, but it should be remembered that MNC presence in the host country probably facilitates imitation of MNC technology.

8. What we call spillovers have elsewhere been termed, for example, "external effects" (MacDougall, 1960), "technology leakages" (Caves, 1971), and "involuntary dissemination of technology" (Zander, 1991).

9. The determinants of the MNCs' choice between exports, licensing, and foreign direct investment are not discussed in this study, but treated in detail by e.g. Blomström and Zejan (1991), Contractor (1984), Davidson (1980, 1983), Davidson and McFetridge (1985), Stobaugh (1988), Telesio (1979), Vernon and Davidson (1979), and Zander (1991).

10. It has been noted that the transfer lag, i.e. the time between initial introduction and transfer has tended to become shorter over time, see Vernon (1979) and Davidson (1980).

11. The relatively simple mathematical theory of contagion, well-known for its S-shaped or logistic pattern of diffusion, has been the base of much work on technological diffusion in general (without reference to MNCs) see e.g. Nabseth and Ray (1974). Modern theories are more complex, incorporating factors such as firm size, demand impulses, heterogeneous firm behavior, and subsequent improvements in innovations. Game theoretic models of diffusion have also appeared. For a review, see e.g. Coombs, Saviotti, and Walsh (1987), Gomulka (1990), and Stoneman (1983).

12. To prove the conclusion, Das refers to a viable alternative to optimizing, that is always open to the multinational: after importing new technology, the MNC may keep its old output quantities and prices, but still make more profits as a result of the lower unit cost. This higher profit rate will remain over time, since the rate of spillovers does not change unless output volumes do.

13. Gehrels (1983) also takes into account the effect of spillovers on the MNCs' activities in a theoretical model of FDI. Given that spillovers occur, he argues that the stock of foreign capital will be sub-optimal, seen from the point of view of the host

country, and that it pays to subsidize foreign firms.

14. A possible addition to Wang and Blomström's model would be to allow the MNC to spend resources on "directly unproductive profit-seeking activities" (DUP-activities, see Bhagwati, 1982) or rent-seeking, in order to protect its proprietary technology from spilling over to local firms: this would be a highly realistic addition, considering the MNCs' concern for the erosion of their technological advantages. (For a recent discussion, see Zander, 1991.) The MNC's optimization problem would, in that case, be to choose how much to spend on importing new technology, given the transfer costs and the spillover functions, and also to decide how much to spend on the DUP-activity.

15. The definitions of factor-intensities vary between the studies. Depending on data availability, factor-intensity is measured as the ratio of capital stocks, capital services, fixed assets, total assets, machinery and equipment, or electricity consumption to employment.

16. Solomon and Forsyth (1977), in a study of nine narrowly defined industry groups in Ghana 1970, suggest that it may be difficult to see any differences between MNC affiliates and local firms that are run by resident expatriates: indigenous local firms, by contrast, are likely to behave differently than the affiliates.

17. Lall (1978) is critical against the approach taken by Courtney and Leipziger, and argues that aggregation to two- and three-digit levels introduces much uncertainty and gives cause to wonder whether the compared products and technologies are in fact comparable. In a related study, Leipziger (1976) looks at the production characteristics of domestic firms and U.S. affiliates in India in the mid-1960s, and comes to different conclusions. He argues that the affiliates' *ex ante* technology choices are less capital-intensive than those of "comparable" local firms, but that their *ex post* technologies are more capital-intensive because they face higher wage-interest ratios. Leipziger suggests that this may be explained by the MNCs' greater access to international capital markets, direct or indirect capital subsidies from the Indian government, or tougher pressure from the Indian labor unions. However, the industrial breakdown of the sample of local firms differs from that of the affiliates, and he adjusts it by weighting the Indian data to correspond to the (two-digit) industry distribution of the MNC sample. The "comparability" of the samples is therefore questionable, and the conclusions are also open to serious criticism.

18. Note, however, that the profitability of affiliates need not be higher than that of local firms. As discussed in Parry (1974), the technical superiority of MNC affiliates is likely to show up in greater size and faster growth rather than higher profitability, even barring transfer pricing.

19. Lecraw (1978) finds that MNCs from less developed countries operating in Thailand lie closer to their profit-maximizing rates of capacity utilization than both locally owned firms and MNCs from developed countries. This might mean that some of the competitive advantages of LDC multinationals are related to management in LDC conditions, whereas MNCs from the industrialized countries thrive more on product and process technology. Lim (1976) observes that foreign firms have higher rates of capacity

utilization than local firms, but attributes this to factors other than foreign ownership, e.g. firm size and capital-intensity.

20. Similarly, Tyler (1979), in a detailed study of the Brazilian plastics and steel industries, is unable to see any significant effects of foreign ownership on technical efficiency. However, Chen and Tang (1987) argue that the trade orientation of the MNC affiliates has a significant impact on their technical efficiency: export-oriented affiliates are more efficient than import-substituting, because of the competitive pressure from the world market.

21. In addition, it is possible that local firms may already have imitated the example of the MNC affiliates at the time of the comparison.

22. The evidence on technology differences reviewed here is mainly taken from LDCs, which might suggest that the conclusions should be limited to these countries. However, summarizing a chapter on technology and productivity, Caves (1982, p. 225) concludes that the limited evidence that is available "suggests that the presence of MNEs is associated with more rapid diffusion of technical knowledge, at least in industrial-country markets". There is no inconsistency, since Caves bases his conclusion on *realized* spillovers (and there are more diffusion studies available for industrialized countries), while the emphasis here is more toward technology differences and the *potential* for spillovers.

23. Another noteworthy point is that there are no empirical studies of how technology characteristics or the size of the technology gap influence spillovers, although there are theoretical arguments to suggest a connection.

24. This distinguishes the concept from Hirschman-type linkages, where supply or demand changes lead to price changes and entrepreneurial opportunities: these can occur as pure market transactions. See Hirschman (1958).

25. Lall (1980) also discusses linkages related to financing and pricing, and benefits from the long-term contracts between the principals and their subcontractors, but these fall outside the present topic.

26. Two of the five firms surveyed were licensees, but Watanabe did not note any major differences between these and the MNC affiliates.

27. The UNCTC study also includes much of the material on India presented by Lall (1980).

28. Lall (1978) reviews numerous other studies of linkages between MNCs and local firms, and Halbach (1989) summarizes a detailed study of subcontracting and linkages in several South-East Asian industries.

29. Studies of the life-cycle development of the salary levels of MNC employees could perhaps give some indication of how much "transferable human capital" they absorb in the MNC. Although MNCs generally pay higher entry salaries than local firms (in order

to attract more qualified employees, or because they are less familiar with the local labor market) there is no reason for the salary levels of MNC employees to increase faster than those of comparable employees in local firms, unless MNC employees acquire specific skills that can be transferred to competing local firms. The value of these skills could perhaps be estimated from data on wage payments.

30. For a closer discussion, see Jenkins (1990).

31. Jenkins (1987), Lall (1978), and Newfarmer (1985) review additional studies of MNCs and industry structure in LDCs.

32. Caves (1982), referring to Baba (1975), suggests that the Japanese government's protection of the largest domestic sellers (in the most concentrated industries) might be responsible for this. Lecraw (1983) finds that the correlation between FDI and concentration is most pronounced for MNCs from Europe and the U.S., while Japanese and LDC multinationals are more active in less concentrated industries.

33. Sölvell's findings are also related to those of Graham (1978), who notes that oligopolists imitate each other by establishing affiliates in each other's markets.

34. Another reason for the increased concentration pointed out by Newfarmer (1979) is that the MNCs often entered through acquisitions. Caves (1982, p. 102) also notes the increasing frequency of acquisitions and mergers as the modes of entry, but asserts that this "does not qualify out of existence the concentration-reducing effect of MNE entry."

35. There are, of course, examples where local LDC firms have learned enough from the foreign affiliates to mount a competitive challenge even in high-tech industries: see e.g. Chudnovsky (1979), where the Argentine pharmaceutical industry is studied.

36. The Peruvian automotive industry in the late 1960s and early 1970s (like many other industries in countries with extreme import-substitution policies) provides a striking example of the fact that low concentration does not necessarily equal high efficiency. At that time, "13 firms, each with some foreign ownership, were assembling 18 brands and over 25 models of automotive vehicles, mostly passenger cars. Facing a limited local market, none of these firms was able to use more than 30 per cent of its installed capacity" (UNCTC, 1981, p. 19).

37. It should also be noted in this context that both intra-industry and inter-industry R&D spillovers have been identified and estimated, mainly for developed countries, but without explicit reference to MNCs and FDI. See e.g. Bernstein (1988, 1989) and Nadiri (1991a). The fact that this kind of spillover seems to take place offers some indirect support to the hypothesis that there are technology spillovers between MNC affiliates and local firms. The conclusion that technological innovations (proxied by R&D measures) in some domestic firms have positive effects on the productivity of other domestic firms is analogous to the situation where technological innovations (proxied by the size of the technology gap or the amount of technology imports) in foreign affiliates have positive effects on the productivity of local firms.

38. Chen (1983a) also presents a detailed discussion and some statistical evidence of spillovers in the major manufacturing industries in Hong Kong, although he does not examine the whole manufacturing sector. More specifically, he shows that foreign firms have been more active than local firms in importing new technologies to Hong Kong, and that the rates of technology diffusion have been higher in the industries where foreign firms hold larger market shares.

39. In addition, Caves (1974) estimates effects of foreign presence on the rates of profit of domestic Canadian firms: strictly interpreted, the results offer no support for the hypothesis that foreign presence improves the allocative efficiency by increasing competition enough to lower profit rates.

40. Apparently, the data used by Haddad and Harrison (1991) are only available at the sector level, which precludes replicating the tests made by Globerman (1979a) and Blomström and Persson (1983).

41. Since Aitken and Harrison (1991) do not seem to control for industry differences in scale economies and levels of producer concentration, their caution may be warranted.

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CHAPTER III

HOST COUNTRY CHARACTERISTICS AND TECHNOLOGY TRANSFER BY U.S. MULTINATIONALS

3.1 INTRODUCTION

There is a wide variation in the technology choices and technology imports of MNC affiliates in different host countries, as noted in Chapter I, and these cross-country differences are likely to have some impact on the costs and benefits of foreign direct investment. It has, for instance, been argued that imports of technology are necessary to create a potential for the kinds of spillovers that are related to demonstration and imitation. Some theoretical models of spillovers have also hypothesized that the size of the technology gap between affiliates and local firms (which is a function of the affiliates' technology imports) determines the extent or size of technology spillovers. The exact relation between the MNC affiliates' technology imports and the host countries' benefits - e.g. through spillovers - is unclear, but these arguments, together with the host countries' eagerness to attract as much technology as possible through the foreign MNCs operating in their markets, reveal its importance.

The purpose of this chapter is to examine and explain cross-country differences in the technology imports of majority-owned foreign manufacturing affiliates of U.S. MNCs operating in 33 host countries, and to briefly discuss the host countries' possibilities to influence the technology flows.

Considering the voluminous literature on transfer of technology in general, there is surprisingly little said about the determinants of MNC affiliates' technology imports, but there some studies of closely related questions that provide a starting point for our analysis. For instance, Mansfield and Romeo (1980) study the characteristics of technologies transferred to MNC affiliates, and compare them to those licensed to independent companies. They find significant differences in the ages of the technologies transferred to affiliates and outsiders - the latest technologies seem to be reserved for intra-firm use - but they do not discuss differences between affiliates. Teece (1976) examines the resource cost of technology transfers from a home country perspective, and looks at transfers to subsidiaries as well as to independent licensees. He shows that the transactions within MNCs are more efficient than those with external licensees, but that there are significant costs involved in both types of transfers: the age of the technology and the MNC's previous experience of similar technology transfers are identified as important determinants of these transfer costs. In addition, Teece points to differences in the learning capability of the technology recipients as possible explanations of cross-country variations in transfer costs, but does not examine other host country characteristics. Behrman and Wallender (1976) reach similar results. They find that the level of education of the host country partly determines which types of technology are transferable, and they emphasize the continuous character of the intra-MNC technology flows (and their qualitative advantages) as compared with sales of technology to outsiders.

Davidson (1980, 1983), who studies transfers of 954 product innovations by 57 U.S. multinationals, also concentrates on the role of firm and technology characteristics. He concludes that the time between the first commercialization and the first transfer is shorter when the MNC has previous experience of technology transfer, and that firms with higher than average R&D expenditures are likely to transfer their technology to affiliates rather than to outsiders. Regarding types of technology, Davidson notes that transfers occur earlier for products that are imitations, as opposed to innovations, which suggests that competition (or at least the existence of substitutes) encourages faster transfers of technology. Zander (1991) studies the impact of technology characteristics on transfer timing in closer detail. His findings indicate that transfers take place earlier when the technologies are articulable, i.e. easily expressed in manuals and documents, but he does not find any significant effects of other technology characteristics, such as observability, complexity, and process (in)flexibility. Zander also concludes that the transfer lags are shorter when competing firms are involved in developing similar products: this is in agreement with Davidson's results for innovations versus imitations, and is the only factor in his study that can be expected to vary between host countries. Empirical studies have, in other words, concentrated on firm and technology characteristics as determinants of the technology flows between MNC parents and affiliates.

Theoretical analyses of intra-firm technology transfer are also rare, and Wang and Blomström (1992) is one of the few works that explicitly discuss the magnitude and determinants of parent-affiliate transactions. They note that the amount of technology transferred through MNCs varies across countries, and develop a model of international technology transfer where competition from host country firms pushes MNCs to transfer more technology to their affiliates. One conclusion of their model is that host country governments might be able to increase the transfer of technology through MNCs by making sure that the affiliates are exposed to competition (e.g. by improving the learning capabilities of competing local firms): this would be an alternative to stipulating performance requirements for the multinationals.[1] By contrast, Katrak (1991), argues that market rivalry may induce MNCs operating in less developed countries to choose older and more labor-intensive technologies. The conflicting hypotheses regarding the effects of competition are explained by different assumptions about product characteristics: Wang and Blomström assume that the products are heterogeneous, so that a newer technology yields more "attractive" products, whereas Katrak assumes a homogenous good. The focus in the theoretical models is, however, not on product or technology characteristics, but rather on the effects of learning capability, competition and market rivalry in the host country.

With the evidence from these studies as a base, we will continue by discussing the possible effects of some host country characteristics on the affiliates' technology imports in the next section. Section 3.3 presents and discusses the data material and the variables used for our empirical tests. The statistical results are reported in section 3.4, and section 3.5 summarizes and concludes the chapter.

3.2 SOME HOST COUNTRY DETERMINANTS OF THE TECHNOLOGY IMPORTS BY MNC AFFILIATES

Many of the factors that determine the amount of technology transfers between MNC parents and affiliates are probably specific to the firms and technologies in question, as suggested by e.g. Teece (1976), Davidson (1980, 1983), and Zander (1991). Keeping this in mind, we will now abstract from firm and technology characteristics and instead focus on some host country characteristics that may explain differences in the technology imports of affiliates in different host countries. For this purpose, we will also make some simplifying assumptions about technology and foreign direct investment.

Firstly, following the neo-classical school of foreign direct investment (represented e.g. by Caves, 1982), we assume that a firm is able to become multinational only if it possesses some intangible asset that yields a rent to the firm, and that it can transfer to affiliates in different host countries. The MNC's intangible proprietary asset is technology, defined, as earlier, to include the knowledge, skills, and means for production, distribution, and marketing. This asset is made up of the parent company's currently used skills and production processes as well as older vintages of products and techniques. We also assume that new technology is only produced in the parent company of the MNC, so that there are only transfers from parents to affiliates.[2] These can take the form of *product innovations*, that are made up of products that are entirely new to the affiliate or "better and improved" variants of old products, and *process innovations*, which are cost reducing improvements of manufacturing techniques for existing products. Moreover, following Teece (1976), we note that while all technology transfers are costly, transfers of newer and more advanced technologies are the most expensive.

Hence, technology is divisible into several dimensions. Imports of product innovations can involve many or few products, that may be newer and more advanced or older and less advanced; newer products embody "more" technology than old ones, and are therefore more expensive to transfer. Likewise, newer process innovations are more efficient in cutting production costs, but also more complicated and more expensive to transfer. For both types of technology it is reasonable to assume that the cost of transferring the very latest innovations is prohibitively high.

Once the multinational corporation has entered a host country and set up an affiliate, it has to decide, in each time period, how much technology it will transfer to the affiliate.[3] In analogy to the firm's other decisions, the guiding rule for technology transfers must be that the marginal cost of adding more technology should equal the marginal revenue that the technology is expected to yield. Thus, the lower the transfer cost and the higher the affiliate's revenue from the transfer, the higher the expected imports of technology. This leads us to examine what host country factors determine the cost and revenue of technology transfer. To keep the discussion as simple as possible, we focus on product innovations in the discussion below, particularly when we refer to the revenue from technology imports. All actual transfers are likely to involve both process and product innovations, but manufacturing MNCs are typically involved in markets with differentiated goods, where technical progress often takes the form of "new and improved" products.

3.2.1 Costs of Importing Technology

It is easy to recognize many host country variables that influence technology transfer costs, and several have also been noted in the literature. The most apparent is perhaps the host country's level of education, labor skills, or learning capability. As mentioned above, Teece (1976), seconded by Behrman and Wallender (1976), argues that the higher the level of education and labor skills in the host country, the lower the expenses for in-house training and expatriate experts, and the shorter the learning process that is necessary when innovations are introduced. Both these studies also show empirical evidence supporting the argument that higher skill levels translate into lower transfer costs and higher imports of technology. Similarly, Mansfield and Romeo (1980) present data on the age of a sample of technologies at the time of their first transfer abroad, suggesting that affiliates located in developed countries imported more technology: the average age of the technologies imported by affiliates in developed countries was 5.8 years, but increased to 9.8 for developing country affiliates. One reason is probably the lower skill level of developing countries, although Mansfield and Romeo are unclear about the causes: somewhat vaguely, they state only that transferring technology to developing countries is "difficult and expensive".

The indecisiveness of Mansfield and Romeo regarding the causes for the relatively small technology imports by affiliates in developing countries illustrates a major problem in examining the factors that influence technology transfer costs: many of the possible determinants are connected to the host country's general development level, and are difficult to analyze separately in practice, although their effects are easy to trace in theory. Weak infrastructure, uncertain property rights, and political risks are only a few additional examples of "development-related" host country characteristics that may explain the pattern found by Mansfield and Romeo (1980), but that are very difficult to quantify and analyze in cross-country studies.

On a theoretical level, however, it is possible to make a distinction between development-related factors that increase the costs of transferring any specific existing technology on the one hand, and factors that are related to adaptation costs on the other hand. Learning, skills, and education, together with the other characteristics mentioned above, belong to the former group. Relative factor endowments and factor prices are among the host country characteristics in the latter group. Findlay (1978) provides a simple illustration and analysis of the effects of factor endowments and prices on adaptation costs. He argues that the technologies developed and used by MNC parents are designed for the relative factor prices that prevail in the home countries. Typically, labor is relatively scarce and expensive in the developed home countries of MNCs, but more abundant and cheaper in the host countries, which means that MNC technology is designed for high labor costs. (Similarly, Chipman, 1970, holds that the type of technological progress that takes place in the home countries of MNCs is mainly labor-saving, because of the continuously increasing wage rates.) Furthermore, Findlay claims that only limited factor substitution is possible without costly efforts to adapt technologies. There is accordingly no conventional isoquant that illustrates existing techniques (for all possible factor price ratios) that can be transferred directly to the affiliates.

Instead, isoquants are "indications of what can be achieved within the existing framework of general scientific knowledge" (p. 276), given that resources are spent to modify and transfer technologies. The larger the distance along the "hypothetic" isoquant between the capital-labor ratio in the home country and that which is optimal for the host country's relative factor prices, the higher the necessary adaptation costs. In other words, the lower the host country's capital-labor price ratio, the lower the imports of technology are likely to be, all other things held constant. Hence, low development is likely to inhibit technology transfer for two reasons: both learning costs and adaptation costs are high.

Some other factors (not necessarily related to development levels) influencing technology transfer costs have also been discussed in the literature. For instance, it is argued that affiliates are likely to use more capital-intensive technologies if there are minimum-wage laws that cause wage rates to exceed the market equilibrium rates, or if over-valued exchange rates subsidize the use of imported equipment and intermediaries (Katrak, 1991). However, it is unclear whether these policies affect the total amount of imported technology, or only the kind of technology (capital-intensive versus labor- or skill-intensive) that is imported.

Another policy related variable that is likely to be important is mentioned by Sekiguchi (1979), who argues that transfers of Japanese textile technology have been disturbed by the presence of technology transfer requirements in the host countries. Also Grosse (1989), in a study of the effects of the Andean Foreign Investment Code, concludes that MNCs' operating policies are affected by such requirements. To the extent that various technology transfer requirements imposed by host countries change the MNCs' profit maximizing behavior - by forcing them to employ a minimum of local labor, make technologies available for local firms, restrict imports, or use local suppliers - it is clear that they also increase the cost of technology transfer and depress the amount of transfers. Yet, a reservation is in order. Robinson (1983) suggests that many requirements have "pushed in the direction in which a foreign firm was already inclined" (p. 151) and that most MNCs have the means to evade most regulations. It is therefore possible that requirements (like capital-subsidies and minimum-wage laws) mainly have an effect on the choice of technology transfer channels, rather than on the overall imports of technology.

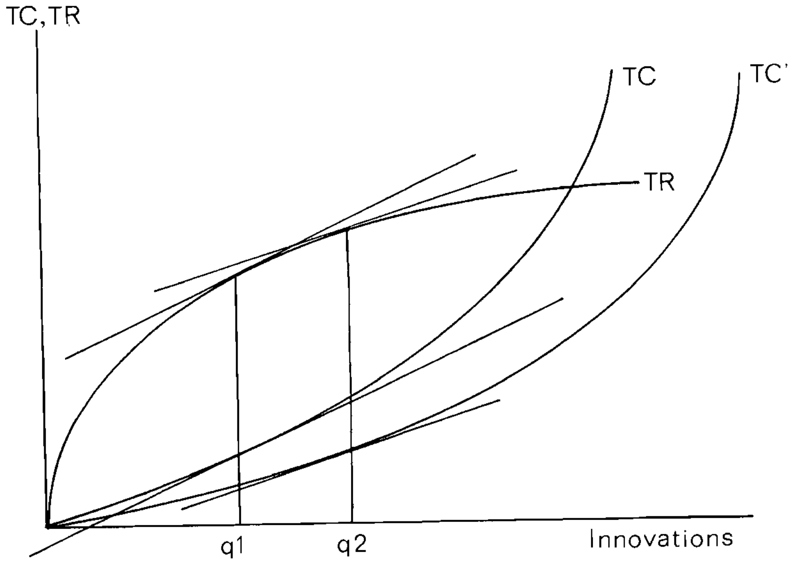
The effects of variations in technology transfer costs on imports of technology are summarized in Figure 3.1. The horizontal axis shows all innovations that can potentially be imported, ordered according to "technology content", so that the older and less complicated innovations are to the left and the newer and more advanced ones to the right. The vertical axis measures the MNC affiliate's total revenues and costs from importing each innovation. The curve TC shows that transfer costs increase with the complexity of the technology, and that the most recent innovations are extremely expensive to import. The curve TR is drawn to show total revenue as an increasing function of the technology level of the affiliate: more advanced technologies are assumed to produce goods of better quality and richer characteristics, which are also more highly valued by the consumers. TR is defined for a given level of local competition, as will be discussed, and we assume for the moment that it is fixed.

The optimizing MNC affiliate will decide to import the technology that maximizes profit, i.e. where marginal revenue equals marginal costs. Here, the optimal import quantity is q1, where the slopes of the curves TR and TC are equal and the distance between the curves is maximized. Importing more technology is not optimal, because the increase in revenue does not make up for the increase in transfer cost.

The effect of a higher learning capability (or more generally, a higher level of development) or a lower level of technology transfer requirements can be illustrated by a shift downwards and to the right of the cost curve, to TC'. The character of the shift is such that the cost reduction for the least advanced technologies is smaller than that for more advanced technologies; however, the transfer costs for the newest technologies are still prohibitively high. In the case of improvements in learning capability, the reason is that the cost of transferring relatively simple technologies is not much affected by a higher technological capability - there are diminishing marginal effects of learning for all technologies.

The argument for expecting a similar shift from a liberalization in technology transfer requirements is that the distortion imposed by the requirement is less serious for the less advanced technologies, e.g. because local suppliers of simple intermediate products are nearly as effective as foreign sources. In the diagram, this means that the slope of TC' is lower than that of TC for all technologies (or at least for the relevant range of technologies.)

FIGURE 3.1 *Effects of Changes in Learning and Transfer Requirements on the Technology Imports by MNC Affiliates*



After the shift, q1 is no longer the optimal decision, because the marginal increase in transfer cost of importing a slightly more advanced technology is smaller than the marginal increase in revenue. The new import decision will instead be q2, where the slopes of the curves TR and TC' are equal. Given the assumptions about the character of the shift, q2 will unambiguously involve higher imports of technology by the affiliate.[4]

3.2.2 *Revenues from Importing Technology*

The host country characteristics that affect the affiliates' revenue from technology imports are less discussed and less apparent than those that influence costs. When restricting the analysis to product innovations, however, it seems that the structure of demand (i.e. the preferences for "local goods" and "MNC goods", respectively) is an obvious determinant of the revenue, but it is not obvious what determines demand.

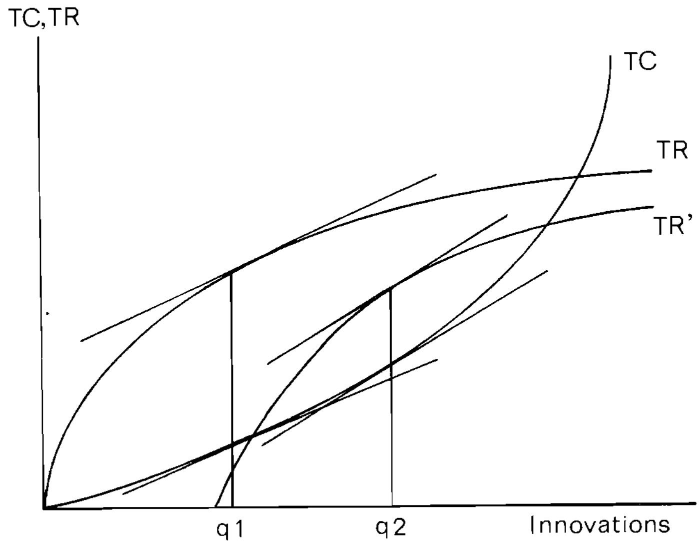
Burenstam Linder (1961) provides some clues as he suggests that the similarity of the demand structures of two countries is commensurate with the extent to which the average income or development levels are also similar. Since MNC technology generally emanates from advanced countries, the demand for MNC products - and the potential revenue from using MNC technology - is likely to be higher the higher the level of development of the host country.

Wang and Blomström (1992) take a somewhat different approach, and model the quasi-profits of the MNC affiliate as a function of the technological gap between the affiliate and local firms. The affiliate is operating in a monopolistic market, where its technological lead is assumed to give its products a quality advantage before local firms: the newer and more advanced the products, the more attractive they are to the consumers. This translates into high demand, and either a higher market share or a higher mark-up, or both, all of which increase profits.

Figure 3.2 illustrates the affiliate's technology imports in this situation, given the technology level of its competitors and the market conditions. As in the previous figure, the horizontal axis depicts the product innovations that could potentially be imported by the affiliate, sorted with newer and more advanced products further to the right. The vertical axis shows the total transfer costs and revenues connected to imports of the innovations. The curves TC and TR are also defined as before. The initially optimal import decision is at q1, where marginal revenue and marginal cost coincide and the MNC affiliate's profit is maximized.

The picture changes when investment by local firms narrows the technology gap and begins to erode the affiliate's profits. In that situation, the affiliate may decide to import more technology (a newer and more advanced product) in order to restore its leading position. In terms of Figure 3.2, the affiliate's revenue curve shifts downwards and to the right, to TR', because the technological level of local firms has increased - we assume here that nothing happens with the cost curve TC. The character of the shift, with a larger impact for less advanced technologies, and a smaller (perhaps negligible) effect for more advanced product innovations, is explained by the local firms' lower technology levels: they are mainly able to compete in the older product groups.

FIGURE 3.2 Effects of Changes in Competition on the Technology Imports by MNC Affiliates



In other words, TR' is always below (or, for very advanced technologies, equal to) TR, and the slope is always higher than (or equal to) that of TR.

Hence, the revenue from importing q1 is lower than before, because local firms have captured a share of the market, but the affiliate is able to recapture some customers by offering a more advanced product. The new equilibrium, at q2, is characterized by higher imports of technology, but the affiliates' profits are smaller than before.[5]

In other words, the revenue of technology imports (and the amount of transfers) depends on the level of domestic investment and competition in the host country. If local firms do not invest much, there is little change in the technology gap, the initial profit maximizing equilibrium remains unchanged, and the marginal revenue of importing technology is lower than the marginal cost. If local firms do invest, the technology gap narrows, MNC profits fall, and the affiliate's marginal revenue of technology transfer increases. However, this impact of local investment depends on the existence of competition between local firms and affiliates. If the degree of substitutability between the affiliates' products and local products is very low, or if the MNCs are protected - e.g. by market imperfections - there is little direct competition and few effects of the type discussed above.

In sum, in each time period, MNC affiliates can be expected to import technology until the marginal revenue of further technology transfer equals the marginal cost. Various host country characteristics influence both the costs and revenues of technology transfer. Relative factor prices, the host country's learning capability, the level of economic development, and the existence of technology transfer requirements are included among the determinants of transfer costs. Revenue is related to the levels of development and competition in the host country. These characteristics vary across host countries, and it should therefore be possible to observe predictable cross-country differences in the affiliates' technology imports.

