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THE CHOICE OF ENTRY BY GREENFIELD OR TAKEOVER

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The Choice of Entry by Greenfield or Takeover

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Abstract

An entrepreneur or a firm entering a new market has a choice of setting up a greenfield operation or of taking over a firm already in the market. Recent models of this choice have assumed that takeover occurs at a price set as a function of either incumbents' pre-entry profits or post-entry profits or, by some bargaining process, inbetween those. In this paper the takeover price is modelled endogenously, assuming the target firm is efficiently evaluated by a competitive stock market. This gives rise to a highly nonlinear relationship between the probability of entry by takeover and explanatory variables such as the entrant's technological advantage, technological compatibility and the degree of incumbents' precommittment in entry-deterring investments. The non-linear relationship is confirmed empirically using data on a sample of Swedish product markets. The results imply that entrants are most likely to enter by takeover if they have a small to medium level of technological advantage over incumbents, while entry by greenfield is more likely if the entrant has either a very large technological advantage or a large disadvantage.

1. Introduction

An entrepreneur or a firm entering a new market has a choice of setting up a greenfield operation or of taking over a firm already in the market. These two choices are often close substitutes. Takeover has the advantage of eliminating a competitor and allowing entry without creating excess capacity in the market. On the other hand greenfield investment may be a better choice when the entrant's technology is not compatible with incumbents' capital stock, or when the takeover price is too high. In this paper entrants' choice of greenfield or takeover is analyzed, taking account of an endogenously determined takeover price, entry deterring investments by the incumbent, and the level and compatibility of the entrant's technology compared to the incumbents'.

With a few exceptions entry and takeover have been treated as entirely separate questions in much of the industrial organization literature. Studies of entry generally focus on entry by firms starting greenfield operations in a new industry [1], while takeover studies tend to focus on takeover within a product market, or on the implications of takeover for the principal-agent relationship between owners and managers.

A few theoretical studies have considered the choice of entry by takeover or greenfield.[2] Gilbert and Newbery (1988) focus on defensive tactics of the incumbent firms in a Cournot-Nash model. A similar model is developed in Fölster and Nyberg (1993) where the effects of cost differences between firms and compatibility of firm technologies are analyzed. In general these models construe the takeover price of the incumbent as a function of pre-entry profits, post-entry profits, or some weighted average of these. Only

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[1] For example Orr (1974), Hause and Du Rietz (1984), Gorecki (1975) and Mata (1993).

[2] In a related literature Salant, Switzer and Reynolds (1983), Deneckere and Davidson (1985), and Perry and Porter (1985) examine merger and acquisition decisions under different technological and competitive conditions. The tradeoffs involved in a firms' decision to acquire a competitor bears some similarity to those involved in the choice of entry by greenfield ortakeover.

Fölster and Nyberg fully consider the implications of varying levels of an entrant's technological advantage and technological compatibility with an incumbent's capital stock.

The model analyzed in this paper starts from the observation that both takeovers and greenfield investments in practice take considerable time - sometimes years - to complete. Entrants incur considerable costs investigating a takeover target or planning a greenfield site. Then they start acquiring shares, but usually some time elapses before they gained control. Entrants may even pursue both takeover and greenfield simultaneously. At some point in the decision process they settle on either greenfield or takeover.

During this transaction period the incumbent has time to react with defensive measures. Gilbert and Newbery (1988) analyze the consequences of shark repellents, such as wage increases to employees, implemented by the incumbent to deter takeover. Here, instead, the incumbent's pre-committment to strategic investments is modelled - such as signing orders for new production capacity - that makes both takeover and greenfield investment less profitable for the entrant. While Gilbert and Newbery show that "weak" shark repellents sometimes increase share-holders profits, our model implies that pre-committment to strategic investment nearly always is in the shareholders interest.

The analysis implies a highly non-linear relationship between the probability of entry by takeover and explanatory variables such as the entrant's technological advantage and technological compatibility with the incumbent's capital stock. Greater technological compatibility trivially increases the likelihood of takeover. For medium levels of compatibility entrants are most likely to enter by takeover if they have a small to medium level of technological advantage over incumbents. In this case takeover has a synergic effect on the industry and the cases the sum of n+1 firms' profits would be smaller than the sum of n firms' profits. Entry by greenfield is more likely if the entrant has either a very large technological advantage or a large disadvantage since a takeover in these cases does not lead to higher industry profits than greenfield entry.

Some empirical studies have analyzed entrants' choice of greenfield vs takover (Yip, 1982; Baldwin & Gorecki, 1987; Khemani & Shapiro, 1988; Fölster & Nyberg, 1993). These studies generally take the choice of entry mode to be a linear function of explanatory variables. We show here that neglecting non-linearities significantly affects the results. A non-linear probit model is estimated and compared to linear specifications using a non-nested test.

Only one of the previous empirical studies, by Fölster & Nyberg (1993), analyze the role of technological compatibility and technological advantage that are found to be important even in this study.

