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THE PERFORMANCE CONSEQUENCES OF SUBFIELD ENTRY

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The emergence of technical subfields is a common phenomenon in dynamic as well as relatively stable industries. The proper strategic response to the emergence of a subfield, that is, the decision on whether to enter or not to enter, is a key determinant of future firm performance. We propose that this entry decision is not a simple one. The effects of subfield entry may be influenced by strategic factors related to the subfield as well as to the greater industry environment. In this study, we apply a population ecology framework to the study of subfield birth and evolution and use this perspective to develop and test several propositions related to the effects of subfield entry on performance. The data pertain to the evolution of the automatic teller machine subfield over the first 9 years of its existence for a population of over 3500 banks. Our results support the population ecology framework, generally emphasizing the positive performance consequences of early subfield entry. © 1997 by John Wiley & Sons, Ltd.

INTRODUCTION

Technical subfields are an important area of strategy research. Subfields are the markets that emerge following a significant technological advancement in an industry (Mitchell, 1991; Tushman and Anderson, 1986). The proper strategic response to the emergence of a technical subfield is important as it may offer the rare chance to achieve a somewhat sustainable competitive advantage in an otherwise mature and stable industry. Further, research on technical subfields may produce insights that are useful for other areas of strategy research. For example, research on the diffusion of innovations (Pennings and Harianto, 1992), technology policy (Zahra and Covin, 1993), diversification strategies (Chatterjee and Wernerfelt, 1991), and competitive action and response (Haveman, 1993) all may benefit from insights gained in the study of emerging technical subfields. Therefore, the fundamental question guiding this research is:

> *What are the performance consequences of subfield entry and how are they influenced by other aspects of technical subfield dynamics?*

In order to study subfield change and evolution, dynamic methods are needed (cf. Haveman, 1993). Unfortunately, subfield research has been hampered by a lack of both dynamic conceptual frameworks and appropriate methodologies. A population ecology approach (Hannan and Freeman, 1977; Lambkin, 1988) may provide such a valid framework within which we can study the performance consequences of subfield entry and other aspects of subfield evolution.

Applying a population ecology framework to the study of subfields provides other benefits. It responds to the call for the study of competitive dynamics through the application of well-established conceptual frameworks from related fields (cf. Chen and Miller, 1994). Also, despite the extensive use of population ecology in other areas

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of management research (e.g., Astley and Fombrun, 1983; Boecker, 1991; Wholey and Brittain, 1986), fundamental questions remain regarding the applicability of the framework to the study of organizational dynamics (cf. Betton and Dess, 1985). Therefore, in addition to being well suited for our examination of subfield entry effects, this study will provide additional insights of interest to ecological researchers.

This study examines the early stages of the evolution of the automatic teller machine (ATM) subfield in the banking industry. The data cover the period from 1971 to 1979 and include over 3500 banks. This period of evolution for the ATM subfield has been treated as the 'early adoption' phase, including entry by both 'first mover' and 'early follower' firms (Dos Santos and Peffers, 1995). ATM adoption provides an interesting context for the study of subfield entry and organizational ecology. While the ATM is a standard fixture in banks today, the development of this subfield took place over a surprisingly extended period of time. Despite the significant benefits provided by the innovation such as improved service delivery (Dos Santos and Peffers, 1995), higher service quality (Glaser, 1988; Zimmer, 1978) and a resultant inducement for customer switching (Banker and Kaufman, 1988), approximately 88% of all commercial banks still had not entered the subfield 10 years after its inception. Given the readily available nature of the technology, other factors were clearly present that caused most competitors to hesitate in entering the market. Thus, these data should provide interesting and valuable insights into factors influencing the subfield's evolution as well as the performance consequences of subfield entry. Further, the methodology employed in this study offers several advantages over previous work in the area, including the use of panel data, incorporating data from both entrants *and* nonentrants to the subfield, controlling for unobservable factors that may have an impact on profitability, and overcoming several limitations of previous PIMS-based studies.

In the sections that follow, we first consider some of the fundamental principles underlying the population ecology perspective. Next, we extend this perspective to consider subfield birth and evolution. Then, we present our study of the evolution of the ATM subfield in the banking industry. We conclude with several implications for the study of emergent subfields and the performance consequences of subfield entry.

POPULATION ECOLOGY

Based on the seminal work of Hannan and Freeman (1977), Aldrich (1979), and others (e.g., Brittain and Freeman, 1980; Lambkin, 1988), the population ecology metaphor has been used to explore several aspects of market evolution (see Betton and Dess, 1985; Boecker, 1991; Haveman, 1993; Lambkin and Day, 1989; McKelvey and Aldrich, 1983; Wholey and Brittain, 1986). One area that has been studied using an ecological perspective is the emergence and use of technology. In this literature, the ecological model has not always been supported. For example, it has been shown that certain technological fields have extremely extended or even indiscernible life spans (e.g., Henderson, 1995). Other areas of technology research may benefit from an ecological perspective. For example, population ecology may provide an explanation for the finding that radical and incremental innovations have differential effects on competitive behaviors and performance (Gilbert and Newberry, 1982; Reinganum, 1983). We examine a related area in this study by exploring several factors that may moderate the relationship between entry into an innovation-spawned subfield and firm performance. Next, we consider the fundamental assumptions of the population ecology model in more detail and extend these principles to the study of technical subfields.