3.3 DATA AND VARIABLES

3.3.1 Dependent Variables: Measures of Parent-Affiliate Technology Transfers

Technical knowledge is transferred in many ways between MNC parents and their foreign affiliates, and it is not surprising that there are no perfect empirical measures for these technology flows. The transfer of the parent's proprietary technology can take the form of, for instance, technical documentation, education and training of the affiliate's labor force, exchanges of technical personnel, shipments of machinery and equipment, or continuing communication to solve whatever problems occur in the production processes. Each transfer is likely to include several of these modes; yet, only a few of the transfer forms are usually recorded. There is reason to be cautious even when data are available, for several reasons. One problem is that only a few parent companies may have developed precise methods for pricing the technology that is supplied to affiliates (Behrman and Wallender, 1976, p. 20). Another complication has to do with transfer pricing: intra-corporate technology payments are likely instruments for concealing repatriated profits and evading host country taxes, because market prices for the technologies are usually lacking (Kopits, 1976; Caves, 1982, Chapter 8).

The present data on technology transfers are calculated from the U.S. Department of Commerce surveys of *U.S. Direct Investment Abroad*, and relate to the manufacturing operations of majority-owned affiliates of U.S. multinationals in 33 host countries (U.S. Department of Commerce, 1981, 1985).[6] Because of the measurement problems noted above, we have used three alternative indicators of technology transfers: two input measures and one output measure. The two input measures are calculated from data on the payments for royalties and license fees by U.S. majority-owned foreign affiliates (MOFAs) in 1982 and their imports of capital equipment from the U.S. in 1982, whereas the output measure is based on the affiliates' labor productivity growth rates between 1977 and 1982.

The total value of the payments for licenses by U.S. MOFAs (in the manufacturing sector) to U.S. parents in 1982 amounted to USD 3,051 million. Out of this, 2,856 million dollars were accounted for by affiliates in the developed countries, and only 195 million by affiliates in developing countries. In the same year, USD 1,358 million worth of capital equipment was exported from the U.S. to the affiliates, with 874 million going to developed country affiliates and 484 million to the developing countries. Table 3.1 on the next page presents some measures of the intensity and industry distribution of the license payments (LICENSE) and imports of capital equipment (CAPIMP) by U.S. MOFAs in 1982.

It can be seen that the differences between industries are very large for the license measures: the license payments range from USD 90 per employee (or a tenth of a per cent of the value of sales) in transport equipment to USD 2,890 per employee (or over three per cent of sales) in machinery. The differences in equipment imports are less pronounced, but still notable.

A consequence of the large inter-industry differences shown in the table is that the industry distribution of affiliates may have some impact on the aggregate license payments (and capital imports) of any host country: for example, in Sweden, most U.S. investment is in machinery, and technology imports can be expected to be high for this reason alone. It is even possible that the industry effects overshadow other explanations for cross-country differences in technology imports. Some alternative dependent variables were, therefore, constructed for the estimations.[7]

TABLE 3.1 Measures of U.S. MOFAs' Payments of Royalties and License Fees and Imports of Capital Equipment, 1982 (weighted averages).

	LICENSE/ SALES (USD)	LICENSE/ LABOR	CAPIMP/ SALES (USD)	CAPIMP/ LABOR
Food products	0.0049	450	0.0020	183
Chemical products	0.0133	1,504	0.0018	197
Metal products	0.0049	334	0.0057	388
Machinery	0.0315	2,890	0.0106	969
Electric equipment	0.0087	390	0.0055	246
Transport equipment	0.0009	90	0.0058	574
Other manufacturing	0.0118	761	0.0047	300
Total manufacturing	0.0113	909	0.0050	405
Total manufacturing, developed countries	0.0130	1,234	0.0040	378
Total manufacturing, developing countries	0.0038	187	0.0095	464

Source:
Calculated from U.S. Department of Commerce (1985), Tables III.D.3, III.F.3, III.G.14, and III.H.12.

The first of these is termed LICDIF, and attempts to measure the difference between actual and "expected" license payments. It is constructed in the following way. First, the average license payment per employee was calculated for each of the seven broad industry groups.[8] We then multiplied the U.S. affiliates' employment in each industry in each host country by the average license payment for that industry. That way, we were able to measure the expected license payments for each country/industry observation, and, summing across industries, to estimate the total expected license payment for each host country, taking into account its industry distribution of affiliates. Finally, to get the variable LICDIF, we subtracted these estimates from the actual license payments of the host country. Contrary to the ratio of actual license payments to labor, LICDIF is not automatically high if a large share of the country's affiliates are in "licensing-intensive" industries, since the expected license payment in that case is also high. Instead, LICDIF is hypothesized to be high only when the affiliates import more technology than "normal". Measures for CAPDIF, the difference between actual and expected imports of capital equipment, were calculated analogously.[9]

The differences between developed and developing countries, in particular for the license payment variables, are also strikingly large, as shown in Table 3.1. Differences in industry distribution explain part of this, but there may be other factors that depress the technology flows to developing countries. These include, of course, the weaker learning capability of developing countries, but also weak infrastructure, fragmented markets, political instability, and a host of other matters that were mentioned in Section 3.2.1, and that we have no comprehensive data for. For some of the tests, we have therefore recalculated the dependent variables with separate expectations for developed and developing countries - in other words, the measures for expected license payments from developing countries have been based on average license payments from developing countries only.[10] The resulting variables, which take both the industry distribution and development level into account, are termed LICDIF* and CAPDIF*, and allow us to concentrate more directly on the effects of those host country characteristics we have data for. All of the input measures have been scaled in two ways, i.e. divided by sales and divided by employment, to provide several alternative measures of technological effort.[11]

The output measure is labelled $CONV^{aff}$, and it is a proxy for the rate of convergence in labor productivity between the U.S. affiliates in each host country and their parents during the period 1977-1982. We assume that the affiliates' productivities converge towards their parents' productivity levels as a result of technology transfer: the larger the technology transfer, the faster the convergence. To construct the variable, we first use PRD^{aff}, the affiliates' sales-labor ratio, as a proxy for their labor productivy, and PRD^{par} as the corresponding measure for the parents. The affiliates' relative labor productivity at any specific time is then proxied by the ratio of PRD^{aff} to PRD^{par}. Convergence (or divergence) shows up as an increase (a decrease) in this ratio. Thus, we define the rate of convergence between 1977 and 1982 as

$$(3.1) \qquad \frac{(PRD^{aff} / PRD^{par})_{1982}}{(PRD^{aff} / PRD^{par})_{1977}} = CONV^{aff}.$$

This is an even more indirect measure of technology transfer than LICENSE or CAPIMP, and it is necessary to point out some of its possible shortcomings. Firstly, we assume that labor productivity is related to the quantity of sales per employee, but value added per employee (which is not available) would clearly have been a more correct measure: affiliates in some countries and industries use more intermediate inputs than others, and may therefore exhibit higher sales per employee without being more productive *per se*. However, this is a serious problem only if the relation between value added and sales changed in a systematic manner between 1977 and 1982. If the changes are random (as we assume), then it may be concluded that there is some correspondence between increases in the sales-labor ratio and increases in labor productivity.[12]

Secondly, we assume that the convergence of the affiliates' labor productivities toward that of their parents is a result of "technological effort", which may take the form of e.g. license or equipment imports, better training of employees, more cost-conscious management, new management practices, or any other means of improving efficiency or productivity. One weakness here is that we measure sales per employee, rather than sales per quality adjusted hour of labor input. Host-country specific factors may therefore influence the observed labor productivity of affiliates even when technology transfers do not take place: for instance, demand fluctuations may affect capacity utilization, and thereby sales per employee. Furthermore, changes in exchange rates may bias the results, since all our data on sales are recorded in U.S. dollars.

What makes convergence an attractive measure, on the other hand, is that the different modes of technology transfer discussed earlier are difficult to separate, quantify, and evaluate, but that a common denominator of most types of new technologies is that they normally increase labor productivity (Chipman, 1970). Yet, the results must be interpreted with caution because of the data problems noted above, and we include the variable mainly to check the results of our other estimations.

Table 3.2 presents a summary of the rates of labor productivity convergence for developed and developing country affiliates in the seven industry groups and in total manufacturing. Overall, the labor productivities of affiliates seem to have converged toward those of the parents, although rates of convergence have varied between industries and have generally been higher for affiliates in developing countries.

TABLE 3.2 Rates of Labor Productivity Convergence Between U.S. MOFAs and U.S. Parents 1977-1982 (weighted averages).

	Rates of convergence for affiliates located in	
	Developed Countries	Developing Countries
Food products	1.09	1.22
Chemical products	1.04	1.02
Metal products	0.86	0.90
Machinery	1.10	1.29
Electric equipment	1.04	1.00
Transport equipment	1.00	1.16
Other manufacturing	1.02	1.06
Total manufacturing	1.05	1.08

Source:
Calculated from U.S. Department of Commerce (1981), Tables III.S.1, III.R.1, III.F.5, and III.G.3, and U.S. Department of Commerce (1985), Tables III.N.2, III.O.1, III.D.3, and III.F.3.

Consequently, results for $CONV^{aff}$ may be biased, and we have calculated an alternative variable - CONVDIF* - that measures the difference between actual and expected convergence for aggregate manufacturing, when the industry distribution of affiliates and the development status of the host country is taken into account.

In total, we have eight alternative dependent variables to measure the technology transfers between MNC parents and affiliates, as summarized in Appendix Table 3.1 at the end of the chapter.[13]

3.3.2 Independent Variables: Local Competition, Education, and Requirements

LICENSE and CAPIMP Regressions

Because of the differences between the dependent variables, it has not been possible to use the same proxies for local competition, education, and requirements in all estimations. Beginning with the equations estimating license payments and imports of capital equipment, we have proxied local competition with two alternative measures of investment intensity. The assumption is that investment reflects either new entrants into industry, or an upgrading of the technological level of existing firms, both of which increase competition. The variables are INV/OUTPUT, the gross fixed capital formation/gross output ratio, and INV/EMPLOY, gross fixed capital formation per employee, and both cover the host countries' entire manufacturing sectors, excluding the U.S. affiliates. They are based on data from various issues of *Industrial Statistics Yearbook*, and for the INV/EMPLOY variable, capital formation figures have been converted from local currency to U.S. dollars and corrected for international differences in capital goods prices.[14] Investment by non-U.S. multinationals has not been subtracted, which means that "local competition" refers to all non-U.S. actors in the host country market, including MNC affiliates from other countries.[15] INV/OUTPUT and INV/EMPLOY are used interchangeably in the estimations: the variables provide alternative, although related, measures of competition, as seen by the simple correlation of about 0.5 (see Appendix Table 3.2).[16]

To account for the cross-country differences in learning capabilities and labor quality, we use the variables ED2ND and ED3RD. They measure the share of the appropriate age-group in secondary and third level education in each host country 1980, and are taken from *UNESCO Statistical Yearbook 1990*, Table 3.2. The relative price of labor and the development levels of the host countries are proxied by the variable RGDP82, real GDP per capita 1982 in current USD, which is taken from Summers and Heston (1988).

To measure the impact of the host country's technology transfer requirements on the affiliates' imports of technology, we have calculated two proxies from U.S. Department of Commerce (1985), Table II.I.3. The first of these, labelled TREQS, focusses directly on technology transfer requirements, and measures the share of U.S. affiliates in each host country in 1982 that were reported to operate under requirements to use as advanced technology as possible, perform R&D locally, have access to the U.S. parent's patents, or train local personnel. However, the interpretation of many of these direct technology transfer requirements is arbitrary: the affiliate decides which technologies are viable, there may not be any direct connection between R&D and imports of new technology, and guaranteed access to the parent's patents does not ensure actual transfer. The expected effect of the variable is therefore uncertain. The alternative proxy PREQS reflects the share of affiliates that faced various quantitative performance requirements in 1982 (including import restrictions, minimum local content, and minimum local employment requirements).[17] This may be more suitable for present purposes, because quantitative rules are easier to uphold, and because the performance requirements that increase the extent of local participation also increase the costs of using advanced technologies. Both these proxies cover all non-bank affiliates of U.S. parents with more than 10 per cent U.S. ownership, rather than only the majority-owned affiliates included in the measures of technology imports. The general pattern, with OECD countries and some South-East Asian economies registering the lowest formal requirements and Latin American and South Asian nations exhibiting the highest ones, is the one we would expect also for more comprehensive measures of technology transfer requirements.[18]

CONVERGENCE Regressions

In the regressions where the rate of labor productivity convergence between affiliates and parents is used as the dependent variable, competition is proxied by the relative performance of the manufacturing sector in the host country over the 1977-1982 period. The variable $CONV^{loc}$ proxies the rate of labor productivity convergence between the host country's manufacturing sector (excluding U.S. affiliates) and the U.S. manufacturing sector between 1977 and 1982, and it is constructed in the same manner as the dependent variable $CONV^{aff}$ (and the same cautions regarding data quality apply).[19] If the host country's output-employment ratio is rapidly approaching that of the U.S., it is assumed that the competition faced by the affiliates operating there is also relatively high.

A proxy for the distortions in the host economy, DIST82, based on the distortion index in the World Bank's *World Development Report 1983*, is also included in these estimations. The index is based on the level of distortions in goods and factor markets, ranging from 1.00 for countries like Hong Kong to 2.43 for Argentina and Chile. There is a notable correlation between DIST82 and the requirement proxies (see Appendix Table 3.2), but the variables may not capture the same effects. While the two variants of the requirement variable can be assumed to have an impact on certain types of formal technology transfer arrangements by increasing technology transfer costs, their effects on overall technological effort, growth, or convergence over time are less apparent; if needed, the affiliates may be able to choose among several modes of technology transfer and can perhaps also avoid regulation that way, as noted by Robinson (1983).[20] DIST82, on the other hand, should capture the level of overall distortions and regulations that limit the effective level of competition and thereby the need to import more technology. In addition, distortions are, of course, likely to increase technology transfer costs. A problem with the distortion index is that it is only calculated for developing countries: for developed countries, it has therefore been fixed at 1.00, which makes it an extremely crude proxy.[21]

To capture the effects of changes in the level of labor skills, we use the two variables ED2CH and ED3CH, that measure the changes in the variables ED2ND and ED3RD between 1975 and 1980. The source is *UNESCO Statistical Yearbook 1990.*

All variables have been normalized by division with the sample means when used for the estimations, and all variables and data sources are summarized in Appendix Table 3.1.

3.4 STATISTICAL TESTS AND RESULTS

Combining the hypotheses with the data material at hand, we can now set up some simple equations summarizing the expected relations between variables, and then proceed to estimate linear versions of these by OLS. For the license variables (LICENSE, LICDIF and LICDIF*), the hypothesized effects are straightforward. We expect investment in the local market (measured by INV/OUTPUT or INV/EMPLOY) and the level of local labor skills (proxied by ED2ND or ED3RD) to have a positive impact on the dependent variables, whereas technology transfer requirements (particularly those captured by the proxy PREQS) are supposed to have a negative effect. Since we have the *a priori* expectation that our development proxy RGDP82 will be highly correlated with the education and labor quality proxies (as shown in Appendix Table 3.2) - and because the variable also reflects infrastructure, capital-intensity, resource endowments, institutions, and all other characteristics that affect national income levels - we have chosen not to include it in the estimations presented in the tables below. It may, however, already be noted that the coefficient of RGDP82 is positive and significant in all of the LICENSE estimations, but that the coefficients of the education and requirement variables become less significant when RDGP82 is used. The effects of RGDP82 on the CAPIMP and convergence estimations are less distinct.

Hence, we have the following equation (with LICENSE, INVESTMENT, REQS, and EDUCATION as shorthand for the alternative formulations of the proxies, and the hypothesized effects in parentheses):

$$\text{(3.2)} \qquad \text{LICENSE} = f(\underset{(+)}{\text{INVESTMENT}}, \underset{(-)}{\text{REQS}}, \underset{(+)}{\text{EDUCATION}})$$

For the capital import variables, the expected effect of competition is positive, but it is not easy to foresee in which direction the effects of education and requirements lead. One reason is that there may be some substitution between different modes of technology transfer. For instance, higher learning capability and labor quality in the host country should be connected with larger technology transfer to affiliates, as earlier, but it might not take the form of capital goods imports. In countries with high levels of education, it may be possible to find local suppliers of advanced machinery and equipment - the needed machine technology can probably be imported in the form of blueprints - and CAPIMP may remain low although technology transfers at large are high. In the less developed countries, on the other hand, levels of education are low, but CAPIMP may be relatively high anyway because all advanced machinery may have to be imported. Similarly, shortages of skilled labor might lead developing country affiliates to choose technologies that are embodied in capital goods, rather than "soft" technologies that require skilled labor. This suggests a more complex case, with several effects pulling in different directions. The estimations may therefore be seen as tests of which of these effects are the strongest.

There are question marks also concerning the effect of requirements. Most technology transfer requirements usually aim to control the transfer of disembodied technology, e.g. by demanding special training of the local labor force, whereas performance requirements are often initiated to reach some target level of local content or to restrict imports of intermediary goods for macro-economic reasons. It is not certain that these rules have major effects on imports of machinery and equipment. In fact, if requirements are strong (and increase the cost to transfer soft technologies) they might even lead affiliates to prefer to transfer embodied technology, because it is less likely to spill over. The equation, with hypothesized effects in parentheses, should thus be:

$$(3.3) \qquad \text{CAPIMP} = f\,(\underset{(+)}{\text{INVESTMENT}},\ \underset{(-?)}{\text{REQS}},\ \underset{(+?)}{\text{EDUCATION}})$$

For the convergence measures, CONV^{aff} or CONVDIF*, the hypotheses are, again, straightforward: the higher the local firms' rate of growth or convergence, i.e. the more intense the competition in the host country, the higher the technological effort needed to retain market shares and profits, and the higher the affiliates' rate of convergence with respect to their parents. The requirement variables might not have much impact, for the reasons noted above, but DIST82 should have a negative effect. Improvements in the education variables, finally, are expected to have positive effects. This gives the equation:

$$(3.4) \qquad \text{CONV}^{\text{aff}} = f\,(\underset{(+)}{\text{CONV}^{\text{loc}}},\ \underset{(-)}{\text{DIST82}},\ \underset{(+)}{\text{EDUCATION}})$$

3.4.1 Payments of Royalties and License Fees by MNC Affiliates

The results of the OLS estimations of the U.S. MOFAs' license payments, with data aggregated to cover the entire manufacturing sector, are reported in Table 3.3. In equations (1) and (2) the dependent variables are based on the unadjusted license data, equations (3) and (4) refer to the LICDIF variables, and equations (5) and (6) focus on the LICDIF* measures.

Looking first at the estimations with LICENSE, it can be seen that the results are close to what we expected. Local competition and education are positively related to the affiliates' imports of technology, whereas requirements seem to discourage technology transfer. The coefficients for the two variants of the local competition proxy, INV/EMPL and INV/OUTPUT, are both highly significant, but the former performs better in terms of adjusted R^2.[22] This holds for the other equations as well, and the reason is probably that INV/EMPL captures some of the differences between the countries' capital intensities: high rates of gross investment per employee are likely to be connected to high capital-labor ratios (simply because much capital must be replaced in every period), and also to high levels of technical skills that facilite the affiliates' technology imports.[23] The coefficients for the requirement proxies TREQS and PREQS are both negative, but TREQS is not significantly different from zero in many estimations, and it is therefore not shown in the table.

TABLE 3.3 *Results of OLS Estimations. Payments of Royalties and License Fees by Affiliates 1982.*

Equation	Constant	INV/ EMPL	INV/ OUTPUT	PREQS	ED3RD	Adj. R^2	F	N
LICENSE/LABOR								
(1)	0.0907	0.9446	--	-0.5075	0.6536	0.445	9.55	33
	(0.161)	(3.099)***	--	(2.575)**	(1.695)			
LICENSE/SALES								
(2)	0.2016	--	0.9250	-0.5444	0.4178	0.348	6.51	32
	(0.402)	--	(2.587)**	(3.140)***	(1.375)			
LICDIF/LABOR								
(3)	0.2058	0.6335	--	-0.3392	0.4999	0.477	10.71	33
	(0.559)	(3.178)***	--	(2.632)**	(1.982)*			
LICDIF/SALES								
(4)	0.7743	--	0.1610	-0.1512	0.2158	0.382	7.40	32
	(5.080)***	--	(1.481)	(2.869)***	(2.336)**			
LICDIF*/LABOR								
(5)	0.4102	0.4630	--	-0.0995	0.2263	0.252	4.59	33
	(1.372)	(2.858)***	--	(0.950)	(1.104)			
LICDIF*/SALES								
(6)	0.4758	--	0.4249	-0.1364	0.2356	0.223	3.96	32
	(1.971)*	--	(2.468)**	(1.634)	(1.611)			

Notes:
Estimated coefficients are shown together with the absolute value of the t-statistic in parentheses. *, **, and *** indicate significance at the 10, 5, and 1 per cent levels of confidence (two-tailed tests). For definitions of variables and data sources, see Appendix Table 3.1.

This may suggest that the requirements captured by TREQS have little effect on the affiliates' costs of importing technology, whereas performance requirements force them to spend resources on transferring some skills to local suppliers, as discussed earlier.[24] Neither ED2ND nor ED3RD have highly significant effects.[25] However, it is difficult to draw firm conclusions from these statistical results, although they seem to confirm some of our hypotheses. As discussed earlier, the cross-country differences in licensing intensity may be caused mainly by differences in the industry distribution of affiliates, and not by our explanatory variables. The observed effects of competition, education, and technology transfer requirements may therefore be related to decisions about industry localization rather than to the determinants of the affiliates' technology imports.

In equations (3) and (4), an attempt has been made to account for the effects of industry distribution on license payments. The results show, interestingly enough, that the explanatory power of the equations (in terms of adjusted R^2 or F-values) improves somewhat when we use LICDIF instead of LICENSE. All parameters have the expected sign, and the coefficients for both PREQS and ED3RD are significant. However, only INV/EMPL of the local competition measures has a significant effect. A possible reason for this is that the license payments from developed and developing countries differ so much that local competition alone, as proxied by INV/OUTPUT, cannot explain the pattern. INV/EMPL contains some information about capital-intensities, and is probably significant for that reason.[26]

The major consequences of the crude adjustment for development levels in the variable LICDIF* is that the observed effects of PREQS and ED3RD become less significant, although the signs of coefficients remain as expected. In equation (5), where INV/EMPL is used to capture local competition, its own coefficient is significant at the one per cent level, whereas those for PREQS and ED3RD are not significantly different from zero. In equation (6), the coefficient of the alternative competition proxy INV/OUTPUT is significant at the five per cent level, but the confidence levels for requirements and education are below 10 per cent.[27]

Summing up these results, there is fair support for the hypotheses regarding the effects of host country characteristics on the cross-country variation in the license payments of U.S. MOFAs. All coefficients have the expected signs, the effect of local competition is significant at the 5 per cent level in all but one of the estimations, and the adjusted R^2 ranges between 0.22 and 0.47.[28]

3.4.2 *Imports of Capital Equipment by MNC Affiliates*

Table 3.4 presents some of the estimations for CAPIMP, CAPDIF, and CAPDIF*. The dependent variable in equations (7) and (8) is based on the unadjusted data for the affiliates' imports of capital equipment, but has been adjusted for the industry mix of the affiliates operating in the host country in equation (9), and also for the host country's development level in equation (10). The results are less convincing than those for the license measures - most notably, the fit of the model, in terms of adjusted R^2, is significantly weaker - but the positive coefficient of local competition remains significant at the 10 per cent level for all variants of the equation. The coefficient of PREQS is also positive in all estimations, although never significant. The signs of the coefficients of TREQS and the education proxies vary, but none of them is significant.

TABLE 3.4 Results of OLS Estimations. Imports of Capital Equipment from the United States by Affiliates 1982.

Equation	Constant	INV/ EMPL	INV/ OUTPUT	PREQS	ED3RD	Adj. R^2	F	N
CAPIMP/LABOR								
(7)	0.1514	0.6329	--	0.1867	0.0289	0.081	1.88	31
	(0.288)	(2.154)**	--	(0.947)	(0.081)			
CAPIMP/SALES								
(8)	0.3995	--	0.9594	0.0566	-0.4154	0.084	1.88	30
	(0.558)	--	(1.840)*	(0.214)	(0.979)			
CAPDIF/LABOR								
(9)	0.2277	0.5391	--	0.2623	-0.0291	0.082	1.90	31
	(0.453)	(1.919)*	--	(1.391)	(0.086)			
CAPDIF*/LABOR								
(10)	0.2393	0.5107	--	0.1407	0.1093	0.034	1.35	31
	(0.469)	(1.792)*	--	(0.736)	(0.317)			

Note:
Estimated coefficients are shown together with the absolute value of the t-statistic in parentheses. *, **, and *** indicate significance at the 10, 5, and 1 per cent levels of confidence (two-tailed tests). For definitions of variables and data sources, see Appendix Table 3.1.

Thus, there is some evidence that local competition may have a positive effect on the affiliates' imports of technology that is embodied in capital goods. The costs posed by the host countries' performance and technology transfer requirements do not seem to discourage imports of capital equipment - if anything, there is a slight positive effect of requirements that perhaps reflects the preference to transfer more embodied technology when the costs for other transfer modes are high - and differences in the level of education do not have any determinate effect. However, the weak fit of the model suggests that much capital equipment is imported by the affiliates for reasons other than those included in the model.

We also tested the hypotheses for a dependent variable constructed as the sum of CAPIMP and LICENSE, to examine how the differences in the "aggregate" technology imports of U.S. affiliates can be explained. The results of the estimations were surprisingly strong, although we had uncertain expectations regarding the effects of PREQS and ED3RD. The estimated equation, with the dependent variable Y defined as the ratio (CAPIMP+LICENSE)/LABOR, and with t-statistics in parentheses, is

$$(3.5) \qquad \underset{(0.18)}{Y = -0.07} + \underset{(4.72)^{***}}{1.00\ \text{INV/EMPL}} + \underset{(1.50)}{0.38\ \text{ED3RD}} - \underset{(2.22)^{**}}{0.32\ \text{PREQS}}$$

In other words, the impact of local competition appears to be even more significant than in any of the other estimations. Moreover, there were notable improvements in the overall fit of the equation: adjusted R^2 increased to 0.55, and the F-value to 13.47.[29]

3.4.3 Labor Productivity Convergence between MNC Affiliates and Parents

The statistical tests examining the determinants of labor productivity convergence between MNC affiliates and parents over the period 1977-1982 are reviewed in Table 3.5. The dependent variables are $CONV^{aff}$, the actual rate of labor productivity convergence, in equation (11) and CONVDIF*, the difference between actual and expected labor productivity convergence, in equation (12).

The results are similar for both dependent variables, and provide mild support for the hypothesis that the performance of U.S. affiliates is related to that of other firms in the host country market, especially when the level of distortions that may inhibit competition is low: the coefficient of $CONV^{loc}$ is positive and that of DIST82 is negative, and both are significant at the five per cent level.[30] The large estimated coefficient of the distortion proxy is noteworthy: the fit of the equation is weaker when DIST82 is not taken into account, and the coefficients of the alternative variables TREQS and PREQS (included in alternative formulations of the equations, but not reported in the table) were not significant. This supports the suspicion that formal requirements may have an impact on which modes of technology imports are used, but that more general decisions about production and technology are not determined primarily by such factors: the general market environment - as proxied by DIST82 - seems to be more important for the decision to upgrade productivity and technology.

ED2CH and ED3CH, that reflect the changes in the education proxies between 1975 and 1980, do not appear to have any significant impact on convergence. (Only ED3CH is included in Table 3.5, but the estimated coefficients for ED2CH are not significant either; in addition, they are negative in most estimations.) It is possible that this is because there is a time lag between improvements in the educational system and changes in the skill level of the labor force (or that the variables are simply poor approximations of the changes in the stock of skilled labor): however, the data needed to reach more definite conclusions were not available.

TABLE 3.5 *Results of OLS Estimations. Labor Productivity Convergence between U.S. MOFAs and Parents 1977-1982.*

Equation	Constant	$CONV^{loc}$	ED3CH	DIST82	Adj. R^2	F	N
$CONV^{aff}$							
(11)	0.7688	0.4451	0.0809	-0.2949	0.144	2.57	29
	(3.043)***	(2.107)**	(0.479)	(2.540)**			
CONVDIF							
(12)	0.3896	1.1049	0.2877	-0.8205	0.156	2.60	27
	(0.641)	(2.194)**	(0.689)	(2.628)**			

Note:
Estimated coefficients are shown together with the absolute value of the t-statistic in parentheses. *, **, and *** indicate significance at the 10, 5, and 1 per cent levels of confidence (two-tailed tests). For definitions of variables and data sources, see Appendix Table 3.1.

Nevertheless, in spite of the insignificance of the education proxies, it seems that the data on rates of convergence between MNC affiliates and parents are compatible with the hypotheses that local competition forces MNC affiliates to work harder (and import more technology from abroad), and that distortions of different kinds may discourage productivity growth and technology transfer.[31]

3.5 SUMMARY AND CONCLUSIONS

This chapter has examined and attempted to explain the cross-country differences in the imports of technology by affiliates of U.S. MNCs. It was hypothesized that MNC affiliates import technology to the point where the marginal cost of technology transfer equals the marginal revenue. Abstracting from the physical features and qualities of technologies and concentrating on host country characteristics, we argued that the cost of technology transfer is determined by factors such as the learning capability and technology transfer requirements of the host country; revenue, on the other hand, was hypothesized to depend on the level of competition confronting the affiliate.

Empirical evidence from U.S. majority-owned foreign affiliates in 33 host countries offer some support for these hypotheses. Estimations based on several different measures of technology transfers - calculated from data on the affiliates' payments for royalties and license fees, their imports of capital equipment, and the rate of productivity convergence between affiliates and parents - consistently show that the technology imports of MNC affiliates increase with (various proxies for) the competitive pressure in the host economy.