The empirical analysis performed here is made possible by an unusually detailed dataset on a sample of Swedish manufacturing industry using product markets rather than industries as the unit of observation. Industries, in the standard statistical classifications, usually contain distinct product markets that often have little in common. For example, two industries at the SNI 4-digit level are "Radio, TV and communication equipment and apparatus" and another is "Electrical industrial machinery and apparatus." Empirical tests at this level of aggregation miss much information on the product market structure and, as shown in Fölster & Nyberg (1993), can lead to biased coefficient estimates.

2. Theory

The Model of New Entry

Initially a Cournot market is assumed with only one incumbent firm and one entrant. The entrant decides whether to establish a new firm or to take over the existing one. The incumbent chooses the pattern of competition prevailing in the industry after the new firm is established. It takes advantage of its monopoly position and can precommit to a particular output level, thus becoming a Stackelberg leader. The incumbent can also adopt a non-precommitment strategy and will then - if the entrant chooses greenfield - play a Cournot duopoly game.

A takeover is realized on the competitive stock market which estimates firms' value efficiently, according to expected future profits. The expected profitability depends on both firms' choice of strategy.

Firms play a two-stage game. During the first stage they make strategic decisions about the mode of new entry and the pattern of competition. During the second stage either both firms compete as duopolists or the entrant has, by takeover, become a monopolist.

It is assumed that the entrant and the incumbent make their strategic decisions simultaneously. This reflects the common experience that a takeover, and even more so a greenfield investment, takes time, sometimes years, giving the incumbent ample time to indulge in entry-deterring investment. When the entrant begins buying shares he will not know how much entry-deterrence the incumbent will have invested in by the time takeover is completed, in particular since some types of entry deterrence, such as signing an order additional production machinery, can be installed quickly. This is consistent with the observation that takeovers are frequently initiated but not completed.

Vice versa the incumbent has to decide whether to precommit without knowing for certain whether the takeover will be completed.

This situation is in our judgement best modelled as a simultaneous game, allowing firms to play mixed strategies. However, several alternative approaches lead to similar results. Although not shown in detail we delineate the outcome of two other approaches: A) a sequential model where the incumbent decides first whether to precommit and the entrant then decides whether to take over, and B) a multistage model where the entrant and incumbent make a simultaneous decision at each stage to add an incremental investment in takeover/greenfield or precommitment.

The following notation is used: M_e is the present value of future (ex-post) monopoly profits of the taking over firm; D_e^c and D_i^c are duopoly present values of future profits of the new and old firms, respectively, under Cournot competition. If the incumbent precommits and the entrant starts a greenfield operation then the incumbent is assumed to assume the role of Stackelberg leader. D_e^s and D_i^s are the present values of future duopoly profits of those firms in the Stackelberg game; S is the market value of the existing firm, $S = S_1$ in the case of non-precommitment, and $S = S_2$ in the opposite case. The first-stage game is represented in matrix form as:

	Precommitment	Non-precommitment
Take over	M_e - S, S	M_e - S, S
Greenfield	D_e^c, D_i^c	D_e^s, D_i^s

The probability of takeover by the entrant is p and the probability of precommitment by the incumbent is q. The efficient pre-entry stock market price of the targeted firm is equal to the expected market value

$$S = pM_eq + pM_e(1-q) + (1-p)D_i^sq + (1-p)D_i^c(1-q). \tag{1}$$

If the existing firm plays pure strategies, it is evaluated as $S = S_1 = pM_e + (1-p)D_i^s$ or $S = S_2 = pM_e + (1-p)D_i^c$.

If the parties play mixed strategies, their expected payoffs are:

$$\Pi_e = p(M_e - S) + (1-p)D_e^sq + (1-p)D_e^c(1-q), \tag{2}$$

$$\Pi_i = pS + (1-p)D_i^sq + (1-p)D_i^c(1-q). \tag{3}$$

For simplicity it is assumed that both existing and entering firms use linear technologies with no scale effects. The unit cost of the incumbent is denoted c_i and the ex-ante unit cost of the entrant is c_e. The parties are supposed to be perfectly informed about unit costs in the various outcomes of the game.

Technological compatibility is defined in terms of a difference between ex-ante and ex-post technologies of the entering firm in the case of takeover. The former exists as a blueprint knowledge, while the latter is materialized in the incumbent firm's production equipment. The outcome is determined by the degree of technological compatibility, which, in turn, depends on the flexibility of existing technology. If greenfield entry was decided, the ex-post technology of this firm is identical to the ex-ante technology.

The ex-post unit cost of the taking-over firm is represented by the linear combination: $c_e' = \alpha c_e + (1-\alpha)c_i$, where α is the compatibility parameter.

