Industriens Utredningsinstitut
THE INDUSTRIAL INSTITUTE FOR ECONOMIC AND SOCIAL RESEARCH

A list of Working Papers on the last pages

No. 398, 1993

ENTRY AND THE CHOICE BETWEEN GREENFIELD OR TAKEOVER: THE NEGLECTED TECHNOLOGICAL DETERMINANTS

by
Stefan Fölster and Sten Nyberg

November 1993

Postadress
Box 5501
114 85 Stockholm

Gatuadress
Industrihuset
Storgatan 19

Telefon
08-783 80 00
Telefax
08-661 79 69

Bankgiro
446-9995

Postgiro
19 15 92-5

2.92 10.000

Preliminary draft, October 29 1993

Entry and the Choice between Greenfield or Takeover: The Neglected Technological Determinants

Stefan Fölster and Sten Nyberg*

The Industrial Institute for Economic and Social Research
Box 5501, 114 85 Stockholm

Abstract: Previous theories of the determinants of entry have emphasized profit margins, barriers to entry and adjustment costs. Here we show that technological variables may offer more important explanations of the extent of entry and the entrant's choice of starting a greenfield operation or of taking over an existing firm. An empirical test, using a sample of Swedish product markets, confirms that 1) total entry is mainly determined by the degree to which potential entrants have generated technological advances or competence that can be brought to bear upon the market they enter and 2) the choice of entry by greenfield or takeover is mainly determined by the degree to which entrants can make use of the capital stock in existing plants in implementing their technological advance.

Keywords: Entry, greenfield, takeover, technology, oligopoly.

---

*We are indebted to Per Lundborg, Erik Mellander and Gunnar Eliasson for helpful comments. Generous financial support from The Bank of Sweden Tercentenary Foundation is gratefully acknowledged.

1. Introduction

Technological factors may be more important determinants of both the rate of entry and the mode of entry (greenfield or takeover) than previously recognized. Many recent empirical studies seem to show that high profit and growth rates in an industry lead to higher rates of entry. These studies resemble an earlier literature, following Bain (1951), that found a close correlation between profits and industry concentration. As it became increasingly clear that both concentration and the profit rate tend to be simultaneously determined by technological variables this approach grew less popular. This paper argues that the same problem afflicts the entry literature and studies of the entrants' choice between entry by greenfield or by acquisition of an existing firm.

A classic study by Orr (1974) concludes from cross-section estimation that net firm entry is related to industry profit margins and entry barriers. Hause and Du Rietz (1984) propose an alternative theory: rapid market growth induces entry because incumbent firms' costs for adjusting capital stocks may exceed new firms' entry costs.[1] Later studies of greenfield entry generally include industry growth rates as well as profit margins and proxies for barriers to entry as explanatory variables.[2]

These studies, however, tend to ignore technological variables which may give rise to an omitted-variables bias.[3] In fact, we find that variables such as profit margins and industry growth lose much of their explanatory power when our measures of entrants' technological capability are taken in to account. This suggests that neither the structure-conduct-performance paradigm nor the adjustment cost hypothesis provide a complete explanation of the rate of entry. Furthermore, many empirical studies of entry focus narrowly on new firm creation and neglect entry by takeover which also makes them vulnerable to misspecification bias.

---

[1] Using employment growth as a proxy for capital growth they show, in a cross-section analysis, that industries with high employment growth rates have higher gross plant entry rates. This work extends other studies of entry such as Hause (1962), Mansfield (1962), McGuckin (1972), Duetsch (1975), Du Rietz (1975, 1980), and Gorecki (1975).

[2] For example, one line of research has been to examine characteristics of entrants -such as whether entrants are "de novo" or firms already established in other markets (see e.g. Mata, 1993; Khemani & Shapiro, 1986; Schwalbach, 1987).

[3] For instance, wider technological opportunities in an industry may prompt little entry if the new opportunities center around a technology that incumbent firms are best suited to exploit. Conversely, if firms in other industries, or university researchers, are better equipped to exploit the new opportunities then entry may be substantial. Suppose large technological jumps more often originate outside the industry. Since new technological opportunities lead to greater profit margins, industry growth and increased R & D, it would not be surprising to find a correlation between these variables and the rate of entry. Yet this type of analysis would fail to determine the underlying cause of changes in all of these variables.

Industries that they record as having a low rate of entry may simply be those where entry more often has occurred by takeover.

Ultimately the rate of entry is determined by the entrants' individual profit prospects. The profitability of entry is, in turn, jointly determined by a number of factors including market conditions and entrant characteristics. High market profitability indicates favorable market conditions and can be expected to be correlated with the rate of entry. For a very efficient firm entry may, however, be feasible even if market profits are low and vice versa for an inefficient firm. Technological achievements giving the entrant a cost advantage has a direct and exclusive effect on the entrants's profits while, for instance, the benefits of increased market growth are shared with the incumbent firms. Unless the entrant has a cost advantage, quite large growth increases may be needed to induce entry. Furthermore, improved market conditions may be transitory in which case they may not constitute a basis for entry that requires sunk investments. A technological edge can also be temporary but may often be the result of a better R & D capability in which case the lead is more sustainable. Hence, while market profitability and market growth naturally can induce entry in their own right technological factors may be often be decisive, or perceived as decisive, for the entrant.

