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R&D, LEARNING–BY–DOING AND THE MULTINATIONAL GROWTH OF SWEDISH FIRMS

by

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I. Introduction

The theory of the size and growth of multinational enterprises (MNE's) is but a geographic extension of the theory of the size and growth of firms in general. It has to adress two separate questions. First, what determines the size and growth of firms? And, second, what determines the location of production. The presence and creation of firm–specific knowledge is central to answering the first question. Locational factors is central to the second.

Firm–specific knowledge has long played a role in the literature on the MNE. More recently it has been made the foundation of the theory of the firm (Demsetz, 1988) as well as of formal trade models incorporating MNE's (Helpman and Krugman, 1985). Endogenous knowledge creation and increasing returns to the use of knowledge in production is also central in recent models of aggregate long–run growth. (Romer, 1986)

The purpose of this paper is to empirically analyze the determinants of the growth of Swedish MNE's. In particular, I seek to determine whether firm growth can be explained by the accumulation of knowledge through research and development (R&D) and learning–by–doing. Actual knowledge is, as is usually the case, not observed directly but is measured imperfectly by resources devoted to R&D and, for learning–by–doing, by the age of the firm. The rationale for the latter is that learning–by–doing is assumed critically related to the length of time of "doing". I will also infer the role of learning from the influence of certain industry characteristics, which will reveal if "acquired" comparative advantage, in Grossman and Helpman's (1989) terminology, becomes firm-specific and transferable within the MNE.

The data are unique micro data on Swedish MNE's in the manufacturing sector collected at the Industrial Institute for Economic and Social Research (IUI) in Stockholm.[1] They cover all MNE's in each of five years during a 20–year period (1965–86). They allow cross–sectional analysis and pooled

[1]The data have been described and analyzed in four earlier monographs – Swedenborg, 1973, 1979, 1982, and Swedenborg et al. 1986 – only one of which – 1979 – was in English.

cross–section and time–series analysis. They also allow us to follow a group of continuing firms over time. The time–series dimension is one important feature that sets the analysis apart from earlier empirical analyses of the determinants of MNE growth, which has been confined to cross–sectional data. (E.g., Horst, 1972, Caves, 1974, Lipsey and Weiss, 1976, Lipsey, Kravis and O'Connor, 1983, Swedenborg, 1979, but not 1982.) With few exceptions (Lipsey et al., ibid, Swedenborg, ibid) such analysis has also been based on industry data.

The paper is organized as follows. Section II gives the theoretical context, while section III discusses certain implications of trade theory in the presence of MNE's. Section IV gives some empirical magnitudes about Swedish MNE's. Section V contains the empirical analysis and section VI contains summary and conclusions.

II. Knowledge, the growth of firms and multinationality – the theoretical context

Several different bodies of theory converge in attributing a central role to knowledge in explaining the size and growth of firms. In the literature on direct investment the task has been to explain the multinational expansion of domestic firms or why foreign production, given that it is more profitable, is undertaken by a MNE rather than by a local producer. The answer given is that the MNE must possess a firm–specific asset (Hymer, 1960, Kindleberger, 1969, Caves, 1971) which gives the foreign investor a competitive advantage over local producers. The asset must be firm–specific in the sense that it can be transferred relatively more easily within a firm, even though geographically dispersed, than between separate firms in the market. If it is not firm–specific, licensing and other arm's length contracts should take the place of multinational expansion.

An asset such as knowledge has this property. Thus, Johnson (1970) identified knowledge as **the** asset being transferred in the direct investment process and thus the driving force behind the multinational growth of firms. He also noted that knowledge has the characteristic of a public good to the firm, i.e., once produced the marginal cost to the firm in further use is zero (assuming no other potential users of this knowledge).

The theory of the firm has adressed the related but more general question of why firms exist and what determines the boundaries of firms, i.e., whether activities or transactions are organized within a firm or carried out in the market. Coase (1937) and, more recently, Williamson (1975, 1986) have pointed to transaction and information costs in determining this choice. Alchian and Demsetz (1972) stressed the superior productivity of team production and argued that the organizational problems that it gave rise to required the central authority of a firm.

Demsetz (1988), however, notes that the transaction costs literature is deficient in implicitly assuming that all firms can produce all goods and services equally well and that the Alchian–Demsetz theory is deficient in not explaining the sources of the superior productivity of team production. Instead he proposes a kind of comparative–advantage theory of firms: firms are differentially good at producing different things. They are bundles of specialized knowledge, about "technology, personnel, and methods". Information costs make this knowledge specific to the firm and mean that its bundle cannot be easily altered or imitated.

He goes on to argue that the productivity of team production is especially important when individuals have invested in specialized knowledge, since specialized knowledge is not much good unless it can be used jointly with other specialized knowledge. Furthermore, the boundaries of firms are determined so as to economize on the cost of knowledge. Vertical (or horizontal) integration stops when the product can be sold to new users (or ultimate consumers) without these users themselves having to have knowledge about the production of this product.[2]

But how do firms get to be "bundles of specialized knowledge"? By grafting a theory of how firm–specific knowledge is acquired onto the Demsetz story of "why firms" the theory becomes dynamic and explains how firms grow.

Knowledge can be created in two ways, through learning–by–doing and through the purposive devoting of resources to knowledge creation as in R&D.

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[2]The intuitive appeal of Demsetz' theory lies in the fact that this is how firms often define themselves, i.e., as having specialized know–how in particular fields. For example, Swedish SKF "knows" roller-bearings and Alfa Laval "knows" the separator in all its forms and applications.

The theory becomes dynamic when we recognize that the creation of new knowledge affects growth. In fact, in recent aggregate growth models the accumulation of knowledge by private agents (firms) is seen as the single most important determinant of continued growth in the long run. (Romer, 1986, Grossman and Helpman, 1989). The creation of knowledge in the firm enables the firm to grow. It will grow faster than other firms in the same industry, provided that the knowledge does not immediately or fully become disseminated, but in part, at least, is specific to the firm.

Multinationality is merely a spatial extension of firm growth. At some point, further growth requires that the firm expands into new geographic markets. For firms based in a small country exporting becomes necessary at quite an early stage. Depending on the advantages of concentrated production due to scale economies, relative factor prices in different regions and countries, and the importance of transportation costs and other barriers to trade, growth will also entail locating new production plants in other regions and countries.

This innocuous story of firm growth puts us in a world of imperfectly competitive firms. Information is not perfect. Firms are not identical, not characterized by non–increasing returns to scale, not price takers able to sell as much as they want at a given market price.

The "new theory of international trade" not only incorporates many of these features of imperfect competition but it also includes the MNE. (Krugman, 1983, Helpman, 1984, Helpman and Krugman, 1985) Thus, as Krugman (1983) notes, many trade models in this vein share the following basic features: (1) consumers would demand a large number of (differentiated) products if offered; (2) there are fixed costs in production, which leads to declining average cost, so that the number of products is limited by the extent of the market; (3) the market structure is one of Chamberlinian monopolistic competition, with each firm a monopolist producing a differentiated product and setting marginal revenue equal to marginal cost but where free entry pushes profits to zero.