The inverse demand function is also known to both firms. It is linear in total output X: $a - (b/2)X$, where a and b are positive parameters, the former exceeding the unit costs of the firms. One can show that given these assumptions, the second-stage profits of the firms supplying the market with positive quantities of goods are:

$$M_e = (a - c_e')^2/2b, \tag{4}$$

$$D_e^c = 2(a - 2c_e + c_i)^2/9b, \tag{5}$$

$$D_i^c = 2(a - 2c_i + c_e)^2/9b, \tag{6}$$

$$D_e^s = (a - 3c_e + 2c_i)^2 /8b, \tag{7}$$

$$D_i^s = (a - 2c_i + c_e)^2/4b = (9/8)D_i^c. \tag{8}$$

Define the ratio $\lambda = (c_i - c_e)/(a - c_i)$, $\lambda \in R$, as a measure of entrant's technological advance. It is the easy to show that there is no zero output in the second-stage game, if λ belongs to the interval (-1/3, 1). To simplify the model we do not consider the values of λ beyond this interval.

The model solution

Firms simultaneously maximize their expected first-stage profits (2) and (3) with respect to p and q, subject to the market efficiency condition (1). Denote expected duopoly payoff, given that the entrant plays the greenfield strategy, as $D_e = qD_e^s + (1-q)D_e^c$ and $D_i = qD_i^s + (1-q)D_i^c$.

Consider the set of λ satisfying the following condition:

$$M_e > D_i + D_e. \tag{9}$$

This means that it is more beneficial for the entrant to buy the incumbent firm at the lowest price $S = D_i$ than to make greenfield entry. Another interpretation is that takeover investment yields some synergic effect to the industry: monopoly profit of the entering firm must be higher than total expected profits of the duopolists.

Given that the incumbent plays strategy q* and parameter λ satisfies (9), the entrant chooses mixed strategy

$$p^* = [1 - D_e/(M_e - D_i)]/2. \tag{10}$$

When the entrant expects zero profit from the greenfield entry, $D_e = 0$, he simply "drops the coin": $p^* = 1/2$. If $D_e > 0$, the probability of takeover is the product of 1/2 and the net return from takeover $(M_e - D_i - D_e)/(M_e - D_i)$. From (4) - (8) and (10) it is:

$$p^* = p(\lambda,\alpha,q^*) = \frac{1}{2}[1 - \frac{9(1+3\lambda)^2-(17\lambda^2-10\lambda-7)(1-q^*)}{36(1+\alpha\lambda)^2-2(1-\lambda)^2(8+q^*)}] \tag{11}$$

Thus, condition (9) means that the entrant chooses takeover with some probability. In the earlier theoretical studies referred to above (e.g. Gilbert & Newbery, 1988) conditions similar to (9) implied a certain takeover decisions.

If (9) does not hold and λ satisfies: $M_e > D_i$, the entering firm plays the pure strategy: $p^* = 0$. Note that condition (9) is sufficient but not necessary for the positivity of the probability of takeover. If λ belongs to the interval such that $D_i - D_e < M_e < D_i$, the entrant chooses the pure strategy $p^* = 1$. In this case technological disadvantage is consistent with choosing to acquire the existing firm. In what follows we do not consider these situations and focus only on the values of λ which satisfy (9).

The existing firm simultaneously chooses q^* maximizing Π_i. Since after some manipulations $\Pi_i = p^2M_e + (1-p^2)D_i$, the optimal strategy is leadership precommitment, that is $q^* = 1$. Thus it is always better for the incumbent firm to play the Stackelberg game against any mixed strategy of the entering firm. As an example, equation (10) in this case and for $\alpha = 1$ is (see fig.1):

$$p^* = [1 - D_e^s/(M_e - D_i^s)]/2 = [1 - (1+3\lambda)^2/2(\lambda^2+6\lambda+1)]/2 \qquad (12)$$

At this point it may be useful to delineate som alternative modelling strategies. One argument that can be made is that the entrant often knows whether the incumbent makes a precommitment when the final choice between takeover and greenfield is made. This could be modelled as a sequential game where the incumbent makes the first move. The entrant observes the decision of the incumbent and chooses the probability of takeover maximizing the expected profit (2) given that q^* equals 0 or 1. In this case the reaction function of the entrant is as (11) with $q^* = 0$ or 1. At the first step of the first-stage game the incumbent chooses a pure strategy, providing there is a maximum to the expected profit (3) conditional on the reaction function of the entrant.[3]

Returning to our simultaneous decision model, there are several ways to change the model so that both firms use mixed strategies. The most

[3] We could also consider a model with a finite or infinite sequence of simultaneous games at the first stage in the spirit of Committee Game of Farrell and Saloner (1988). At each step of this multistage game the sides negotiate about the sales price making at the same time small incremental investment in takeover/greenfield or precommitment (hiring of new employees, R&D, marketing and so forth). Farrel and Saloner show that this type of model leads to qualitatively similar outcomes as the one-shot simultaneous game.

straightforward approach is to impose external restrictions on precommitment. Suppose that parties are represented by two populations of firms and there is an upper bound on the probability of precommitment $q \leq q_0$, $0 < q_0 < 1$. One can interpret $1 - q_0$ as an exogenous share of existing firms that for some reason are unable to precommit credibly to leadership and have to play the Cournot game. Obviously, in this case the population of incumbent firms chooses $q^* = q_0$.