The results also show that performance requirements on affiliates tend to be negatively correlated with such transfers of technology that are captured by data on payments of license fees and royalties - our hypothesis is that requirements increase transfer costs and depress technology imports, although the correlation can also be interpreted to mean that countries with small inflows of technology are more likely to introduce requirements - but that their effects on other modes of technology transfer are more uncertain. Regarding technology transfer at large, it is likely that the overall level of distortions in the host economy is more important determinant of technological development than any specific requirement, through its impact on both competition and transfer costs. The local level of education, finally, seems to have a notable positive effect on the transfers of licensed technologies, which are perhaps more advanced and demand higher labor skills. For imports of capital equipment, the effects of education are not determinate; the same is true for the convergence variables, where we might not be able to capture the changes in the skill level of the labor force by looking only at changes in the education variables.

These findings have some very concrete policy implications. If MNC affiliates actually adapt their behavior to local conditions - read local competition and supply of educated labor - then the set of instruments for the host countries' technology policy increases notably. Rather than relying only on controls and direct supervision of MNCs to secure some transfers of technology to the affiliate (and hopefully to local firms) host country governments have instead the option to support local investment, competition, and education, to create an environment which fosters increased technology imports by the MNC affiliates. This option is particularly interesting in conjunction with the idea that spillovers from foreign investment are potentially important sources of technology for local firms: technically skilled local firms are probably needed to absorb spillovers, and continuous imports of technology by the MNC affiliates may be necessary to create a potential for continuous spillovers, but spillovers may not take place if the affiliates are allowed to operate in isolation from local competition.

With this perspective, supporting competition in the industry where a MNC enters, e.g. through subsidies to education and training in local firms, has dual benefits. Firstly, the MNC is forced to adjust to competition by upgrading its production processes and importing technology, in pace with the competitors' productivity improvements. Secondly, the continuous inflow of technology increases the spillover potential, at the same time as the support to local firms increases the likelihood of actual spillovers. In other words, a "virtuous circle" of productivity and technology growth is possible, in contrast to the "vicious circles" that may occur if the MNC is allowed to operate without any local competition and isolate itself from the surrounding economy.[32] A problem, of course, is that some of these policies may be contrary to those that are commonly used by host countries to attract new MNCs, e.g. subsidies, tax holidays, and protected markets. In practice, it may therefore be necessary to weigh the benefits from larger inflows of technology to already present MNC affiliates against the possible costs in terms of foregone new investment.

3.6 NOTES

1. Modern theories of endogenous growth, innovation, and international technology transfer outline similar processes, where competition between innovators and imitators determines the rate of technical progress and diffusion (as noted in the introductory chapter). However, these models are typically not focussed on the behavior and decisions of MNCs, although Grossman and Helpman (1991) touch upon the subject.

2. Evidently, these are large simplifications. Firstly, it can be discussed whether "intangible assets" are necessary for the emergence of MNCs, or if the cost savings from *internalization* are sufficient. Secondly, the "assets" must not solely consist of technology, but can also be related to other matters, such as preferential access to goods or factor markets, or strong political connections. Thirdly, the "traditional" technology transfer sequence, which runs from technology creation in the advanced parent company to intra-firm transfer to diffusion to outsiders may not always be an accurate description of reality. The *competitive international industry approach* to FDI, discussed in detail by Cantwell (1989), argues that the creation and diffusion of technology are interdependent in modern international industries. Lall *et al.* (1983) emphasize the importance of "reverse technology transfer" for multinationals from developing countries. However, neither of these alternative views seem to be appropriate here, because we look at the operations of U.S. MNCs in both developed and developing host countries.

3. Technology transfer between MNC parents and affiliates and the technology imports of MNC affiliates are treated as synonyms in this chapter. The latter is a wider concept since it includes technology purchases from third parties, but the distinction does not change the results or conclusions of the analysis.

4. An additional point to note (e.g from Figure 3.1) is that the effect of an increase in the learning capability of the host country is larger the lower the initial level of technology. This seems reasonable: for instance, it is unlikely that foreign affiliates operating in Sweden or Germany would import very much more technology in response to an improvement in the countries' levels of education.

5. Das (1987) also predicts a decline in the affiliates profits over time, because local firms benefit from spillovers of technology.

6. The surveys cover affiliates in about 50 individual countries, and the data are presented for aggregate manufacturing plus seven broad industry groups. The seven industry groups are Food and Kindred Products, Chemicals and Allied Products, Primary and Fabricated Metals, Machinery, except Electrical, Electric and Electronic Equipment, Transportation Equipment, and Other Manufacturing. Lack of host country data for the explanatory variables has forced us to exclude many countries, and those remaining for the tests are Australia, Austria, Belgium, Canada, Chile, Colombia, Denmark, Ecuador, France, West Germany, Greece, Hong Kong, India, Indonesia, Ireland, Italy, Japan, Luxembourg, Malaysia, Netherlands, New Zealand, Norway, Panama, Peru, Philippines, Portugal, Singapore, South Korea, Spain, Sweden, Turkey, U.K., and Venezuela. Some of the estimations cover fewer countries because of missing observations.

7. Including additional explanatory variables that reflect industry characteristics (e.g. measures of R & D intensities or advertisement expenditures weighted according to the industry distribution of affiliates in the host country) captures many of the industry effects, and serves the same purposes as the alternative dependent variables. However, including such industry characteristics diverts the focus from the host country characteristics we are interested in.

8. In addition to the data for aggregate manufacturing, the U.S. Department of Commerce also publishes some data on license payments and capital equipment imports for U.S. MOFAs in each of the seven broad industry groups discussed earlier. The most accurate measure to construct the LICDIF variable would probably be the unweighted average LICENSE/LABOR figure calculated across all countries. However, for reasons of confidentiality, data on employment and/or license payments for several countries and industries have been suppressed. The number of observations available to calculate the unweighted averages is therefore quite small for some industries, and the results may be misleading. Some of the missing values can be estimated or extrapolated from the available data, but this introduces considerable uncertainty into the calculations. We have therefore used the weighted averages appearing in Table 3.1 for the estimations that are reported in Section 3.4.

However, all LICDIF estimations have also been made with variables that are based on the unweighted averages presented below, with little or no difference for the signs and confidence levels of parameters. For reference, row (a) gives the unweighted average license payments per employee in USD for those observations that are actually published in U.S. Department of Commerce (1985), while row (b) presents our own 'best estimates' of the unweighted averages. Both variants include data for the 33 countries mentioned in note 5 above plus observations for Argentina, Brazil, Mexico, South Africa, Switzerland, Taiwan, and Thailand; industries without U.S. MNCs are not included.

	Food	Chem.	Metl.	Mach.	Elec.	Tran.	Othr.
(a)	73	184	92	164	70	44	95
(b)	75	176	73	222	65	36	85

The large number of suppressed observations for the SALES variable has prevented us from using the LICENSE/SALES measure in this context.

9. Only weighted industry averages have been used for the variable CAPDIF: it has not been possible to calculate unweighted average capital imports because of the large number of missing observations.

10. The LICDIF* variable has been constructed in two alternative versions, with weighted as well as unweighted industry averages used for the calculations, but only the results using the former variant are reported in the tables below. See also note 27. For CAPDIF*, it was only possible to construct the variable from weighted average capital imports, for reasons of data availability.

11. We do not present any estimation results for the individual industry groups, because of the many suppressed observations. This not only limits the number of observations for each industry, but may also introduce a bias into the sample, since the missing observations are not randomly distributed. Instead, Chapter IV will focus on a more disaggregated sample.

12. To partially account for the gap between sales and value added, we subtracted the affiliates' imports of intermediate products from the U.S. from the sales data: the results remained unchanged, which we interpret to mean that there were no systematic changes in the relation between sales and value added in the period 1977-1982.

13. We also constructed some proxies for the MNC affiliates' technology imports (or the level of their technological activity) from data on the affiliates' R&D expenditures. However, it was found that the only host country characteristics that had any significant impact on these variables were the size and the income level of the host economy, which is entirely in line with the conclusions of Zejan (1990). Some probable reasons for the findings are that adaptive R&D to suit the MNCs' products to local demand patterns is profitable only in the larger markets, and that the scientific resources required to conduct R&D are available only in the larger and more advanced economies. Moreover, it is possible that MNCs concentrate their R&D resources to only a few of the host countries, because of the substantial economies of scale involved.

14. The exchange rates and price indices used for the corrections are from Summers and Heston (1988). The tests were also made for investment data without the corrections for international price differences for capital goods. The results were largely similar to those for price-adjusted data, and are therefore not presented separately.

15. There are no comprehensive data for MNC affiliates from other countries, which means that our results may, to some extent, capture the international competition between multinationals of different nationalities. For this topic, see further e.g. Knickerbocker (1973) and Sölvell (1987).

16. Capital stock data are not available for all countries, so we have not been able to use the perhaps more appropriate ratio of gross investment to capital stock.

17. More specifically, PREQS was calculated as a weighted average of the share of affirmative answers to three questions relating to performance requirements (import restrictions, minimum local content, and minimum local employment). Both TREQS and PREQS refer to the share of *responding* affiliates facing the various types of requirements. On aggregate, the share of "no response" observations for the variables varies between two and six per cent.

18. Regarding the Andean Investment Code, it should be noted that the well-known Decision 24, instituted in 1970/71, prohibited payments of royalties and license fees from wholly-owned affiliates to parents. If implemented strictly, this would have meant that the LICENSE measures for the Andean Pact countries Bolivia, Colombia, Ecuador, Peru, and Venezuela would have been uninteresting. (Chile withdrew from the Pact in 1976.) Yet, the rules have been implemented with varying firmness, and license payments have not disappeared, although they fell significantly during the early 1970s. By the early 1980s, there did not seem to be any remaining significant differences in the use of royalties and license fees between these countries and the rest of Latin America. See Grosse (1989), pp. 113-131 and p. 201. We have therefore not accounted for Decision 24 other than via the variables TREQS and PREQS, where the Andean Pact countries exhibit relatively high values.

19. More specifically, $CONV^{loc}$ is defined as the change in ratio of $PROD^{loc}$ to $PROD^{US}$ between 1977 and 1982. The variable PROD is defined as output per employee, either in the host countries or in the U.S.. It should be noted that we have used gross sales for the affiliates' productivity measures, but gross output for the host countries, because $CONV^{loc}$ and $CONV^{aff}$ are calculated from different data bases.

20. In interviews with MNC officials, Grosse (1989), p. 121, found that formal technology transfer requirements did not appear to have any impact at all on foreign investment location decisions. What impact they might have on actual technology transfers was, however, not discussed.

21. Assigning higher values *ad hoc* for some of the European countries with the highest values for TREQS or PREQS (e.g. Greece and Portugal) improves the estimation results, but the data needed to systematically calculate country-specific values for DIST82 for all the developed economies are not available.

22. Analysis of residuals suggests that the effect of local competition is not linear. Instead, it is reasonable to assume that the impact is even stronger than what the linear formulation implies. Adding a squared term for local competition yields a significant negative coefficient for the simple local competition proxy, a significant positive coefficient for the squared term, and improves the fit of the model somewhat. This applies for all estimations where the dependent variable is based on LICENSE, and most notably when INV/EMPL is the competition proxy; changes are smaller for INV/-OUTPUT. However, the qualitative results and conclusions do not change, so we retain the simple linear formulation. There are no similar effects for the CAPIMP and convergence estimations.

23. The same need not be true for INV/OUTPUT, since higher capital intensity will probably increase labor productivity and sales. Throughout, all regressions have therefore been made with both INV/EMPL and INV/OUTPUT, but the tables only show results for "matched" combinations (INV/EMPL with LIC/LABOR or INV/OUTPUT with LIC/SALES). Results for "unmatched" pairs are typically similar to those reported in the tables, but with somewhat lower levels of significance.

24. A warning regarding causality should be noted at this point. It is possible that the causal ties between requirements and technology transfer are the opposite from what we have hypothsized, i.e. that requirements have been instituted in some countries because the technology imports of MNC affiliates were considered to be too small.

25. Only the results with ED3RD are reported in the tables, because of the higher correlation between ED2ND and PREQS, see Appendix Table 3.1. It is unlikely that ED2ND would give any significant results even if the multicollinearity problem could be solved, because the variation in the levels of secondary education is relatively small.

26. Adding a measure of real GDP per capita to the equation gives some further support for this explanation: the coefficient of RGDP82 takes on a significant positive value, and that of INV/OUTPUT becomes significant. The results are similar if a developing country dummy is used instead of RGDP82.

27. The results for the LICDIF* version that was calculated from data for unweighted average license payments were somewhat stronger, particularly for the LICDIF*/SALES equation: there, both INV/SALES and REQS were significant at the five per cent level, and ED3RD was significant at the 10 percent level. The coefficient estimates were, however, quite similar to those presented in the table.

28. Dropping the observations with the lowest or highest values for investment, education, and requirements does not change the signs and confidence levels of any estimates.

29. The fit of the equation is somewhat weaker when the dependent variable is defined as (CAPIMP+LICENSE) / SALES and when INV/OUTPUT is used as the competition proxy, but the signs of coefficients remain unchanged, and the effect of competition is always significant at around the one per cent level.

30. The results are similar if we adjust the convergence measures for cross-country differences in the affiliates' imports of intermediate and finished goods from the United States. The picture remains much the same if we look at cumulative growth rates of the affiliates' SALES/LABOR ratios over the 1977-1982 period, rather than convergence.

31. The data could also be interpreted with the opposite causality in mind, i.e. that MNC affiliates with high rates of convergence and large technology imports give rise to larger spillovers and therefore faster productivity growth in local firms. Chapter V will look into this possibility. Simultaneous interactions between affiliates and local firms are also possible, and will be examined more closely in Chapter VI. In fact, given that the convergence measures cover changes in labor productivity over a five-year

period, it is reasonable to assume that affiliates and local firms have been influenced by each other and that each type of firm has been able to (or forced to) react in some way to the actions of the other party.

32. Cantwell (1989) also discusses similar 'virtuous circles', but concentrates on developed countries and argues that the benefits will only occur in industries where local firms are already competitive when the foreign firms enter: here, we have a less deterministic view, and assume that local firms can grow to become competitive, possibly with the help of policy interventions.

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APPENDIX TABLE 3.1 List of Variables and Data Sources

	DEPENDENT VARIABLES: proxies for the technology imports of U.S. MOFAs (Basic data are from U.S. Department of Commerce, 1981, 1985.)
LICENSE	- payments of royalties and license fees to the U.S. by U.S. MOFAs in host country i 1982.
LICDIF	- difference between LICENSE and expected license payments, defined for each country i as $LICENSE_i - \Sigma_j \; LABOR_{ij} * AVELIC_j$ where $LABOR_{ij}$ is the employment in country i's industry j and $AVELIC_j$ is the average license payment per employee in industry j, shown in Table 3.1.
LICDIF*	- as LICDIF, but AVELIC calculated separately for developed and developing countries.
CAPIMP	- imports of capital equipment from the U.S. by U.S. MOFAs in host country i 1982.
CAPDIF	- difference between CAPIMP and expected imports of capital equipment, calculated as LICDIF.
CAPDIF*	- as CAPDIF, but average capital imports calculated separately for developed and developing countries.
$CONV^{aff}$	- rate of labor productivity convergence between U.S. MOFAs and their parents between 1977 and 1982, defined as the change in the ratio of PRD^{aff} to PRD^{par} over the period. The PRD variables are based on gross sales, and defined as $PRD = SALES \; / \; LABOR$
CONVDIF*	- difference between $CONV^{aff}$ and expected convergence, calculated as LICDIF*.

(continued...)

APPENDIX TABLE 3.1 List of Variables and Data Sources (continued...)

	INDEPENDENT VARIABLES (Data sources in parentheses.)
INV/EMPL	- gross fixed investment per employee in the host countries' manufacturing sector 1982 (excluding U.S. MOFAs), corrected for international price differences for capital goods. Proxy for local competition. (Industrial Statistics Yearbook, various.)
INV/OUTPUT	- ratio of gross fixed investment to gross output in the host countries' manufacturing sector 1982 (excluding U.S. MOFAs). Proxy for local competition. (Industrial Statistics Yearbook, various.)
TREQS	- share of U.S. affiliates in host country i facing various technology transfer requirements 1982. (U.S. Dep't of Commerce, 1985.)
PREQS	- share of U.S. affiliates in host country i facing various performance requirements 1982. (U.S. Dep't of Commerce, 1985.)
DIST82	- distortion index for host country i (developed countries set at 1.00). (World Development Report 1983.)
RGDP82	- real GDP per capita 1982 in fixed 1980 USD, host country i. Proxy for development level. (Summers and Heston, 1988.)
ED2ND	- per cent of age group (13-18) in secondary level education 1980, host country i. Proxy for labor skills. (UNESCO Statistical Yearbook, 1990.)
ED3RD	- per cent of age group (18-24) in third level education 1980, host country i. Proxy for labor skills. (UNESCO Statistical Yearbook, 1990.)
ED2CH	- change in ED2ND between 1975 and 1980, host country i. Proxy for improvement in labor skills. (UNESCO Statistical Yearbook, 1990.)
ED3CH	- change in ED3RD between 1975 and 1980, host country i. Proxy for improvement in labor skills. (UNESCO Statistical Yearbook, 1990.)
$CONV^{loc}$	- rate of labor productivity convergence between the manufacturing sector of host country i and U.S. manufacturing 1977-1982, defined as the change in the ratio of $PROD_{loc}$ to $PROD_{US}$ over the period. The PROD variables are the ratios of gross output to employment. Proxy for local competition. (Industrial Statistics Yearbook, various.)

APPENDIX TABLE 3.2 *Simple Correlation Coefficients for Independent Variables.*

Equations with LIC and CAPIMP

	INV/ EMPL	INV/ OUTPUT	ED2ND	ED3RD	PREQS	TREQS	RGDP82
INV/EMPL	1.00						
INV/OUTPUT	0.52	1.00					
ED2ND	0.12	-0.33	1.00				
ED3RD	0.20	-0.08	0.67	1.00			
PREQS	-0.04	0.36	-0.75	-0.39	1.00		
TREQS	-0.06	0.55	-0.64	-0.49	0.52	1.00	
RGDP82	0.06	-0.38	0.79	0.48	-0.70	-0.68	1.00

Note:
There are 33 observations for all variables except INV/OUTPUT (N=32). For data sources and definitions of variables, see Appendix Table 3.1.

Equations with $CONV^{aff}$

	$CONV^{loc}$	ED2CH	ED3CH	DIST82
$CONV^{loc}$	1.00			
ED2CH	-0.01	1.00		
ED3CH	0.02	0.38	1.00	
DIST82	0.43	0.35	0.13	1.00

Note:
There are 29 observations for all variables. For data sources and definitions of variables, see Appendix Table 3.1.

CHAPTER IV

TECHNOLOGY IMPORTS BY FOREIGN FIRMS IN MEXICAN MANUFACTURING INDUSTRIES

4.1 INTRODUCTION

In the previous chapter, it was argued that the technology imports of MNC affiliates are partly determined by various host country characteristics that affect the costs and revenues of technology transfer. More specifically, we hypothesized that high levels of education and labor skills lower the affiliates' transfer costs and encourage technology imports; that competition from local firms reduces the revenue from existing technologies, and forces the affiliates to import more technology; and that performance and technology transfer requirements increase transfer costs and discourage certain types of technology imports. In the empirical analysis, we examined how the technology imports of majority-owned manufacturing affiliates of U.S. MNCs operating in 33 host countries were related to proxies for the host countries' labor skills, competition, and requirements, and found some support for the hypotheses.

However, we also noted that there is reason to be cautious in the interpretation of the empirical results, because of the weak quality of the data. One problem was that all of our host country data referred to aggregate manufacturing (although we tried to make some rough adjustments for the industry distribution of affiliates), and another was that the sample covered only 33 countries. In addition, many of the important differences between host countries seemed to be related to their levels of economic development.

On the basis of our theoretical reasoning, we chose to focus on education and performance requirements, but "development" is a many-faceted concept, and the combined weight of other development-related factors may have contributed more to the results than the variables we used. Furthermore, we examined only majority-owned affiliates of U.S. MNCs, and it is uncertain whether the results apply equally for minority-owned affiliates and MNCs from other countries.

To complement the findings of Chapter III, we will therefore devote this chapter to an analysis of the technology imports of foreign firms in 144 Mexican four-digit manufacturing industries in 1975. By focussing on the differences in the technology imports of foreign firms in several narrowly defined industries in *one* host country, we are able to avoid some of the shortcomings of the previous chapter. Most importantly, factors related to the general development level of the host country - political and economic stability, institutions, security of property rights, infrastructure, and overall distortions - are not likely to influence the results very much. It is also likely that the data are of better quality than in the previous chapter: the present data set is based on detailed census information from individual plants, covering practically all industrial establishments in Mexico, and the number of observations is significantly larger than in Chapter III. Moreover, the foreign firms in Mexico include MNCs from several different countries (although U.S. firms dominate), which allows for more general conclusions regarding the behavior of foreign affiliates.

However, it should also be noted that there are still some weaknesses in the present data. One problem is that we do not have information about distortions and requirements at the industry level, which means that we are forced to omit variables that are probably important. Another problem is that the nation and the individual four-digit industries are perhaps not the ideal units of aggregation, as discussed in the introductory chapter: regional differences and the inclusion of several types of products in the same industry group may obscure the relations between variables. Nevertheless, these difficulties are likely to be less serious here than in the previous chapter. A remaining problem, however, is the need to use imperfect proxies for education, competition, and other theoretically concise but empirically obscure concepts.

In addition to the statistical test for the whole sample of 144 industries, we will make some exploratory tests to examine whether the determinants of the technology imports of MNC affiliates vary across industry groups with different characteristics, such as the level of technical complexity, the size of the foreign share of employment, and the level of producer concentration. It is conceivable, for instance, that pressure from local competitors has an effect on the behavior of affiliates only when the technology gap between domestic and foreign firms is relatively small, i.e. when it is likely that the two kind of firms produce comparable products. In fact, the decision to exclude the least developed countries from the empirical analysis of the previous chapter and to divide the sample into industrialized and developing countries was based on such a conjecture. It is also possible that education and labor skills are more important determinants of technology imports of firms operating in relatively advanced industries. These kinds of differences between industries (if they occur at all) are important qualifiers for any policy conclusions that may emerge from the analysis.

Adopting the theoretical framework of the previous chapter, we will move directly to a discussion of the data and the statistical model in the next section. Section 4.3 presents the statistical results, and section 4.4 concludes the chapter.

4.2 DATA, DEFINITION OF VARIABLES, AND STATISTICAL MODEL

The empirical data for this chapter are taken from unpublished worksheets provided by *la Dirección de Estadísticas de la Secretaría de Industria y Comercio* in Mexico, collected in connection with the Mexican Census of Manufactures 1971 and 1976, and refer to industry characteristics and operations in 1970 and 1975. Some supplementary information has been taken from U.S. Department of Commerce (1985). The Mexican data are gathered at the plant level, and aggregated into 230 four-digit manufacturing industries in 1970 and 235 industries in 1975. The change in the classification system between 1970 and 1975 (and missing information for some of the variables) has forced us to drop a number of industry observations from the estimations (more specifically, all four-digit industries that were divided into two or more classes in 1975 were excluded, as were all industries without foreign firms). Consequently, the sample is limited to 144 industries.

For these industries we have information on capital stocks, employment, gross output, advertizing expenditures, labor quality, and payments for imported patents, trade marks, and technical assistance. Except for data on labor quality and advertizing expenditures, the information is available separately for foreign and domestic firms. A plant is included in the foreign category if 15 per cent or more of its shares are owned by foreigners. (Thus, we are not able to separate between joint ventures and majority-owned foreign affiliates.) The category "domestic firms" includes private as well as state-owned plants.[1] The data from the U.S. Department of Commerce surveys of U.S. FDI refer to the average license payments per employee in U.S. affiliates 1982.

On the basis of the theoretical discussion in the previous chapter, and given the information available in the present data set, we can now set up some testable hypotheses regarding the determinants of the technology imports of foreign affiliates. Firstly, to construct our dependent variable, we use data on the foreign firms' technology payments to abroad to measure their technology imports. Data on the share of white-collar employees in the industry's labor force or the wage payments by foreign firms approximate labor quality. Growth rates of domestic firms' output, capital stocks, capital-intensities, or output-labor ratios serve as rough proxies for local competition. The expected effects of labor quality and competition are, of course, positive. In addition to these factors, we need to control for the variation in technology imports that stems from basic differences in technology: data on the domestic firms' technology payments, the average license payments in U.S. industries, and the advertizing expenditures of Mexican industries are used for this purpose. Equation (4.1) summarizes the resulting function (where LQ and COMP are shorthand for several alternative proxies for labor quality and local competition, and expected effects are shown in parentheses below), and the following paragraphs define the variables in closer detail:

$$\text{(4.1)} \qquad PAT^{f} = f\,(\underset{(+)}{PAT^{d}},\ \underset{(+)}{USLIC},\ \underset{(+)}{ADV},\ \underset{(+)}{LQ},\ \underset{(+)}{COMP}).$$

The dependent variable, PAT^{f}, measures the foreign firms' average payments per employee for imported patents, trade marks, and technical assistance in 1975. This measure underestimates the affiliates' true technology imports, since much technology is transferred through machinery, equipment, and personnel, but we assume that it is an accurate reflection of the imports of disembodied technology. A possible problem is that the proxy may capture some degree of transfer pricing activities if foreign parents overinvoice the technology transactions with affiliates - because of data limitations, we can neither examine the gravity of the problem, nor make any meaningful corrections.

PAT^d is the corresponding measure for local firms, and it is included as a control variable, to account for the industry-specific variation in the imports of disembodied technology: some industries are more dependent on imported patents, trade marks, and technical assistance because of the industry's technological characteristics, irrespective of the level of competition or labor skills in the host country. The assumption is that the patent payments of the local firms reflect these features, so its expected effect is positive.

An alternative proxy for these industry characteristics is USLIC. It measures the average patent and license payments per employee of all foreign affiliates of U.S. MNCs in 1982, and it has an expected positive impact on PAT^f. However, the U.S. data are not available at the four-digit level of aggregation, so the Mexican industries have been classified into 16 groups depending on the size of the average patent payments in corresponding U.S. two-digit industries.[2] Hence, there is some reason to be cautious with the interpretation of the results. A further problem with the variable is that it was not possible to find U.S. two-digit equivalents for all Mexican industries, because of the differences in the national classification schemes, so USLIC is defined only for 142 of the industries in the sample. It is nevertheless interesting to use USLIC in some estimations: when it is included, PAT^d can be interpreted as a proxy for local competition, rather than a control variable.

A third control variable is ADV, which measures the ratio of each industry's advertizing expenditures to gross output in 1970 (data for 1975 were not available) and is intended to account for the cases where trade marks are commonly used, and where the PAT^f variable can be expected to be high for that reason alone. There is probably reason to include both ADV and either PAT^d or USLIC as control variables, because the marketing and advertizing behavior of foreign firms may differ considerably from those of local firms. (See Caves, 1982, Chapter 4.) Hence, PAT^d might not capture the cases where foreign firms make large payments for trade marks irrespective of labor quality, competition, or other industry or market characteristics.

LQ is our first proxy for labor quality. It measures the ratio of white-collar to blue-collar workers in each Mexican industry 1970 (1975 data were not available for this study) and assumes that the share of white-collar workers reflects some of the labor skills that are needed to use the types of disembodied technologies in question. The higher the level of labor skills, the lower the adaptation and technology transfer costs: hence, the expected effect is positive. $WAGE^f$, the ratio of the foreign firms' wage payments to their employment in 1970, is an alternative measure for labor quality: the underlying assumption is that labor with more advanced skills earns higher wages. However, wage rates are highly correlated with capital-labor ratios, so we run the risk of capturing spurious correlations between capital-intensities and technology payments when this variable is used.

Our first proxy for local competition is termed ΔK^d, and it measures the relative increase (in per cent of the 1970 value) in the real capital stock of domestic firms between 1970 and 1975. The hypothesis is that industries with higher rates of domestic investment during the period have become more competitive. One reason may be that a larger share of the total capital stock in these industries is made up of "new" and more efficient vintages of machinery and equipment. High investment figures may also signal the entry of many new local firms into the industry, and/or rapid growth in the size of existing firms: both these circumstances are likely to translate into increased competition.[3]

An alternative proxy, ΔGO^d, measures the percentage increase in real gross output in domestic firms in the 1970-1975 period.[4] As above, we assume that industries where local output increases faster are also those where competition is becoming tougher - what separates this variable from the investment figures is that it also reflects the efficiency of investment.

A problem with both these proxies is that the increase in capital stock or output may be caused by an expansion of demand, which must not be connected to any increase in competition. We have therefore included measures for the real growth rates of the domestic firms' capital-labor ratios and gross output-labor ratios as additional proxies for competition. These variables are labelled $\Delta K/L^d$ and ΔPRD^d, respectively, and we assume that industries where the capital-intensity or labor productivity of local firms has grown faster, in real terms, have also become more competitive.[5]

Finally, to check the results for PAT^f, we have also made some estimations with an alternative dependent variable that measures the real growth rate of the foreign firms' average gross output-labor ratio between 1970 and 1975. The variable, termed ΔPRD^f, is available for 126 industries. We hypothesize that the foreign firms exhibiting higher increases in this rough proxy for "labor productivity" also imported more technology during the 1970-1975 period - in other words, ΔPRD^f is analogous to the convergence measure used in the previous chapter. Obviously, this is a less precise measure than PAT^f, since the gross output-labor ratio is affected by capacity utilization, use of intermediate inputs, the capital-intensity of production, and many other factors aside from technology. The magnitudes of some of these possible errors diminish, because we are looking at the changes in the ratio. For instance, differences in capacity utilization and use of intermediary inputs bias the results only if there have been systematic changes between industries between 1970 and 1975. Yet, the remaining problems are considerable, and it is uncertain whether the estimations of ΔPRD^f alone provide any significant insights.