Krugman shows how "a slight twist" can convert these models into models of the MNE. The twist is that the fixed cost is not in production but in headquarter services, such as R&D or anything that gives the MNE a firm–specific advantage. Then, production no longer needs to be centralized in one location because of decreasing costs. Plants can be established in different countries to take advantage of differences in production costs, to reduce transportation costs or avoid tariffs.

Krugman goes on to show that except when the motive is to avoid tariffs (when the effect is ambiguous) the effect of multinational production is to raise welfare in both countries by making more of the differentiated product available. It is trade that produces the welfare gain, but it is not trade in products. It is trade in information, knowledge of how to produce the differentiated product. This knowledge can be traded directly, through technology transfer in the MNE or through licensing a foreign producer, or indirectly, by trading the products incorporating this technology. Technology transfer is a substitute for trade, just as factor movements are a substitute for trade in the factor proportions model of trade. Thus, the Mundell (1957) results with regard to equalized goods prices through factor mobility apply analoguously to technology transfer.

The "new" trade theory does not produce new conclusions about the MNE. But it does yield more precise predictions. Perhaps most importantly, it brings the MNE, as a vehicle for the international transfer of knowledge, into the rigorous framework of general equilibrium trade theory.

III. Firms, endogenous learning and country comparative advantage

The hypothesis we want to examine is that the overall size and growth of firms – in our case, Swedish MNE's – can be explained by the accumulation of knowledge in the form of both R&D results and learning–by–doing. Knowledge is then assumed to be a firm–specific attribute, which affects the firm's overall competitive advantage but not the location of production.

But we are also interested in the influence of certain industry characteristics both on the competitive advantage of firms in different countries and on the location of production by MNE's. These have an interest in themselves. But they also have to be taken account of to the extent that firms in different industries are compared. Defining industry as a collection of firms producing similar output and using similar technology means that industry characteristics would include relative factor use (capital, skill, natural resource and R&D intensity), economies of scale, product mobility and the size and growth of the industry's market.

The competitive advantage of home country firms is likely to be affected by factors determining the home country's comparative advantage, since a country's comparative advantage becomes an absolute advantage to firms located in that country. Neo–classical trade theory relates country comparative advantage to differences in relative factor prices between countries and in relative factor use between industries. Then, firms which are in industries in which Sweden has a comparative advantage should have an absolute advantage in the same industries. (Caves, 1971) They should be large domestically and, perhaps, grow faster than domestic firms in other industries.

In the case of firms producing in more than one country, MNE's, it is not clear what the effect of country comparative advantage should be on the firm's overall size and growth. On the one hand, differences in comparative advantage between countries should affect the location of production. (This is what drives MNE production in, e.g., Helpman, 1984). For example, if Sweden has a comparative advantage in relatively capital intensive (or domestic resource intensive) production, then domestic production in these industries should be favored relative to foreign production. Firms in these industries should locate relatively more of their production in Sweden than firms in other industries. But they need not locate all their production in Sweden and for two reasons. One is that not all the firm's output necessarily is capital (or resource) intensive. The other is that "learning" accumulated by the exporting firm producing in these industries can be transferred through the MNE to subsidiaries in other countries with relatively similar resource endowments or protected by trade barriers. The latter implies that the theory of comparative advantage becomes less well–defined in the presence of firm–specific learning and MNE's. In fact, one could argue that relatively more learning is generated in a country's exporting industries (through specialization and size), so that it is precisely in these industries that one should expect a learning advantage and relatively sizeable foreign production by the country's MNE's. (Swedenborg, 1979) That would follow if learning is modelled as joint output, as in Rosen (1972). At the very least, one can note at the theory when applied to MNE's generates hypotheses in two opposing directions.[3]

Other industry characteristics which might affect either the firm's overall size and growth or the location of production may be associated with the "new" theory of international trade. They include economies of scale, product mobility and the size and growth of the industry's market. Scale economies, product mobility and market size constrain the efficient size of firms.

In contrast to firm–specific knowledge, industry characteristics can affect the locational choice of MNE's. For example, differences in relative factor prices between countries or trade barriers might be a motive for foreign production, while substantial scale economies by making multi–plant operations uneconomical might argue against it.

IV. Regression model and variables

The determinants of the overall size of multinational firms can be analyzed within the theoretical framework of a firm serving many national markets and having the option of producing in different countries. A simple model of this kind (Horst, 1969, Swedenborg, 1979) is one of a profit–maximizing, single–product firm in a two–country setting. The firm is assumed to face a downward sloping demand curve both at home and abroad. It is also assumed that domestic sales come from domestic production, while foreign sales can be supplied both through exports and through foreign production.[4]

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[3]Eliasson (1988) also notes that the notion of national comparative advantage becomes diffuse when "the knowledge base" of a country is mobile within its MNE's.

This kind of learning effects has not been modelled in trade theory. Grossman and Helpman (1989) in their recent model of trade and growth come close, however. They distinguish between "natural" and "acquired" comparative advantage, where the latter is the endogenous augmentation of comparative advantage through cumulative experience. Since there are no MNE's in the model, the learning advantage remains country-specific, however.

[4]Foreign production could, of course, be sold in the home market as well as in foreign markets. The assumption that it is only sold in foreign markets is a theoretical simplification, which happens to be empirically valid in the case of Swedish MNE's.

In such a model the firm's total sales (ST) can be decomposed into domestic production for the home market (SH) and domestic production for foreign markets (SX) and foreign production for sale abroad (SQ). These magnitudes are determined simultaneously by the firm's domestic and foreign cost and revenue functions and by the conditions for profit maximization. The latter are, specifically, that

(1) $MC_H = MR_H$

(2) $MC_A = MR_A$

(3) $MR_H = MR_A$

where MC = marginal cost, MR = marginal revenue and subscripts H and A refer to home and abroad respectively.

The structural parameters in the model are the intercepts and slopes of the cost and revenue functions. The exogenous variables that I want to focus on are the underlying determinants of these parameters. They include the firm–specific characteristics affecting the firm's competitive advantage and the country characteristics affecting country comparative advantage discussed above. The coefficients of these variables are estimated in reduced form.

The purpose of the empirical analysis is not to determine the values of the structural parameters of the underlying model, i.e., the cost and revenue functions. Therefore, the question of theoretical and empirical identification of these parameters is not dealt with.

The regression equations contain the following variables, where the sign below the variable indicates its expected influence.