In the extreme case when none of the existing firms is able to precommit to the Stackelberg game, that is $q_0 = q^* = 0$ ($\alpha = 1$), the share of takeover will be (fig.1)

$$p^* = [1 - D_e^c/(M_e - D_i^c)]/2 = [1 - 4(2\lambda+1)^2/(5\lambda^2+26\lambda+5)]/2 \tag{13}$$

Another option would be to introduce adjustment costs that decrease the takeover profit of the new firm in the case when the target firm precommits. If these costs are high enough, the value of the incumbent becomes lower than it would be in the case of non-precommitment, $S_2 < S_1$. This will remove dominance between the pure strategies of the incumbent firm and induce use of mixed strategies. The possible economic interpretation for such adjustment costs is that precommitment is based on some long-run (labor) contracts which may be binding for the entrant in the event of takeover.

Examples (12) and (13) demonstrate the typical forms of the probability of takeover as a function of λ in the case when compatibility effect is non-significant (α is near 1). Takeover may then occur even when the entrant has a minor technological disadvantage. The probability of takeover is increasing at small (in absolute value) to medium levels of entrant's technological advantage and decreasing if λ is large. The intuition is that entrants with a small technological advantage (or disadvantage) have to pay a high price for the acquisition. Those with a large technological advantage but who are unable to benefit much from utilization production equipment of the target firm will probably gain more from greenfield operations. However, the probability of takeover is monotonously increasing with λ if compatibility effect is very strong (α is above 2). Indeed, function (11) is increasing in λ at the point $\lambda = 1$, if $\alpha > (9 - q^*)/(3 + q^*)$. In this case the entrant's behavior is somewhat counterintuitive. Takeover is the most attractive mode of entry when technological advantage allows the entrant to force the incumbent out of the market.

The case of market oligopoly

The above model can be extended to the case of oligopolistic markets initially populated with $n > 1$ homogenous incumbent firms. The entrant at the first stage decides whether to take over one of those firms or establish a new one. Both the entrant and the incumbents know at this stage which particular firm will be acquired in the case of takeover. The strategic decision of the entrant concerns the target firm to a greater extent than non-target firms. Therefore it is reasonable to assume that only the target firm reacts strategically: it may precommit credibly to a higher output level and gain from the leadership position in the market in the case of greenfield entry. Managers of the target firm, unlike managers of other incumbent firms, face a high risk of being fired in the case of takeover and therefore have incentives to undertake irreversible actions. They can invest in additional production capacity in order to prevent takeover or to benefit from the increasing market value of the firm in the case of takeover. Since the target firm is evaluated by the competitive stock market, the efficient stock price incorporates both probabilities of takeover and precommitment.

If the entrant chooses greenfield investment, then $n+1$ firms compete at the second stage as Cournot or Stackelberg oligopolists. If the entrant takes over and the target firm does not precommit, then n firms compete in the Cournot sense. In the case when the acquired firm precommits, the entering firm either can inherit the leadership position in the market or lose it. Accordingly, we consider two cases when in this situation the entrant becomes a leader or competes as Cournot oligopolist with n-1 incumbent firms.

The notation for the second stage profits is (the superscript is related as above to the pattern of competition): π_n^s, π_n^c - profits of the entering firm in the case of takeover, π_{n+1}^s, π_{n+1}^c - profits of the entrant in the case of greenfield entry; Π_{n+1}^s, Π_{n+1}^c - profits of the target incumbent firm in the case of new firm establishing. The first-stage payoff matrix relates to payoffs of the entrant and the target incumbent firm:

	Precommitment	Non-precommitment
Take over	$(\pi_n^j - S_1 , S_1)$	$(\pi_n^c - S_2 , S_2)$
Greenfield	$(\pi_{n+1}^s , \Pi_{n+1}^s)$	$(\pi_{n+1}^c , \Pi_{n+1}^c)$

Here π_n^j, j = s or c - are entrant's profits in the case of takeover.

The efficient stock price of the target firm is

$$S = p\pi_n^j q + p\pi_n^c(1-q) + (1-p)\Pi_{n+1}^s q + (1-p)\Pi_{n+1}^c(1-q) \tag{14}$$

and, as above, p is probability of takeover and q is probability of precommitment by the target firm, $S = S_1$ if $q = 1$ and $S = S_2$ if $q = 0$.