We also need an additional explanatory variable for these estimations. This is labelled $\Delta K/L^f$, and is included to account for the effects of changes in capital-intensity on the foreign firms' labor productivities. It measures the growth rate of the affiliates' average real capital stock per employee, and we expect it to have a significant positive effect. It should be noted that the inclusion of $\Delta K/L^f$ among the independent variables means that we choose not to examine what determines the affiliates' imports of embodied technology - imported machinery and equipment are included in the variable.

In addition, we hypothesize that the rate of technical progress and the productivity changes in foreign firms are positively related to the level of labor quality, proxied by LQ, and to the degree of local competition, measured by any of our four proxies ΔK^d, ΔGO^d, $\Delta K/L^d$, or ΔPRD^d. Obviously, this formulation leaves out many other possible determinants of changes in the affiliates' gross output-labor ratio. Some of these omitted factors are likely to influence both foreign and local firms, so that the expectation of a positive relation is strongest for the variable ΔPRD^d; consequently, its interpretation is also the most cumbersome. Equation (4.2) summarizes these hypotheses:

$$(4.2) \qquad \Delta PRD^f = f\ (\underset{(+)}{\Delta K/L^f},\ \underset{(+)}{LQ},\ \underset{(+)}{COMP}).$$

All of the variables used in the estimations are normalized by division with the sample means, and the variable definitions are summarized in Appendix Table 4.1, Appendix Table 4.2 shows some descriptive statistics for the data set, and Appendix Table 4.3 presents simple correlations between the independent variables.

We will use ordinary least squares to estimate linear, additive versions of the different variants of equations (4.1) and (4.2). In addition to the estimations that cover all the 144 (or 126) industries, we will also examine sub-samples of industries defined according to some structural characteristics. The purpose is to make some exploratory tests of whether the relations between the technology imports of foreign firms and our proxies for labor skills and local competition differ between industries in a systematic way, depending on these features. More specifically, we will compare the estimated coefficients for labor quality and local competition (there is no reason to assume that the coefficients of the control variables are constant across all sub-samples of industries) between groups of industries with "normal" and "high" values for the variables KLGAP, PGAP, K/L^f, FOR, and HERF (defined below). The comparisons are based on F-tests of the null hypothesis that there is no difference between the sub-samples.

KLGAP is defined as the ratio of the average capital-intensity in foreign firms to that in domestic firms in the same industry in 1975. It is included in order to examine if the technology gap between domestic and foreign firms has an effect on the estimated coefficients for labor quality and local competition. The reason to suspect that coefficients differ between the groups is that a large difference in the capital-labor ratios may indicate that foreign and local firms are not manufacturing the same products, or competing for the same customers.

PGAP, which measures the ratio of the affiliates' gross output per employee to that of domestic firms in 1975, and K/L^f, the capital-labor ratio of foreign firms in 1975, are two alternative selection criteria. The interpretation of PGAP is analogous to that of KLGAP, although the gross output-labor ratio is not a very attractive measure, for reasons discussed above in connection with the ΔPRD^f variable. It can be noted that the simple correlation between KLGAP and PGAP is 0.36, which means that they are related, but not direct substitutes. The choice of K/L^f as a discriminating characteristic has a somewhat different justification. It says nothing about the relative strengths of firms, but it may reveal if high capital-intensity, and the attributes related to it, affect the functional relationships involved. High capital-labor ratios may distinguish some "high tech" industries, but it is not an ideal proxy for technological complexity - for instance, the correlation between PAT^f (which is probably closely connected to advanced technology) and K/L^f is only 0.27. Alternatively, K/L^f may be related to the presence of economies of scale, or high barriers to entry because of high capital requirements.

Some market characteristics may also have an influence on the estimations. To take this into account, we will group the industries according to the variables FOR, which measures the affiliates' share of industry employment in 1975, and HERF, which is the value of the Herfindahl index for 1975.[6] The variables used as selection criteria are summarized in Appendix Table 4.1.[7]

4.3 STATISTICAL RESULTS

Some of the results of the OLS estimations of the determinants of the technology imports by MNC affiliates in Mexican manufacturing industries are reported in Tables 4.1 to 4.4. The first three tables focus on estimations with PAT^f as the dependent variable, while the last table presents results for ΔPRD^f.

4.3.1 Determinants of Foreign Firms' Payments for Imported Patents, Trade Marks, and Technical Assistance

Table 4.1 below reports some of the estimations of equation (4.1). The first four regression equations refer to the full sample of 144 industries, whereas equation (5) is estimated for the 142 industries for which the variable USLIC is available.

TABLE 4.1 *Results of OLS Regressions: Payments to Abroad for Patents Fees, Trade Marks, and Technical Assistance by Foreign Firms in Mexican Manufacturing Industries 1975.*

	(1)	(2)	(3)	(4)	(5)
Constant	-0.0655	-0.1155	-0.1187	-0.0774	-0.1728
	(0.410)	(0.701)	(0.667)	(0.359)	(1.012)
PAT^d	0.1137	0.1415	0.1727	0.0932	0.1194
	(2.369)**	(2.962)***	(3.421)***	(1.747)*	(2.494)**
USLIC	--	--	--	--	0.1744
	--	--	--	--	(1.694)*
ADV	0.0957	0.2113	0.0875	0.1825	0.0981
	(1.299)	(2.792)***	(1.082)	(2.532)**	(1.333)
LQ	0.5607	0.5144	0.6170	--	0.4764
	(4.103)***	(3.679)***	(4.175)***	--	(3.254)***
$WAGE^f$	--	--	--	0.4994	--
	--	--	--	(2.502)**	--
ΔK^d	0.2954	--	--	0.3023	0.2988
	(6.105)***	--	--	(6.023)***	(6.196)***
ΔGO^d	--	0.2483	--	--	--
	--	(5.471)***	--	--	--
$\Delta K/L^d$	--	--	0.2385	--	--
	--	--	(3.513)***	--	--
Adj. R^2	0.444	0.420	0.353	0.404	0.454
F-value	29.60	26.92	20.50	25.24	24.46
N	144	144	144	144	142

Notes:
The dependent variable is PAT^f. All variables are normalized by division with the sample means. Estimated coefficients are shown together with the absolute value of the t-statistics in parentheses. *, **., and *** denote significance at the 10, 5, and 1 per cent levels of confidence (two-tailed tests). For definitions of variables, see Appendix Table 4.1.

The estimation results provide strong support for our hypotheses regarding the determinants of the foreign firms' technology imports. All coefficient estimates have the expected signs, the model appears to explain nearly half of the variation in the dependent variable, and the significance levels for most estimates are high.

Equations (1) to (3) estimate our basic model, where PAT^d and ADV are included to control for the industry-specific variation in the use of foreign patents and trade marks, LQ accounts for the effects of labor quality differences, and ΔK^d, ΔGO^d, and

$\Delta K/L^d$, respectively, are used as proxies for local competition. There are only small differences in the estimates between the regression equations, and both labor quality and local competition appear to have significant positive effects. The coefficient of our fourth local competition proxy, ΔPRD^d, is not significant, and it is therefore not shown in the table, nor in Tables 4.2 and 4.3. The high positive correlation between the competition proxies (particularly ΔK^d) and PAT^d may disturb the results (see Appendix Table 4.3), but we believe that multicollinearity is a minor problem, since small random changes in the sample size have little effect on the coefficient estimates.

In regression equation (4), we have included the variable $WAGE^f$ instead of LQ, as a proxy for labor quality. The estimation results with the different competition proxies are very similar to those in equations (1) to (3) and we therefore only show the function with ΔK^d in the table.

Equation (5) introduces USLIC as a control variable for the industries where disembodied technology is more frequently used. This allows us to interpret PAT^d as an additional proxy for local competition: the hypothesis is that it may mark industries where local firms are particularly active in importing technology, and where foreign firms are therefore forced to innovate and import technology. USLIC appears to have the expected positive impact, and both PAT^d and the other three successful proxies for local competition (only ΔK^d is shown in the table) have significant positive effects. In other words, equation (5) offers some additional support to the hypothesis that local competition matters. However, the coefficient of USLIC is not highly significant, and the explanatory power of the equation, as measured by the value of adjusted R^2, does not improve much. For this reason (and because USLIC is defined at the two-digit level of aggregation, rather than the four-digit level, and based on data for 1982, rather than for 1975) we have chosen not to use the variable in subsequent estimations.

Table 4.2 shows the results for sub-samples of industries characterized by their values of KLGAP and K/L^f. These equations are intended to examine if it is reasonable to assume that the effects of labor skills and local competition on PAT^f are independent of the complexity of MNC technology. Our base cases are illustrated by equation (6), where the capital-labor ratios of foreign firms were at most twice as high as those of domestic firms in 1975, and equation (7), where the estimated capital-intensity of foreign firms in 1975 was at most 250,000 pesos.[8] Equations (8) and (9) cover industries with higher values for KLGAP and K/L^f, and presumably more complex technologies.[9] Only estimations with ΔK^d as a proxy for local competition are shown in the table: results for ΔGO^d and $\Delta K/L^d$ are comparable.

It can be seen that the estimation results differ somewhat depending on whether we look at industries with moderately advanced or highly advanced technologies. Our model appears to explain a large share of the variation in PAT^f in industries with low values for KLGAP and K/L^f - both R^2 and F-values are high in equations (6) and (7).

TABLE 4.2 Results of OLS Regressions: Payments to Abroad for Patent Fees, Trade Marks and Technical Assistance by Foreign Firms in Mexican Manufacturing Industries 1975. Industries Grouped According to KLGAP and K/L^f.

	(6) Small KLGAP	(7) Low K/L^f	(8) Large KLGAP	(9) High K/L^f
Constant	0.0345	-0.4104	0.1547	0.6450
	(0.192)	(2.306)**	(0.414)	(1.916)*
PAT^d	0.1833	0.1748	0.0308	0.0308
	(3.102)***	(3.363)***	(0.421)	(0.329)
ADV	-0.0161	-0.0177	0.2848	0.1233
	(0.204)	(0.178)	(1.913)*	(1.306)
LQ	0.4150	0.9357	0.5763	0.0995
	(2.704)***	(5.508)***	(2.287)**	(0.395)
ΔK^d	0.3834	0.3177	-0.0465	0.1013
	(7.105)***	(6.622)***	(0.181)	(0.697)
Adj. R^2	0.596	0.659	0.252	-0.031
F-value	37.56	50.33	4.62	0.70
N	100	103	44	41

Notes:
The dependent variable is PAT^f. The average capital-labor ratio of foreign firms is at most twice as high as that of local firms in equation (6), and at most 250,000 pesos per employee in equation (7). All variables are normalized by division with the sample means. Estimated coefficients are shown together with the absolute value of the t-statistics in parentheses. *, **., and *** denote significance at the 10, 5, and 1 per cent levels of confidence (two-tailed tests). For definitions of variables, see Appendix Table 4.1.

By contrast, the model explains only a quarter of the variation for the industries with large differences between foreign and local firms' capital-intensities, and nothing for the industries with high foreign capital-intensities.

The coefficient estimates and significance levels for individual variables differ accordingly. The estimated effects of PAT^f, LQ, and ΔK^d in equations (6) and (7), i.e. for the industries with less advanced technology, are all positive and significant at the one per cent level (however, ADV does not have any significant effect). The impact of local competition appears to be greater than in the full sample, reported in Table 4.1, and labor quality seems to have a remarkably large effect in equation (7), in the group of industries where foreign firms have low or moderate capital-intensities.

Only ADV and LQ have significant coefficients in the large KLGAP sample. It is interesting to note that the estimated effect of ADV is significant in this sample, but not in the previous two equations. A possible explanation is that the differences between foreign and local firms' marketing behavior and technological complexity coincide: ADV should not have any impact in equations (6) and (7) if the expenditures for imported trade marks are similar when technologies are similar (or simple enough for local firms to master). Moreover, the estimated coefficient for ΔK^d is negative, although not significant. This implies that foreign firms that are much more advanced than the local firms in their industry are not very sensitive to local competition. However, F-tests suggest that the difference in the coefficient estimates for ΔK^d is not statistically significant: the variation among the high KLGAP industries is so large that we cannot exclude the possibility that the underlying relationship between PAT^f and ΔK^d is the same in both sub-samples.[10]

None of the estimated coefficients in the group of industries with high foreign capital-intensity, in equation (9), is significant, and it can be suspected that there is no systematic relation between foreign firms' technology imports, labor skills, and local competition in the sub-sample. Yet, the only estimate that is significantly different from those in equation (7) is that for LQ. It is surprising that labor quality has no apparent effect in this sub-sample, since more complex production processes should require higher labor skills. A partial explanation for the lack of significance may be that average LQ is higher (and its variation is smaller) in industries with high K/L^f. It is also possible that high K/L^f does not proxy the level of technology, but rather the presence of scale economies: in that case, requirements for skilled labor may be smaller.

There are more apparent reasons why local competition might not have a significant impact on PAT^f in these industries. Highly capital-intensive production processes may demand fixed amounts of technology imports irrespective of the economic environment, or high values for K/L^f may characterize industries where local firms are not able to compete directly with the foreign affiliates because of the high complexity of the technologies in question, or because the capital requirements are too high: foreign and local firms may produce different products, for different customers. Some (but probably not all) of the industries in the high K/L^f may be characterized by these features - the fact that F-test cannot establish a significant difference between the coefficients of ΔK^d in equations (7) and (9) suggests that there are also some advanced industries where local competition matters.

The findings of Blomström, Kokko, and Zejan (1992) are consistent with these results. They also analyze the technology imports of foreign firms in Mexican manufacturing (using the present data base), and conclude that local competition has a highly significant effect on the affiliates' patent payments in industries producing consumer goods and intermediate goods, but no significant impact in capital goods and durable goods industries. These two categories largely coincide with our taxonomy of industries with moderately advanced or highly advanced technologies in foreign firms.[11]

Table 4.3 summarizes the estimation results for sub-samples of industries grouped according to some market structure characteristics. Equation (10) includes only industries where the foreign share of employment is lower than 40 per cent and equation (11) focusses on industries with relatively low levels of producer concentration: the value of the Herfindahl index is below 0.50: the foreign share or the level of concentration is higher in equation (12) and (13).[12]

There are some notable differences also between these sub-samples of industries. The main findings for the groups distinguished by the levels of foreign presence, in equations (10) and (12), is that local competition appears to have a significantly larger impact in industries with lower foreign shares, but that labor quality is significantly

TABLE 4.3 *Results of OLS Regressions: Payments to Abroad for Patent Fees, Trade Marks, and Technical Assistance by Foreign Firms in Mexican Manufacturing Industries 1975. Industries Grouped According to FOR and HERF.*

	(10) Low FOR	(11) Low HERF	(12) High FOR	(13) High HERF
Constant	-0.1952	-0.1264	-0.1621	0.2845
	(0.783)	(0.644)	(0.997)	(0.891)
PAT^d	0.1634	0.1871	0.0259	0.1128
	(2.554)**	(2.106)**	(0.468)	(1.557)
ADV	0.1821	0.2202	-0.0297	-0.0675
	(1.893)*	(2.105)**	(0.314)	(0.641)
LQ	0.3459	0.5417	0.8274	0.3141
	(1.800)*	(3.142)***	(5.205)***	(1.151)
ΔK^d	0.5038	0.1774	0.3385	0.3561
	(4.512)***	(2.551)**	(7.298)***	(4.397)***
Adj. R^2	0.317	0.474	0.779	0.388
F-value	12.94	23.31	35.34	7.82
N	104	100	40	44

Notes:
The dependent variable is PAT^f. The foreign share of employment in equation (10) is below 50 per cent, but higher in equation (12). The value of the Herfindahl index is below 0.50 in equation (11) but higher in equation (13). All variables are normalized by division with the sample means. Estimated coefficients are shown together with the absolute value of the t-statistics in parentheses. *, **., and *** denote significance at the 10, 5, and 1 per cent levels of confidence (two-tailed tests). For definitions of variables, see Appendix Table 4.1.

more important for industries with high foreign shares.[13] There are several possible explanations for the stronger effect of local competition in the low FOR industries. For instance, industries with higher foreign shares exhibit more advanced technology, so the differences may be related to the findings in Table 4.2. Moreover, the local firms in industries where foreigners have captured large market shares may be relatively weak, and perhaps forced into segments of the market where foreign firms do not operate. Yet, it should be noted that there is a significant positive impact of local competition also in the group of industries with high foreign shares.

The differences between the sub-samples in the estimates of labor quality can also be related to the higher level of technical complexity in the high FOR sample: the skill level of the labor force can be expected to be more important in industries with more advanced technology. This result is not entirely consistent with the lack of significance for LQ in regression equation (9), unless high FOR is a better indicator of "high tech" industries than high K/L^f. In addition, the coefficient of ADV is positive in the low FOR group, but negative (although not significant) in the high FOR group: we have no obvious explanation for this finding. It can also be noted that the adjusted R^2 of equation (12) is remarkably high, and the model explains over three fourths of the cross-sector variation in the dependent variable.

The coefficient estimates in the low and high HERF groups are more similar. The only coefficient that appears to differ significantly (at the ten per cent level) between the two groups is that for ΔK^d, which is higher in the high HERF industries. It is possible that the results for these groups combine two partly opposing effects. On the one hand, high HERF industries generally exhibit more advanced technologies, judging from their higher capital-labor ratios, patent payments, and gross output-labor ratios. This implies that local competition may have a relatively small impact on the technology imports of foreign firms, as discussed above. On the other hand, local firms in the more concentrated industries are probably larger and stronger, and may therefore pose a more serious threat to the foreign firms. Apparently, the latter effect dominates the results.

Summarizing, it seems that the labor quality is an important determinant of the foreign firms' technology imports in all industries except those where foreign firms exhibit the highest capital-labor ratios. Local competition has a significant positive impact in all industries except those where the technology gap between foreign and local firms is large and where the capital-intensity of foreign firms is large. There are also signs of stronger effects of local competition in industries where foreign shares are smaller, and where the level of producer concentration is larger. Our interpretation of these findings is that local competition is important (and perhaps possible) mainly when foreign and local firms manufacture similar products. High foreign shares and high capital-intensities in foreign firms may mark industries where foreign affiliates operate in isolation from the surrounding economy: the decisions made by the firms in these "enclaves" are likely to be independent of the actions of domestic firms that happen to be classified in the same industry group.[14] It is also possible that the technological capability of domestic firms must rise above some minimum level before their operations have any impact on the decisions of foreign firms. Finally, the results are consistent with a situation where local competition is always important, but where our various proxies are meaningful only in industries where foreign and domestic firms actually manufacture comparable products.

4.3.2 Determinants of Labor Productivity Growth in Foreign Firms

Table 4.4 summarizes the results of our examination of the determinants of the growth rate of real gross output per employee in foreign firms in Mexican manufacturing industries between 1970 and 1975. This rough estimate for labor productivity growth is regressed against proxies for the growth rate of the foreign firms' capital-labor ratios, the industry's labor quality, and local competition. We include these regressions mainly to test whether the changes in "labor productivity" are consistent with the results concerning the foreign firms payments for patents, trade marks, and technical assistance. As discussed earlier, gross output measures are only weak proxies of productivity, and the use of $\Delta K/L^f$ as an independent variable excludes an important part of the technical progress that takes place in foreign firms, so these estimations alone are not likely to provide very much information about the technology imports of foreign firms.

Equation (14) shows the results of the estimation for the whole sample of 126 industries for which all variables are available. It can be seen that the model is relatively weak, and explains only a quarter of the variation in the dependent variable. As expected, $\Delta K/L^f$ seems to be the most important determinant of ΔPRD^f, but the coefficient of ΔPRD^d is also positive and significant at the five per cent level. In other words, foreign labor productivity seems to increase more in those industries where domestic productivity also grows faster. This is consistent with the hypothesis that local competition forces foreign firms to import technology. However, our other proxies for local competition (that are not shown in the table) have no significant effects, although their coefficients are positive, as expected. This may mean that there is no causal relation between the two ΔPRD variables, but that they are both influenced by some exogenous omitted factor.

TABLE 4.4 *Results of OLS Regressions: Labor Productivity Growth in Foreign Firms in Mexican Manufacturing Industries 1970-1975.*

	(14)	(15) Small PGAP	(16) Large PGAP	(17) Low FOR	(18) High FOR
Constant	0.4667	0.6235	0.3287	0.5018	0.2016
	(3.350)***	(6.616)***	(1.918)*	(3.066)***	(1.197)
$\Delta K/L^f$	0.3214	0.1570	0.5905	0.2489	0.5843
	(5.973)***	(4.360)***	(5.837)***	(4.115)***	(4.794)***
LQ	0.0211	0.0067	-0.0163	-0.0835	0.2352
	(0.291)	(0.316)	(0.526)	(0.929)	(2.331)**
ΔPRD^d	0.1909	--	--	--	--
	(2.142)**	--	--	--	--
ΔGO^d	--	0.1309	0.0205	--	--
	--	(2.454)**	(0.496)	--	--
$\Delta K/L^d$	--	--	--	0.3328	-0.0211
	--	--	--	(3.120)***	(0.709)
Adj. R^2	0.245	0.215	0.466	0.280	0.465
F-value	14.53	8.85	12.04	12.42	11.43
N	126	87	39	89	37

Notes:
The dependent variable is ΔPRD^f. Equation (14) covers all industries. The value of PGAP is lower than 1.7 for the industries in equation (15), and higher in equation (16). The foreign share of employment is below 0.4 in equation (17), and higher in equation (18). All variables are normalized by division with the sample means. Estimated coefficients are shown together with the absolute value of the t-statistics in parentheses. *, **., and *** denote significance at the 10, 5, and 1 per cent levels of confidence (two-tailed tests). For definitions of variables, see Appendix Table 4.1.

The coefficient of LQ is not significant, which may be because we have no data for the change in LQ between 1970 and 1975, but only its absolute level in 1970. We can therefore not draw any conclusions regarding the possible effects of labor quality from these estimations.

Equations (15) and (16) refer to sub-samples defined according to the size of PGAP.[15] These equations offer some more support for the hypothesis that there is a relationship between labor productivity growth in affiliates and local competition, because ΔPRD^d is not the only local competition proxy with a significant effect (the table shows only ΔGO^d.) Local competition appears to have a larger effect in the small PGAP group than in the large PGAP group; however, the difference in the size of the coefficients is not statistically significant. This is also consistent with the results of the tests reported earlier: large differences in technology levels may isolate foreign firms from the actions of local firms. The estimated impact of LQ is not significant in either of the industry groups.

Finally, the results for groups of industries distinguished by the foreign share of employment are shown in equations (17) and (18). These are consistent with the findings in Table 4.3 above. Local competition has a larger and more significant impact in the low FOR sample than in the high FOR group, whereas labor quality seems to have a stronger impact in the high FOR group. The estimations for industry groups characterized by values of K/L^f, KLGAP, and HERF are not shown here, but it can be noted that they yield results that are compatible with those presented in Tables 4.1 to 4.3, although coefficient estimates are seldom highly significant.

4.4 CONCLUDING COMMENTS

In this chapter, we have examined some determinants of the technology imports of foreign firms in Mexican manufacturing industries in 1975, to complement and verify the findings of the exploratory cross-country analysis in the previous chapter. The results of our OLS estimations provide strong support for our hypotheses regarding the effects of labor quality and local competition on the technology imports of MNC affiliates: as shown in Table 4.1, our proxies for labor quality and local competition had positive coefficients that were highly significant (at the one per cent level), even after we had controlled for inter-industry differences that are primarily related to technological characteristics.

In addition, we have explored whether the determinants of technology imports differ systematically between groups of industries distinguished by certain structural characteristics - the size of the technology gap between foreign and domestic firms, the capital-intensity of foreign firms, the foreign share of employment, and the level of producer concentration. The findings, presented in Tables 4.2 and 4.3, indicate that industries where foreign firms hold high employment shares or exhibit very high capital-intensities may differ from other industries. We have offered three alternative, but related, interpretations of these results. Firstly, foreign firms may be so much more advanced than local firms that they do not perceive the increases in local investment and output as a threat. Secondly, they may manufacture entirely different products than domestic firms, and operate in "enclaves" that are isolated from the local economy. Thirdly, it is possible that competition is always important, but that our proxies fail to measure the level of competition in these industries.

From a policy perspective, these findings lead us to make some additions to the conclusions of Chapter III. (However, it should be noted that the relevance of our comments may be limited to the case of Mexico, since we have not examined detailed data for any other country.) We found there that support to technical education and competing local firms may be an alternative to technology transfer and performance requirements imposed on foreign affiliates. At a general level, the present results provide very strong support for these conclusions. At a less aggregated level, however, some modifications may be necessary. Most importantly, small increases in labor quality and local competition may have negligible effects on foreign affiliates in industries with high foreign shares and high capital-intensities, i.e. industries where it is reasonable to suspect that enclaves have formed.

4.5 NOTES

1. The 1970 data are available separately for private and state-owned Mexican firms, but the two groups are summarized here, because the 1975 data do not make this distinction.

2. A concordance scheme between U.S. two-digit and Mexican four-digit SIC codes is provided by Blomström and Wolff (forthcoming).

3. However, it should be noted that the capital stock data for 1970 and 1975 are not directly comparable. The 1970 data for local firms are defined as *capital invertido*, which is the book value of net property, plant and equipment plus intangible capital; for

1975, local capital stock is defined as *activos fijos brutos*, which is the gross value of property, plant, and equipment. We have therefore made some transformations of the 1975 data. The 1970 data base includes both variants of the capital stock for industry totals, and we calculated industry-specific ratios between the two measures. These were then used to transform the *activos fijos* data for 1975 into *capital invertido* proxies, which were deflated using the wholesale price index. This corresponds to the data transformations made in Blomström, Kokko, and Zejan (1992). There is a significant absolute difference between the two measures, but there is also a high simple correlation between them, at about 0.9. Hence, the regression results are similar for both proxies.

4. We have used industry-specific price indices, rather than the wholesale price index, to deflate the 1975 data for gross output, but the choice of deflator does not have any large impact on the regression results.

5. The data on capital and gross output are deflated in the same manner as for ΔK^d and ΔGO^d, and the capital stock for 1975 has been transformed to *capital invertido*. Another possible proxy for local competition, ΔFOR, measuring the change in the foreign share between 1970 and 1975, is also conceivable. However, it suffers from a certain simultaneity bias, because the performance of the foreign firms is probably related to their technology imports: the cases where the foreign share has fallen may be such where the foreign firms' response to local competition, e.g. in terms of imports of technology, has been weak.

6. The Herfindahl index is calculated from plant level data, and is defined as:

$$\text{HERF} = \Sigma_i \, (x_i \,/\, X)^2$$

where x_i is the employment of the n individual plants in the industry, and X is the total employment of the industry.

7. The correlations between the selection criteria are given below. For comparison, PAT^f has also been included in the table. It can be noted that the gap between foreign and domestic firms' technology payments (the ratio PAT^f / PAT^d) is not significantly correlated with any of these measures.

PAT^f	1.00					
KLGAP	0.15	1.00				
PGAP	0.28	0.37	1.00			
K/L^f	0.27	0.35	0.29	1.00		
HERF	0.10	0.05	0.01	0.12	1.00	
FOR	0.25	0.19	0.10	0.26	0.36	1.00
	PAT^f	KLGAP	PGAP	K/L^f	HERF	FOR

8. The figure 250,000 pesos refers to our estimate of *capital invertido*. This corresponds roughly to a value of *activos fijos brutos* per employee of 150,000 pesos. However, the two sub-samples are not entirely identical, since the correlation between values for

capital invertido and *activos fijos brutos* is not perfect, but regression results are very similar.

9. The choice of cut-off points for the sub-samples reported in Table 4.2 is based on analysis of residuals from regression equations (1) to (5). We have chosen to divide the sample at points where the average size or direction of residuals change. Results for higher cut-off points are similar to the ones presented in the table (as long as at least 20 observations remain in the high KLGAP and high K/L^f groups), but the differences between the sub-samples diminish (and disappear eventually) for lower cut-off points.

10. The F-tests that are reported in the text have been made on data that is not normalized by division with sample means. The average values for ΔK^d differ between the sub-samples, and F-tests on normalized data sometimes give other results. In this case, F-tests with normalized data offer mild support, at the ten per cent level, for the hypothesis that the impact of local competition differs between the two sub-samples.

11. We also examined sub-samples grouped according to values of PGAP, which we use as a proxy for the labor productivity differences between foreign and local firms. The differences in the estimated effects of LQ, ΔK^d, and ΔGO^d were insignificant (although the third proxy for local competition, $\Delta K/L^d$, had a significantly larger impact in the low PGAP group) and the results are not shown in the table.

12. The cut-off points have been chosen on the same grounds as in Table 4.2. Small changes in the cut-off point have little or no effect on the estimations.

13. F-tests on normalized data indicate that the differences are not statistically significant. There are notable differences in the average values of ΔK^d and LQ between the sub-samples, which may make the results of the F-tests on normalized data misleading.

14. We have also combined the two selection criteria K/L^f and FOR, and have made the estimations for groups of industries with low/high foreign capital-intensities as well as low/high foreign shares. The estimated coefficients for the local competition proxies are larger in the low group: F-tests indicate that the difference is highly significant (at the 0.002 level). There are no other significant differences between the two groups.

15. The division of the sample has been made in the same way as in Table 4.2.

4.6 REFERENCES

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APPENDIX TABLE 4.1 Definitions of Variables

Dependent Variables (data from unpublished worksheets provided by la Dirección de Estadísticas de la Secretaría de Industria y Comercio in Mexico)

PAT^f - Average payments per employee for imported patents, trade marks, and technical assistance, foreign firms, 1975. Proxy for technology imports.

ΔPRD^f - Increase in labor productivity 1970-1975, foreign firms. Ratio of gross output per employee in 1975 to gross output per employee in 1970. 1975 data deflated by industry-specific price indices. Proxy for technology imports.