(4) $SH_{it} = f_1$ (RD, LS, YR, KL, NR, SC)$_{it}$

(5) $SX_{it} = f_2$ (RD, LS, YR, KL, NR, SC)$_{it}$

(6) $SQ_{it} = f_3$ (RD, LS, YR, KL, NR, SC)$_{it}$

where

SH = net sales in Sweden

SX = exports from Sweden

SQ = net foreign production for sale abroad

RD = R&D intensity

LS = skill intensity

KL = physical capital intensity
NR = natural resource intensity
SC = scale economies in production
YR = age of foreign manufacturing
i = the ith firm (i = 1...n)
t = data years for the cross–sections (t = 1...m)

Variables missing in (4) – (6) are those specifically affecting the demand side, viz., the size of the home and foreign markets respectively, and barriers to trade (both natural and artificial). The reason is that it is virtually impossible to construct such measures from external data for the individual, often highly diversified, firm. However, it is not clear that a market size variable, at least, is needed. The reason is that for a diversified, monopolistically competitive firm the size (and growth) of its market is an endogenous variable. Firm–specific ability (here measured by R&D and age) determines not only the firm's cost functions but also its revenue functions.

In most of the specifications the variables are in logarithmic form so that the the estimated coefficients are elasticities.

Since the variables vary both across firms (i) and over time (t) the equations will be estimated both as pure cross–sections across firms for each of the five years (as well as growth rates in the period) and as pooled cross–sections for all years, holding the influence of time on both the intercept and slope coefficents constant by a dummy variable (Dt).

They will also be estimated as a time–series relationship for each firm, which is pooled across firms using a dummy variable (Di) to control for influences which are unique to individual firms. Since there are, at most, five observations over time for an individual firm, the dummy variable will only be applied to the intercept in the time–series analysis. The intercept is allowed to vary between firms but the slope coefficients are assumed to be the same across firms. (Allowing the slope coefficients to vary would reduce the degrees of freedom too much.)

Cross–section and time–series analyses answer different questions. The cross–section analysis adresses the question of whether differences between firms in size (or growth) can be explained by differences between firms in, e.g., knowledge. The time–series analysis adresses the question of whether a single firm's growth over time can be explained by the growth of knowledge over time. The two questions need not elicit the same answers.

The independent variables are defined as follows. Knowledge as a result of R&D is measured by the firm's (current) R&D intensity (total R&D expenditures/total sales). (An alternative would have been cumulated R&D expenditures.) It is the firm's overall R&D intensity, since R&D results are assumed to be available to the firm both in its domestic and foreign operations, independent of where actual R&D is carried out.

Usually, data limitations force analysts to use domestic R&D intensity, measured as domestic R&D/domestic sales value of output, which – in the case of MNE's – leads to a more positive relationship between R&D and multinational operations. The reason is that R&D is usually concentrated in the home country while production is not and the more production the firm has abroad the higher is measured R&D intensity. This comes out strongly, as we shall see, in the case of Swedish MNE's.

It is not obvious what the deflator should be, however. The Krugman model of fixed costs in R&D as an explanation of foreign production implies that it should be large fixed costs relative to the size of the domestic market that should account for growth through exports and foreign production. On the other hand, as an empirical matter, the line of causation is ambiguous. Is a high domestic R&D intensity the reason for large international sales or do large international sales enable the firm to have a high domestic R&D intensity? The measure used here begs the question, since the overall R&D measure is independent of both where R&D and where production is located.

Knowledge in the form of accumulated learning–by–doing is assumed related to the firm's age. Here, we measure only the age of the firm's foreign operations (year of first establishment of foreign manufacturing affiliates), which should be most directly related to learning in foreign manufacturing. It is, of course, a very crude and indirect measure of learning. The objection is not so much that age or time is not related to the accumulation of learning, but rather that age can reflect many other influences as well.

In a cross–section over firms a positive relationship between age and size may merely reflect the fact that it takes time to grow large and the current size of the firm depends on when it was started. In a time–series analysis of a single firm, however, a positive relationship between the growth of output over time and the change in the firm's age **could** be the result of learning. But it could also show that firms just grow over time – for whatever reason.

Another problem in the interpretation of the age variable has to do with sample selection bias due to attrition. Old investors which survive are still in the data set at the end of the period, while those that fail are not. That means that the data sample is biased towards growing firms. (Cf Hall, 1987) It is also possible that firms which already have survived for some time as MNE's have a greater probability of surviving subsequently. That is, non–viable firms have already been weeded out from their "age group". (This yields a testable hypothesis: Is the probability of survival in the period 1965–86 a function of the firm's age in 1965? Or: The older the firm is at the beginning of the period, the more likely it is to be a "successful" firm.)

The industry characteristics that we measure are more traditional though not necessarily more straightforward in their interpretation. (See the more detailed discussion of the theory behind the corresponding variables in Lars Lundberg's paper for this conference.) They include measures of physical capital intensity and skill intensity in the MNE's domestic operations as well as a dummy variable to distinguish industries intensive in domestic natural resources (the paper and pulp and the steel industries). Physical capital intensity is measured as book value of property, plant and equipment per employee, while skill intensity is measured as the average wage. Both intensities refer to the firm's Swedish operations.

These variables should show the extent to which relative factor endowments in countries and factor use in production have an effect on the location of production and the direction of trade. In particular, they should show whether the factor proportions theory of trade holds on the individual firm level. Since several studies (see Lundberg, ibid) have shown Sweden to have a comparative advantage in both physical and human capital and domestic resource intensive industries, one would expect that these factor intensities should favor exports from Sweden relative to foreign production by Swedish MNE's. But, as noted above, in the case of MNE's the effect is not clear cut.

Through "learning" Swedish MNE's might have a competititve advantage in these industries also in their foreign production.

A final industry characteristic is the importance of scale economies in production. It is measured as the average plant size in the firm's industries (on 5–digit SNI, weighted and summed across the industries in which the firm produces). Large scale economies should argue against producing abroad (actually, in many locations), but given that the firm produces abroad foreign production should be on a relatively large scale.

V. Some empirical magnitudes

A relatively small number of companies (some 110 firms) make up the population of Swedish MNE's in the manufacturing sector. These companies account for a substantial part of total Swedish manufacturing, however, since they are very large **on average**. In 1986 they accounted for nearly 50% of Swedish manufacturing employment and their total employment in majority–owned foreign affiliates (both sales and manufacturing) was almost as large. In addition to being large, they are export oriented (accounting for 56% of Sweden's exports) and highly R&D intensive (accounting for 90% of industrial R&D in Sweden).

This is not necessarily a description of all MNE's, however. Size measures are dominated by a handful of Sweden's largest companies. Thus, the 10 largest MNE's account for 25% of manufacturing employment in Sweden and over 70% of foreign manufacturing employment.