The incumbent firms have the same unit cost c_i; the ex-ante and ex-post unit costs of the new firm are c_e and c_e'. Given that all firms deliver positive quantities to the market, the second-stage profits are calculated straightforward as:

$$\pi_n^c = 2[a-c_e' + (n-1)(c_i-c_e')]^2/b(n+1)^2, \tag{15}$$
$$\pi_n^s = [a-c_e' + (n-1)(c_i-c_e')]^2/2bn, \tag{16}$$
$$\pi_{n+1}^c = 2[a-c_e + n(c_i-c_e)]^2/b(n+2)^2, \tag{17}$$
$$\pi_{n+1}^s = [a-c_e + 2n(c_i-c_e)]^2/2b(n+1)^2, \tag{18}$$
$$\Pi_{n+1}^c = 2[a - 2c_i + c_e]^2/b(n+2)^2, \tag{19}$$
$$\Pi_{n+1}^s = [a - 2c_i + c_e]^2/2b(n+1). \tag{20}$$

The expected profits of the new firm are $\pi_n = q\pi_n^j + (1-q)\pi_n^c$ in the case of takeover, and $\pi_{n+1} = q\pi_{n+1}^s + (1-q)\pi_{n+1}^c$ in the case of greenfield entry. The expected profit of the target firm under greenfield entry is $\Pi_{n+1} = q\Pi_{n+1}^{s} + (1\text{-}q)\Pi_{n+1}^{c}$. The first-stage payoffs of the participants are:

$$\pi = p(\pi_n - S) + (1\text{-}p)\pi_{n+1} \tag{21}$$

$$\Pi = pS + (1\text{-}p)\Pi_{n+1}. \tag{22}$$

As above, the measure of the entrant's technological advantage is $\lambda = (c_i - c_e)/(a - c_i)$. Consider λ and n satisfying inequality:

$$\pi_n > \Pi_{n+1} + \pi_{n+1}, \tag{23}$$

that means the same as (9) does for the duopoly case.

The probability of takeover is then expressed similarly to (10):

$$p^* = g(\lambda, n, \alpha, q^*) = [1 - \pi_{n+1} / (\pi_n - \Pi_{n+1})]/2. \tag{24}$$

where $q^* = q_0$, an exogenous upper bound on the probability of precommitment. (The Stackelberg game is preferable to the target firm.) The explicit form of function (24) is found in Appendix A. The rest of the paper deals with the estimation of (24) as a non-linear probit model.

3. Empirical analysis

The aim is to estimate the probability of entry by takeover as a function of technological advantage, technological compatibility and the probability that the target firm precommits using the functional forms derived in the model. The analysis is conducted conditional on firms entering. We do not analyze the determinants of entry as such.

Method

The dependent variable is a dummy taking the value 1 if an entrant chooses takeover and 0 if an entrant chooses greenfield. In order to derive probabilities, one approach would be to group observations by industry or time period. This would be inefficient, however, because it would also force us to use averages over industrial groups or time periods for entrants' characteristics such as technological advantage. Instead variations of the probit method are used which are modified to account for the non-linearity in the probability equation.

The basic method is to use maximum likelihood estimation in which the following likelihood function is maximized, where T is the dummy dependent variable taking the value 1 if entry occurs by takeover and 0 if it occurs by greenfield.

$$L = \prod_{Ti=0} \text{Prob}(T_i = 0) \prod_{Ti=1} \text{Prob}(T_i = 1)$$

Since the theoretical model (equation 24) yields a probability function the most straightforward implementation is model A, while model B is an extension that incorporates an error term.

Model A:

$$\text{Prob}(T_i = 1) = g(\lambda_i, \alpha_i, n_i, q_i)$$

where λ is the entrant's technological advantage, α is the technological compatibility, n is the number of incumbents and q is the share of incumbents that can precommit. Further q and α are assumed to be linear functions of explanatory variables as explained in more detail in the next section. We assume that $\alpha_i = \alpha_0 + \alpha_1 s_i$ and $q_i = \text{ß}'X_i$. The coeffients α_0, α_1 and the coefficient vector ß are then estimated by the maximum likelihood procedure.

Model B:

One might suspect that there is a random error in how the function g(.) affects the actual probability of takeover. To model this case we interpret the probability equation (24) as expressing an underlying response variable T^* that determines whether a particular entrant i chooses takeover or not with a random error u.

$$T^*_i = \gamma_0 + g(\lambda_i, \alpha_i, n_i, q_i) + u_i$$

Here γ_0 is a constant that is added in order to allow the following assumption that the actual T that is observed is

$$T_i = 1 \text{ if } T^*_i > 0$$
$$T_i = 0 \text{ otherwise}$$

Following the parallel of the linear probit model we get

$$\text{Prob}(T_i = 1) = \text{Prob}(u_i > -\gamma_0 - g(.)) = 1 - F(\gamma_0 + g(.))$$

where F is the cumulative normal distribution function for u.

In the last section of the paper we also test how the estimates compare to those derived in a normal linear probit model.

Data

In each regression the dependent variable is a vector of 291 observations of entry, from 218 product markets. The product markets are a representative selection from Swedish industry in 1990.[4] The data were collected for a time period of 15 years from 1976 to 1990.