Independent Variables (data from unpublished worksheets provided by la Dirección de Estadísticas de la Secretaría de Industria y Comercio in Mexico, unless otherwise stated)

PAT^d - Average payments per employee for imported patents, trade marks, and technical assistance, domestic firms, 1975. Used as control variable.

USLIC - Average payments per employee of license fees by U.S. manufacturing affiliates. Defined for 16 two-digit (U.S. SIC) industries, 1982. Used as control variable. (Source: U.S. Department of Commerce, 1985)

ADV - Ratio of advertizing expenditures to gross output, industry totals, 1970. Used as control variable.

LQ - Ratio of white-collar workers to blue-collar workers, industry totals, 1970. Proxy for labor quality.

$WAGE^f$ - Ratio of wage payments to employment, foreign firms, 1970. Proxy for labor quality.

ΔK^d - Increase (per cent) in real capital stock 1970-1975, domestic firms. 1975 data transformed from activos fijos brutos to capital invertido with industry-specific ratios from 1970, and deflated by the wholesale price index. Proxy for local competition.

ΔGO^d - Increase (per cent) in real gross output 1970-1975, domestic firms. 1975 data deflated by industry-specific price indices. Proxy for local competition.

continued...

APPENDIX TABLE 4.1 Definitions of Variables (continued...)

ΔPRD^d	- Increase in labor productivity 1970-1975. Ratio of gross output per employee in 1975 to gross output per employee in 1970, domestic firms. 1975 data deflated by industry-specific price indices. Proxy for local competition.
$\Delta K/L^d$	- Increase in capital-intensity 1970-1975, domestic firms. Ratio of capital stock per employee in 1975 to capital stock per employee in 1970. Capital stock data for 1975 adjusted and deflated as for ΔK^d. Proxy for local competition.
$\Delta K/L^f$	- Increase in capital-intensity 1970-1975, foreign firms. Ratio of capital stock per employee in 1975 to capital stock per employee in 1970. Capital stock data for 1975 adjusted and deflated as for ΔK^d. Used in estimations of ΔPRD^f.
	Selection Criteria for Grouping of Industries
KLGAP	- Ratio of capital-intensity in foreign firms to capital-intensity in domestic firms, 1975.
K/L^f	- Capital-labor ratio, foreign firms, 1975.
PGAP	- Ratio of gross output per employee in foreign firms to gross output per employee in domestic firms 1975.
HERF	- Value of Herfindahl index, 1975. Calculated for plant level data.
FOR	- Foreign share of industry employment, 1975.

APPENDIX TABLE 4.2 *Some Descriptive Statistics for Mexican Manufacturing Industries.*

Variable	Unit	Mean	Std Dev	Minimum	Maximum
Data for 1975					
PAT^f	'000 pesos	4.43	6.72	0	38.43
PAT^d	"	1.75	3.94	0	25.05
K/L^f	"	134.86	123.52	1.01	742.51
K/L^d	"	110.72	219.82	10.75	2430.95
GO/L^f	"	391.35	309.21	0.88	1626.40
GO/L^d	"	299.47	240.55	70.09	1709.41
Data for 1970					
ADV		0.01	0.01	0	0.09
LQ		0.31	0.24	0.06	1.63
$WAGE^f$	'000 pesos	31.90	10.82	5.36	60.58
Changes between 1970 and 1975					
ΔK^d	per cent	58.5	335.8	-93.4	326.5
ΔGO^d	"	114.1	452.8	-81.4	453.9
ΔPRD^f		1.08	0.73	0.01	4.52
ΔPRD^d		1.43	0.76	0.27	4.75
$\Delta K/L^f$		0.94	0.93	0.05	6.78
$\Delta K/L^d$		1.10	1.84	0.15	21.85

Notes:
There are 144 observations for all variables except $\Delta K/L^f$ and $\Delta PRDf$ (N=126). The capital stock data used to compute K/L^f and K/L^d in this table are defined as *activos fijos brutos*. For definitions of variables, see Appendix Table 4.1.

APPENDIX TABLE 4.3 *Simple Correlation Coefficients for Exogenous Variables, Mexican Manufacturing Industries 1970-1975.*

Estimations of PAT^f

PAT^d	1.00								
USLIC	0.00	1.00							
ADV	0.18	0.09	1.00						
LQ	0.23	0.35	0.37	1.00					
WAGE	0.42	0.18	0.15	0.42	1.00				
ΔK^d	0.45	-0.03	0.19	0.14	0.15	1.00			
ΔGO^d	0.37	0.02	-0.06	0.09	0.16	0.46	1.00		
ΔPRD^d	0.20	-0.01	-0.07	-0.10	-0.02	0.30	0.19	1.00	
$\Delta K/L^d$	0.39	-0.05	0.24	0.05	0.07	0.85	0.05	0.37	1.00
	PAT^d	USLIC	ADV	LQ	WAGE	ΔK^d	ΔGO^d	ΔPRD^d	$\Delta K/L^d$

Notes:
There are 144 observations for all variables except USLIC (N=121). For definitions of variables, see Appendix Table 4.1.

Estimations of ΔPRD^f

$\Delta K/L^f$	1.00					
LQ	-0.08	1.00				
ΔK^d	-0.02	0.13	1.00			
ΔGO^d	0.01	0.08	0.45	1.00		
ΔPRD^d	0.11	-0.09	0.31	0.20	1.00	
$\Delta K/L^d$	-0.01	0.06	0.86	0.05	0.37	1.00
	$\Delta K/L^f$	LQ	ΔK^d	ΔGO^d	ΔPRD^d	$\Delta K/L^d$

Notes:
There are 126 observations for all variables. For definitions of variables, see Appendix Table 4.1.

CHAPTER V

TECHNOLOGY AND MARKET CHARACTERISTICS AS DETERMINANTS OF SPILLOVERS

5.1 INTRODUCTION

Three major observations have been made in the discussion of spillovers and the analysis of the MNC affiliates' technology imports in the previous chapters. Firstly, technology is often the intangible proprietary asset that allows a firm to become multinational, and a continuous flow of proprietary technology from the parent to the affiliates is one of the important features of multinational corporations. This technology flow creates a potential for spillovers to local firms in the host countries. The affiliates may demonstrate technologies that have not been used in the host country before, they may train workers who later establish their own firms or take employment in existing local companies, and their presence in the host country's market may contribute to a more competitive environment, all of which may lead to increases in the productivity of local firms.

Secondly, there is empirical evidence to suggest that some of the potential spillovers have been realized. Studies of aggregate manufacturing in various countries - Australia (Caves, 1974), Canada (Globerman, 1979), and Mexico (Blomström and Persson, 1983) are the best known examples - have found a positive impact of foreign presence on the productivity of local firms, and disaggregated case studies have provided more detailed information about spillovers from demonstration, linkages, training of labor, and competition, as seen in Chapter II. However, there may also be cases where potential spillovers are not realized, as suggested by studies of FDI in various European countries (Cantwell, 1989), in Moroccan manufacturing industries (Haddad and Harrison, 1991), and in Venezuelan manufacturing (Aitken and Harrison, 1991).

Thirdly, the amount of technology that could potentially spill over to local firms is probably not exogenously given, but rather dependent on policy-related factors. The preceding two chapters have argued that host country and host industry characteristics, such as the degree of competition from local firms, the skill level of the local labor force, and the presence of foreign direct investment regulations, are among the determinants of the MNC affiliates' imports of technology. These characteristics also determine the potential for spillovers.

Yet, there is no direct empirical evidence available to show how the spillovers we can observe are related to the level of technology in MNC affiliates, and it is not entirely obvious from a theoretical perspective what the relation should be. In fact, two opposing arguments can be found in the literature on foreign investment and technology transfer. On the one hand, a certain technology gap is necessary for those spillovers that occur as local firms copy MNC technology or benefit from the MNCs' training of local employees; these spillovers may grow with the technology gap between MNC affiliates and local firms. On the other hand, it is possible that affiliates typically use technology that is too advanced to leave any mark on local firms (as is sometimes argued in discussions of the "appropriateness" of MNC technology) and that higher technology gaps only serve to isolate the MNCs more effectively from local firms. The policy relevance of the finding that the spillover potential can be influenced (and perhaps also the assessment of some of the benefits of FDI) depends on which of these points of view is more correct.

The purpose of this chapter is to investigate how spillovers observed in static cross-section analyses are related to the technology gap between locally-owned host country firms and MNC affiliates, and to various proxies for the level of complexity of MNC technology. In the course of the study, we will also find reason to briefly examine the relation between spillovers and some market characteristics. The next section discusses the two contending perspectives on technology gaps and spillovers, and reports some findings from existing empirical studies of closely related questions. Section 5.3 describes the data set and the statistical model used for the empirical tests, section 5.4 presents and discusses the results, and section 5.5 concludes the chapter.

5.2 SPILLOVERS AND TECHNOLOGY GAPS: EVIDENCE FROM THE LITERATURE

5.2.1 Theoretical Arguments

The hypothesis that spillovers increase with the size of the technology gap between local firms and MNC affiliates is rarely discussed explicitly in the literature, but it can be found in several theoretical models, perhaps most clearly in that of Wang and Blomström (1992). However, Wang and Blomström point to Findlay (1978) as the source of the hypothesis, and we will therefore briefly look at Findlay's dynamic model of technology transfer between "advanced" and "backward" countries.

According to Findlay, the spillovers of technology from MNC affiliates to local firms can be thought of as the sum of two separate but related processes. Firstly, there is a convergence effect that is directly related to the size of the technology gap. Referring to the works of Thorstein Veblen and Alexander Gerschenkron on industrialization and convergence in Europe during the 19th and early 20th century, Findlay argues that the rate of growth of less developed countries may be faster because "the greater the backlog of available opportunities to exploit, measured by the distance between the advanced and backward region's current level of development, the greater the pressure for change within the backward region" (Findlay, 1978, p. 2). This can be interpreted to mean that the larger the technology gap between the MNC affiliates and the local firms, the larger are the spillovers.[1]

Secondly, there is a contagion effect that is a function of the foreign share of the host country's industry. Foreign investment is regarded as the major channel for the transfer of technology from the advanced to the backward region: MNC affiliates are assumed to fully embody their home country technology and to accelerate the diffusion process by demonstrating new technologies to local firms. The argument that the extent of foreign presence determines the rate of spillovers is based on an analogy between the diffusion of technology and the spread of contagious diseases: technological innovations are most likely to spill over when there is personal contact between those who already have the knowledge and those who are to adopt it.

More formally, the convergence hypothesis can be stated as follows:[2] letting A(t) be an index of the technological level of MNC affiliates at time t (rather than that of the home country, as in Findlay's formulation), A_0 the affiliates' initial level of technology, and n the affiliates' exogenous rate of technology imports, we have the relation

$$(5.1) \qquad A(t) = A_0 \, e^{nt} \; .$$

With B(t) denoting the technological level of the host country firms at time t, the convergence hypothesis implies that

$$(5.2) \qquad dB/dt = \lambda \; [A_0 e^{nt} - B(t)]$$

where the term λ measures the rate of convergence, and is a function of various factors that affect the local firms' ability to realize the potential spillovers and adopt modern technology. Apart from the exposure to foreign firms, Findlay mentions the quality of management and the level of education of the labor force, but the list has been extended by other authors to include also geographical, cultural, institutional, and political factors.[3] Keeping these factors constant, it can be seen that the spillovers of technology (or the rate of technology diffusion) to local firms are larger the larger is A(t) - B(t), i.e. the technology gap, and the larger is n, the foreign firms' imports of technology.

Integrating this differential equation, the technological level of host country firms at time t is given by the equation

$$(5.3) \qquad B(t) = \frac{\lambda}{(n+\lambda)} A_0 \, e^{nt} + \frac{(n+\lambda) \; B_0 - \lambda \; A_0}{(n+\lambda)} \, e^{-\lambda t} \; .$$

Here, we see that the absolute level of local technology is higher the higher the affiliates' initial technology level, A_0, the higher their imports of technology, n, and the higher the rate of convergence, λ.[4]

The contagion process is not specified in the same detail as the convergence effect. It seems reasonable to assume that the diffusion of technology is a logistic function of foreign presence, as numerous studies of diffusion patterns have suggested.[5] However, as we will see, the relation between foreign presence and spillovers has generally been assumed to be linear.

Combining the convergence and contagion hypotheses, and defining x as the inverse of the technology gap and y as the degree of foreign penetration, Findlay then states the growth rate of the host country firms' technical level as

$$\text{(5.4)} \qquad \frac{\delta B(t)/\delta t}{B(t)} = f\,(x,\, y)$$

with the partial first derivatives $\delta f / \delta x < 0$ and $\delta f / \delta y > 0$.

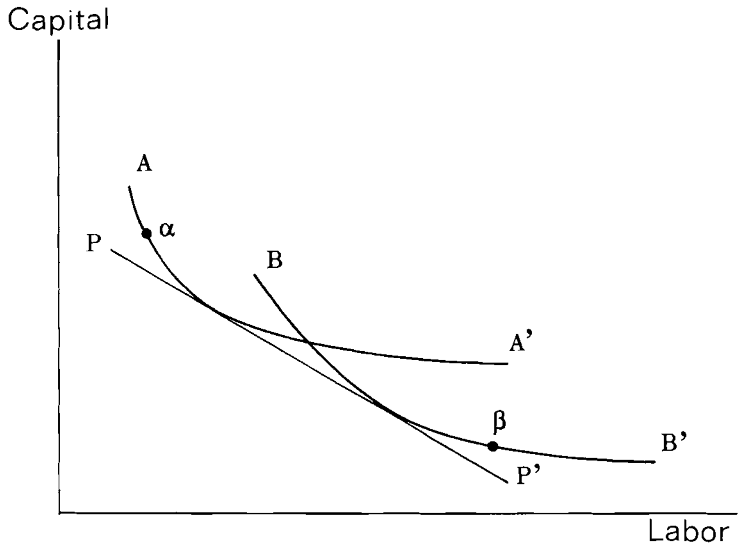
In other words, the host country firms' rate of technological development increases with both foreign penetration and the technology gap between foreign MNCs and local firms. The larger the capital share of MNCs, *ceteris paribus*, the more severe the contagion, and the higher B(t). Conversely, the larger the technology gap, for any given share of MNCs, the faster the rate of convergence, and the higher B(t). In the model, these two effects are merged together via the MNCs' investment function, so that the foreign firms' willingness to invest and their share of capital is related to the technology gap: in essence, the higher the gap, the higher the MNCs' profits, and the higher their investments.

Wang and Blomström (1992) also interpret the technology gap discussed by Findlay in terms of the distance between MNC affiliates and local firms, and argue that its size is one of the determinants of technology spillovers. However, their model is more complex, and separates between the costless contagion-type spillovers and spillovers arising from the competition between MNC affiliates and local firms. A more detailed discussion of the model will be postponed to Chapter VI, but the distinction between these two types of spillovers is worth emphasizing here. The only spillover effects in the extreme case where the MNC affiliate has no technological advantage before local firms (but bases its presence on other "assets", e.g. superior access to capital) are those that come about because MNC presence may increase competition and lead to improvements of X-efficiency; when there is a technology gap, there are also demonstration effects and possible spillovers through linkages and the training of employees, as discussed in Chapter II. A larger technology gap increases this *potential* for spillovers.

The opposite view may be represented by e.g. Lapan and Bardhan (1973) and Berglas and Jones (1977). Referring to the concept of "localized technical progress" introduced by Atkinson and Stiglitz (1969), they discuss the argument that "technical advances applicable to the factor-proportions of capital-rich developed countries are hardly of any use in improving techniques of low capital-intensity in less developed countries" (Lapan and Bardhan, 1973, p. 585).

The possibility that spillovers are negatively related to the size of the technology gap is illustrated by Figure 5.1 on the following page. We assume first that the technologies used by MNC affiliates are based on relatively advanced and capital-intensive home country technologies. Hence, the MNC affiliate's technology corresponds to isoquant AA' in Figure 5.1, and that the technology used by local firms is given by BB'. We assume further that the affiliate produces at point α, whereas locals produce at point β, i.e. that affiliates face relatively higher labor costs than locals. A reason for this may be that the more advanced technologies used by MNCs require more skilled labor, that the MNCs' capital cost is lower because they have privileged access to the international capital market, or that they pay their workers a premium to minimize conflicts and ensure more "harmonious" labor relations.[6] Given these two assumptions, it can be seen that the affiliate's technology is not appropriate for the local firm (from the point of view of profit maximization) at the ruling wage rates: the unit cost of production of technology AA' is higher than that of technology BB' if labor is relatively cheap. More generally, it can be seen that MNC technology is not "appropriate" in this sense if the relative wage faced by local firms is lower than that indicated by the line labelled PP'.

FIGURE 5.1 The Appropriateness of MNC Technology.



Note:
Adapted from Berglas and Jones (1977), p. 174.

Consequently, in a static context, spillovers may not be very high, and in particular, they may be decreasing with the size of the technology gap, i.e. the distance between isoquants AA' and BB'.[7]

The Latin American dependency school is often associated with similar conclusions, typically in the framework of a more general (but perhaps outdated) discussion about the overall development effects of foreign direct investment.(See e.g. Blomström and Hettne, 1984, for a review.) MNCs are criticized for being overly import-intensive, displacing indigenous production, worsening the distribution of income, and encouraging inappropriate patterns of consumption, and many of these adverse effects are contributed to the MNCs' use of too capital-intensive or advanced technologies.[8] Lall and Streeten (1977, p. 71) summarize some of the discussion by stating that:

...the fulfilment of preferences expressed in the market is not the final criterion of

> welfare, certainly not in extremely poor countries, and ... the use of scarce resources for the production of goods which are over-differentiated, over-packaged, over-promoted, over-specified, and within the reach of only a small elite, or, if bought by the poor, at the expense of more essential products, is not conducive to national welfare. This is not to say that all TNC technology is unnecessary in LDCs - clearly that would be absurd. But the free import of foreign capital and the sort of technology many TNCs would excel in would reproduce the pattern of the developed countries and would be undesirable.

The more general "appropriateness" aspects of foreign technology emphasized by this quote will not be discussed here: however, we can note that also these studies imply the hypothesis that spillovers are likely to decrease with the technology gap or the complexity of MNC technology.

5.2.2 Empirical Evidence

Blomström and Wolff (forthcoming) is one of the few empirical studies explicitly discussing technology gaps and spillovers together. Analyzing data for 20 two-digit industries in Mexico in 1970 and 1975, they examine some factors influencing the average annual rate of growth of gross output per employee in locally owned Mexican firms, and the convergence of the levels of gross output per employee between locally owned firms and foreign affiliates operating there.

They find that both local labor productivity growth and convergence are positively related to the foreign share of industry employment and the initial productivity gap between locals and multinationals. This is consistent with the hypothesis that spillovers increase with the size of the technology gap. However, their study addresses a broader question, and it is difficult to see what their findings imply for our purposes: the convergence effect reflects not only flows of information between locals and MNCs, but includes all other factors that have an impact on international technology transfer and convergence. Hence, the faster rate of growth of relatively "backward" Mexican industries could be explained by diffusion of technology from the existing international stock of knowledge - via trade journals, information embodied in imported goods, visits abroad, and so forth - rather than by particularly large spillovers from the advanced MNCs operating in these industries.

Haddad and Harrison (1991), in a study of Moroccan manufacturing, also touch upon the subject when they examine the effect of foreign presence on the relative productivity of local firms (i.e. firm-level productivity related to the most efficient firm in the industry). They find that higher foreign presence leads to smaller deviations from best practice technologies in "low tech" industries, but that there is no such effect in "high tech" sectors, that are defined to include machinery, transport equipment, electronics, scientific instruments, and chemicals. Their interpretation is that competition from foreign firms may push local firms toward best practice, e.g. by forcing the least efficient firms out of business, but that there are no spillovers of advanced technology. An alternative interpretation that is consistent with their data is that some types of spillovers may be possible if the technology gap is small, but not otherwise.

Another study addressing the relation between technology gaps and spillovers is Cantwell (1989), Chapter 4, where the responses of local firms to the entry and presence of U.S. multinationals in the European markets 1955-1975 are examined. Cantwell argues that the most positive impact on local technological capability can be seen in the industries where the local firms had a strong technological tradition, and were able to challenge the invading U.S. affiliates. In other words, he concludes that spillovers have probably been most important in the industries where the technology gap has been small.

However, Cantwell's study focusses on developed countries and the competition between European and U.S. MNCs. The data for the empirical part of this study are from Mexico 1970, and it is not clear whether the conclusions will carry over: it is difficult to find industries where Mexican firms are technologically strong in comparison with the affiliates of foreign MNCs, and even more difficult to find Mexican MNCs and foreign MNCs in competition with each other. The typical case is instead that the foreign affiliates are more competitive than the local firms.

Summarizing the discussion up to this point, two opposing hypotheses regarding the effect of the technology gap on spillovers can be identified in the literature. Reasoning based on e.g. Findlay (1978) and Wang and Blomström (1992) implies that spillovers should be larger when the technology gap is larger or the MNC affiliates' technology level is higher. Arguments emphasizing "appropriate" technology, in contrast, suggest that large technology gaps or advanced MNC technologies are likely to be connected with small or no spillovers. The issue has not been addressed directly in earlier empirical studies, and the available evidence from studies of related problems do not resolve the question. To tests the hypotheses more explicitly, we will therefore compare observed spillovers across groups of Mexican manufacturing industries with different technological characteristics.

5.3 DATA AND VARIABLES

The empirical data used here to examine the effects of technology differences on spillovers refer to the Mexican manufacturing industry 1970, and are from unpublished worksheets provided by *la Dirección de Estadísticas de la Secretaría de Industria y Comercio* in Mexico, collected for the Mexican Census of Manufactures 1971.[9] The information is gathered at the plant level and covers the entire manufacturing sector, which is divided into 230 four-digit industries with a further break-down according to three ownership categories: domestic private, foreign, and state ownership. Plants with at least 15 percent of shares owned by foreigners are defined as "foreign", and those where the Mexican state owns more than 49 percent are defined as state-owned, irrespective of the share of foreign ownership. The state-owned plants are excluded from the sample, since they may operate under soft budget constraints, or have other goals (related to e.g. employment creation or geographical localization of operations) than profit maximization, as discussed in Blomström and Persson (1983).

Because of missing information, 14 of the 230 industries had to be discarded from the sample. For the remaining 216 industries, the data set includes information on employment, assets, value added, industry concentration, payments of patents, and the division of employees between blue-collar and white-collar workers. For the 156 industries that hosted foreign MNC in 1970, the data on employment, assets, and value added are available separately for foreign and private local firms: for the other variables, information is only available for industry totals, without the break-down according to ownership.

The statistical models used to examine spillovers in most earlier empirical studies of aggregate manufacturing (Caves, 1974, Globerman, 1979, Blomström and Persson, 1983) have been based on linear estimations of the labor productivity of locally-owned firms as a function of the foreign firms' market share and various other industry characteristics, such as capital-labor ratios, labor quality, scale economies, and concentration. If foreign presence has been found to have a significant positive effect on local labor productivity (after the other determinants have been taken into account), it has been concluded that spillovers take place.[10] The main difference between the earlier models, as discussed in Chapter II, is that only Blomström and Persson (1983) use the capital-intensity of local firms as an exogenous variable. Hence, they focus on spillovers that affect the efficiency in the use of given factor inputs, whereas Caves (1974) and Globerman (1979) also capture the effect of foreign presence on the local firms' capital-labor ratios. We adopt the former model here, because it is likely to provide a more conservative estimate of the extent of spillovers. However, the data allow us to check the results by performing "Globerman-type" tests as well, and we will come back to these in Section 5.4.4.

Thus, we hypothesize here that the labor productivity of local firms can be estimated by the function

$$VA/L^d = f(K/L^d, LQ, HERF, FOR), \tag{5.5}$$

where variables are defined as follows:

The dependent variable is VA/L^d, the average labor productivity in domestic firms, and it is measured as the ratio of value added to total employment in locally-owned plants. The domestic firms' capital-labor ratio, K/L^d, is the ratio of total assets to total employment in locally-owned plants. The labor quality measure, LQ, is based on the ratio of white-collar workers to blue-collar workers (W/B) in each industry's total employment. However, we know *a priori* that foreign firms are likely to employ a higher share of white-collar workers, and since the W/B ratio refers to each industry as a whole, there is also a troublesome correlation between that and our measure of foreign presence. We have therefore constructed our labor quality proxy LQ as the sum "$\alpha + \epsilon$" from the regression

$$(5.6) \qquad W/B = \alpha + \beta \text{ FOR} + \epsilon.$$

In other words, LQ intends to reflect the share of W/B that is not explained by the degree of foreign presence in the industry.[11] The variable HERF is the Herfindahl index, and measures the level of concentration in each industry.[12] It is included to account for the expected effect of market structure on the value of output: more concentrated industries are supposedly better able to engage in monopoly pricing and should therefore display higher labor productivity, *ceteris paribus*. FOR, finally, is the ratio of the foreign plants' employment to total employment in each industry, and measures the degree of foreign presence: if spillovers take place, it is expected to have a significant positive effect.[13]

In addition to the variables appearing in function (5.5), we have three proxies for the technological characteristics of industries. The first one is PGAP, the labor productivity gap between local and foreign firms, and it is defined as the ratio of value added per employee in foreign plants to value added per employee in private locally-owned plants. This is an indirect measure of the technology gap, which assumes that higher productivity signals higher technology, but using it for the grouping of industries may cause some selection bias, as will be discussed later.

The second selection variable, PATENT, is the average payment of patent fees per employee in each industry. PATENT reflects the formal technology payments of all actors taken together (private local, foreign, and state-owned) but it is likely to be particularly highly correlated with those of foreign firms (although that information is not available separately for 1970): as noted in Chapter II, MNC affiliates account for most of the world's formal technology payments.[14] Hence, PATENT can serve as a proxy for the technology level of either entire industries or the foreign firms in each industry - here, we mean the latter - and the higher the patent payments, the more advanced are the affiliates' technologies assumed to be.

The average capital intensity of the foreign affiliates, K/L^f, is another industry characteristic that may be positively related to high technology. However, the simple correlation between PATENT and K/L^f is only 0.11, and it is apparent that both cannot measure technological complexity accurately. With perfect data, we would have preferred the PATENT measure, but because of its possible shortcomings - as discussed in Chapters II and III, MNC parents' technology pricing practices may not be cohesive, all technologies may not be patented, transfer pricing may occur, *et cetera* - we use capital intensity as an alternative proxy for technology. Both K/L^f and PATENT can also be thought of as alternative measures of the technology gap, since local private firms in Mexico are likely to be further behind the MNC affiliates in the industries that are technologically more advanced.[15]

Appendix Table 5.1 summarizes the variables, Appendix Table 5.2 provides some descriptive statistics for the data set, and Appendix Table 5.3 presents a correlation matrix.

To examine spillovers in industries with different technology gaps or levels of technological complexity, we divide the sample into six sub-samples characterized by high or low values for the variables PGAP, PATENT, and K/L^f. We then estimate a linear specification of function (5.5) with ordinary least squares for each of these, and compare the estimated coefficients for each pair of high-low sub-samples. The assumption is that significant differences in parameter estimates reflect differences in the underlying processes. Two types of tests are performed to check the significance of any observed differences in estimates. The comparisons of the overall functional relationships between high and low technology groups are based on Chow-tests, whereas statements comparing the coefficients for any specific variables are based on F-tests of the null hypothesis that there is no difference in the coefficient estimates between the two sub-samples.[16]

5.4 REGRESSION RESULTS

Regression equations (1) and (2) in Table 5.1 below present the results of OLS estimations of function (5.5) for the entire sample of 216 industries, and for the 156 industries where foreign MNCs were present in 1970.[17] Equation (1) is included to allow a comparison with the tests in Blomström and Persson (1983), and the results here are very similar to theirs. Capital-intensity, labor quality, and foreign presence all have highly significant positive effects (in other words, spillovers, as we have defined them, are present), but the impact of producer concentration on local labor productivity is negligible. We have no scale variable, but its absence seems to have only a marginal effect on the coefficients of other variables: similarly, dropping the HERF variable leaves the results unchanged.[18]

Turning to equation (2), where only the 156 industries with foreign firms present are included, we see some small changes in estimated coefficients, and a fall in the significance level for the impact of labor quality. However, the main effect of excluding industries without foreign firms is a decline in the explanatory power of the equation.

TABLE 5.1 *Results of OLS Estimations: Labor Productivity in Private Locally-Owned Manufacturing Firms in Mexico 1970.*

Equation	Constant	K/L^d	HERF	LQ	FOR	Adj. R^2	F	N
ALL INDUSTRIES								
(1)	0.2652	0.4642	-0.0029	0.1613	0.1122	0.531	61.84	216
	(2.467)**	(11.77)***	(0.037)	(2.577)**	(3.486)***			
ALL INDUSTRIES WITH MNCs								
(2)	0.2557	0.4431	0.0303	0.1299	0.1410	0.425	29.62	156
	(1.987)**	(8.474)***	(0.295)	(1.876)*	(2.383)**			

Notes:
The dependent variable is VA/L^d. All variables are normalized by division with the sample means. Estimated coefficients are shown together with the absolute value of the t-statistic in parentheses. *, **, and *** denote significance at the 10, 5, and 1 per cent level of significance (two-tailed tests). For definitions of variables, see Appendix Table 5.1.

Adjusted R^2 falls notably and the F-value is halved, which perhaps suggests that there is some type of threshold effect involved: the difference between some MNC presence and no MNC presence at all may be larger than that between more or less MNCs. Yet, the spillover effect is still significant. It should be noted that the estimations discussed below include only industries where foreign firms were present in 1970 (because technology differences and technology gaps between locals and MNC affiliates are meaningful concepts only when both types of firms are present). We are therefore not able to capture any threshold effects, and the explanatory power of the following equations may be lower than that of equation (1).