The mode of entry may differ depending on factors like market concentration, profitability, entrant characteristics like the relative cost level, and the value of an incumbent firm's assets to the entrant. Greenfields and takeovers obviously have quite different effects on an oligopoly market. The former add capacity to the market thereby lowering profits in industries where firms compete in quantities. On the other hand, acquiring a firm is costly and much of the gain from less intense competition accrues to incumbent firms. Salant, Switzer and Reynolds (S-S-R, 1983) analyze a similar tradeoff in a merger context and find that the market power benefits are small unless the merger encompasses a very large fraction of the market. [4] Gilbert and Newbery (1988) examine the choice between greenfield and takeover in a Cournot-Nash model focusing on the role of shark repellents, i.e. ex ante measures to counter takeover attempts, in diverting acquisition attempts to other potential targets. Our

[4] In a Cournot model with linear demand and identical firms they show that mergers, or cartels, must involve at least 80% of the firms to be profitable. Other authors have argued that this result does not obtain in more realistic models. Deneckere and Davidson (1985) find that the incentives to merge are much stronger in industries with differentiated products where firms compete in prices. Furthermore, Perry and Porter (1985) critizise the S-S-R model for not taking capital into account. A merger of two or more firms in the S-S-R model does not result in a larger unit, it just reduces the number of identically sized firms on the market. In the takeover vs greenfield context this critique appears less serious since a takeover does reduce industry capacity as compared to a greenfield.

model is similar in spirit to Gilbert and Newbery's, but focuses instead on cost differences between firms, shifts in market demand, and the compatibility of firm technologies.

In our model entrants are assumed to be able to transfer their technology, and cost level, to the greenfield operation or the acquired firm. The model suggests that unless the entrant can utilize the assets of an acquired firm, thereby reducing the cost of transferring its technology, the "softer competition" aspect of a takeover is not sufficient to make it more attractive that a greenfield. Hence, asset compatibility may be a strong determinant of the mode of entry.

Some empirical studies have analyzed entrants' choice of greenfield vs takeover (e.g. Yip, 1982; Baldwin & Gorecki, 1987; Khemani & Shapiro, 1988). In contrast to these studies we find that the main determinant of the choice of takeover or greenfield is the extent to which an entrant can make use of the capital stock in an existing firm. Other studies have considered multinational firms mode of entry in foreign countries (Dubin, 1976; Stopford, 1976; Zejan, 1990; Andersson, Arvidsson & Svensson, 1992). These studies focus on the characteristics of the entrant and tend to find that large diversified companies more often acquire foreign firms, while R & D intensive firms more often enter by greenfield. Our results suggest that this pattern may be explained by the fact that R & D intensive firms often enter foreign markets with more significant technological advances and therefore have less use for existing firms' capital stock.

Since technological variables are usually difficult to measure we have relied on direct survey questions to entrants (Table 1). The first question captures whether entry was motivated by technological advances that arose outside the product market. Not surprisingly, greenfield entries were more often related to technological advances than takeovers.Questions two and three capture asset compatibility.

Table 1. Survey questions that underlie the technology variables.

		Greenfield-entrants	Takeover-entrants
1. "Was entry partially or entirely motivated by technological advances or competence that could be applied in the entered market?"			
	Yes	84%	45%
	No	16%	55%
2. "What investments costs did you incur in order to implement the technological advances that motivated takeover?"			
Investment costs as a share of Capital Stock		-	14%[1]
3. "What investment costs would you have incurred if you had taken over competitor X in order to implement the technological advances that motivated takeover?"			
Investment costs as a share of X's capital stock		54%[1]	-

[1] Calculated only from respondents that answered yes to question one.

A final point in our study is that empirical studies of entry generally focus on the industry as the unit of observation. An industry however, in the standard statistical classifications, usually contains distinct product markets that often have little in common.[5] Empirical tests at this level of aggregation would certainly fail to distinguish between growth that occurs within a product market and industry growth that occurs because new product markets arise. Here it is shown that the hypothesized relationships are considerably stronger at the product market level than at the industry level.