Some studies on related questions have shown that using more detailed data can significantly change results. Kwoka and Ravenscraft (1986), for example, use "line-of-business" data and report, in contrast to previous studies, that higher concentration is correlated with lower profits. Here the level of disaggregations is even lower. 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.[5] 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. In total there are 626 firms in the database, but the average number of firms in any year is only 414. Of the entrants 230 entered by greenfield and 61 by takeover.[6]

The main variables in the database are described in table 1. Several of these are then used to calculate λ_i and α_i as described below.

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[4] The data were collected in 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).

[5] As an example, different kinds of aluminum profiles would fall into one product market, while different types of software would not. In order to check the definition of product markets firms were asked who they viewed as competitors. In fourteen cases this led to a redefinition of the respective product group.

[6] The large number of greenfield entrants relative to takeover entrants can be explained partly by the fact that the data comes from a time period where firms abandoned diversification as a corporate strategy, and partly as a result of our definition of greenfield which does not actually require that an entrant builds a new factory. Greenfield by our definition includes cases where entrants enter a new product market from existing facilities, that is, without buying out an incumbent.

Table 1. Variables and descriptive statistics

Variable	Description	Mean	Std dev
T	Dummy dependent variable taking value 1 when entrant chose takover and 0 when entrant chose greenfield	0.21	0.24
n	Number of incumbent firms in the product market*	2.93	1.1
s	Entrant's technological compatibility with incumbents' capital stock	0.64	0.43
c'_e	Entrants unit costs in the case of takeover as an average over three years after entry	0.79	0.22
c_i	Incumbents' unit costs as an average over three years prior to entry	0.85	0.17
CN	Capital intensity, average for product market as percent of value added	1.6	0.64
CU	Capacity utilization	0.77	0.19
RD	R&D intensity R&D as percent of value added	4.15	3.11

* includes importers.

A special problem is posed by the occurrence of import and export, which in a small country like Sweden is significant. For about half the product markets in the sample import accounts for more than 10 percent of home market sales. At the same time previous studies show that Swedish markets for many tradables are segmented from foreign markets (e.g. Fölster & Peltzman, 1994). This means that often there is only one, or a few, importers that, together with home market producers, are able to extract some oligopoly rents. The implication is that importers are viewed as firms counted in the variable n. Further it is assumed that unit costs, capacity utilization and other variables are the same for imported goods as the average for the home market firms. In addition exports have to be accounted for since they affect the demand that firms face. The estimated demand curves described below concern both home and foreign demand that firms face.

Calculating technological advantage and compatibility

The technological advantage requires a measure of incumbent's costs, entrants costs, and the demand function parameter a. Here we show how these measures are derived for a particular product market, dropping the subscript i.

There are two ways of deriving a. The first is to estimate demand parameter demand functions are estimated for each product market. Using the simple simultaneous demand-supply framework

$$P = a - (a_1/2)\,X \qquad \text{demand equation}$$
$$P = b - b_1\,X + b_2\,cc \qquad \text{supply equation}$$

Here the demand equation is identified by the exogenous variable in the supply equation which is the change in average factor cost for all firms in the product market.

The second way of calculating a is to calculate the price P from the model as

$$P_{c,n+1} = (a + c_e + n\,c_i)\,/(n+2) \qquad \text{Cournot case}$$
$$P_{s,n+1} = (a + c_e + 2\,n\,c_i)\,/(2n+2) \qquad \text{Stackelberg case}$$

The price can then be used to estimate the demand function and thereby a. As it turns out the two measures of a estimated in this way are closely correlated with $r^2 = 0.94$.

The next step is to derive the unobserved c_e. The first step is to define α =

$\alpha_0 + \alpha_1$ s. The values of s follow from a survey question shown in the following table. The question concerns the investments an entrant claims to have to make in order to implement his own technology in an incumbent firm. We take this as a measure of technological compatibility that should be fairly closely related to the theoretical measure α.

Table 2. Survey question on technological compatibility

	Greenfield-entrants	Takeover-entrants
1. "What investment costs did you incur in order to implement the technological advances that motivated takeover (if any)?" Investment costs as a share of incumbent's capital stock[1]	–	14%
2. "What investment costs would you 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[1]	54%	–

[1] This is set to zero for entrants claiming that technological advantage was not a factor in deciding to enter.

After that it is simple to calculate λ. Technological compatibility α is also defined by the relationship $c'_e = \alpha\, c_e + (1 - \alpha)\, c_i$, where c'_e is the entrant's unit cost of production if he takes over, c_e is the entrant's ex ante unit production cost and c_i is the incumbents' unit production cost. Substituting then leads to the following formula for λ where is α is a function of S as shown above.

$$\lambda = (c_i - \alpha^{-1}(c'_e - c_i) + c_i)/(a - c_i)$$

The entrant's unit cost are calculated for a four year period subsequent to entry.

Estimating probability equations

The non-linear probit is estimated using a maximum likelihood routine in Gauss. Table 3 shows two different specifications, representing models A and B as described above.