5.4.1 Spillovers in Industries Grouped According to Size of PGAP

Table 5.2 presents the regression results for two groups of industries termed SMALL PGAP and LARGE PGAP. The SMALL PGAP group (equation 3 and equation 5) is characterized by a small productivity or technology gap, in the sense that the difference in the labor productivity of local and foreign plants is moderate; on average, the value added per employee in foreign plants is at most twice as high as that in private locally-owned plants. Consequently, the foreign plants in the LARGE PGAP group (equation 4 and equation 6) are more than twice as productive as the private locally-owned plants.[19]

In regression equations (3) and (4), we estimate local labor productivity as a function of K/L^d, LQ, and FOR. We have dropped the HERF variable from these estimations, in order to emphasize some important differences between the SMALL and LARGE PGAP groups.

Looking at the results, it can be seen that the coefficient of FOR is relatively large and highly significant in the SMALL PGAP group (equation 3), but close to zero and insignificant in the LARGE PGAP sample (equation 4). In other words, judging from these two equations, there are spillovers in the SMALL PGAP group, but not in the industries where the technology gap is large. In addition, differences in labor quality seem to explain much of the productivity differences in the LARGE PGAP group, but not in the SMALL PGAP industries.

If we instead look at equations (5) and (6), where the level of concentration

(HERF) has been reinstated among the explanatory variables, the differences in spillovers disappear. The coefficient of FOR in the LARGE PGAP sample takes on a value that is not significantly different from that in the SMALL PGAP group, and the effect of concentration appears to be significant, but opposite in the two sub-samples: this is notable, since concentration did not have any effect for the full sample. The overall functional relationships are still different (judging from a Chow-test), but now the differences are due mainly to these opposite impacts of concentration.

On the basis of these results, it seems reasonable to suspect that high concentration and large technology gaps together signal the existence of some type of "enclaves" or "dual markets" (just as in the previous chapter, where similar features marked industries where local competition did not seem to affect the MNCs' technology imports).

TABLE 5.2 *Results of OLS Estimations: Labor Productivity in Private Locally-Owned Manufacturing Firms in Mexico 1970. Industries Grouped According to Size of Productivity Gap.*

Equation	Constant	K/L^d	HERF	LQ	FOR	Adj. R^2	F	N
SMALL PGAP								
(3)	0.3173	0.3832	--	0.0551	0.2444	0.449	22.22	105
	(2.962)***	(5.445)***	--	(0.823)	(3.572)***			
LARGE PGAP								
(4)	0.1671	0.4001	--	0.3866	0.0462	0.675	35.55	51
	(1.404)	(8.332)***	--	(4.453)***	(0.817)			
SMALL PGAP								
(5)	0.1062	0.3752	0.2609	0.0754	0.1824	0.432	27.36	105
	(0.720)	(5.406)***	(2.049)**	(1.131)	(2.470)**			
LARGE PGAP								
(6)	0.4333	0.4406	-0.3430	0.3419	0.1272	0.743	37.12	51
	(3.378)***	(9.994)***	(3.672)***	(4.377)***	(2.319)**			

Notes:
The dependent variable is VA/L^d. All variables are normalized by division with the sample means. Estimated coefficients are shown together with the absolute value of the t-statistics in parentheses. *, **, and *** denote significance at the 10, 5, and 1 per cent level of significance (two-tailed tests). For definitions of variables, see Appendix Table 5.1.

Industries are classified in the SMALL PGAP group if the average labor productivity of foreign plants is at most twice as high as that of private locally-owned plants, and in the LARGE PGAP group otherwise. Industries without foreign plants have been omitted.

The foreign affiliates in industries with these characteristics may be more or less isolated from the local economy - the typical local firm may, for instance, manufacture an entirely different product from that of the foreign multinational - which leaves very little room for spillovers to local firms. Accounting somehow for these industries (in this case, by including the variable HERF in the LARGE PGAP sample), it seems that spillovers may occur even when there is a large technology gap. The finding that HERF has a significant positive effect in the SMALL PGAP group also warrants some comments, and we will return to discuss this shortly.

In interpreting and generalizing from the results that concern spillovers, it should, however, be noted that there is a possible selection bias in the grouping of industries according to PGAP. It is conceivable that we have automatically placed the industries without spillovers in the LARGE PGAP group, whatever the reason for the lack of spillovers: the productivity gap is likely to become smaller if spillovers take place, but it may remain unchanged or even grow otherwise. In other words, the technology gap may not have been a cause for the lack of spillovers, but rather a result thereof. As noted in the previous paragraph, it is also likely that the observations in the LARGE PGAP group include all existing "enclaves", whatever the explanation for their emergence. Hence, there is reason to examine the results when we instead base the grouping of industries on the values of PATENT and K/L^f.[20]

5.4.2 *Spillovers in Industries Grouped According to Level of PATENT and K/L^f*

Table 5.3 shows the results of the estimations for sub-samples of industries grouped according to levels of PATENT and K/L^f. Industries have been classified in the LOW group if their average payments for patents, trade marks, and other fees per employee are lower than 600 pesos (equation 7), or if the average capital-intensity of the foreign affiliates in the industry is lower than 200,000 pesos per employee (equation 9). Correspondingly, the industries in the HIGH groups are characterized by higher average patent payments (equation 8) or higher capital intensities (equation 10).[21]

The results from the estimations differ somewhat depending on whether PATENT or K/L^f is used to determine the technology level of industries, but there are also notable similarities. The main difference is that the labor productivity of local firms does not appear to be determined by the same factors in the LOW and HIGH technology industries (according to a Chow-test) when the grouping is based on PATENT; when K/L^f is the distinguishing characteristic, it is reasonable to assume that the determinants are the same.

More specifically, it can be seen that the impact of labor quality is fairly large and significant in the LOW PATENT group (equation 7), but not significantly different from zero in the HIGH PATENT group (equation 8). This is a somewhat unexpected result, and not very easy to explain on theoretical grounds. It may be related to the definition of LQ (as $\alpha + \epsilon$ from the equation $W/B = \alpha + \beta\ FOR + \epsilon$) and the fact that most industries with high VA/L^d and high FOR are found in the HIGH PATENT group.

TABLE 5.3 *Results of OLS Estimations: Labor Productivity in Private Locally-Owned Manufacturing Firms in Mexico 1970. Industries Grouped According to Level of Patent Payments and Capital-Intensity.*

Equation	Constant	K/L^d	HERF	LQ	FOR	Adj. R^2	F	N
LOW PATENT								
(7)	0.1403	0.4326	-0.0588	0.3176	0.1677	0.412	17.85	97
	(0.739)	(5.994)***	(0.148)	(2.623)**	(2.407)**			
HIGH PATENT								
(8)	0.2181	0.4489	0.1549	0.0647	0.1140	0.397	10.55	59
	(1.014)	(5.359)***	(0.980)	(0.701)	(0.847)			
LOW K/L^f								
(9)	0.3900	0.4247	-0.1361	0.1133	0.2079	0.456	30.40	107
	(2.646)***	(7.236)***	(1.196)	(1.413)	(3.342)***			
HIGH K/L^f								
(10)	0.2532	0.4259	0.2535	0.0535	0.0139	0.224	4.46	49
	(1.088)	(3.540)***	(1.260)	(0.661)	(0.112)			

Notes:
The dependent variables is VA/L^d. All variables are normalized by division with the sample means. Estimated coefficients are shown together with the absolute value of the t-statistics in parentheses. *, **, and *** denote significance at the 10, 5, and 1 per cent level of significance (two-tailed tests). For definitions of variables, see Appendix Table 5.1.

Industries are classified in the LOW groups when the industry's average patent payments per employee are lower then 600 pesos (equation 7) and when the average capital intensity of the MNC affiliates in the industry is lower than 200,000 pesos per employee (equation 9). Correspondingly, the industries in the HIGH group are characterized by either higher patent payments per employee (equation 8) or higher capital intensities in MNC affiliates (equation 10). Industries without foreign plants have been omitted.

This means that high VA/L^d, high FOR and low LQ coincide in these industries, which may explain the confusing results.

The most important similarity between the PATENT and K/L^f samples is that the coefficient of FOR is positive and significant in the LOW groups, but not significantly different from zero in the HIGH groups. In isolation, this finding implies that spillovers are less likely in industries where the foreign firms use high technology. However, F-tests suggest that the null hypothesis of equal effects of FOR in both groups cannot be rejected. These partly conflicting findings can be interpreted to mean that the variance in the HIGH groups is so large that we cannot, at reasonable levels of significance, exclude the possibility that there are spillovers also in this group. This is consistent with what we found in Table 5.2: the foreign affiliates in some high technology industries may belong to "enclaves", in which case there are no spillovers. In other high technology industries where local firms are in direct competition with the MNC affiliates, spillovers may well occur.[22]

Another similarity is that HERF has a negative coefficient in both LOW technology groups, but a positive one in the HIGH samples, although it is never very significant. The signs of the coefficients are difficult to explain, unless HERF is somehow connected to the presence of scale economies. An *a priori* reason to believe in a connection of that kind is, of course, that HERF *should* be positively correlated with the presence of scale economies, since the largest firms are then able to outcompete the smaller ones. Another reason is that the coefficient of HERF is consistently positive in the industries where we would expect to find scale economies, but negative in other industries. For instance, industries with advanced or capital-intensive technology are likely to exhibit economies of scale, and HERF has a positive coefficient in the sub-samples with these characteristics.[23]

The results for the PGAP samples, where the coefficient of HERF was positive in the SMALL PGAP group and negative in the LARGE group, are also consistent with this hypothesis. Local firms in the SMALL PGAP group are on average relatively large and productive, and may therefore benefit from scale economies. In the LARGE PGAP group, locally-owned firms are smaller and less productive, both in comparison to locals in other industries and to the larger foreign firms in their own industry: both are reasons why they may not benefit from scale economies. Hence, we may be able to capture some scale effects via the HERF variable.

5.4.3 Spillovers in Industries Grouped According to FOR and HERF

The results so far have turned our attention away from purely technology-related industry characteristics as explanations of inter-industry differences in spillovers, and have instead pointed to the importance of market characteristics such as concentration and competition: above, we have used the terms "enclaves" and "dual markets" to describe the industries where spillovers might not take place. To complete the picture, we have therefore made some additional estimations for groups of industries distinguished by different levels of concentration, as proxied by the Herfindahl index, or by different levels of foreign penetration. Both high concentration and high foreign presence may be expected to signal markets where competition is relatively limited, and where enclaves may occur. Using foreign presence as a distinguishing characteristic, of course, implies that the effect of FOR is not linear, which takes us slightly beyond the general purpose of this study.[24] However, there are no theoretical reasons for the effect to be linear (although previous analyses of spillovers in aggregate manufacturing have implicitly assumed so). On the contrary, studies of technology adoption typically find logistic patterns of diffusion, and it is possible that the same applies for the relation between foreign presence and spillovers of technology to local firms.

Table 5.4 on the next page shows the estimation results for groups of industries distinguished by the extent of foreign presence:[25] the foreign share of employment in the industries included in equation (11) is below 50 per cent, but above 50 per cent in equation (12).[26] The results for industries separated by their values of HERF are not shown in the table, because there were no significant differences between the groups.[27]

For the sub-samples marked by their values of FOR, there are notable differences depending on whether foreign firms dominate the industry or not. When the foreign share is smaller than 50 per cent (equation 11), differences in the average productivity of locally-owned firms are explained remarkably well by our model: all coefficients are significant at the one per cent level and the adjusted R^2, at about 0.8, is markedly higher than that for the whole sample, in equation (2). High capital intensity, labor quality, and foreign presence all contribute significantly to increase local productivity, whereas concentration seems to have a negative effect.[28] The explanatory power of equation (12), for the industries with foreign shares above 50 per cent, in contrast, is very much weaker, and only capital intensity appears to have a significant effect. In particular, there are no traces of spillovers; instead, FOR has a large negative coefficient that is significantly different from that in the LOW FOR group.

Since all industries in the HIGH FOR sample are characterized by large foreign presence, we cannot exclude the possibility that spillovers take place: some spillover effects may be captured by the estimated constant or the coefficient for capital-intensity. A more cautious interpretation of the results is instead that the spillovers that possibly occur in the HIGH FOR group do not increase with the foreign share. In other words, the spillover effect is probably not linear (see also note 24).

TABLE 5.4 *Results of OLS Estimations: Labor Productivity in Private Locally-Owned Manufacturing Firms in Mexico 1970. Industries Grouped According to Level of Foreign Presence.*

Equation	Constant	K/L^d	HERF	LQ	FOR	Adj. R^2	F	N
LOW FOR								
(11)	0.4625	0.4668	-0.1819	0.1580	0.0946	0.786	114.93	125
	(7.790)***	(17.04)***	(3.828)***	(4.631)***	(3.341)***			
HIGH FOR								
(12)	0.5680	0.5319	0.6317	0.0768	-0.8084	0.159	2.42	31
	(0.772)	(2.967)***	(1.482)	(0.516)	(1.119)			

Notes:
The dependent variable is VA/L^d. All variables are normalized by division with the sample means. Estimated coefficients are shown together with the absolute value of the t-statistics in parentheses. *, **, and *** denote significance at the 10, 5, and 1 per cent level of significance (two-tailed tests). For definitions of variables, see Appendix Table 5.1.

Industries with foreign shares of employment below 50 per cent are categorized as LOW FOR, whereas those with higher foreign shares belong to the HIGH FOR group. Industries without foreign plants have been omitted. Plants are characterized as "foreign" if at least 15 per cent of shares are owned by foreigners.

The reason may be that contagion spillovers in general are logistic functions of foreign presence, or that high foreign presence marks the existence of enclaves, where there is little direct competition between local firms and MNCs. Unfortunately, the data are not detailed enough to prove either hypothesis, but a look at what industries are included in the HIGH FOR sample may provide some further guidance.

About one third of the 31 industries in the HIGH FOR sample are such where superior marketing abilities and proprietary brand names and labels are likely to make up the competitive assets of foreign firms. Examples of the goods produced are perfumes and cosmetics, beer, cigars and cigarettes, chewing gum, instant coffee, prepared food products, records and tapes, film, clocks and watches, and toys. The monopolistic nature of these industries may mean that the products of foreign and local firms are not directly comparable, that foreign and local firms aim at different segments of the market, and that there may not be much scope for spillovers of production technology. (However, Caves, 1971, suggests that marketing technology may also spill over.) These industries can probably be labelled as "enclaves".

Another third of the industries are such where MNCs operate with advanced technologies or benefit from economies of scale, and hold very high market shares. Examples here are office and computing machines, machinery for the mining and oil industries, synthetic fibers, and some primary metal industries. Local firms may not be able to overcome the entry barriers made up by scale economies, and instead be forced to operate in market niches that are overlooked or ignored by the foreign firms: this would lead to the same kind of enclaves as in the case of highly diversified products. It is also possible that the large scale of MNC technologies is in itself an obstacle to spillovers, even if the products are relatively homogenous. A small local producer may not be able to benefit much from learning about machines or management practices that are optimal for a plant that is fifty or a hundred times larger.

For the last third of the industries in the sample, the enclave characteristics - except for the high foreign shares - are less pronounced, and it is hard to find specific arguments for why spillovers should not occur. These cases may instead illustrate (although they do not prove) the more general possibility that spillovers are perhaps not monotonously increasing functions of foreign presence. Yet, the tentative conclusion from equations (11) and (12), and the examination of the industries in the HIGH FOR sample, is that high foreign shares, especially in combination with high technology, are marks of those industries where enclaves have emerged, and where the scope of spillovers is probably limited for that reason.[29]

5.4.4 Globerman-Type Tests: Endogenous Capital-Labor Ratios

The capital-intensity of locally-owned firms has been included among the explanatory variables in the estimations discussed above, and the FOR variable has therefore not captured the variation in local productivity that comes about because capital-intensities vary among industries. Assuming that the local firms' fixed capital-intensities correspond to fixed technologies, this would mean that our tests have mainly captured competition-related spillovers that affect X-efficiency. However, the relation between capital-intensity and technology is not so simple. For instance, formal technology payments (as measured by the variable PATENT) and capital-intensities are not highly correlated, as seen in Appendix Table 5.3. It is therefore likely that the results also reflect some spillovers from demonstration and contagion, although it is possible that we underestimate the total spillover effect: foreign presence may have some effect on local capital-intensity.

Globerman's (1979) analysis of spillovers in Canadian manufacturing industries differs from ours on this point. Instead of including the local firms' capital-labor ratios among the exogenous variables, he uses the affiliates' capital-intensities to control for industry differences in productivity and technology. In other words, Globerman estimates an equation of the type:

$$(5.7) \qquad VA/L^d = f\,(K/L^f, LQ, HERF, FOR).$$

The estimated coefficient of the variable FOR will reflect some of the impact of foreign presence on the average capital-intensity of local firms (or on the average deviation between local and foreign firms' capital-intensities) in addition to the spillover effects recognized by our tests. It is useful to make some estimations based on this alternative formulation on our data for Mexican manufacturing, to check the results and conclusions presented above.

Table 5.5 below shows the results of these estimations. Equation (13) covers all industries with foreign firms present in 1970, equations (14) and (15) refer to the LOW PATENT and HIGH PATENT groups (defined as in Table 5.3), and equations (16) and (17) focus on the LOW FOR and HIGH FOR sub-samples (defined as in Table 5.4).[30]

To begin with, we can note some general results that apply to all of the equations presented in Table 5.5. First, the overall explanatory power of the Globerman-type estimations - in terms of F-values and adjusted R^2 - is consistently lower than that of the earlier ones. This is an expected result, because capital-intensity is a major determinant of labor productivity, and because there is no immediate correspondence between the capital-labor ratios of MNC affiliates and local firms.

TABLE 5.5 Results of OLS Estimations: Labor Productivity in Private Locally-Owned Manufacturing Firms in Mexico 1970. Globerman-Type Tests.

Equation	Constant	K/L^f	HERF	LQ	FOR	Adj. R^2	F	N
ALL INDUSTRIES WITH MNCs								
(13)	0.3055	0.1536	0.1252	0.1529	0.2629	0.220	11.93	156
	(2.033)**	(3.645)***	(1.051)	(1.870)*	(3.960)***			
LOW PATENT								
(14)	-0.0323	0.2142	0.2003	0.4206	0.1972	0.240	8.58	97
	(0.148)	(2.624)**	(1.295)	(2.995)***	(2.467)**			
HIGH PATENT								
(15)	0.3151	0.1195	0.1891	0.0762	0.3001	0.139	3.43	61
	(1.271)	(2.309)**	(1.131)	(0.701)	(2.396)**			
LOW FOR								
(16)	0.3952	0.1632	0.0371	0.2507	0.1538	0.451	26.46	125
	(4.111)***	(6.310)***	(0.503)	(4.666)***	(3.427)***			
HIGH FOR								
(17)	0.6063	0.1445	0.3112	-0.0017	-0.0602	-0.113	0.24	31
	(0.709)	(0.550)	(0.641)	(0.010)	(0.076)			

Notes:
The dependent variable is VA/L^d. All variables are normalized by division with the sample means. Estimated coefficients are shown together with the absolute value of the t-statistics in parentheses. *, **, and *** denote significance at the 10, 5, and 1 per cent level of significance (two-tailed tests). For definitions of variables, see Appendix Table 5.1.

For the classification of industries in the different samples, see Tables 5.3 and 5.4. Industries without foreign plants have been omitted.

Second, the estimated coefficient of FOR is larger in Table 5.5 than in the corresponding estimations in Tables 5.1, 5.3, and 5.4. A possible reason is that foreign presence does, in fact, have some impact on local labor productivity via its effect on the average capital-intensity of local firms. We will return to this in a moment.

Looking more closely at the LOW PATENT and HIGH PATENT samples in equations (14) and (15), another interesting issue emerges. Whereas we did not find any significant spillovers in the HIGH PATENT sample in Table 5.3 (although we could not exclude the possibility that some spillovers occurred) we do find significant spillovers in that sub-sample now, in equation (15). This underlines our conclusion that high technology alone is probably not an absolute obstacle to spillovers. However, the result leads us to wonder whether technology characteristics have an impact on what kinds of spillovers may take place. A large technology gap (and, consequently, production of differentiated goods) might, for instance, lead to some market segmentation, so as to preclude competition-related spillovers. Yet, local firms might benefit from demonstration effects, and be encouraged to employ more advanced (or capital-intensive) technologies in their own segments of the market.

The available data allow only very crude tests of this hypothesis. To see whether higher foreign presence actually affects the capital-intensities of local firms, we examined the correlation between foreign presence, FOR, and the ratio of the capital-intensity of local firms to that in foreign firms.[31] For the full sample of 156 industries, there is no correlation between the two variables. The same is true for the sub-sample consisting of LOW PATENT industries. However, the correlation coefficient in the HIGH PATENT sample is positive, although relatively small (0.16). In other words, the possibility that foreign presence has some effect on the capital-intensity of local firms in "high tech" industries cannot be excluded, but more research is needed before any more precise conclusions can be drawn.

Finally, continuing to the LOW FOR and HIGH FOR samples in equation (16) and equation (17), it can be seen that the estimated coefficient of FOR is still negative in the HIGH FOR sample. This seems to confirm our earlier conclusions regarding the lack of spillovers in the sub-sample where enclaves are most likely.

5.5 CONCLUDING COMMENTS

This chapter has examined technology spillovers in various groups of Mexican manufacturing industries 1970, and has attempted to determine whether differences in the technology gap between local and foreign firms or differences in the level of technological complexity have any impact on the observed spillovers. A conclusion from the regression analysis is that observed spillovers do seem to differ between industries, but that technology *alone* does not seem to explain the differences. Large technology gaps and complex MNC technologies *may* act as obstacles to spillovers, but market characteristics such as competition and concentration appear to be even more important.

An indication of this was that foreign presence had a significant positive effect on local productivity, once the effects of concentration were taken into account, even in the industries where the productivity gap between local and foreign firms was very large. Likewise, higher foreign shares seemed to generate higher local productivity in the industries with the highest levels of technology (as measured by their technology payments) when we allowed foreign presence to influence the capital-labor ratios of local firms (in the Globerman-type estimations).

The group of industries where spillovers appeared least likely (or where it is most probable that spillovers do not increase with increasing foreign presence) was instead that where both high technology and high levels of concentration and foreign shares coincide. Some important features of these industries seem to be that foreign and local firms are not in direct competition with one another, either because they do not produce the same goods, or because they operate in different segments of the market. The terms "enclaves" and "dual structures" have repeatedly been used to describe these market conditions. It is also possible that the impact of foreign presence on local productivity is not linear, so that higher foreign market shares are no longer associated with increasing spillovers in industries already dominated by foreign firms.

These findings suggest that the relationship between local productivity and foreign presence alone may not be the most accurate indicator of spillovers. In the next chapter we will pursue this discussion further, and make an attempt to take competition more explicitly into account in the estimation of spillovers.

There are also some interesting policy conclusions relating to the discussion in the preceding two chapters, where the possibilities to influence the technology imports of MNC affiliates were discussed. Not even the most effective technology transfer requirements may benefit a host country if there are no local firms to which technology might diffuse or spill over. However, if the MNCs' imports of technology are not forced by requirements, but rather triggered by surges of local investment or improvements in the technical skills of the labor force - as was suggested on the basis of the analysis in Chapters III and IV - it is more likely that competing local firms are in a position to absorb the potential spillovers. Hence, local policies and the behavior of local firms are important determinants of the benefits which FDI will bring.

Finally, turning to the two hypotheses about the effects of technology gaps on spillovers: the results of our tests clearly offer some support for both views, but also some disagreement with each of them. The existence of "enclaves" supports the hypothesis that spillovers may not occur if the technology gap is very large, but it is not reasonable to consider these cases as the standard outcome. The finding that spillovers occur also in "high tech" industries is consistent with the hypothesis that spillovers are positively related to the technology gap, but there is no convincing support for the view that spillovers would *increase* with the complexity of the technology or the technology gap. Thus, the results seem to point somewhere between the two polar hypotheses. It is not unlikely that there is some "optimal technology gap" that maximizes the spillover benefits to the local economy, given local competence and market characteristics, but the present data do not allow any further tests of this hypothesis.

5.6 NOTES

1. Obviously, Findlay's discussion refers to the technology gap between the advanced and the underdeveloped regions, and not to the gap between MNC affiliates and local firms, which is focussed on in this chapter. However, assuming that diffusion to local firms takes place mainly from the stock of technology used by the affiliate, Findlay's model provides an argument for why spillovers should increase with the technology gap. It should also be noted that Findlay (1978, p. 2), like most other authors, states that "the disparity must not be too wide for the thesis to hold." This should be kept in mind when

interpreting the results from the empirical part of this chapter. We look at data for Mexican manufacturing industries in 1970, and the conclusions might not hold for economies that are significantly less developed than Mexico.

2. The illustration follows Nelson and Phelps (1966).

3. The convergence school is discussed in detail by e.g. Abramowitz (1986), Baumol (1986), and Baumol, Blackman, and Wolff (1989).

4. Assuming that n is exogenously given (or that it is not a strategic variable) it can be seen that the ratio $B(t) / A(t)$, i.e. the relative size of the technology gap, will approach an equilibrium level of $\lambda / (n+\lambda)$ as time approaches infinity. Wang and Blomström (1992) treat the affiliates' technology imports and the local firms' learning investments as strategic variables, but they also find a similar steady-state technology gap.

5. Findlay refers to Mansfield (1961, 1968); other examples are found in e.g. Nabseth and Ray (1974).

6. The assumption seems to be realistic, and there is empirical evidence to show that MNC workers are actually better paid than those employed by local firms. See Caves (1982), pp. 150-153, 266.

7. However, in an intertemporal context, spillovers may nevertheless be important. Berglas and Jones (1977), p. 175, note that today's advanced technology may be useful for the developing country tomorrow. This means that exposure to advanced technologies may have spillover effects in the future, when increasing wage rates will have made the present MNC technologies more "appropriate" for the developing country.

8. Biersteker (1978) provides a survey of the dependency school's views on multinationals.

9. This is essentially the same data base as that used by Blomström and Persson (1983), and parts of these data were used already in the previous chapter. *IX Censo Industrial 1971: Tomo 1*, Secretaría de Industria y Comercio, Mexico City, 1973 summarizes much of the information, but the published data are not presented separately for local and foreign firms.

10. The models presented by Aitken and Harrison (1991) and Haddad and Harrison (1991) differ from the earlier studies on this point. They use plant level data for several years, and examine the determinants of total factor productivity growth and deviations from best practice technology. We are not able to replicate their tests because of the lack of suitable data.

11. Blomström and Persson (1983) construct a similar labor quality proxy, but define it as only the error term "ϵ" in the regression estimating W/B. We include the constant, to be able to interpret LQ as "labor quality that is not explained by foreign presence." The choice between these two alternatives does not affect the estimation results.

12. The Herfindahl index is calculated from plant level data, and it is defined as:

$$\text{HERF} = \Sigma_i (x_i / X)^2$$

where x_i is the employment of the n individual plants, and X is the total employment of the industry.

13. Looking at the variables included in the model, Blomström and Persson's (1983) estimations are very similar to ours, as noted above, except that they include a proxy for economies of scale and the number of effective work days among the independent variables: we were not able to replicate either of these two variables because of lack of data. Globerman (1979) uses the average number of hours worked and proxies for plant-scale and product-scale economies to capture the same effects, and finds a significant positive impact of plant-scale economies, but in most cases no significance for the other two variables. As discussed later in Section 5.4.4, he also uses the affiliates' capital-intensities, rather than those of local firms, as exogenous variables. Caves (1974) estimates a somewhat different model, where capital-intensity is not included as a determinant of local productivity, apparently for reasons of data availability. Haddad and Harrison (1991) and Aitken and Harrison (1991) do not estimate labor productivity, but rather total factor productivity growth and deviations from the industry's best practice technology, and their estimations are therefore not comparable to the present ones.

14. Fairchild (1977) surveys 25 pairs of manufacturing firms with direct U.S. equity investment and 100 per cent Mexican ownership, respectively, operating in Monterrey, Mexico. Comparing the two types of firms, she concludes that four times as many U.S. firms (or "joint ventures") than local firms used U.S. patents or licenses in 1973. Since her sample of firms was closely matched in terms of the goods produced, and the firms' age, assets, net sales, and employment, it is likely that the foreign affiliates' share of the total sum of patent payments is even higher for our more heterogeneous sample. The data on patent payments by firms in Mexican manufacturing industries 1975, used in the previous chapter, are consistent with Fairchild's estimates, although they do not allow us to make a distinction between private and state-owned Mexican firms.

15. The simple correlation between PATENT and PGAP is 0.53. The correlation between KL^f and PGAP is 0.28.

16. Various other methods to capture the effects of technology differences have been tried. K/L^f has a positive but insignificant coefficient when included among the determinants of local productivity. Squaring the variable, to take account of possible non-linearities, yields a positive coefficient for the simple terms, and a negative one for the squared terms; however, the effects are not significant, nor is there any clear impact on the coefficient of FOR. The same results occur when PATENT is included in the equation, but the interpretation is more complicated. The reason is that the technology imports of local firms may be reflected by the PATENT variable (although we know that foreign firms account for most of the PATENT payments), and the positive impact on productivity may simply show that technology is another factor of production. To avoid simultaneity problems, we have not included PGAP directly into function (5.5):

the denominator of PGAP and the dependent variable are identical.

17. All results reported in the tables refer to linear estimations of the model. The estimations have also been made with logarithmic transformations of the variables: typically, adjusted R^2 increases, but the signs and significance levels of the coefficients remain unchanged. See further note 24. We retain the linear model throughout this paper in order to be able to compare the results with earlier studies, and because the division of the sample into various sub-groups accounts for some of the non-linearities, as will be seen below.

18. More detailed comparisons with the results in Blomström and Persson (1983) are not possible, since it is not known how their variables were normalized. Here, all variables appearing in the equations have been normalized by division with the sample means.

19. Analysis of residuals indicates that some differences between industries begin to be visible at approximately PGAP=2. Lower cut-off points yield results where the differences between the two groups are smaller, but the results noted below change little for higher cut-off points (as long as more than 20 observations remain in the LARGE PGAP group).