2. Greenfield vs takeover in a Cournot model

Consider a market with n firms competing in quantities, á la Cournot. There are two stages. First, a potential entrant decides whether to enter the market and which mode of entry to employ. The ownership structure in the market is assumed to stable in that incumbent firms

[5]For example, two industries at the ISIC 4-digit level are "Radio, TV and communication equipment and apparatus" and another is "Electrical industrial machinery and apparatus."

are not about to merge.[6] In the second stage, firms sell the goods they have produced at the equilibrium price, which is assumed to depend linearly on the aggregate supply. This stage could be thought of as summarizing all future periods, given a stable market structure. Furthermore, we assume that marginal costs are constant and that the least efficient technology used in the market is readily available but not efficient enough to allow for entry of a new firm. The profit of a firm, say firm i, in the market is simply given by

$$\pi_i = P(Q)q_i - c_i q_i \qquad (1)$$

where P(Q) is the inverse demand function and Q is the aggregate quantity supplied by the firms. Each firm decide on the optimal, positive, capacity, or quantity to produce, taking the other firms' strategies as given. Furthermore, since firms are only distinguished by their marginal cost level more efficient firms will also be more profitable.

Now, consider a firm pondering whether to enter the market. Entry is normally associated with substantial investments. Establishing a new operation from scratch involves capital-, marketing- and organizational-investments. If the entrant chooses to acquire one of the incumbent firms some of that firm's assets may fit in well with the entrant's technology while others are worthless.[7] The entrant is assumed to be able to transfer its technology, if it is superior to that of the acquired firm, at some cost that depends on the degree of compatibility between the acquiring firm's technology and the capital stock of the target firm. For simplicity we assume that the entrant wishes to implement the same cost level irrespective of the mode of entry. Let the set-up costs that have to be incurred to have a new unit up and running be denoted z_e. Let c_e be the marginal cost of the entrant. The entrant's profit when starting a greenfield is then given by

---

[6]In a Cournot market profits are superadditive implying that all firms in the market have incentives to merge and divide the monopoly profits. Outright monopolization is normally countered by antitrust- or competition-law. Furthermore, as S-S-R show it is not the case that the profit of a merged subset of firms would necessarily exceed the sum of the individual firm profits since the benefits of reduced competition are shared with the firms outside the merging group.

[7]Assets for which there are well functioning secondary markets possess some degree of compatibility whether they are useful to the new unit or not. Specialized investments in machinery or human capital are more difficult to utilize if they are not in tune with the new organization.

An important aspect of takeovers is that it allows the acquirer to enter the market much faster than if a new unit had to be built from scratch. In the model speed considerations could be interpreted as another facet of compatibility in that existing capital is worth more, relatively speaking, when speed is a prime concern.

$$\Pi_{e,GF} = \pi_{e,GF} - z_e \,. \tag{2}$$

In a takeover, the entry cost is assumed to be reduced by a fraction of the acquired firm's assets, λz_j. Entry via acquisition of course also entails the direct cost of purchasing the target firm. Denoting the acquisition price, a_j, the entrant's profit after taking over firm j becomes

$$\Pi_{e,T(j)} = \pi_{e,T(j)} - a_j - z_e + \lambda z_j \,. \tag{3}$$

If one of these expressions, or both, are greater than zero entry is viable. Hence, the entrant prefers takeover to greenfield if the following expression is positive, provided of course that the takeover profit is positive.

$$d = \Pi_{e,T(j)} - \Pi_{e,GF} = \pi_{e,T(j)} - (\pi_{e,GF} + \pi_{j,GF}) + \pi_{j,GF} - a_j + \lambda z_i \tag{4}$$

Letting the inverse demand function be given by P(Q) = k - Q the optimal output of firm i, taking other firms' strategies as given, can be written

$$q_i = k - c_i - Q, \tag{5}$$

where Q is the sum of all firms' output. Thus, summing q_i over i and rearranging

$$Q = \frac{nk - C}{1+n}, \quad where \quad C = \sum_{i=1}^{n} c_i \,, \tag{6}$$

Hence, in equilibrium the profit for the individual firm is given by

$$\pi_i = \left[\frac{k+C}{1+n} - c_i\right]^2 = q_i^2. \tag{7}$$

Substituting (7) into (4) yields an expression for d in terms of the entrant's costs, the other firms' costs, the acquisition price and the compatibility factor. To simplify the analysis we assume that all the incumbent firms are sufficiently efficient to survive a greenfield entry. Let $\bar{c}$ be the cost level that gives an incumbent a zero post-greenfield profit, for given C and ç, and let the number of firms after a greenfield be n and after a takeover n-1.

While there are advantages to acquire an efficient firm it is also more costly. The incumbent firms' profits depend on whether the potential entrant does indeed enter, the mode

of entry – greenfield or takeover, and in the latter case which firm is taken over. The worst outcome, from the incumbent firms' point of view, is a greenfield entry since that stiffens competition the most. Hence, the lowest price shareholders would ever tender their shares for is their firm's post-greenfield value, $a_j = \pi_{j,GF}$. If the entrant can commit to greenfield entry unless its favored target sells then its post-greenfield value is the appropriate price.[8] [9] If not, the price is determined by the properties of the bargaining game played by the entrant and the potential targets. (See Gilbert and Newbery 1988.) If the entrant can elicit competition between the target firms then the highest price the entrant will ever have to pay is the target's pre-entry profits, $a_j = \pi_{j,GF}$. [10] However, in most takeovers the acquiring party pays a premium on the purchased shares suggesting that the price may lie closer to the pre-entry price than the post-greenfield price. We simply assume that the acquisition price, a, is a weighted average of the post-greenfield- and the pre-entry- value.