Table 3. Maximum likelihood estimates for new firm entry

Independent variable/parameter	Model A	Model B
γ_0	–	-0.23 (0.19)
β_0	-0.145^{**} (0.066)	-0.091^{**} (0.041)
CN	0.11^{**} (0.042)	0.10^{**} (0.037)
CU	0.18 (0.12)	0.11 (0.14)
RD	0.07^{**} (0.02)	0.09^{***} (0.01)
α_0	1.34^{**} (0.69)	1.28^{**} (0.62)
α_1	-0.82^{***} (0.09)	-0.87^{***} (0.11)
Chi-square value of the likelihood ratio test	180.1	211.1
Prob > Chi-square	0.0001	0.0001
Number of wrong predictions (percent)	23	26
Percent of takeovers wrongly predicted	19	16
Percent of greenfields wrongly predicted	24	28

Standard error in parenthesis. Levels of significance are ***, ** and * percent respectively, Size of sample equals 626.

Showing the estimates from specification 1 in graphical form yields the curve shown in figure 2 for the average values of α (0.94) and q (0.6). Three graphs are shown for n = 1,2,3. In addition the data are plotted in terms of the share of takeovers within each decile of λ, averaging over α, q and n. While the averaging over important explanatory variables makes this a very rough grafical representation of the data, it does convey an impression that the data fit the nonlinear form. However, this way of presenting the data incorporates the empirical estimate of α which determines λ and may therefore be biased toward showing a better fit than actually exists.

Comparing models

A final question we adress is how to interpret studies using linear models of the choice between entry by greenfield investments and takeover. In doing so we do not use the actual linear models used by authors like Baldwin and Gorecki (1987) (linear regression), Andersson et al. (1992) (linear probit) or Fölster and Nyberg (1993) (first differences linear regression), since these differ among a number of dimensions. Instead we consider three similar models where the first is our model B as discussed above, and the second and third are linear probit models, differing only with respect to the inclusion of α. We use model B rather than model A for the comparison since it has an error term and is therefore most similar to the usual linear probit model.

In each case the models are expressed in terms of the underlying response variable T_* as described above.

$$M1:\ T_* = \gamma_0 + g(\lambda, \alpha, n, q) + u$$
$$M2:\ T_* = a_0 + a_1 n + a_2 \lambda + a_3 CN + a_4 RD + u$$
$$M3:\ T_* = a_0 + a_1 n + a_2 \lambda + a_3 CN + a_4 RD + a_5 \alpha + u$$

Since the functional form of g(.) does not allow a nested comparison we use non-nested comparisons of non-linear regressions as suggested by Pesaran and Deaton (1978). This is a variation on the theme of the Cox (1962) test, yielding a test statistic N_0 which is asymptotically distributed as N(0,1).[7] This type of test tests the maintained hypothesis that one model is true against the data and the performance of another model, and vice versa. In principle the test can lead to the rejection of all tested models.

For the three models discussed here this yields the following table of N-statistics. Each row relates to a particular maintained hypothesis while each column relates to the alternative. We have filled in the matrix by listing along the diagonals the values of σ^2 for each model to give an idea of the absolute fit as well as of comparative performance.

Table 4. N-statistics and σ^2 for models 1, 2 and 3

Alternative hypothesis:		M1	M2	M3
Maintained hypothesis:	M1	**0.78**	0.35	0.64
	M2	−44.1	**0.71**	−15.7
	M3	−18.7	8.6	**0.65**

The N-statistics implies that the maintained hypothesis of M1 cannot be rejected against the evidence of the data and M2 - respectively M3 -

[7] N is calculated as $N_0 = T_0 / V_0(T_0)^{0.5}$ .The basic technique is that given two models that have the general form $y = f(\theta,X) + u$ the first step is to estimate both equations by maximum likelihood. Second the predicted values from the first regression for model 1 are used as dependent variables in a second maximum likelihood regression of model 2, and vice versa. From these $T_0 = T/2 \log(\sigma^2_1/\sigma_{210})$ can be calculated. Here T is the number of observations, σ^2_1 is the variance of the first maximum likelihood regression and σ^2_{10} is the variance of the second maximum likelihood regression. The variance of T_0, $V_0(T_0)$, is the residual sum of squares from a a linear regression of the predicted values of the dependent variable in the first maximum likelihood regression on the derivative of the predicted value with respect to the vector of estimated parameters.

combined. Vice versa the maintained hypotheses M2 and M3 are massively rejected. This seems to support the intuitive story that the non-linear shape of the probability function in our model cannot be well approximated by linear models.

Further model 2 is rejected against model 3. The negative value when M2 is maintained suggests that the true model deviates from M2 in the direction of M3.

Conclusion

Both the model and the empirical analysis confirm a highly nonlinear relationship between the probability of entry by takeover and explanatory variables such as the entrant's technological advantage, technological compatibility and the degree of incumbents' precommittment in entry-deterring investments. It implies that entrants are most likely to enter by takeover if they have a small to medium level of technological advantage over incumbents, while entry by greenfield is more likely if the entrant has either a very large technological advantage or a large disadvantage.