Table 1 shows the change in the population of Swedish MNE's in the period 1965–86. The total number of firms has remained relatively constant (especially from 1970 when there were 107 firms). But that is mainly because the large number of entries to multinational status has been balanced by an almost equally large number of disappearances of firms. Only 27 firms have survived as independent, Swedish–owned MNE's in the period 1965–86. Of the disappearing firms, 18 remain as Swedish MNE's but have merged with the 27 continuing firms. The table thus illustrates the problem of sample attrition in an analysis of firms over time. It also reveals that continuing firms are far from "identical" firms.[5]

Tables 2 and 3 show the size and growth of Swedish MNE's relative to Swedish industry. They reveal that Swedish MNE's have increased their share of manufacturing employment in Sweden 1965–86, partly due to new firms becoming multinational but also because of a higher rate of growth of continuing firms. Also, MNE employment growth abroad has been even higher than in Sweden.

Table 4 can serve as a backdrop for the age variable. It shows when foreign manufacturing affiliates of Swedish MNE's were first established. Here, too, there is considerable attrition, which can be seen by comparing the three columns, which show year of establishment of manufacturing affiliates existing in 1970, 1978 and 1986 respectively.

In 1970, for example, there were 252 affiliates which had been established 1960–1970. By 1986 that number had dropped to only 101. That is, some 150 of the affiliates established in this period had been sold, reorganized or otherwise discontinued. Since this applies to all earlier periods, the rate at which foreign manufacturing affiliates have been established in later periods is consistently overestimated relative to earlier periods.

Finally, table 5 shows the R&D intensity of continuing MNE's and how it has changed in the period under study. The first line shows overall R&D intensity, which is independent of both where R&D and manufacturing is located. This is the measure used in the empirical analysis. The second and third lines show total R&D and Swedish R&D respectively related to domestic size only. These measures yield a much higher R&D intensity and one, moreover, which increases in proportion to the size of foreign operations. Comparing the latter two reveals that R&D is mainly performed in Sweden (85%, in fact).

One way of looking at the difference between the three measures is that multinational operations enable firms to maintain a high level of R&D in

[5]In the data set MNE's which have merged in the period have been combined for earlier years or treated as independent in later years.

Table 1 Change in the population of Swedish multinational enterprises (MNE's) 1965–1986

	Number of firms
Swedish MNE's in 1965	81
Continuing	27
Disappearing 1965–86	119
of which	
due to the parent firm	
having merged with a continuing MNE	18
having discontinued its foreign manufacturing operations, been acquired by foreign firm, etc.	101
Swedish MNE's in 1986	105
Continuing	27
New entrants 1965–86	143
Net increase 1965–86	24

Footnote: Swedish MNE's are defined as Swedish corporations with majority owned manufacturing affiliates abroad.

Table 2 Employment in Swedish parent companies, and in their foreign manufacturing affiliates compared to total Swedish manufacturing 1960–86

	1960	1965	1970	1974	1978	1986
Swedish manufacturing	880 260	938 915	921 780	929 200	874 230	777 270
Swedish parent companies		325 980	395 990	431 750	420 460	375 020
in % of Swedish manufacturing		35	43	46	48	48
Foreign manufacturing affiliates	105 510	147 290	182 090	221 110	227 150	259 820
in % of Swedish manufacturing	12	16	20	24	26	33

Table 3 Employment in continuing Swedish parent companies and in their foreign manufacturing affiliates compared to total Swedish manufacturing 1960–86

	Employment				
	1965	1970	1974	1978	1986
Continuing MNE's					
Swedish parent companies	267 580	296 800	332 180	304 535	294 330
in % of Swedish manufacturing	28	32	36	35	38
Foreign manufacturing affiliates	138 490	166 150	200 650	201 495	222 785
in % of Swedish manufacturing	15	18	22	23	29

Table 4 Age of surviving foreign manufacturing affiliates

Year of establishment	Affiliates existing in		
	1970	1978	1986
1875–1919	20	17	14
1920–1929	37	31	15
1930–1939	31	19	18
1940–1949	30	23	14
1950–1959	57	46	31
1960–1970	252	162	101
1971–1978		269	151
1979–1986			299

Table 5 R&D intensity of continuing MNE's 1965–86 using alternative measures of R&D intensity

	1965	1970	1974	1978	1986
Total R&D/total sales	1.83	2.18	2.28	2.36	4.17
Total R&D/ Swedish group sales	2.55	3.17	3.39	3.90	7.82
Swedish R&D/ Swedish group sales	2.31	2.62	2.89	3.33	6.73

Sweden. That is, without foreign manufacturing the R&D intensity in Sweden (the third line) would have been the same as the overall R&D intensity (the first line) and the difference, then, is an "effect" of foreign operations. On the other hand, looking at R&D as a fixed cost, the high "domestic" R&D intensity (second line) may be a cause of foreign operations. That is, foreign production is a **sine qua non**, given the large required R&D relative to domestic size.

Also worth noting is that R&D intensity has increased steadily through most of the period but made a sharp jump 1978–86. This abrupt increase has meant that Sweden has advanced from a middle to a top position among industrial countries in relative expenditures on R&D. In fact, Sweden in 1986 had the highest R&D intensity (measured as R&D/GNP) of all industrial countries. (OECD, 1988)

VI. Empirical results

Can the size and growth of Swedish multinational firms be explained by the accumulation of firm–specific knowledge? How is the size and growth of Swedish firms related to factors affecting Sweden's comparative advantage? What role is played by scale economies? We start by looking at what determines differences between firms in the relative size of exports and foreign production in a particular year and then go on to an analysis of the determinants of the growth of exports and foreign production over time, holding firm constant. Finally, we investigate whether differences between firms in rates of growth can be explained by any of the same variables.

Tables 6 – 8 show the results of cross–sectional analyses for each of the five survey years. The regressions show the extent to which differences between firms in the relative size of foreign sales and production can be explained by presumed firm–specific characteristics such as R&D and age, on the one hand, and industry attributes, on the other. The dependent variable is total foreign sales (SX+SQ), exports (SX) and foreign production for sale in foreign markets (SQ) respectively.

Both R&D intensity (RD) and age (YR) have a consistently positive and mostly significant influence on both exports and foreign production. However, YR consistently has a stronger effect on foreign production than on exports.

Skill intensity (LS) is mostly insignificant, while capital intensity (KL) and natural resource intensity (NR) either separately or jointly, have a positive effect on the relative size of both exports and foreign production. However, when a measure of scale economies (SC) is included – bottom of the table – it is more significant and even replaces KL and NR in the regressions. The reason is that these variables are highly correlated, because the resource based industries – steel and paper and pulp – are characterized by both high capital intensity and large plant size. Although it is hard to disentangle the separate influence of these variables, it appears that scale economies is the more important explanation of size differences between firms.

A pooling of the individual cross–sections for the different years using dummy variables (Dt) to allow for differences between years confirms that the estimated coefficients are relatively stable over time. There are very few significant deviations in either the intercepts or slope coefficients between different years. (Appendix table 1) This is a remarkable result in view of the very large changes in the population of firms between different years. Only 28 continuing firms are present throughout the period.