We now turn to examine in what way the costs of other firms, specifically the costs of a potential target firm, affects the takeover vs greenfield choice. If firms have equal cost and technologies are incompatible the model becomes S-S-R's Cournot example where a greenfield always dominates a takeover of a single firm unless that firm is a monopolist.

Now, suppose firms have different costs. Since firm profits depend only on aggregate cost, C, and the own cost level greenfield profits are independent of the distribution of costs among incumbent firms. Thus, a greenfield entrant is concerned about the level of competition on the market but less interested in the competitiveness of individual firms. The profitability of a takeover does, however, depend on the target firm's cost but is independent of how costs are distributed among other firms. Let the target firm's marginal cost, c_j, be some fraction, γ, of the aggregate cost such that $c_j \in [c_e, \bar{c}]$. The significance of the target firm's marginal cost for the profitability of a takeover can now be examined, for any C.

---

[8]If incumbent firms can be bought at their post-greenfield value a takeover could be viewed as a sequential decision, involving a greenfield stage. Given that the entrant has already opened up a greenfield, will it pay to buy one of the other firms at the market price and shut it down? This is equivalent to asking whether the joint profit of the merged firms exceeds that of these firms' individual pre-merger profits put together.

[9]If a potential target suspects that resistance on its part will merely make entrant acquire another firm (unless they can commit not to sell), rather that enter through greenfield, then its reservation price is as least as high as to make the entrant is indifferent between acquiring the firm and greenfield, and possibly higher.

[10]Suppose the entrant can afford to buy one of the incumbent firms, reimbursing the shareholders with the non-entry profit, and still make a profit. To do this the entrant must be more efficient than the firm it is buying which in turn means that the post-entry profits of the remaining firms have been reduced. Thus, any of these firms would have done better if the raider would have acquired them instead at any price exceeding the post-entry profits.

The likeliehood of the entry modes thus seem to influence the acquisition price which in turn affects the entry mode decision. Losely speaking, greenfield becomes more attractive, and more "probable", the acquisition price would go down increasing the profitability of a takeover and so on and so forth.

Proposition 1: d is strictly concave in the target firm's cost, γ, and has an interior maximum on the interval $c_j \in [c_e, \bar{c}_j]$.

Proof: In appendix.

This suggests that moderately less efficient firms may be the most attractive takeover targets. The attractiveness of takeover as a mode of entry thus depends on the availability of target firms with suitable cost characteristics. Bearing this in mind, we can define an "ideal target" as a hypothetical firm with a cost level that maximizes d. Presumably, what constitutes an ideal target depends on wheter the acquisition price is close to the target's pre-entry or post-greenfield value.

Corollary 1: The higher the aquisition price the less efficient is the ideal target.

Proof: In appendix.

Note that if the acquisition price equals the target's pre-takeover value then entry cannot be profitable unless the entrant has a cost advantage or the market expands, i.e. k increases. Furthermore, unless the buyer can improve firm performance a takeover cannot be profitable. However, that a takeover is viable does not imply that it is more attractive than a greenfield.

Proposition 2: Absent technological compatibility, $\lambda = 0$, (i) greenfield dominates acquisition at pre-entry prices, but (ii) at post greenfield prices acquiring a firm with an intermediate cost level may be more attractive than a greenfield investment.

Proof: In appendix.

This suggests that unless the entrant can acquire the target firm below its current value or that firm's capital stock is valuable to the entrant greenfield is generally a more attractive mode of entry. Acquisitions where the shareholders are offered the current value of the firm, and perhaps a premium on top of that, are in this model attributed to the entrant's ability to exploit the target firm's capital stock. We proceed by stating the intuitively obvious - namely:

Proposition 3: Increased technological compatibility, λ, in a market (i) favors takeovers and (ii) makes more efficient firms more attractive targets.

Proof: (i) The first claim is obvious. (ii) Note that λ enters linearly in the entrant's post-takeover profit. Hence, in any pairwise comparison between potential targets an increase in λ will make acquisition of the more efficient target correspondingly more attractive.

When an entrant brings a fundamentally new technology, or product, to the market the existing capacity is likely to be significantly less interesting, i.e. λ is low. Hence, pioneering high-tech firms should be more prone to expand through greenfield. For higher λ takeovers may be more attractive than greenfield even at pre-entry prices. We conclude this section with examining the effects of market demand, k, and the entrant's costs, c_e, on the choice of entry mode.

Proposition 4: Increased market demand, k, makes greenfields (acquisition of an ideal target) relatively speaking, more profitable at pre-entry (post-greenfield) prices.