These results imply that the most common mode of entry may vary significantly over time. I periods where firms outside of the industry make significant advances that can be applied in the industry greenfield entry may be high (e.g. electronic watches). When outsiders make modest advances greenfield entry will be smaller and entry by takeover more common. Finally when incumbent firm makes most technological advances, but at the same time demands monopoly rents greenfield entry may be more common.

It is often claimed that new startups are an important engine for long-term growth. The results shown here imply rather the reverse causality. Significant technological advances result in high long-term growth. When these advances are invented outside of the industry, then high growth will occur in the form of much greenfield entry.

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Appendix A.

The probability of takeover (24) is given explicitly by the equations:

$$g(\lambda,n,\alpha,q)=\frac{1}{2}(1-\frac{q(1+(2n+1)\lambda)^2+(1-q)4(1+(n+1)\lambda)^2s_{n+1}}{f_n(\alpha\lambda,q)-(1-\lambda)^2(q(n+1)+(1-q)4s_{n+1})}), \qquad (A1)$$

where $s_{n+1} = ((n+1)/(n+2))^2$,

$f_n(\alpha\lambda, q) = 4(1+n\alpha\lambda)^2$, in the case the entrant does not precommit if he takes over,

$f_n(\alpha\lambda, q) = q(1+n\alpha\lambda)^2(n+1)^2/n + (1-q)4(1+n\alpha\lambda)^2$, in the opposite case.

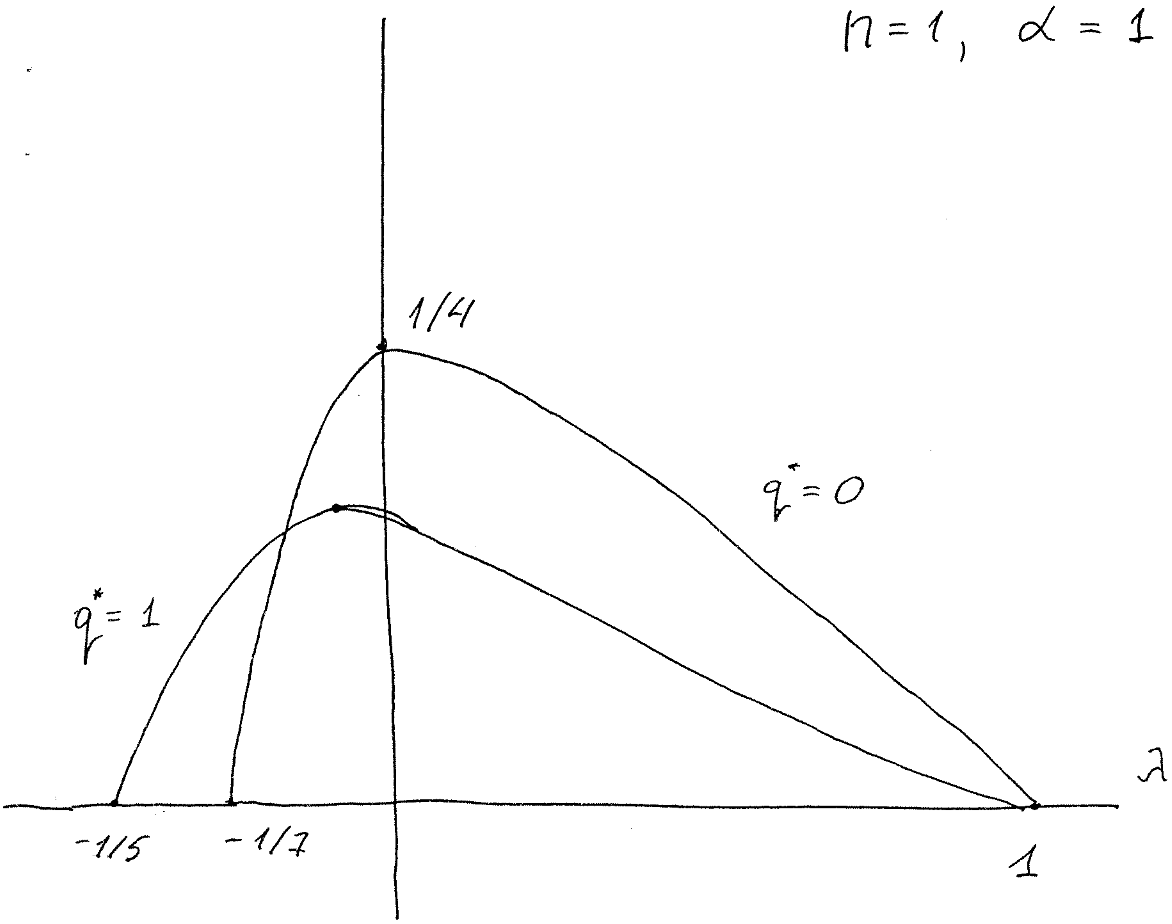

Figure 1. Probability of takeover

FIGURE 2. PROBABILITY DENSITY OF TAKEOVER