A high R&D intensity, large scale economies in production and the age of the firm's foreign production emerge as the most important factors determining differences between Swedish MNE's in the relative size of **both** exports and foreign production. Together they seem to support the "new" theory of international trade and production, which gives emphasis to a firm–specific R&D advantage, scale economies in production and "historical" origins of current specialization patterns. They do so at the expense of the factor proportions theory as a theory of MNE's, unless that theory is modified to take account of (firm–specific) learning effects.

The influence of R&D intensity is consistent with the notion that MNE's have a competitive advantage based on R&D. The influence of plant size is less obvious. On the one hand, scale economies would argue against producing in too many locations. On the other, given that the firm produces abroad, its

Table 6

Cross–sections for individual years: total foreign sales (log SX+log SQ)

		Independent variables (log)							
Year	Const.	RD	LS	KL	NR	SC	YR	DF	R^2
1965	–1.32	0.12	2.80* (1.9)	0.94** (2.7)	1.22 (1.4)		0.65** (3.8)	58	0.40
1970	8.82** (3.8)	0.43** (2.9)	0.43	0.46** (1.9)	2.20** (2.8)		0.60** (3.6)	82	0.34
1974	8.04* (2.5)	0.26** (3.0)	0.42	0.30 (1.5)	1.94** (3.1)		0.98** (7.2)	93	0.54
1978	2.01	0.22* (1.8)	1.30 (1.4)	0.69** (3.6)	0.75 (1.2)		0.99** (6.7)	104	0.51
1986	11.22 (1.5)	0.41** (3.0)	0.03	0.19 (1.6)	2.84** (3.4)		0.93** (6.3)	103	0.45
Including SC in the regressions									
1974	0.35	0.17* (2.2)	0.76 (1.2)	0.0	0.39	0.77* (5.8)	0.71* (5.7)	93	0.67
1978	–2.32	0.14 (1.3)	0.75	0.40 (2.2)	–0.33	0.79* (4.9)	0.87* (6.4)	104	0.60

Regression model:

$$\log Y_{it} = a + b_1 \log X_{it} + \ldots\ldots + b_k \log X_{kit}$$

i = 1.....n (firms)
t = 1.....5 (1965, 1970, 1974, 1978, 1986)

Numbers in parentheses are t–statistics. t < 1 not shown. *, ** indicate significance at the .10 and .05 level respectively. R^2 is corrected for degrees of freedom.

Table 7

Cross–sections for individual years: exports (log SX)

		Independent variables (log)							
Year	Const.	RD	LS	KL	NR	SC	YR	DF	R^2
1965	–1.70	0.12	3.05* (1.8)	0.81** (2.0)	1.82* (1.9)		0.39** (2.0)	63	0.29
1970	9.80** (3.9)	0.50** (3.1)	0.39	0.31 (1.2)	2.89** (3.4)		0.32* (1.7)	82	0.28
1974	8.91** (2.4)	0.25** (2.5)	0.04	0.41* (1.9)	2.26** (3.1)		0.80** (5.1)	93	0.43
1978	7.28 (1.6)	0.45** (3.3)	0.35	0.63** (2.9)	1.80** (2.5)		0.80** (4.8)	104	0.45
1986	11.88** (7.4)	0.58** (4.5)	0.09	0.09	3.91** (4.5)		0.74** (4.8)	103	0.43
Including SC in the regressions									
1974	–0.37	0.14 (1.6)	0.45	0.06	0.38	0.93* (6.2)	0.47* (3.3)	93	0.60
1978	2.52	0.37* (2.9)	–0.26	0.31 (1.5)	0.61	0.87* (4.8)	0.67* (4.4)	104	0.54

See footnote of Table 6.

Table 8

Cross–sections for individual years: foreign production (log SQ)

		Independent variables (log)							
Year	Const.	RD	LS	KL	NR	SC	YR	DF	R^2
1965	–0.0	0.22* (1.9)	2.02 (1.4)	0.75** (2.2)	0.41*		1.02** (6.1)	63	0.52
1970	5.20** (1.9)	0.38** (2.2)	0.56	0.45* (1.7)	1.72* (1.9)		1.18** (6.2)	82	0.41
1974	4.95 (1.4)	0.38** (3.8)	1.13 (1.3)	–0.11	1.76** (2.5)		1.38** (9.0)	93	0.60
1978	–5.0 (–1.1)	0.02	2.32** (2.3)	0.58** (2.7)	–0.30		1.35** (8.1)	104	0.52
1986	9.02** (4.6)	0.32* (1.8)	–0.0	0.26* (1.7)	1.89* (1.8)		1.21** (6.5)	103	0.40
Including SC in the regressions									
1974	–0.29	0.31* (3.2)	1.39* (1.2)	–0.34 (–1.6)	0.54	0.60* (3.7)	1.17* (7.5)	93	0.65
1978	–8.67* (2.0)	–0.0	1.85* (1.9)	0.34 (1.6)	–1.21* (–1.7)	0.67* (3.5)	1.24* (7.8)	104	0.57

See footnote of Table 6.

foreign production would have to be on a relatively large scale. Evidently, it is the latter effect that we see here.[6]

The meaning of the age variable is, however, more ambiguous, as noted earlier. It reveals clearly the important role of dynamic–historical factors for cross–sectional analysis. But does it merely show that it takes time to grow large, so that current size depends on when the firm started growing? Or does it show that "aging" firms acquire a knowledge advantage as they go along?

My next question is whether the same factors can explain the growth of an individual firm over time. Specifically, can the growth of the firm's exports and foreign production be explained by increasing R&D intensity, skills, capital intensity and age?

In adressing this question the analysis must be confined to firms for which there are data for several years. The sample, then, consists of firms which are continuing throughout most of the period, in effect, relatively old and surviving MNE's.

At most, time–series regressions can be based on five data points in time and then pooled across firms with a dummy variable for each firm. The dummy variable only allows the intercept to vary between firms, while the slope coefficients are estimated for all firms jointly (to preserve degrees of freedom). Such regressions have been estimated both for the 28 firms existing 1965–86 and for the 39 firms existing 1970–86. Only the former is presented in Table 9. (In these regressions, all absolute values are in constant prices to avoid a common inflationary trend.)

The first thing to note is that the high explanatory value of the regressions come from the firm dummies, which are, in the main, highly significant. (The intercept shows factors unique to the first firm. The other firm dummies are not shown.) This suggests that factors which are unique to firms (cannot be captured by a common intercept) are very important in explaining differences in growth rates betweeen firms. Holding these factors constant, however, the firm's growth over time also significantly depends on the increase in its R&D

[6]In regressions explaining the choice between exports and foreign production across countries, scale economies has the expected negative effect. (Cf Swedenborg, 1979, 1982)

intensity, increased skill of its domestic labor force and age of its foreign manufacturing. R&D intensity and age mainly have this effect on foreign manufacturing growth, while "labor skill" has a strong effect on both exports and foreign production.