Proposition 5: Lower entrant costs, c_e, makes greenfields (acquisition of an ideal target) relatively speaking, more profitable at pre-entry (post-greenfield) prices.

Proofs: In appendix.

Clearly, increased market demand as well as lower entrant costs makes entry more profitable. The effect on the entry mode decision, however, depends on the pricing assumption. Pre-entry prices are more favorable to greenfields than are post-greenfield prices and vice versa for takeovers. Both increased market demand and lower entrant costs reinforce these differences in relative profitability. So, if firms are priced at their pre-entry value the effect is that greenfields become relatively more profitable. However, in the absence of technological compatibility greenfields dominate takeovers at pre-entry prices. Provided there is some variability in technological compatibility it seems likely that this may be a more important factor in determining the mode of entry at pre-entry prices.

3. Empirical analysis

There has been a vivid discussion of alternative entry measures - such as the absolute number of firms (Khemani & Shapiro, 1986) - and there is currently no agreement on which measure is best. Here entry is measured by the ratio of employment in new firms, not previously established on the product market before or firms taken over by an entrant at the end of a period, to total industry employment at the beginning of the period. Since entry occurs in two varieties, greenfield and takeover, we have two entry measures, E_g and E_t.[11] [12] [13]

As dependent variables in estimation we use total entry $E = LN(E_g + E_t)$ and the proportion of greenfield entry $G = LN(E_g/(E_g + E_t))$. In each regression the dependent variable is a vector of 218 observations, each from one product market. The product markets are a representative selection from Swedish industry in 1990.[14] The data were collected for a time period of 15 years from 1976 to 1990. The definition of product markets starts at the ISIC seven digit-level, and then groups products together into one product market if they are closely related in the sense that they can be produced using largely the same machinery and skills.[15] For each product market all Swedish firms are accounted for, including firms that enter during the 15-year period (1976-1990) for which data were collected.[16] The variables are described in table 2.

Most studies use a larger number of explanatory variables. Here we focus on the variables that are used in nearly all studies (product market growth, profit rate, minimum firm size and R & D intensity) in order to show how these interact with our technological

---

[11] The results could be affected by the fact that entry is weighted by employment. Presumably an entrant taking over a firm may take over many more employees than he would employ if he started a greenfield operation. To check this we analyzed entry also at the firm level, estimate a logit model with greenfield and takeover taking the values 0 and 1 respectively. This led to quite similar results.

[12] Greenfield here encompasses both firms that actually build a new plant and firms that have existing plants (that produce for other product markets), but that make significant new investments in machines and marketing channels in order to enter the new product market.

[13] Unity is added to the number of entrant employees before calculating E_g and E_t. This follows a procedure suggested by Khemani and Shapiro (1986) in order to deal with industries in which no entry occurred.

[14] The data were collected from two surveys conducted at the Industrial Institute for Economic and Social Research in Stockholm, the Planning survey conducted by the Federation of Swedish Industry, companies' annual reports, company registration records and the cartel register. A more detailed description of the database is available in Fölster & Peltzman (1993).

[15] As an example, different kinds of aluminum profiles would fall into one product market, while different types of software would not.

[16] In total 626 are in the database. There are 132 greenfield entrants and 194 firms are affected by takeover.

variables. Table 2 also shows the signs of coefficients our theoretical reasoning would lead us to expect.

Each variable represents an average over a number of years. For the initial OLS regressions the variables are 15-year averages. For subsequent first-difference regressions the variables are seven-year averages. The point of using averages of fairly long time periods is to capture the employment effect that entrants generate in the years subsequent to entry. Such simple OLS regressions are shown in table 3, but they should be treated with caution. For these regressions all variables are in logs which is possible here since all variables are positive.

Table 2. Variables and descriptive statistics.

Variable	Description	Mean	Std dev	Total entry	Greenfield
E_t	Share of employees in percent affected by entry by takeover, per annum.	5.1	5.6		
E_g	Share of employees in percent in greenfield entrant firms, per annum.	2.7	2.8		
PG	Product market growth as index of new employees relative to initial level 100.	106.9	3.45	+	+
PM	Profit rate[17]	0.23	0.46	+	+
MF	Minimum firm size[18]	115.6	122.1	-	?
RD	R & D intensity as percent of value added.	4.15	3.11	?	?
TA	Entry motivated by technological advance.	0.32	0.39	+	?
TC	Entrant's need to invest, lack of compatibility with existing firms' capital stock	0.64	0.43	?	+

Simple OLS regressions seem to confirm the hypothesis that technological shifts are more important than profits, entry barriers or adjustment costs in explaining the relationship between entry and growth. In regression (2) and (4) the explanatory variables profit margin, employment growth and R&D-intensity lose much of their size and significance when the technology variables TA and TC are included.

[17] Gross rate of return for the product market. This is calculated as the total activity value added less wages and salaries divided by the product market capital stock.