20. However, the expected effect of the bias is to lower the size and significance of the estimated coefficient of FOR in the LARGE PGAP group. It is notable that the coefficient of FOR in equation (6) is still positive and significant, in spite of the possible bias.

21. The cut-off points have been chosen on the same grounds as those for PGAP. In addition, it is interesting to note that no significant spillovers can be observed for the 20 to 30 industries with the lowest values for PATENT. The result is not strong enough to warrant any definite conclusions, but it seems to support the hypothesis that a certain technology gap is necessary to create a potential for spillovers.

22. Alternative proxies for the technology levels, based on the labor quality measures and the average labor productivity of foreign affiliates were also used for the grouping of industries, with results very similar to the ones in Table 5.3. The impact of FOR was consistently significant and positive in the low technology group, but not significantly different from zero in the high technology group; yet, F-tests failed to reject the null hypothesis that the coefficients of FOR were equal in the HIGH and LOW sub-samples.

23. Blomström (1986) and Blomström (1989) also interpret HERF as a proxy for scale economies.

24. The fit of equation (2) improves (adjusted R^2 increases from 0.42 to 0.67) if we use logarithmic variables, which indicates that the effects are not linear. However, the signs and significance levels of parameter estimates remain unchanged. The coefficient of a squared FOR term included in equation (2) is negative but not highly significant.

25. It would also be interesting to examine if wholly- or majority-owned foreign affiliates and joint ventures have identical impacts on local technology and productivity, but the data do not distinguish between these two kinds of "foreign" firms.

26. The reasons for the choice of cut-off point are given in note 19.

27. One reason for why the Herfindahl measures might not capture "enclave" characteristics very well is that foreign dominance might be carried out by several foreign firms. In fact, the sample includes industries where foreigners are entirely dominant, but where the Herfindahl values are moderate.

28. Also this result is consistent with the hypothesis that HERF reflects scale economies. It is probably easier for foreign firms - with access to international capital markets, modern technology, etc - to capture large market shares in industries with notable scale economies than in industries without.

29. Excluding the industries that were dominated by foreign firms from the samples estimated in Table 5.3 improves the explanatory power of the equations, and underlines the conclusion that technology alone does not explain all of the differences in spillovers between industries.

30. The samples grouped according to PGAP and K/L^f are not presented here. The possible selection bias in the PGAP grouping remains, and the grouping according to K/L^f is dropped because the foreign firms' capital-intensity is included among the explanatory variables, and we have no reason to assume that its effect is non-linear.

31. Foreign firms are more common in the more capital-intensive industries, and there is, therefore, an *a priori* known positive correlation between K/L^d and FOR. This correlation does not say anything about causality. By instead looking at the correlation between the ratio K/L^d / K/L^f and the variable FOR, we may be able to see whether higher foreign presence pushes local firms towards the capital-labor ratios employed by foreign firms.

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APPENDIX TABLE 5.1 *Definitions of Variables.*

	Dependent Variable
VA/L^d	- the ratio of value added to the total number of employees in private locally-owned manufacturing plants in each industry. Proxy for labor productivity.
	Explanatory Variables
K/L^d	- the ratio of total assets at book value to the total number of employees in private locally-owned plants in each industry. Proxy for capital intensity.
HERF	- a Herfindahl index for each industry, including also foreign and state-owned plants. Measure of producer concentration.
W/B	- the ratio of white-collar workers to blue-collar workers in each industry, including also foreign and state-owned plants. Proxy for labor quality.
LQ	- the intercept and error term, "$\alpha + \epsilon$", from the regression $W/B = \alpha + \beta\ FOR + \epsilon$, to correct for the *a priori* known correlation between W/B and FOR. Proxy for labor quality.
FOR	- share of each industry's total employment accounted for by foreign plants.
	Selection Criteria for Grouping of Observations
PGAP	- ratio of value added per employee in foreign plants to value added per employee in private locally-owned plants in each industry. Proxy for the technology gap.
PATENT	- ratio of the value of payments of patent fees and trade marks to total number of employees in each industry, including foreign and state-owned plants. Proxy for technological complexity.
K/L^f	- ratio of total assets at book value to total number of employees in foreign plants in each industry. Proxy for capital intensity.

APPENDIX TABLE 5.2 *Descriptive Statistics for 156 Mexican Manufacturing Industries with Foreign Firms Present 1970.*

Variable	Unit	Mean	St. Dev	Minimum	Maximum
VA/L^d	'000 pesos	54.77 (49.10)	35.56 (34.34)	12.97 (2.63)	259.89 (259.89)
K/L^d	'000 pesos	112.57 (98.47)	92.06 (91.28)	14.54 (4.55)	568.63 (568.63)
HERF		0.43 (0.44)	0.19 (0.19)	0.19 (0.19)	1.00 (1.00)
W/B		0.33 (0.29)	0.23 (0.21)	0.06 (0)	1.63 (1.63)
LQ		0.01 (0)	0.21 (0.19)	-0.35 (-0.35)	1.39 (1.39)
PATENT	'000 pesos	1.84 (1.36)	6.03 (5.19)	0 (0)	51.14 (51.14)
FOR		0.31	0.25	0	0.99
PGAP		2.03	1.62	0.41	10.19
K/L^f	'000 pesos	196.98	207.80	0	2296.17

Notes:
Figures within parentheses include also the 60 industries where foreign plants were not present in 1970. For definitions of variables, see Appendix Table 5.1.

APPENDIX TABLE 5.3 *Simple Correlation Coefficients for Exogenous Variables, 156 Mexican Manufacturing Industries with Foreign Firms Present in 1970.*

K/L^d	1.00							
HERF	0.23 (0.19)	1.00						
W/B	0.24 (0.40)	0.05 (0.01)	1.00					
LQ	0.11 (0.19)	-0.15 (-0.11)	0.91 (0.90)	1.00				
FOR	0.34 (0.38)	0.48 (0.23)	0.34 (0.45)	-0.08 (0.00)	1.00			
PATENT	0.19 (0.20)	0.04 (0.14)	0.23 (0.27)	0.13 (0.14)	0.28 (0.31)	1.00		
PGAP	-0.02	0.14	0.02	-0.04	0.13	0.53	1.00	
K/L^f	0.38	-0.01	0.23	0.22	0.05	0.11	0.28	1.00
	K/L^d	HERF	W/B	LQ	FOR	PATENT	PGAP	K/L^f

Notes:
Figures within parentheses include also the 60 industries where foreign firms were not present in 1970. For definitions of variables, see Appendix Table 5.1.

CHAPTER VI

COMPETITION AND ENDOGENOUS SPILLOVERS:

Tests of some recent spillover hypotheses

6.1 INTRODUCTION

The previous chapters have argued that the conduct and performance of foreign affiliates and locally-owned host country firms are interdependent: however, we have presented the empirical evidence for the argument in two separate parts. On the one hand, Chapter III and Chapter IV have demonstrated that the technology imports (and probably also productivities) of MNC affiliates are partly determined by the competition from local firms. On the other hand, Chapter V has shown that the productivity (and technology) of local firms is simultaneously determined by the presence of foreign affiliates, via spillovers.

In this chapter, we combine the two arguments, and suggest that the apparent simultaneity means that technology and productivity spillovers cannot be considered as exogenous effects of foreign presence. In fact, several recent theoretical works have come to similar conclusions, and modelled the technology transfer via MNCs to their host countries as an endogenous outcome of the competition between MNC affiliates and local firms. For instance, Cantwell (1989), argues that the effect of US investment on the technological capability of local firms in Western Europe 1955-1975 was largely a function of the response of host country firms. Wang and Blomström (1992) maintain that the automatic contagion-type spillovers that arise from the presence of foreign firms are complemented by spillovers that depend directly on the competitive pressure in the host economy and the actions taken by local firms. The effects of competition, they argue, may dominate those from contagion and demonstration, and explain why large foreign presence may co-exist with slow technology transfer, as in many Latin American countries. In addition, it is interesting to note that several recent contributions to the theoretical literature on economic growth - e.g. Romer (1990) and Grossman and Helpman (1991a) - also argue that technological change is endogenous, and that the rates of technical progress and international diffusion of technology are determined by the competition between imitators and innovators. These growth models are not directly applicable for our purposes, but the more general processes they outline are compatible with the argument that spillovers are partly endogenous results of competition between local firms and MNC affiliates.

Hence, the traditional approach in statistical studies of spillovers in aggregate manufacturing, where it is hypothesized that spillovers are present if there is a significant positive impact of foreign presence on the labor productivity of local firms (see Caves, 1974; Globerman, 1979; Blomström and Persson, 1983) may sometimes be misleading: if a significant share of spillovers are endogenous functions of the competition between local and foreign firms, it is apparent that there is no simple relationship between the size of the foreign share and the extent of spillovers.

For instance, the traditional approach suggests that large spillovers from contagion are likely in industries where the foreign share is large. However, taking effects of competition into account, it is obvious that large foreign presence may arise in industries where local firms are weak and unable to absorb technology spillovers. Established wisdom predicts that large spillovers are unlikely in industries with small foreign shares. Yet, small foreign shares may signify some sectors where considerable spillovers have already taken place and where local firms have become so much more competitive and technologically advanced over time that they have recaptured lost market shares or restricted the expansion of foreign MNCs. The foreign firms that remain may still contribute significantly to spillovers, because the pressure from competitive local firms may force them to upgrade their technologies continuously.

This chapter will test the hypotheses that the productivities of local and foreign firms are simultaneously determined, and that competition has an independent spillover effect on the technology and productivity of local firms, even after spillovers from contagion are taken into account. For this purpose, we will formulate and estimate a simple simultaneous model, using data on foreign and local firms in Mexican manufacturing 1970. We hypothesize that the labor productivity of local Mexican firms is a function of capital intensity, industry concentration, labor quality, the foreign share of the industry *and* the competition from foreign firms (proxied by their productivity) and that the foreign firms' productivity is simultaneously determined as a function of capital intensity, concentration, labor quality, and the competition from local firms (proxied by their productivity). The idea underlying the model is that competition affects the X-efficiencies of both foreign and local firms, so that each is forced to "work harder" if the other one does so: the productivity of each firm is not only determined by capital intensity, labor quality, and industry concentration, but also by the productivity level of its competitor.

An obvious weakness of the model is that competition also affects the choice of technology and thereby capital intensity, although we are forced to treat this as an exogenous variable. As was discussed in closer detail in Chapter V, it is therefore possible that the estimates of spillovers from the present model may underestimate the true effects. Another possible problem is related to omitted variables and deserves some attention already at this point: the results we interpret as signs of simultaneity and spillovers from competition may be caused by some omitted industry-specific variable that influences the productivities of foreign as well as local firms. However, it should also be noted that our results are seriously affected by this problem only if the omitted variable is not significantly correlated with any of the variables that are included in the analysis.

The remainder of the chapter is organized as follows. Section 6.2 provides a theoretical framework and looks more closely at some earlier studies of endogenous spillovers. Section 6.3 presents and discusses the data and the estimation method, section 6.4 reports the regression results, and section 6.5 concludes the chapter.

6.2 ENDOGENOUS SPILLOVERS IN SOME THEORETICAL MODELS

Until recently, technology spillovers from foreign investment were typically modelled in an *ad hoc* manner, as increasing functions of the foreign share of the host industry or country, without much attention being paid to the transfer process itself. However, several theoretical models where spillovers emerge as endogenous outcomes of the competition between local firms and MNC affiliates have appeared during the past years.[1] In this section, we will briefly look at some of these studies, with emphasis on what they say about the interactions between local and foreign firms.

Cantwell (1989) examines the technological competition between European and US firms in international industries during the post-war period. An important idea underlying his analysis is the theory of "technological accumulation" (coined by Pavitt, 1987) proposing that technological development within a firm is a cumulative process. According to this view, technological change is slow and incremental, it reflects past technological accumulation, and it is therefore differentiated between firms and locations. Hence, the pattern of technological advantages is likely to remain relatively stable over time. This gives reason to distinguish between three possible groups of industries depending on the relative technological strength of foreign and local (i.e. US and European) firms: first, industries where foreign firms are strong and locals are weaker and more narrowly specialized; second, those where foreign firms are relatively weak and local firms are strong; and third, those where strong foreign and local firms coexist in competitive interaction.

Because "the assimilation of foreign innovation is most easily accomplished where it is complementary to the existing pattern of technological specialization" (p. 46), Cantwell argues that foreign investment is not likely to produce any large spillover benefits for the local firms in the first group. Instead, the foreign challenge may cause a "vicious circle", where the surviving locals are forced to even narrower specialization, and where the possibilities to adapt and adopt foreign technologies diminish over time.

In the second group, by contrast, foreign entry may arouse "lethargic" local firms, and eventually force them to draw "on the hidden reserves of their own technological expertise to restore their position" (p. 63). Thus, competitive pressure is a major driving force in this group. The outcomes for the third group of industries are the most interesting. There, it is likely that the technological skills of foreign and local firms are complementary, and that foreign investment and competition may create continuing two-way exchanges between the firms, with important spillovers, "reverse technology transfer", and intra-industry trade and production as a result. Consequently, it is argued that the creation and diffusion of technology in these industries become interdependent in "virtuous circles" of competition, innovation, and spillovers.

Although Cantwell's model may be an accurate description of the interactions between US and European multinationals, it may not be very well suited for less advanced economies (such as Mexico) where few, if any, local firms are technologically comparable to or stronger than the foreign MNCs. The prediction of the model for those cases is, clearly, that "catching up" is likely to be very limited, but a look at the real world shows that this is not always correct: for instance, many industries in Japan and the Asian NICs have started from very low levels and have rapidly converged toward, and sometimes even overtaken, the leading Western industries.

The more traditional picture of international technology transfer - as a sequence that runs from *innovation* in an advanced country, to *transfer* to an affiliate or licensee abroad, to *diffusion* to other firms in the local industry - is perhaps a more generally applicable description of the process, and the models departing from this paradigm may be more relevant for present purposes.

The interactions between foreign and local firms have come to play an increasingly more prominent role also in this line of analysis. In the early models of foreign investment and technology transfer, such as Findlay (1978) and Koizumi and Kopecky (1977), it is argued that local firms are affected by foreign direct investment through technology spillovers, but the opposite flow of effects is not endogenous: variations in the size and importance of spillovers are only caused by changes in underlying parameters, e.g. the educational level of the labor force, the saving rate, or the tax rate on foreign firms. Newer models have more explicitly taken into account the behavior of both local and foreign firms as determinants of spillovers.

Das (1987) may illustrate a first step in this direction. He formulates a model where MNC affiliates explicitly recognize the costs of technology leakages to local firms. Spillovers are modelled as a function of the size of foreign output, and included in a standard price-leadership model, where the MNCs optimization problem is to maximize the discounted sum of profits subject to the costs from technology leakages. In other words, the MNC is understood to weigh the profit increases arising from technology transfer (via larger market shares or lower production costs) against the costs from tougher local competition that would follow from increased spillovers.[2] However, local firms are considered to absorb spillovers passively, so that Das considers only one side of the possible interactions.

A number of concurrent studies where related questions are analyzed in a strategic game-theoretic environment go further in modelling the kind of interdependence that we are interested in. The topics addressed by these inquiries include international R&D competition (Cheng, 1984b, 1987; Spencer and Brander, 1983), export rivalry (Brander and Spencer, 1985), foreign investment decisions and benefits from foreign direct investment (Horstmann and Markusen, 1987, 1989), and international transfers of product technology (Jensen and Thursby, 1986, Grossman and Helpman, 1991b, 1991c). An important common feature of these models is that foreign and domestic firms are in direct competition with each other, and that the actions of both firms are simultaneously determined and interdependent.

For instance, Jensen and Thursby (1986), who are perhaps closest to the present topic, describe how the decisions of both a Northern innovator (an MNC) and a Southern imitator (a local firm) determine the rate of technology transfer. Technology transfer is defined as the process by which the local firm learns the technology required to produce the goods innovated by the MNC. Some transfer will always take place automatically -increasing in line with the number of recently innovated products - but the local firm may also decide to spend labor resources on reverse engineering and imitation, and thereby speed up the rate of transfers.

At the same time, the MNC decides how much labor to spend on R&D and innovation. The current profits of both types of firms depend on the ratio of new products to old products (advanced versus local products) and the number of workers employed in current production (rather than in innovation or reverse engineering). Hence, both firms face dynamic optimization problems, where the choice between current production and investment and the rival's behavior enter as arguments.

Applying similar methods to analyze spillovers and transfers of process technology through MNCs, Wang and Blomström (1992) construct a model where the strategic interactions between foreign and local firms are highlighted, and where the MNCs' technology transfer costs and the local firms' learning costs are explicitly taken into account. It is useful to take a closer look at some of the features of the model, to illustrate the competitive interactions between firms and the determinants of spillovers, as a basis for the statistical model that follows in the next section.

Wang and Blomström assume that technology affects demand, in the sense that technologically advanced products are more attractive because of their higher quality or richer characteristics. The consumers' preferences are assumed to be described by the aggregate utility function

$$(6.1) \qquad U(Y) = U(\Sigma_i G_i Y_i)$$

where Y is an industry output index, Y_i is firm i's output, and the weights G_i reflect the attractiveness of firm i's products. As noted, G_i increases with the firm's technology level K_i. Moreover, the utility function is logarithmic, and $G_i(K_i)$ is of the form K_i^{α}, where α is a positive constant. Then, U(Y) can be expressed as

$$(6.2) \qquad U(Y) = \alpha \ln K_d + \ln(Y_d + k^{\alpha} Y_f)$$

where k is the technology gap, defined as the ratio of the foreign firm's technology level to that of the local firm, and subscript d and f refer to domestic and foreign, respectively.

Since the price of each product is assumed to equal marginal utility in equilibrium, it follows from (6.2) that the prices facing the local and foreign firm are

$$(6.3) \qquad P_d(k, Y_d, Y_f) = (Y_d + k^{\alpha} Y_f)^{-1} \text{ and}$$

$$(6.4) \qquad P_f(k, Y_f, Y_d) = k^{\alpha} (Y_d + k^{\alpha} Y_f)^{-1}.$$

In other words, the prices for both firms' products depend on the quantities of both goods and the technology gap, which determines the relative attractiveness of the two products. Moreover, it can also be seen that $\delta P_f / \delta k > 0$, but $\delta P_d / \delta k < 0$: the price of the MNC affiliate's product (and the affiliate's profit) increases with the technology gap, whereas the price of the local firm's product (and its profit) moves in the opposite direction. Alternatively, if prices for some reason do not move as much as is called for in response to a change in the technology gap, the relative shares of output may change instead, or both prices and quantities may change.[3] This is the channel through which competition enters into the model.

The profit function of firm i, given P_i as above, is then

$$(6.5) \qquad R_i\,(k) = \max_{Y_i} P_i\,(k, Y_i, Y_j)\, Y_i - c_i\, Y_i,$$

where c_i is the firm's marginal (and constant) production cost, and Y_j is the other firm's output. As noted above, the foreign firm's profit is assumed to increase with the technology gap k, but at a diminishing rate. Correspondingly, the narrower the gap, the larger the domestic firms' profit.

Now, we will look at the functions describing the effects of (contagion-type) spillovers. First, the MNC affiliate can increase its technological level by investing resources I_f to import technology from its parent. Hence,

$$(6.6) \qquad DK_f = I_f\, K_f,$$

where D marks the time derivative. The local firm's technological development is expressed as

$$(6.7) \qquad DK_d = \phi\,(I_d)\; k\; K_d \qquad \text{with}$$
$$\phi' > 0, \;\; \phi'' < 0, \;\; \phi\,(0) = v > 0.$$

The technological level of the local firm is increasing in response to investments I_d (in e.g. learning), but also through spillovers, as indicated by the ϕ function. The rate of technological progress is an increasing function of the technology gap: Wang and Blomström argue that this is to take into account the "advantages of backwardness" discussed by Findlay (1978).

However, we did not find any support in the previous chapter for the hypothesis that spillovers are an increasing function of the technology gap, and it is perhaps more reasonable to consider the effect that comes from the technology gap k as part of the "contagion" spillovers: equations (6.3) and (6.4) show that the gap is one of the determinants of the demand for the foreign affiliate's products, and thereby a determinant of its market share.

The last two equations taken together define the changes in the technology gap:

$$(6.8) \qquad Dk = [I_f - \phi\,(I_d)\,k]\,k.$$

Thus, the investment decisions of both firms enter as determinants of the technology gap and the amount of technology spillovers. The investment decisions of both firms have direct effect on the size of the technology gap, and thereby on the size of the contagion-related spillovers. There is also a multiplicative indirect effect, since any change in the technology gap is transmitted to the demand for the products of both firms, and causes a response from the firm who feels its profits diminishing. For instance, a decision by the local firm to spend more on learning narrows the technology gap and cuts into the MNC's profits. This may induce the MNC to import new technology to restore its competitive position (as discussed in closer detail in Chapter III). Some of the new technology may spill over to the local firm, which becomes yet a little more competitive, which spurs another response from the affiliate, and so forth. The cumulative effects on productivity and technology from these interactions may be termed competition-related spillovers.

Finally, for completeness, we may also briefly look at the solution of the model. The MNC affiliate's problem is to choose the level of its investment and technology transfer activities I_f (t) for all times t to maximize the discounted value of its profit stream V^f, given that the firm knows about the local firm's learning efforts and the spillovers of technology. In other words, the dynamic optimization problem is very similar in kind to that in Jensen and Thursby (1986), and involves a similar trade-off between current and future profit. Formally, this can be expressed as

$$(6.9) \qquad V^f = \int_0^\infty e^{-rt} \, [R_f \, (k) \; - \; C_f \, (I_f)] \; dt$$

where r is the discount rate used by the MNC affiliate, R_f (k) is the quasi-rent function, as noted above, and C_f (I_f) is the cost for technology transfer, consisting of in-house training of employees, hiring of expatriate experts, and so forth.

Analogously, the domestic firm faces the problem of choosing I_d subject to the spillover function and given the choices of the affiliates. That yields the function

$$(6.10) \qquad V^d = \int_0^\infty e^{-\rho t} \, [R_d \, (k) \; - \; \chi \; C_d \, (I_d)] \; dt$$

where ρ is the domestic firm's discount rate, and the χ parameter represents the cost-efficiency of the firm's learning investment. The smaller χ is, the more effectively the domestic firm's learning activities have been undertaken.

Taken together, these functions describe a differential game that can be solved by defining the steady-state equilibrium conditions for each firm's optimal control problem, given the decisions of the other player, and then finding the steady-state Nash equilibrium of the game. The solution follows the standard optimal control procedure and will not be traced out here. It suffices to say that there will typically exist some positive pair I_f and I_d that define a unique, locally stable steady-state Nash equilibrium. In this steady-state, the prices faced by each firm, as well as their market shares, will be constant, at the same time as technology advances continuously.[4]

The features of the Wang-Blomström model that are important for our present purposes can be summarized as follows: Firstly, approaching the issue as a strategic game clearly spells out the importance of competition and simultaneous interactions between foreign and local firms. As illustrated by equations (6.3), (6.4), and (6.8), improvements in the technology of one of the firms will have an impact on the technology gap, cut into the sales of the other firm, and force it to respond.

Secondly, spillovers from contagion are also likely to take place, but they do so in a less unambiguous way than that which has been implied in the discussion in Chapter V. The reason is that the level of spillovers is related to the technology gap k in two ways, at least if we allow some abstraction from what is specifically stated in the model. There are supposed to be some "advantages of backwardness" that lead to greater spillovers when the gap is larger, but since a larger gap is also assumed to mean a higher demand for the foreign firm's products and probably also an expansion of the foreign share, it is conceivable that some of the effect may come through "contagion".[5] In the next section, we will continue by setting up a simple statistical model that will allow us to test empirically whether spillovers actually occur because of competition as well as contagion.

6.3 DATA AND ESTIMATION METHOD

The empirical data for this study are from unpublished worksheets provided by *la Dirección de Estadísticas de la Secretaría de Industria y Comercio* in Mexico, and refer to the operations of foreign and local firms in Mexican manufacturing industry 1970. This is the same data base as in Chapter V, and we will therefore describe it only briefly here. The data cover the entire manufacturing sector, are gathered at the plant level, and aggregated into 230 four-digit industries with a further break-down according to three ownership categories: domestic private, foreign, and state ownership. Plants are defined as foreign when more than 15 per cent of equity is owned by foreigners, while those where the Mexican state owns more than 49 percent are defined as state-owned, irrespective of the share of foreign ownership. The state-owned plants are excluded from the sample, for reasons discussed in the previous chapter. Moreover, 14 industries were discarded from the sample because of missing information, and 60 industries were dropped because foreign firms were not present in 1970.

For the remaining 156 industries, the data set includes the following variables, where superscripts d and f denote domestic and foreign firms, respectively:

VA/L^d and VA/L^f are our proxies for labor productivity, and measure average value added per employee for locally-owned and foreign firms in each industry.

K/L^d and K/L^f are the average capital-intensities for each industry, defined as the ratio of total assets at book value to total employment.

HERF is the value of the Herfindahl index for each industry, including local, foreign, and state-owned firms, and proxies the level of concentration.

FOR is the measure of foreign presence, calculated for each industry as the ratio of the foreign firms' employment to total employment.

LQ^f is the ratio of white-collar workers to blue-collar workers in each industry (labelled W/B in the previous chapter), and aims to measure the industry's average labor quality. We use it as the labor quality proxy for foreign firms.

LQ^d is the labor quality proxy for local firms, defined as the intercept and error term, "$\alpha + \epsilon$", from the regression $LQ^f = \alpha + \beta\ FOR + \epsilon$, and it is included to correct for the *a priori* known correlation between LQ^f and FOR.

PATENT proxies the level of technological complexity in each industry, and measures the average payments of licenses, royalties, and patent fees per employee for the whole industry.

PGAP, finally, is the labor productivity gap between local and foreign firms, and proxies the technology gap. It is measured as the ratio of VA/L^f to VA/L^d. Most of these variables are summarized in Appendix Table 5.1 in Chapter V; some descriptive statistics and correlations are given in Appendix Tables 5.2 and 5.3.

We can now set up a statistical model to test the hypotheses regarding spillovers from competition and contagion. Adopting the main features of the statistical model used to test spillovers in the previous chapter, we have a simple system illustrated by equations (6.11) and (6.12) below.

$$(6.11) \qquad VA/L^d = \alpha_0 + \alpha_1 K/L^d + \alpha_2 HERF + \alpha_3 LQ^d + \alpha_4 VA/L^f + \alpha_5 FOR + \epsilon$$

$$(6.12) \qquad VA/L^f = \beta_0 + \beta_1 K/L^f + \beta_2 HERF + \beta_3 LQ^f + \beta_4 VA/L^d + \mu$$

Following earlier spillover studies, equation (6.11) suggests that the labor productivity of locally-owned firms is determined by their capital-intensity, K/L^d, the skill level of their labor force, LQ^d, the level of producer concentration, HERF, and the employment share of foreign firms, FOR. In addition to these variables, and unlike earlier studies, we also include the labor productivity of the foreign firms, VA/L^f, among the determinants.[6]

Capital-intensity and labor quality are expected to have positive coefficients, whereas the expected effect of concentration is uncertain. If HERF is mainly a proxy for the possibilities to engage in monopolistic pricing, then its expected effect is positive, as Blomström and Persson (1983) suggest. However, it may also reflect the presence of economies of scale, as discussed in Chapter V, in which case it should have a positive coefficient in industries where local firms benefit from scale economies, and a negative effect otherwise. Local productivity is expected to be positively related to the foreign share if "contagion" type spillovers occur; likewise, VA/L^f should carry a positive coefficient if competition-related spillovers have an additional impact on local productivity, by forcing local firms to increase their X-efficiency.

For simplicity, equation (6.12) assumes that the labor productivity of foreign firms is determined by the same factors (except foreign share) as that of locally-owned firms. The labor quality measure used for the foreign affiliates, LQ^f, differs from that for local firms, but the other variables are defined analogously.[7] The coefficients for capital-intensity, K/L^f, labor quality, LQ^f, and local productivity, VA/L^d, are expected to be positive, but the expected impact of HERF is uncertain also for foreign firms.[8]

To estimate the simultaneous equations (6.11) and (6.12), we use the method of three-stage least squares, 3SLS.[9] If simultaneous interactions take place, the 3SLS estimates are more efficient and consistent than the corresponding OLS estimates. Two-stage least squares, 2SLS, provide a somewhat simpler alternative estimation method, but we prefer 3SLS, because it yields more efficient estimates of the parameters we are most interested in. Keeping in mind the functional relation between LQ^f and LQ^d, it can be seen that equation (6.11) is exactly identified, while equation (6.12) is overidentified. The additional information about error correlations improves the 3SLS estimates for equation (6.11), i.e. those related to spillovers, although both methods give identical estimates for equation (6.12) (Maddala, 1977, 484-485).

Before moving on to the estimations, however, it is useful to briefly examine whether a simultaneous model is necessary for the particular data set we are working with. The reason is that the simultaneity of the present model depends on the existence of competition between locally-owned firms and MNC affiliates, as discussed at length above, at the same time as the foreign affiliates in some industries in our sample are probably isolated from local competition, as discussed in the previous chapter. The gains in efficiency and consistency from using multi-equation estimation methods, rather than OLS, may be small if these industries have a large impact on the overall results. Moreover, competition-related spillovers are cumulative only if there are simultaneous interactions between foreign and local firms.

A convenient test for this purpose is suggested by Geroski (1982), who argues that two equations, such as (6.11) and (6.12) above, are likely to be simultaneously determined (and OLS estimates biased and inconsistent) if the residual of the reduced form estimate of equation (6.12) has a significant impact on the dependent variable in equation (6.11). Thus, we can test for endogeneity of VA/L^f by estimating equation (6.11'):

$$(6.11') \qquad VA/L^d = a_0 + a_1K/L^d + a_2HERF + a_3LQ^d + a_4VA/L^f + a_5FOR + \theta R + \epsilon$$

where R is the residual from the reduced form OLS estimate of VA/L^f.[10] If θ is equal to 0, then we should accept the null hypothesis that VA/L^f is exogenous.[11] If, on the other hand, θ is significantly different from 0, there is reason to believe that VA/L^f is endogenous, and reason to use a multi-equation system to estimate the parameters.