To normalize for differential market growth the same regressions have also been run with the dependent variable in ratio form, i.e., divided by domestic sales. These regressions are shown in the lower panel of Table 9. The dependent variable now measures foreign growth relative to domestic growth (or the relative change in the propensity to export and to produce abroad).

The influence of especially R&D intensity and skill intensity is hardly changed by this. These variables have practically the same positive effect on the growth of foreign production relative to domestic sales as they have on foreign growth alone, from which one can infer that they have almost no effect on domestic growth.

The estimated coefficient of the age variable has undergone an interesting change. It still has a significantly positive effect on foreign production but it now also has a significantly negative effect on exports. The implication is that YR has a positive effect on both domestic growth and foreign growth but not on export growth.

One interpretation of this finding is in terms of the time pattern of growth. Once the firm has established production abroad, foreign markets tend to be supplied increasingly from foreign production rather than through exports. That is, foreign production and exports are net substitutes.

The result is also consistent with a learning hypothesis in so far that "aging"/learning has a positive effect on both domestic sales growth and foreign production growth. But in view of all the caveats regarding the interpretation of this variable (time trends, sample attrition), that is probably about as much as we can say.

It is noteworthy that the pooled time–series results are in broad agreement with the cross–section results. But in comparing the two one must bear in mind that the time–series analysis refers to a much smaller and rather special group of firms. For one thing, they include all the very large and very old

Table 9

Pooled time–series 1965–1986 for a panel of 28 firms

Dep. var. (log)	Const.	RD	LS	KL	NR	YR	DF	R^2
		Independent variables (log)						
SX+SQ	7.75*** (11.8)	0.22*** (3.2)	1.12*** (5.7)	0.20* (1.8)	0.27 (1.0)	0.44*** (5.0)	107	0.91
SX	6.14*** (8.3)	0.10 (1.4)	1.56*** (7.1)	0.15 (1.2)	0.58* (1.9)	–0.03	107	0.90
SQ	5.17*** (5.6)	0.25*** (2.6)	1.07*** (3.9)	0.19 (1.2)	–0.17	1.10** (8.8)	107	0.88
(SX+SQ)/SH	–3.57*** (–4.2)	0.22*** (2.5)	1.17*** (4.7)	–0.03	–0.58* (–1.7)	0.24** (2.1)	107	0.75
SX/SH	–5.17*** (–6.0)	0.11 (1.2)	1.61*** (6.3)	–0.08	–0.26	–0.24** (–2.0)	107	0.74
SQ/SH	–6.15*** (5.6)	0.25** (2.2)	1.13*** (3.4)	–0.05	–1.02** (–2.2)	0.89*** (6.0)	107	0.80

Regression model:

$\log Y_{it} = (a_o + a_i D_i) + b X_{it}$ .....

i = 1....28 (firms)
t = 1....5 (1965, 1970, 1974, 1978, 1986)
D_i = dummy for firm i

Numbers in parentheses are t–statistics. t < 1 not shown. *, ** indicate significance at the .10 and .05 level respectively. R^2 is corrected for degrees of freedom. Absolute values of variables are in constant prices.

MNE's. For another, they are much more heavily weighted towards traditional engineering industries than are newer MNE's. Consequently, one cannot be sure that the time–series relationship for the small group of firms in Table 9 would hold for other firms as well.

This can be checked in two ways. One is the set of regressions run for the larger number of continuing firms (39) present from 1970. Since the larger number of firms in those compensate for the smaller number of observations over time, they serve as a check on the conclusions drawn from Table 9. Thus, it is reassuring to note that, although there are some differences, they confirm the general picture of Table 9. (See appendix table 2)

Another check is to compare the cross–section results for the small group of continuing firms with those for all firms in Tables 6–8 to determine if the time–series results are due to systematic differences between these groups of firms. Such comparisons reveal that the old and continuing firms are, indeed, different. The only variables which are significant in explaining differences between them in the size of exports and foreign production is skill intensity and age and they are only significant in the foreign production equation. (Cf appendix table 3) This shows that the time–series results are **not** due to the fact that, for example, R&D and skill intensity are particularly important in explaining size differences between these firms. On the contrary, the strong influence of R&D, skill intensity and age over time (in Table 9) emerge even though these variables are not correspondingly influential in cross–sectional analysis of the same firms. This, too, lends more credence to the validity of the estimated time–series relationship.

To conclude: Increased R&D intensity and higher age, in particular, do appear to have a positive effect on the firm's growth over time. A rising skill level and capital intensity, surprisingly, do not, at least not consistently..[7]

But unique firm characteristics that cannot be captured in a simple regression model also play an important role, as seen by the large and mostly significant

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[7]Rising capital intensity is significant in the time–series regressions over the larger number of firms in appendix table 3, but it disappears when the dependent variable is expressed in ratio form. That implies that a higher capital intensity for these firms may have a positive effect on growth but not a differentially higher effect on export and foreign production growth.

firm intercepts (the firm dummies in the time–series regressions). The last question I adress, therefore, is whether differences in growth rates **between firms** can be explained by any of the characteristics that have been looked at. Specifically, the question is whether, for example, old firm or firms with a high R&D intensity, etc, have grown faster than other firms in the period 1965–86.

The short answer is no. Basically, it is not possible to explain in any systematic way differences between firms in rates of growth of exports and of foreign production. The explanatory value of the regressions vary between .25 and 0 depending on what period one looks at. The significance of different independent variables also vary between periods.

The regressions shown in Table 10 can illustrate the inconclusive results. The regressions are pooled cross–sections for all the sub–periods (1965–70, 1970–74, 1974–78, 1978–86). Only the intercepts are remotely significant in the first two regressions. The YR variable is significantly negative in the regression on total foreign sales indicating that old MNE's have had a somewhat slower rate of growth in total foreign sales seen over all the periods. But this does not apply consistently to the individual sub–periods or over the longer periods also tried. Hence, old surviving firms do not show clear signs of sclerosis. But nor is aging – and the associated accumulation of experience – a significant positive influence on growth differences between firms.

Perhaps this is as interesting a result as any. One can, to some extent, explain size differences between firms at different points in time. One can also identify some characteristics which affect the growth of individual firms over time. But one cannot, with any of the same characteristics, consistently explain a significant part of the total variance in growth rates among firms.

And this should come as no surprise to economists unable to consistently predict the fortunes of individual firms either in the stock market or as consultants to industrial policy makers.