[18] Average number of employees of entrants during their first two years.

Naturally a variety of econometric issues such as heteroscedasticity, unobservables and measurement error arise. The use of ratios (entry employment to total employment) has the advantage of minimizing heteroscedasticity since all variables are normalized by size. Heteroscedasticity is partly due to the fact that the entry ratios are constrained to be positive, and in part due to the fact that a smaller number of product markets have very high growth rates. This problem could be addressed with regression methods that correct for heteroscedasticity, for example using Harvey regression as Hause and DuRietz (1984) do.

Table 3. OLS regression parameter estimates for new firm entry.

	Dependent variables			
Independent variable	(1) E	(2) E	(3) G	(4) G
Constant	0.26** (0.036)	0.27** (0.026)	-0.17* (0.03)	-0.19** (0.025)
PG	0.54** (0.14)	0.13* (0.08)	0.25** (0.09)	0.001 (0.014)
PM	0.41** (0.11)	0.11* (0.07)	-0.06 (0.09)	-0.05 (0.10)
MF	-0.07 (0.12)	-0.06 (0.1)	-0.35** (0.09)	-0.15* (0.08)
RD	0.02 (0.9)	0.06 (0.08)	0.15** (0.04)	0.005 (0.03)
TA	-	1.83** (0.09)	-	0.01 (0.14)
TC	-	0.4 (0.3)	-	2.1** (0.15)
R^2	0.47	0.68	0.58	0.71

Note that* and ** indicate significance at the 10% and the 5% percent level respectively.

Another possibility of partially solving the problem would be to use a Tobit analysis on firm level data.[19] These approaches, leave other, even more important problems unsolved. In fact, studies of entry have generally ignored problems of unobservable fixed industry

[19] Mata (1993) has not discovered any remaining heteroscedasticity after using Tobit in his data of entry rates in Portugal. Possibly this can be explained by the fact that most product markets in Portugal are growing rapidly leading to a more even inflow of greenfield entry.

effects. Here we can address this problem because we have been able to divide the sample period into two periods of seven years each, Using differenced estimates removes the fixed industry effects that are usually cause problems in cross-section analysis.

Further, all variables must be expected to contain some measurement error. This could be due to reporting error or time aggregation effects, but it can also be due to the heterogeneity across product markets in the sample. Errors due to the heterogeneity of the data sample can, to the extent that they are permanent and additive be controlled for by using differenced estimates which remove fixed firm effects. Pure data recording errors should be less of a problem because the employment figures we use tend to be quite accurate. We could use an instrumental variable approach using lagged independent variables as instruments, but this would also remove the contemporaneous correlation between entry and growth. This contemporaneous relationship between entry and growth as well as other independent variables is clearly a simultaneous effects. Trivially, greenfield entry adds to growth directly, although that may be offset by other firms exiting. More significantly, entrants presumably often enter because they have product or productivity-increasing ideas. Thus entry is likely to stimulate growth regardless of whether it occurs as greenfield investment or as a takeover. The simultaneity is however not a major problem here since our main aim is to show that the correlation between growth and entry is significantly affected by taking account of exogenous technological variables.

To ameliorate the problems discussed we estimate regressions with the variables specified as first differences between two time periods, 1977-1983 and 1984-1990. The equation estimated then has the following form

$$\Delta E = a_0 + \sum_{i=1}^{8} a_i \Delta x_i + u$$

In this specification a Breush Pagan Lagrange multiplier test indicates that heteroscedasticity disappears altogether. Table 4 shows the estimated coefficients. Further a Hausman type test indicates that the relationships in regressions (2) and (4) are not misspecified, while the regressions (1) and (3) are rejected. This confirms that ignoring technological variables biases the results.

Table 4. OLS regressions - first differences.

Independent variable	Dependent variables (1) ΔE	(2) ΔE	(3) ΔG	(4) ΔG
Constant	0.03 (0.026)	0.07* (0.0048)	-0.02 (0.03)	-0.09* (0.025)
ΔPG	0.26* (0.21)	0.14 (0.09)	0.13* (0.012)	-0.004 (0.016)
ΔPM	0.23* (0.18)	-0.02 (0.011)	-0.05 (0.11)	0.03 (0.13)
ΔMF	-0.12 (0.25)	0.08 (0.19)	-0.15 (0.19)	-0.05 (0.17)
ΔRD	-0.04 (0.21)	0.01 (0.18)	0.10 (0.07)	0.02 (0.08)
ΔTA	-	1.53** (0.14)	-	0.06 (0.12)
ΔTC	-	0.22 (0.41)	-	1.61** (0.29)
R^2	0.27	0.39	0.24	0.43

Finally, table 5 shows the consequences of using product markets rather than industries as the unit of observation. The product markets in our sample come from 22 industries at the ISIC four-digit level. Aggregating our product markets within each of these industries yields the results shown in table 5 in levels and first differences. Clearly the correlations are much weaker. In first differences nothing is significant, although the coefficients are of the right sign.