Looking at the entire sample of the 156 Mexican manufacturing industries, the "Geroski-test" does not offer any support for the hypothesis that VA/L^f is endogenous. However, the lack of interactions between locally-owned firms and MNC affiliates in some industries may obscure the endogeneity of VA/L^f elsewhere. To overcome this problem, we will try to distinguish between the industries where affiliates and local firms compete with each other and those where they do not.

Given the limited data set, there is probably no perfectly accurate way to identify competitive industries, but the conclusions of the previous chapter, regarding inter-industry differences in spillovers, provide some guidance. As we may recall, it was found that spillovers seemed to be weaker (or could not be observed) in industries where foreign firms were hypothesized to operate in "enclaves", in isolation from local firms. In the sample, the "enclave" industries were characterized by high foreign penetration (measured as foreign employment shares above 50 per cent) and, to some extent, by high payments of patents, royalties, and license fees (defined as PATENT payments above 600 pesos per employee). Hence, we divide the sample according to the values of PATENT and FOR, and execute the Geroski-test for each of the sub-samples.

The results, which are summarized in Table 6.1 below, support the hypothesis that simultaneous interactions do occur in some groups of industries.

TABLE 6.1 Results of the Geroski-Test of Endogeneity of VA/L^f.

Group of industries	Sample Size	Significance Level for Endogeneity of VA/L^f
Industries with foreign firms present	156	0.34
and		
FOR < 0.5	125	0.09
PATENT < 600	97	0.20
PATENT < 300	67	0.12
PGAP < 2	105	0.26
PATENT < 600 AND FOR<0.5	84	0.02
FOR > 0.5	31	0.73
PATENT > 600	59	0.98
PATENT > 300	89	0.61
PGAP > 2	51	0.03

Notes:
The Geroski-test examines whether R, the residual of the reduced form of equation (6.12), has a significant impact on VA/L^d in the equation:

$$VA/L^d = \alpha_0 + \alpha_1 K/L^d + \alpha_2 HERF + \alpha_3 LQ^d + \alpha_4 VA/L^f + \alpha_5 FOR + \theta R + \epsilon$$

A value for θ that is significantly different from zero implies that VA/L^f is endogenous. The significance levels reported above denote the probability that θ is equal to zero and that there is no simultaneity (as suggested by two-tailed t-tests of the null hypothesis $\theta = 0$).

Looking first at the 125 industries where FOR was lower than 50 percent, we find some support for the endogeneity of VA/L^f, and θ is significantly different from zero at the 9 per cent level. For the 97 industries with PATENT intensities lower than 600 pesos per employee, there is no significant support for the endogeneity of VA/L^f. However, if the sample is restricted some more, to cover only the 67 industries with PATENT payments below 300 pesos per employee, the endogeneity of VA/L^f appears to be more significant, at a level of 12 per cent.[12] Finally, there is strong evidence (significant at the two per cent level) that VA/L^f is endogenous in the sub-sample where we have combined the two selection criteria, and excluded the industries with average PATENT payments above 600 pesos or foreign shares above 50 per cent.[13]

For industries with high values for PATENT and FOR, there are no signs of endogeneity. Interestingly enough, for industries with large productivity gaps between local and foreign firms (where PGAP is larger than two), the Geroski-test indicates that VA/L^f is endogenous, at the 5 per cent level of significance.

In the next section, the results of 3SLS estimations of equations (6.11) and (6.12) are presented for the whole sample, and for the sub-samples characterized by low values of FOR and PATENT, and high values of PGAP. For comparison, OLS estimations are also provided.

6.4 REGRESSION RESULTS

6.4.1 All industries with foreign firms

The regression results for the entire sample of 156 Mexican manufacturing industries with foreign firms present in 1970 are summarized in Table 6.2. It can be seen that 3SLS and OLS give similar parameter estimates for local productivity (equations 1a and 1b) which is what we expect on the basis of the Geroski-test, since there were no signs of endogeneity. Both methods yield the expected positive parameter estimates for capital-intensity, labor quality, foreign penetration, and the foreign affiliates' productivity level, whereas the effect of concentration is small and insignificant in both cases. Regarding spillovers, it can be seen that only the parameter for FOR is significant, which is also consistent with the result of the Geroski-test: if the simultaneous interactions between locals and MNCs are obscured, then so perhaps are the effects of competition.

Regarding foreign firms' productivities, there is one notable difference between the 3SLS and OLS estimations: the effect of local productivity on MNC productivity does not appear to be very large or significant in the OLS estimations (2b), but it has a large, positive and significant impact in the simultaneous estimation (2a). The parameter for capital-intensity is large and highly significant, but neither concentration nor labor quality seem to have any significant effects on VA/L^f.

TABLE 6.2 *Results of 3SLS and OLS Regressions: Labor Productivity in Locally-Owned and Foreign Firms in Mexican Manufacturing 1970. 156 Industries with Foreign Firms.*

Method	(1a) 3SLS	(1b) OLS		(2a) 3SLS	(2b) OLS
Dependent Variable	VA/L^d	VA/L^d		VA/L^f	VA/L^f
Constant	0.2412	0.2454	Constant	0.0058	0.1007
	(1.835)*	(1.892)*		(0,032)	(0.603)
K/L^d	0.3914	0.4304	K/L^f	0.4882	0.5316
	(6.576)***	(7.767)***		(8.128)***	(9.823)***
HERF	0.0127	0.0334	HERF	0.0573	0.1437
	(0.124)	(0.324)		(0.0402)	(1.091)
LQ^d	0.0979	0.1232	LQ^f	0.0348	0.0978
	(1.381)	(1.760)*		(0.359)	(1.101)
VA/L^f	0.0968	0.0321	VA/L^f	0.4139	0.1262
	(1.297)	(0.702)		(2.297)**	(1.291)
FOR	0.1599	0.1355			
	(2.790)***	(2.265)**			
Adj. R^2		0.423			0.452
F-value		23.72			32.91
N	156	156		156	156

System Weighted R-Square for 3SLS Estimations 0.523

Notes:
All variables are normalized by division with the sample means. Estimated coefficients are shown together with the absolute value of the t-statistics in parentheses. *, **, and *** denote significance at the 10, 5, and 1 per cent levels of confidence (two-tailed tests).

6.4.2 *Industries with low FOR*

The results for the 125 industries with foreign employment shares below 50 per cent, i.e. the first of the sub-samples where an attempt has been made to exclude "enclaves", are shown in Table 6.3. Equation (3a) seems to explain the productivity of local firms remarkably well, judging from the fact that all coefficients are significant at the one per cent level. Capital-intensity and labor quality have the expected positive coefficients, and the positive spillover effects acting via FOR and VA/L^f appear to be approximately equal in size.[14] Concentration carries a notable negative coefficient.

TABLE 6.3 *Results of 3SLS and OLS Regressions: Labor Productivity in Locally-Owned and Foreign Firms in Mexican Manufacturing 1970. 125 Industries with Foreign Employment Shares below 50 Per Cent.*

	(3a)	(3b)		(4a)	(4b)
Method	3SLS	OLS		3SLS	OLS
Dependent Variable	VA/L^d	VA/L^d		VA/L^f	VA/L^f
Constant	0.4428	0.4512	Constant	-0.1126	-0.1103
	(7.462)***	(7.734)***		(0.573)	(0.589)
K/L^d	0.4201	0.4404	K/L^f	0.5499	0.5507
	(13.42)***	(15.27)***		(9.264)***	(9.867)***
HERF	-0.1778	-0.1786	HERF	0.2265	0.2268
	(3.772)***	(3.835)***		(1.686)*	(1.693)*
LQ^d	0.1304	0.1433	LQ^f	0.1448	0.1461
	(3.749)***	(4.221)***		(1.359)	(1.455)
VA/L^f	0.0926	0.0532	VA/L^f	0.1915	0.1867
	(2.924)***	(2.471)**		(0.910)	(1.103)
FOR	0.0916	0.0904			
	(3.371)***	(3.254)***			
Adj. R^2		0.795			0.580
F-value		97.08			43.85
N	125	125		125	125

System Weighted R-Square for 3SLS Estimations 0.764

Notes:
All variables are normalized by division with the sample means. Estimated coefficients are shown together with the absolute value of the t-statistics in parentheses. *, **, and *** denote significance at the 10, 5, and 1 per cent levels of confidence (two-tailed tests).

Equation (4a) does not appear to be equally successful in terms of the significance of variables - only capital-intensity and concentration have significant effects - but the parameter estimates appear reasonable. Most interesting perhaps is that concentration has a positive impact on the productivity of foreign firms, in contrast to the negative impact on local firms' productivity. This lends support to the hypothesis that concentration largely marks the existence of scale economies. (See also Blomström, 1989, Chapter 5, and Carlsson, 1972). If scale economies are present, MNC affiliates are likely to operate with large enough plants to be able to benefit from them - hence the positive coefficient for HERF. Local firms, on the other hand, are smaller on average and could therefore suffer from diseconomies of scale (or at least be unable to benefit from scale economies). It can also be noted that OLS estimates differ only slightly from the 3SLS estimates in this sample, in spite of the results of the Geroski-test.

6.4.3 Industries with low PATENT payments

Table 6.4 summarizes the regression results for industries with PATENT payments below 300 pesos per employee. The results for the industries with PATENT payments below 600 pesos were quite similar to these and are therefore not presented separately. A first point to note is that there is a difference between the OLS and the 3SLS estimations of local productivity (equations 5a and 5b). In the OLS regression (5b), VA/L^f has a negative (although insignificant) effect on VA/L^d, which is opposite to what we expect. In the 3SLS version (5a), the coefficient of VA/L^f is large and positive, but neither VA/L^f nor FOR have significant effects. The lack of significance of the parameters for FOR and VA/L^f is probably explained by the relatively high simple correlation between the two variables, which is about 0.4. This multicollinearity problem appears also in the following sub-sample and will therefore be discussed separately below. Concentration has a significant and remarkably large negative effect on local firms' productivity, but a large positive effect on affiliates, as in the low FOR sample discussed above.

In equation (6a) all coefficients are positive, K/L^f is significant at the five per cent level, and HERF and LQ^f at the one per cent level. The confidence level for VA/L^d is somewhat lower, around 14 per cent.

TABLE 6.4 Results of 3SLS and OLS Regressions: Labor Productivity in Locally-Owned and Foreign Firms in Mexican Manufacturing 1970. 67 Industries with PATENT Payments below 300 Pesos.

	(5a)	(5b)		(6a)	(6b)
Method	3SLS	OLS		3SLS	OLS
Dependent Variable	VA/L^d	VA/L^d		VA/L^f	VA/L^f
Constant	0.4764	0.3237	Constant	-0.3536	-0.3346
	(2.234)**	(1.969)*		(1.684)*	(1.618)
K/L^d	0.4774	0.5442	K/L^f	0.1964	0.2343
	(6.366)***	(11.17)***		(2.162)**	(2.690)***
HERF	-0.3544	-0.2227	HERF	0.4116	0.4359
	(2.397)**	(2.028)**		(2.808)***	(3.027)***
LQ^d	0.0119	0.2686	LQ^f	0.5201	0.5952
	(0.053)	(2.330)**		(3.259)***	(3.922)***
VA/L^f	0.3315	-0.0521	VA/L^f	0.2255	0.0692
	(1.091)	(0.660)		(1.503)	(0.579)
FOR	0.0571	0.1382			
	(0.600)	(2.600)**			
Adj. R^2		0.727			0.416
F-value		36.20			12.75
N	67	67		67	67

System Weighted R-Square for 3SLS Estimations 0.742

Notes:
All variables are normalized by division with the sample means. Estimated coefficients are shown together with the absolute value of the t-statistics in parentheses. *, **, and *** denote significance at the 10, 5, and 1 per cent levels of confidence (two-tailed tests).

6.4.4 *Industries with low FOR and low PATENT*

The results for industries with foreign shares below 50 per cent *and* PATENT payments below 600 pesos per employee are shown in Table 6.5. The estimates of the determinants of local productivity are very similar to those for the low PATENT sample, in that the coefficient for K/L^d is positive and significant, that for HERF is significant and negative, and the coefficients for LQ^d and FOR are positive but not significant. A difference from the results in Table 6.4 above is that the coefficient for VA/L^f is notably larger here, and significant at the five per cent level. However, it is not possible to draw any firm conclusions from this estimate, because the simple correlation between VA/L^f and FOR is still significant, around 0.40.

The parameter estimates in equation (8a), for foreign firms, all have positive signs, the coefficient for VA/L^d is significant at the one percent level, and capital-intensity, concentration, and labor quality are significant at the ten per cent level. OLS estimations (equation 8b) yield similar results.

TABLE 6.5 Results of 3SLS and OLS Regressions: Labor Productivity in Locally-Owned and Foreign Firms in Mexican Manufacturing 1970. 84 Industries with Foreign Shares below 50 Per Cent and PATENT Payments below 600 Pesos.

Method	(7a) 3SLS	(7b) OLS		(8a) 3SLS	(8b) OLS
Dependent Variable	VA/L^d	VA/L^d		VA/L^f	VA/L^f
Constant	0.3013	0.3868	Constant	0.0639	0.0558
	(2.571)**	(5.178)***		(0.452)	(0.400)
K/L^d	0.3380	0.4293	K/L^f	0.1274	0.1217
	(5.091)***	(14.28)***		(1.949)*	(1.921)*
HERF	-0.2752	-0.2271	HERF	0.2293	0.2273
	(3.770)***	(4.419)***		(2.329)**	(2.313)**
LQ^d	0.0539	0.1930	LQ^f	0.1761	0.1668
	(0.523)	(3.529)***		(1.690)*	(1.655)
VA/L^f	0.5412	0.1409	VA/L^f	0.4033	0.4284
	(2.133)**	(2.777)***		(2.868)***	(3.536)***
FOR	0.0407	0.0770			
	(0.860)	(2.573)***			
Adj. R^2		0.840			0.422
F-value		88.51			16.12
N	84	84		84	84

System Weighted R-Square for 3SLS Estimations 0.765

Notes:
All variables are normalized by division with the sample means. Estimated coefficients are shown together with the absolute value of the t-statistics in parentheses. *, **, and *** denote significance at the 10, 5, and 1 per cent levels of confidence (two-tailed tests).

6.4.5 Industries with large PGAP

Table 6.6 presents the results for the industries with a large productivity gap between local firms and foreign affiliates. This sub-sample is included to demonstrate that productivity (or technology) differences alone are not necessarily obstacles to spillovers. All of the variables in the 3SLS equation for local firms (9a) have the expected signs and are significant. Both FOR and VA/L^f have positive coefficients, but that of VA/L^f is notably larger.[15] In other words, there seem to be spillovers both through contagion and competition, in spite of the large productivity differences.

TABLE 6.6 Results of 3SLS and OLS Regressions: Labor Productivity in Locally-Owned and Foreign Firms in Mexican Manufacturing 1970. 51 Industries with Large Productivity Gaps between Local and Foreign Firms.

Equation	(9a)	(9b)		(10a)	(10b)
Method	3SLS	OLS		3SLS	OLS
Dependent Variable	VA/L^d	VA/L^d		VA/L^f	VA/L^f
Constant	0.3590	0.4043	Constant	-0.2899	-0.0143
	(2.435)**	(3.167)***		(0.807)	(0.045)
K/L^d	0.2468	0.3851	K/L^f	0.2181	0.3197
	(2.723)***	(6.855)***		(1.968)*	(3.360)***
HERF	-0.2082	-0.2914	HERF	0.0253	-0.0013
	(1.690)*	(2.981)***		(0.114)	(0.006)
LQ^d	0.2130	0.3159	LQ^f	-0.1552	-0.0302
	(2.439)**	(4.014)***		(0.719)	(0.151)
VA/L^f	0.2797	0.0792	VA/L^f	1.2021	0.7264
	(2.583)**	(1.558)		(3.264)***	(2.681)**
FOR	0.1095	0.1058			
	(1.992)*	(1.921)*			
Adj. R^2		0.751			0.523
F-value		31.10			14.71
N	51	51		51	51

System Weighted R-Square for 3SLS Estimations 0.819

Notes:
All variables are normalized by division with the sample means. Estimated coefficients are shown together with the absolute value of the t-statistics in parentheses. *, **, and *** denote significance at the 10, 5, and 1 per cent levels of confidence (two-tailed tests).

HERF has a negative impact on local firms' productivities, which is reasonable considering that the local firms in these industries presumably do not benefit much from scale economies: they are relatively small and operate far below the MNCs' productivity levels. For the foreign firms, the effect of HERF is positive, but not significant.[16] OLS (equation 9b) differs from 3SLS mainly in the estimates of spillovers: in the 3SLS version, the combined spillover effect from the foreign share and the foreign productivity is significantly larger than in OLS.

Only capital-intensity and local productivity have significant effects in the 3SLS equation for foreign firms (10a). The effect of VA/L^d seems to be very strong, but the estimated coefficient is probably much too large, because of some heteroscedasticity.[17] Nevertheless, local firms' behavior appears to have an impact, in spite of the large productivity gap. The coefficient of LQ^f is, surprisingly, negative, but not significant.

6.4.6 Summary of statistical results

Summing up the results of the regression analyses reported in Tables 6.2 - 6.6, there are some general conclusions to be noted. First, in three of the five samples we have examined, we found support for the hypothesis that the productivity of local firms is partly determined by the productivity of MNC affiliates, through competition-related spillovers. These spillovers could be observed in addition to the "traditional" spillovers, defined as effects on local productivity of the foreign share of an industry's total employment. In three of the five samples, there was also support for a corresponding hypothesis for foreign firms, i.e. that the labor productivity of foreign firms is partly determined by the competition from local firms.

One of the cases where the effect of VA/L^f on VA/L^d was not significant was the full sample of 156 industries. As discussed earlier, it is likely that some industries can be characterized as enclaves, and that the lack of interactions between foreign and local firms in these industries explains the result. The other sample where VA/L^d did not have any significant effect was the LOW PATENT group. There, we also have a high correlation between VA/L^f and FOR - the industries with high foreign shares also tend to have relatively high labor productivity. This makes it difficult to separate the two effects, and parameter estimates may not be significant for that reason. In interpreting the results, we have therefore put more weight on the estimations on the two sub-samples where multicollinearity does not appear to be a problem (industries with low FOR and industries with large PGAP): both FOR and VA/L^f have highly significant effects in these groups.[18]

Nevertheless, to overcome the problem of multicollinearity, an attempt was made to add a third equation to the simultaneous system, to explain the relation between the productivity of MNC affiliates and their market shares. If successful, this would have allowed us to separate the effects of VA/L^f and FOR more accurately. Various formulations relating FOR to VA/L^f, VA/L^d, productivity gap measures, patent intensities, and capital intensities were tried, but the results were inconclusive. One reason is that we were not able to adequately explain what determines FOR. The correct functional relationship is unknown, and probably related to past values of the variables, rather than present ones. Consequently, none of the alternative formulations explained more than a third of the variation in FOR. Given that 3SLS estimations are sensitive to mis-specifications of any of the equations in the system, it was not surprising that the results - in particular, the relative sizes of the coefficients for FOR and VA/L^f - varied much depending on how the FOR equation was formulated. Hence, as noted before, we treat the variable FOR as exogenous.

As expected, capital-intensity had a significant positive effect in all estimations. The coefficient for labor quality was also positive in all cases except one (foreign firms in the large PGAP sample), but not always significant. The estimated parameters for HERF, finally, displayed a very distinct pattern: the estimated effect was negative and significant for local firms in four out of five sub-samples, but consistently positive for foreign firms. Our interpretation of this is that HERF captures the existence of scale economies. When the concentration ratio is high, there are probably economies of scale in the industry and foreign firms are usually large enough to benefit from these. Hence, they may be more productive than foreign firms in other industries. The average local firms in these industries, on the other hand, are smaller and may not have the same scale advantages. The results are compatible with what we found in the previous chapter, where local firms appeared to benefit from scale economies only in the industries with more advanced technology.

6.5 SUMMARY AND CONCLUSIONS

On the basis of some recent theoretical models of technology transfer through MNC affiliates and the empirical evidence presented in the previous chapters, we have argued in this chapter that simultaneous interactions between local firms and MNC affiliates are important, and that the traditional approach of measuring technology spillovers as the impact of foreign presence on the productivity of local firms may sometimes be misleading. Instead, we have formulated and estimated a simple simultaneous model based on data for the operations of foreign and domestic firms in Mexican manufacturing 1970, to test the hypotheses that the productivities of foreign and local firm are simultaneously determined, and that competition has an independent effect on the productivity of local firms, even after the spillovers from foreign presence (contagion) have been taken into account.

An initial examination of the data showed that it is not reasonable to expect simultaneity for the entire sample of 156 manufacturing industries. A likely reason is that foreign firms in some industries operate in isolation from locally-owned firms, as was found in the previous chapter, and that their inclusion obscures the simultaneity in the rest of the sample. However, tests of endogeneity suggest that the productivities of foreign and local firms are simultaneously determined in some sub-samples of industries where these "enclaves" are excluded.

The results of 3SLS estimations of the simultaneous model on these sub-samples are consistent with the hypothesis that the production decisions of foreign and local firms are mutually dependent. The productivity of foreign firms appears to have an effect on the productivity of local firms even after other determinants of productivity, including spillovers from foreign presence, are taken into account. Correspondingly, the productivity of local firms seems to have an impact on the productivity of foreign affiliates. The results are not entirely conclusive, however, because of multicollinearity in some of the sub-samples: foreign firms with high productivity may also capture large market shares over time, and in that case, it is difficult to separately measure the effect of either on local productivity. The time series data that would be needed to correct for this is not available, so the conclusion that competition is an important determinant of local productivity is instead based on those sub-samples where foreign shares and foreign productivities are not correlated.

Some important policy conclusions follow from these findings. Most importantly, there is reason to believe that the behavior of local firms, and the policies affecting their behavior, are important determinants of the spillover benefits from foreign direct investment. In particular, foreign investment may not lead to any spillovers if there are no local firms capable of absorbing the potential benefits. Spillovers are also likely to be less important in industries where competition is limited: the rate of technology imports may be lower and there may be less technology to spill over, at the same time as there may be less pressure to "work hard" and realize high levels of X-efficiency. Hence, spillovers are largely endogenous phenomena, and they may not occur if the local environment and local policies are not appropriate.

In conclusion, it is also necessary to consider briefly the shortcomings of the present model. Firstly, the technology choices of both local and foreign firms are, to some extent, seen as exogenously given in the statistical model, since capital-intensity is an exogenous variable. Competition and foreign presence are therefore understood to have an impact mainly on X-efficiency, i.e. that part of productivity that is not explained by the amount of factor inputs. Yet, we have seen in the previous chapters that the technology imports of affiliates depend on the level of competition, and capital intensity should perhaps be endogenously determined in a more complete model. Secondly, we have shown that the productivity levels of foreign and local firms are positively correlated, and argued, on the basis of a theoretical model, that the correlation is caused by responses to competition. However, it is also possible that there is some neglected factor that simultaneously determines the behavior of foreign and local firms, and causes the correlation we are able to detect.

Furthermore, the model says nothing about the long run characteristics of the interaction between local and foreign firms are. Situations where both foreign and local firms are active and productive, and cases where both are "lethargic", are equally consistent with the present results and hypotheses. Thus, an important unresolved problem concerns how to induce an equilibrium where both kinds of firms are active and productive, and where the rate of growth of the host country is maximized.

Wang and Blomström (1992) argue that there may be learning externalities between local firms, so that it is easier and cheaper for a local firm to invest in MNC technology if some other local firm has already done it. In that case, it is likely that the total amount of local investment will be lower than is socially optimal, because the firms cannot take into account the value of the externality when making their investment decisions. Appropriate policy intervention, in order to equalize private return with social benefits, may then help to push the economy from a low level equilibrium to one with higher levels of competition, spillovers, and growth rates. Our own findings from Chapters III and IV provide some other clues. There, it was concluded that the MNC affiliates' technology imports may be discouraged by low levels of labor skills, high distortions or market imperfections, and some types of technology transfer and performance requirements - hence, policies aiming to improve levels of education and reduce the distortions that inhibit competition are also likely to be important. However, much more research is needed before more confident policy conclusions can be proposed. In particular, it seems important to examine second-best policy alternatives for those industries where locals cannot be expected to compete effectively with foreign affiliates in the short run. Yet, this reservation does not change the main conclusions of the present study: technology and productivity spillovers from FDI appear to be determined by various host country characteristics - an important share of spillovers may also be endogenous results of the competition between foreign and local firms - and host countries can probably influence their size and significance through appropriate policies.

6.6 NOTES

1. This seems to follow a more general trend to endogenize the process of technological change and innovation in theoretical models of international trade. For an overview, see Cheng (1984a).

2. Das (1987) also finds that importing more technology is always profitable for the MNC affiliate, but the result seems somewhat trivial, since technology transfer is assumed to be costless. Spillovers are taken to be a function of the affiliate's output, and there is always the option to keep output constant and use the benefits from new

technology to lower production costs instead.

3. In Das (1987), the foreign firm always prefers to increase its profits through higher prices and constant quantities rather than through increased output and market shares, but the choice is more complex here, since spillovers are not only a function of the absolute amount of MNC output. See also Findlay (1978), where higher profits lead to an expansion of the foreign firms' capital stock.

4. Although there is a steady-state technology gap in the model, Wang and Blomström argue that the local firm may well catch up with the lead of the MNC affiliate. This happens when the growth of the stock of the MNC parent's technology (i.e. what can potentially be transferred to the affiliate) falls short of the rate of learning investment in the host country. However, innovation in the parent MNC is exogenous in the model.

5. Findlay (1978) actually models a similar process, although we did not discuss it in detail in Chapter V. Findlay treats the foreign share as an endogenous variable, that is partly determined by the size of the technology gap: the assumption is that a larger technology gap means higher profits for the affiliates, and, consequently, accumulation of foreign capital and an increase in the foreign share. The same kind of adaptation could be assumed to take place here.

6. Caves (1974) also used VA/L^f as an explanatory variable, but apparently not in order to measure spillovers. Instead, it seems that it is included to capture the productivity differences that are related to inter-industry differences in technology and capital-intensity.

7. The reason for using LQ^d in equation (6.11) is the *a priori* expected correlation between W/B and FOR, as discussed in Chapter V. W/B is clearly a more correct measure of labor quality for the foreign firms, and $LQ^f = W/B$.

8. In a more complete model, it would perhaps be desirable to also treat FOR as an endogenous variable, since the productivities of foreign and local firms are likely to be important determinants of the degree of foreign penetration, as discussed earlier. However, we have chosen to keep FOR exogenous, for two reasons. Firstly, it is likely that FOR is a function of *past* rather than *current* values of VA/L^d, VA/L^f, and other variables: we only have observations for one year. Secondly, we do not have any detailed knowledge of what the determinants of FOR are - FDI regulations, trade barriers, and other variables that we have no data for are probably important. See Section 6.4.6 for a further discussion.

9. See Zellner and Theil (1962). In the first stage, the reduced forms of equations (6.11) and (6.12) are estimated by OLS; in the second stage, the fitted values of VA/L^d and VA/L^f are used to get 2SLS estimates of all parameters; in the third stage, the cross-equation variances and covariances derived from the residuals of the 2SLS regressions are used to obtain generalized least-squares estimates of all the parameters (by use of Zellner's "seemingly unrelated regression" method).

10. The reduced form of equation (6.12) is

$$(6.12') \quad VA/L^f = b_0 + b_1K/L^f + b_2HERF + b_3W/B + b_4K/L^d + b_5FOR + r$$

and the residual R is the difference between the estimated and actual value for VA/L^f in this equation. LQ^d is not included in the equation, because it is a function of W/B and FOR.

11. Failure to reject the null hypothesis does not, in principle, rule out endogeneity, as noted by Geroski (1982), p. 150. VA/L^f may be endogenous if the covariance of ϵ and μ equals minus the variance of ϵ times a_4; however, OLS estimates of VA/L^d are still consistent in that case. Geroski also notes another caveat: it is possible to confuse a misspecification of the model with endogeneity. We assume that the model is linear, so this may be a warranted caveat. However, the only significant non-linearity that we have been able to detect is related to the diminishing effect of FOR on VA/L^d, and this is accounted for by excluding the industries with the highest foreign shares.

12. The fact that significant spillovers could be observed for a wider range of industries than those where simultaneous interactions can be seen perhaps suggests that the effects are not entirely symmetric. It is possible, for instance, that some industries are characterized by one-way effects, so that the productivity of local firms is determined by the affiliates' market shares and productivities, whereas the affiliates' decisions are largely independent of what local firms do concurrently.

13. Tests on industries with low K/L^f (where the affiliates' average capital intensities were below 200,000 pesos per employee) and industries with lower than average values for the labor quality proxies LQ^f and $WAGE^f$ (the average wage level of foreign firms) also give some weak support for the hypothesis that VA/L^f is endogenous, but the results are not included in Table 6.1.

14. Taking into account the difference in the variation of FOR and VA/L^f (by estimating beta-coefficients) suggests that the effect of VA/L^f is somewhat stronger than that of FOR. The difference, however, is not statistically significant.

15. Looking at beta-coefficients, VA/L^f appears to have approximately three times as large an effect as FOR. However, there is reason to be cautious when comparing the sizes of coefficients in this sample because of some heteroscedasticity.

16. In the SMALL PGAP group, the coefficients of HERF have the opposite signs - positive for local firms and negative for foreign firms.

17. Rescaling the variables, to obtain beta-coefficients, halves the size of the coefficient of VA/L^d.

18. The simple correlation between VA/L^f and FOR is 0.18 in the low FOR sample, and 0.11 in the large PGAP sample.

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