Table 10

Pooled cross–sections for 4 sub–periods 1965–86: average annual growth rates of exports and foreign production

Dep. var.	Const.	Independent variables D_t70	D_t74	D_t78	RD	KL	LS	NR	YR	DF	R^2
SX+SQ	0.27	0.14	0.05	0.26	0.62	–0.00	–0.00	0.03	–0.003	245	0.02
	(2.5)	(1.9)		(1.1)					(–2.3)		
SX	0.39	0.12	0.00	0.33	0.40	–0.00	–0.00	–0.06	–0.001	245	0.02
	(3.5)	(1.5)		(1.3)					(–1.0)		
SQ	–0.00	–0.08	0.21	0.22	1.06	–0.00	–0.00	0.53	–0.01	245	–0.0
									(–1.0)		

Regression model:

$$(\Delta Y_t/Y_{t-i})i = (a_o+a_tD_t) + bX_{it} + \ldots\ldots$$

a_o = intercept 1965–70
D_t = dummy for 1970–78, 1974–78, 1987–86
X_t = average value of X in each period

Numbers in parentheses are t–statistics. t < 1 not shown. *, ** indicate significance at the .10 and .05 level respectively. R^2 is corrected for degrees of freedom.

VII. Summary and conclusions

This paper has empirically examined the hypothesis that the multinational size and growth of Swedish firms can be explained by the accumulation of knowledge through R&D and learning–by–doing. It has also investigated the influence of industry characteristics such as different factor proportions and scale economies in production on the size and locational choice of firms able to produce in different countries. Two hypotheses regarding the influence of industry characteristics were juxtaposed. One was the prediction from the factor proportions theory of trade that Sweden's comparative advantage in, e.g., capital and skill intensive industries should favor exports relative to foreign production by firms in these industries. The other was that a learning advantage is especially large in the country's exporting industries, so that foreign production should tend to be relatively large in these industries, too.

The results, briefly, indicate the following. Variables assumed to reflect the accumulation of knowledge – such as R&D intensity, the age of the firm and increased labor skills over time – have a significantly positive effect on the size and/or growth of the firm's exports and foreign production. These results come across in both cross–sectional analysis of size differences between firms and in time–series analysis of firm growth over time.

Factor proportion variables – such as capital, skill and domestic natural resource intensity – tend (when significant) to have a positive effect on the relative size of **both** exports and foreign production in a comparison across firms. Only natural resource intensity has a differentially stronger effect on exports than on foreign production.

This suggests that factor proportions and country differences in relative factor prices are not an important explanation of the location of production by Swedish MNE's. Instead, the characteristics which explain the firm's competitive advantage in exporting also explain the size of its foreign production. This is consistent with the hypothesis that a country's comparative advantage becomes a firm–specific competitive advantage through learning. That knowledge can then be transferred to foreign production through the MNE.

Thus, the implications of the factor proportions theory of trade become less precise in the presence of MNE's. In fact, several results suggest that the "new" theory of international trade is more relevant to the growth of MNE's. One is the significance of R&D intensity. The other is the positive effect of scale economies on the size of both exports and foreign production. A third is the role of the firm's age, indicating the importance of dynamic–historical factors for the firm's current position.

Nevertheless, in explaining differences in growth rates between firms, factors that are unique to individual firms and cannot be captured in simple regression models turn out to be the most important. This is seen both in the high significance of firm dummies in the time–series analysis and even more starkly in regressions on the determinants of differences in growth rates between firms. Essentially, it has not been possible to explain such differences in any consistent way in the periods studied.

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Appendix tables

Table A:1

Pooled cross–sections for individual years 1965–1986

A:1a total foreign sales (log SX + log SQ)

A:1b exports (log SX)

A:1c foreign production (SQ)

Regression model:

$$Y_{it} = (a_o + a_t D_t) + (b_o + b_t D_t) X_{it} \ldots$$

a_o = intercept 1970
D_t = dummy for 1965, 1974, 1978,1986

Table A:1a

Model: MODEL5
Dependent Variable: LSXSQ

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	29	1119.85788	38.61579	18.338	0.0001
Error	423	890.72403	2.10573		
C Total	452	2010.58191			

Root MSE	1.45111	R-square	0.5570
Dep Mean	11.95501	Adj R-sq	0.5266
C.V.	12.13812		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	8.818944	2.19875156	4.011	0.0001
LRD1	1	0.438006	0.13802438	3.173	0.0016
LLS1	1	0.434335	0.56432684	0.770	0.4419
LKL1	1	0.464939	0.22353824	2.080	0.0381
LNR	1	2.208827	0.74209128	2.976	0.0031
LYR2	1	0.600162	0.15810339	3.796	0.0002
DT65	1	-10.147298	5.05764519	-2.006	0.0455
DT74	1	-1.161524	3.98221313	-0.292	0.7707
DT78	1	-6.807037	4.61278554	-1.476	0.1408
DT86	1	2.178000	2.67398971	0.815	0.4158
LRD165	1	-0.317932	0.17986353	-1.768	0.0778
LRD174	1	-0.174857	0.16628980	-1.052	0.2936
LRD178	1	-0.217987	0.18766316	-1.162	0.2461
LRD186	1	-0.033110	0.19144291	-0.173	0.8628
LLS165	1	2.371726	1.52015273	1.560	0.1195
LLS174	1	0.087752	0.97692396	0.090	0.9285
LLS178	1	0.870103	1.09040837	0.798	0.4253
LLS186	1	-0.400454	0.60117924	-0.666	0.5057
LKL165	1	0.478224	0.40453710	1.182	0.2378
LKL174	1	-0.198768	0.30017977	-0.662	0.5082
LKL178	1	0.229106	0.29673366	0.772	0.4405
LKL186	1	-0.285515	0.25425916	-1.123	0.2621
LNR65	1	-0.988988	1.10826764	-0.892	0.3727
LNR74	1	-0.254369	0.97974777	-0.260	0.7953
LNR78	1	-1.458357	0.98858128	-1.475	0.1409
LNR86	1	0.540191	1.09237041	0.495	0.6212
LYR265	1	0.054118	0.22932737	0.236	0.8136
LYR274	1	0.418380	0.21087472	1.984	0.0479
LYR278	1	0.392928	0.21862712	1.797	0.0730
LYR286	1	0.434436	0.21502425	2.020	0.0440

Table A:1b

Model: MODEL6
Dependent Variable: LSX

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	29	1011.97700	34.89576	13.665	0.0001
Error	423	1080.23731	2.55375		
C Total	452	2092.21431			