Table 5. OLS regression at the industry level.

Independent variable	Dependent variables (1) E	(2) G	(3) ΔE	(4) ΔG
Constant	0.21**	0.12*	0.03	-0.01
	(0.10)	(0.04)	(0.03)	(0.020)
PG	0.16*	0.02		
	(0.10)	(0.04)		
PF	0.13*	0.04		
	(0.08)	(0.06)		
MF	-0.07	-0.15		
	(0.14)	(0.16)		
RD	0.06	0.07		
	(0.07)	(0.08)		
TA	0.62**	0.06		
	(0.22)	(0.09)		
TC	0.33	0.88**		
	(0.29)	(0.25)		
ΔPG			0.07**	-0.01
			(0.011)	(0.016)
ΔPF			-0.02	0.08
			(0.21)	(0.26)
ΔMF			-0.04	0.001
			(0.051)	(0.032)
ΔRD			0.005	0.01
			(0.07)	(0.08)
ΔTA			0.33*	0.09
			(0.23)	(0.25)
ΔTC			0.11	0.64**
			(0.24)	(0.27)
R^2	0.29	0.21	0.24	0.19

4. Conclusions

We have argued that it is plausible that technological aspects may be more important determinants of entry that what seems to have been previously recognized. Furthermore, our simple model of the choice of entry mode indicates that technological compatibility may play a significant role in this decision, especially if acquisition prices are high, in the sence that an entrant must pay the target firm's pre-entry value or even a premium.

The empirical analyses confirm that technological variables are important determinants of both the rate of entry and the choice of entry by greenfield or takeover. The regressions show that ignoring these variables can significantly bias the results. Total entry is primarily affected by the degree to which outsiders acquire technology that can be implemented in the market they enter. The choice of entry by takeover or greenfield is primarily determined by the degree of technological compatibility between incumbents' capital stock and the technology that the entrant plans to implement.

This suggests that much of the empirical literature on entry may need to be reexamined. Certainly interpretations of results in many studies that high profits or high growth cause a higher rate of entry would seem to be much exaggerated.

References

Andersson, T., Arvidsson, N. and Svensson, R. Reconsidering the choice between takeover and greenfield operations, Industriens Utredningsinstitut, Working paper no. 342, 1992.

Bain, J. Relation of profit rate to industry concentration: American manufacturing, 1936-1940, Quarterly Journal of Economics, 65, 1951.

Baldwin, J. and P. Gorecki, Plant creation versus plant acquisition: The entry process in Canadian manufacturing, International Journal of Industrial Organization 5, no.1, 27-41.

Deneckere, R. and C. Davidson, Incentives to form coalitions with Bertrand competitionRand Journal of Economics, 1985, 16, 473-486.

Dubin, M. Foreign Acquisitions and the Spread of the Multinational Firm, D.B.A. thesis, Graduate School of Business Administration, Harvard University, 1977.

Duetsch, L. L. "Structure, Performance and the net rate of entry into manufacturing industries." Southern Economic Journal, 1975, 41, 450-56.

Du Rietz, G. Etablering, Nedläggning och Industriell Tillväxt i Sverige, 1954-1970 Stockholm, Industriens Utredningsinstitut, 1975.

Du Rietz, G. Företagsetableringarna i Sverige under Efterkrigstiden Stockholm, Industriens Utredningsinstitut, 1980.

Fölster, S. and S. Peltzman, The social cost of regulation and lack of competition in Sweden, IUI working paper, 1993.

Gilbert, R. and D. Newbery, Entry, acquisition, and the value of shark repellent, U.C. Berkeley WP 8888, 1988.

Gorecki, Paul K. "The determinants of entry by new and diversifying enterprises in the U.K. manufacturing sector, 1958-1963: Some tentative results."Applied Economics, 1975, 7, 139-47.

Hause, J. and G. Du Rietz, Entry, industry growth, and the microdynamics of industry supply, Journal of Political Economy, 1984, 92, 733-757.

Hause, J. C. " Entry, industry growth, and microdynamics of industry supply."Journal of Political Economy, 1984, vol.92, no.4, 733-757.

Khemani, R. and D. Shapiro, The determinants of new plant entry in Canada, Applied Economics, 1986, 18, 1243-1257.

Khemani, R. and D. Shapiro, On entry and mobility barriers,Antitrust bulletin, 1988, 115-132.

Mansfield, E."Entry, Gibrat's law, Innovation, and the growth of firms." American Economic Review, 1962, 52, 363-70.

Mata, J. "Entry and type of entrant: Evidence from Portugal." International Journal of Industrial Organization, 1993, 11, 101-122.

McGuckin, R. "Entry, concentration change, and stability of market shares." Southern Economic Journal, 1972, 38, 363-370.