Root MSE	1.59805	R-square	0.4837
Dep Mean	11.33766	Adj R-sq	0.4483
C.V.	14.09503		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	9.803881	2.42138677	4.049	0.0001
LRD1	1	0.498235	0.15200007	3.278	0.0011
LLS1	1	0.386675	0.62146791	0.622	0.5341
LKL1	1	0.315760	0.24617267	1.283	0.2003
LNR	1	2.894693	0.81723194	3.542	0.0004
LYR2	1	0.317046	0.17411219	1.821	0.0693
DT65	1	-11.505554	5.56975848	-2.066	0.0395
DT74	1	-1.340069	4.38543324	-0.306	0.7601
DT78	1	-2.522162	5.07985444	-0.497	0.6198
DT86	1	1.896339	2.94474529	0.644	0.5199
LRD165	1	-0.370901	0.19807567	-1.873	0.0618
LRD174	1	-0.246186	0.18312753	-1.344	0.1796
LRD178	1	-0.041834	0.20666505	-0.202	0.8397
LRD186	1	0.041737	0.21082752	0.198	0.8432
LLS165	1	2.659341	1.67407622	1.589	0.1129
LLS174	1	-0.229464	1.07584267	-0.213	0.8312
LLS178	1	-0.040188	1.20081797	-0.033	0.9733
LLS186	1	-0.300676	0.66205181	-0.454	0.6499
LKL165	1	0.493480	0.44549862	1.108	0.2686
LKL174	1	0.058636	0.33057456	0.177	0.8593
LKL178	1	0.318055	0.32677952	0.973	0.3310
LKL186	1	-0.231309	0.28000424	-0.826	0.4092
LNR65	1	-1.073581	1.22048559	-0.880	0.3796
LNR74	1	-0.603594	1.07895240	-0.559	0.5762
LNR78	1	-1.091013	1.08868035	-1.002	0.3168
LNR86	1	0.914955	1.20297869	0.761	0.4473
LYR265	1	0.072094	0.25254797	0.285	0.7754
LYR274	1	0.530453	0.23222690	2.284	0.0229
LYR278	1	0.485541	0.24076427	2.017	0.0444
LYR286	1	0.468721	0.23679659	1.979	0.0484

Table A:1c

Model: MODEL7
Dependent Variable: LSQ

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	29	1587.23692	54.73231	19.989	0.0001
Error	423	1158.22082	2.73811		
C Total	452	2745.45774			

Root MSE	1.65472	R-square	0.5781
Dep Mean	10.57987	Adj R-sq	0.5492
C.V.	15.64030		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	5.204431	2.50726514	2.076	0.0385
LRD1	1	0.376016	0.15739100	2.389	0.0173
LLS1	1	0.562516	0.64350927	0.874	0.3825
LKL1	1	0.455498	0.25490358	1.787	0.0747
LNR	1	1.723643	0.84621638	2.037	0.0423
LYR2	1	1.180289	0.18028736	6.547	0.0001
DT65	1	-5.208244	5.76729890	-0.903	0.3670
DT74	1	-0.172618	4.54096967	-0.038	0.9697
DT78	1	-10.209132	5.26001963	-1.941	0.0529
DT86	1	3.603524	3.04918541	1.182	0.2379
LRD165	1	-0.153371	0.20510074	-0.748	0.4550
LRD174	1	0.010861	0.18962244	0.057	0.9544
LRD178	1	-0.359499	0.21399476	-1.680	0.0937
LRD186	1	-0.062141	0.21830485	-0.285	0.7760
LLS165	1	1.463448	1.73345002	0.844	0.3990
LLS174	1	0.549383	1.11399916	0.493	0.6222
LLS178	1	1.757978	1.24340691	1.414	0.1581
LLS186	1	-0.623256	0.68553254	-0.909	0.3638
LKL165	1	0.290666	0.46129895	0.630	0.5290
LKL174	1	-0.570937	0.34229891	-1.668	0.0961
LKL178	1	0.127563	0.33836928	0.377	0.7064
LKL186	1	-0.213252	0.28993504	-0.736	0.4624
LNR65	1	-1.308080	1.26377207	-1.035	0.3012
LNR74	1	-0.022453	1.11721918	-0.020	0.9840
LNR78	1	-2.020485	1.12729215	-1.792	0.0738
LNR86	1	0.144865	1.24564425	0.116	0.9075
LYR265	1	-0.159372	0.26150499	-0.609	0.5426
LYR274	1	0.208407	0.24046320	0.867	0.3866
LYR278	1	0.165676	0.24930336	0.665	0.5067
LYR286	1	0.166043	0.24519496	0.677	0.4987

Table A:2

Pooled time-series 1970–1986 for a panel of 39 continuing firms: growth in exports and foreign production

Dep. var. (log)	Const.	RD	LS	KL	NR	YR	DF	R^2
		Independent variables (log)						
SX+SQ	10.49*** (17.1)	0.20*** (3.0)	0.20 (1.5)	0.35*** (3.7)	0.19	0.50*** (6.5)	112	0.94
SX	9.10*** (13.1)	0.06	0.46*** (2.8)	0.24** (2.2)	0.49 (1.5)	0.10 (1.1)	112	0.93
SQ	7.41*** (7.6)	0.21** (2.0)	0.14	0.37** (2.4)	–0.06	1.16** (9.3)	112	0.90
(SX+SQ)/SH	–0.66	0.26*** (3.0)	0.16	0.02	–0.63* (–1.7)	0.39*** (3.9)	112	0.77
SX/SH	–1.71** (–2.0)	0.13 (1.4)	0.42** (2.1)	–0.09	–0.32	–0.0	112	0.77
SQ/SH	–3.40*** (–3.1)	0.27** (2.3)	0.10	0.04	–0.88* (–1.7)	1.05*** (7.4)	112	0.75

Regression model:

$$\log Y_{it} = (a_o + a_i D_i) + b X_{it} \ldots..$$

i = 1....39 (firms)
t = 1....5 (1965, 1970, 1974, 1978, 1986)
D_i = dummy for firm i

Numbers in parentheses are t–statistics. t < 1 not shown. *, ** indicate significance at te .10 and .05 level respectively. R^2 is corrected for degrees of freedom. Absolute values of variables are in constant prices.

Table A:3

Pooled cross–sections individual years for a panel of 28 firms

Dep. var. (log)	Const.	Independent variables (log)					DF	N	R^2
		RD	LS	KL	NR	YR			
SX+SQ	–2.95	–0.11	4.34** (2.2)	0.18	1.08 (1.1)	0.28 (1.3)	110	140	0.42
SX	–0.79	0.03	3.87* (1.9)	0.24	1.77 (1.7)	–0.08	110	140	0.36
SQ	–10.08 (–1.6)	–0.26 (–1.2)	5.88** (3.0)	–0.08	–0.11	0.79** (3.65)	110	140	0.56

Regression model:

$$\log Y_{it} = (a_o + a_t D_t) + (b_o + b_t D_t) X_{it} \ldots$$

a_o = intercept 1965
D_t = dummy for 1970, 1974, 1978, 1986

The intercepts and coefficients for 1970, 1974, 1978 and 1986 are not shown because they do not deviate significantly (at the .10 level) from the coefficients for 1965 shown in the table.