Orr, D. "The determinants of entry: A study of the Canadian manufacturing industries." Review of Economics and Statistics, 1974, 56, 58-66.

Perry, M. and R. Porter, Oligopoly and the incentive for horizontal merger, American Economic Review, 1985, 75, 219-227.

Salant, S., Switzer, S. and R. Reynolds, Losses from horizontal merger: The effects of an exogenous change in industry structure on Cournot-Nash equilibrium,Quarterly Journal of Economics, 1983, 48, 185-200.

Schwalbach, J., Entry by diversified firms into German manufacturing industries, International

Journal of Industrial Organization, 1987, 5, no.1, 39-49.
Stopford, J.M. Changing perspectives on investment by British manufacturing multinationals, Journal of International Business Studies, 1976, 7, 15-27.
Yip, G., Barriers to entry: A Corporate Strategy Perspective, Lexington Books, Lexington, MA, 1982.
Zejan, M.C. New ventures or acquisitions. The choice of Swedish Multinational enterprises, Journal of Industrial Economics, 38, 349-355.

4. Appendix

Proof of Proposition 1: Letting $c_j = \gamma C$ d can be written

$$d = \left[\frac{k+(1-\gamma)C}{n} - c_e\right]^2 - \left[\frac{k+C}{n+1} - c_e\right]^2 - \alpha\left[\frac{k+C-c_e}{n} - \gamma C\right]^2 - (1-\alpha)\left[\frac{k+C}{n+1} - \gamma C\right]^2 \quad \text{(A1)}$$

where $\alpha = 0$ represents post-greenfield and $\alpha = 1$ pre-entry prices. Straightforward differentiation yields

$$\frac{\partial d}{\partial \gamma} = 2C\left[-\frac{1}{n}\left(\frac{k+(1-\gamma)C}{n} - c_e\right) + \alpha\left(\frac{k+C-c_e}{n} - \gamma C\right) + (1-\alpha)\left(\frac{k+C}{n+1} - \gamma C\right)\right] \quad \text{(A2)}$$

and

$$\frac{\partial^2 d}{\partial \gamma^2} = 2C^2\left[\frac{1}{n^2} - 1\right] < 0 \quad \text{(A3)}$$

which establishes concavity. Evaluating d and its first derivative in $c_j = c_e$ and $c_j = \bar{c}_j$ (the highest c compatible with positive output) we see that the first derivative in $c_j = c_e$ is strictly positive whereas the others are strictly negative. Hence, there is a unique interior maximum□

Proof of Corollary 1: Using the first order condition, (A2) equal to zero, the effect of α on γ can be derivid implicitly. Differentiating (A2) with respect to α yields

$$\frac{\partial^2 d}{\partial d \partial \alpha} = 2C\left[\frac{k+C-c_e}{n} - \gamma C - \left(\frac{k+C}{n+1} - \gamma C\right)\right] = \frac{2C}{n}\left(\frac{k+C}{n+1} - c_e\right) > 0\,. \quad \text{(A4)}$$

Since (A3) is negative the the effect of α on γ is positive. □

Proof of Proposition 2: (i) The maximum of d at pre-entry prices, i.e. $\alpha = 1$, is obtained by setting (A2) equal to zero and substituting it into (A1). This can be shown to be strictly negative. (ii) Repeating the same procedure for $\alpha = 0$ yields that there are γ such that d is positive. □

Proof of Proposition 4 and 5: The derivative of d with respect to k, given $\alpha = 1$, can be after some rearrangement be written as

$$\frac{\partial d}{\partial k} = \frac{2}{n^2(n+1)}\left[(n^2-1)(c_j - c_e) - n^2\left(\frac{k+C}{n+1} - c_e\right)\right] < 0$$

It is negative since c_j must be less than (k+C)/(n+1) in order for firm j to have a positive output after a greenfield. Now, consider $\alpha = 0$. Using that (A2) equals zero for and ideal target the corresponding derivative can now be expressed as

$$\frac{\partial d}{\partial k} = \frac{2}{n^2}\left[\frac{k+C}{n+1} - c_j\right] > 0.$$

Similarly, the derivative of d with respect to ç is given by

$$\frac{\partial d}{\partial c_e} = 2\left[\left(\frac{k+C-c_j}{n} - c_e\right)\left(\frac{1}{n} - 1\right) - \left(\frac{k+Cj}{n+1} - c_e\right)\left(\frac{1}{n+1} - 1\right) - (1-\alpha)\left(\frac{k+C}{n+1} - c_j\right)\left(\frac{1}{n+1}\right)\right]. \quad \text{(A7)}$$

The marginal cost of the ideal target when $\alpha = 1$ can easily be shown to be $c_j = (n+1)(k+C)$. Using this and insering $\alpha = 1$expression (A7) can be demonstrated to be strictly positive. Proceeding the same way for $\alpha = 0$, i.e. using the first order condition for the ideal target, it is straigthforward to show that (A7) now is strictly negative.□