Subfield entry and performance

The ecological literature provides mixed views on the likely effects of subfield entry on performance. If entry into a substantially new subfield is viewed as a form of *organizational change*, several insights from ecological research apply. The ecological principle of *structural inertia* (Hannan and Freeman, 1977, 1984) suggests that organizational routines are rigid and that organizations, in general, are resistant to change. In fact, one interpretation of this principle contends that a significant (or 'core') change results in a firm's resources being diverted from operations to reorganization efforts, thereby reducing the efficiency of the organization and increasing the likelihood of firm failure (Amburgey, Kelly, and Barnett, 1983; Carroll and Delacroix, 1982). The key to an organization's surviving such a change appears to be their ability to efficiently adapt and develop new combinations of organizational routines that better fit the changed environment (Nelson and Winter, 1982). The paradox that results from this view is clear: If change increases the risk of failure, why would a firm ever attempt to change? When would change be worth the risk? (cf. Haveman, 1992).

Haveman (1992) addresses this dilemma posed by ecological theory and suggests that change may have a positive effect on performance when the organization is responding to dramatic environmental shifts that threaten the organization's existence (Tushman and Romanelli, 1985). The dramatic environmental shifts creating this type of life-threatening situation have been referred to as 'punctuational changes' (Gould, 1980). In Haveman's (1992) view, change could actually improve performance if the gain from meeting new environmental demands is greater than the loss of operating effectiveness resulting from restructuring.

Haveman (1992) finds support for this assertion. In her study of the savings and loan (S&L) industry she shows that dramatic punctuational changes such as wide fluctuations in interest rates, quantum advancements in technologies, and the deregulation of the banking industry created an environment that forced S&Ls to change in order to avert extinction. In support of her contention, Haveman (1992) generally found that, contrary to the strictest interpretation of population ecology, change was positively related to firm performance.

We feel that an extension of this work provides implications for the effects of technical subfield entry on performance. We propose that Haveman's 'life or death' criterion for a positive relationship between change and performance is not complete. Rather, the distinction is likely one of the *magnitude* of the change. A high-magnitude change is one that has significant actual or potential ramifications for the organization. While these may include 'life-threatening' changes for the organization such as deregulation of the industry, high-magnitude changes would also include opportunities for the firm to achieve significant and sustainable competitive advantages. We would further distinguish between the sort of *involuntary*, unavoidable change described by Haveman (1992) and the *voluntary* changes a firm may elect to pursue such as entry into a new technical subfield. A voluntary, high-magnitude change should provide a powerful impetus for change in organizational routines since, ultimately, the failure to secure meaningful competitive advantages will result in the organization's demise. Our conceptualization of the relationship between the type and magnitude of change and strategic outcomes is illustrated in Figure 1.

As this figure shows, the relationship between change and performance is predicated on the magnitude of the change at hand. We expect that in high-magnitude changes, structural inertia is overcome by necessity (in involuntary changes) or by choice (in voluntary changes) in hopes of superior performance or at least survival. In high-magnitude changes, potential rewards should outweigh the reorganization costs to the organization and a positive change–performance relationship will likely result. Many technical subfields represent such a high-reward potential situation. In low-magnitude changes such as involuntary changes in minor government regulations or voluntary adjustments to the product mix, we expect that the basic principles of population ecology and structural inertia will hold true. Change will come at a cost to the organization which will not be offset by potential benefits.

So, we expect that a high-magnitude, voluntary change such as entry to a new and potentially lucrative subfield will produce a positive relationship between change (i.e., entry) and performance. Further, the firms that manage to overcome their structural inertia and adopt new organizational routines sooner should earn certain advantages over later entrants such as higher returns during early, near-monopoly periods and market position and learning curve advantages (Brittain and Freeman, 1980; Kerin, Varadarajan, and Peterson, 1992). Therefore, our first hypothesis states:

> *Hypothesis 1: In subfield entry (as an example of a high-magnitude, voluntary change) earlier entrants will exhibit superior performance to later entrants.*

In the sections that follow, we consider some potential moderators of this relationship as suggested by the population ecology perspective.

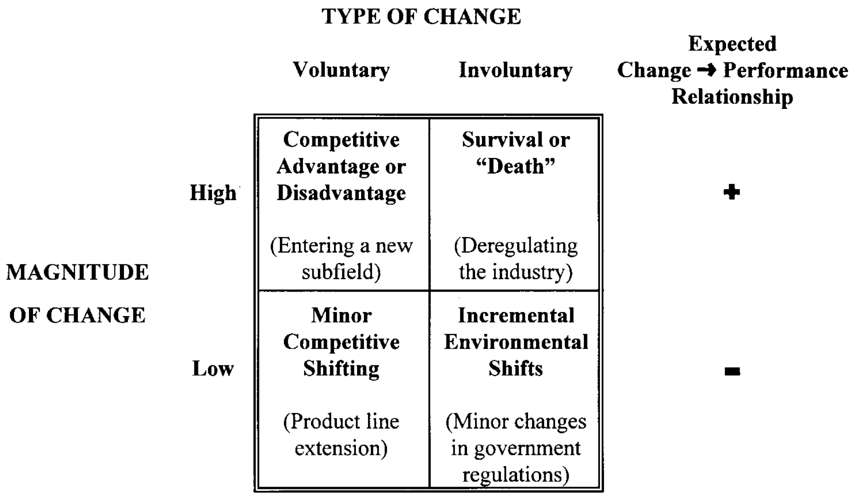

Figure 1. An ecological view of the strategic consequences of change

Niche width and strategic scope

A fundamental concept in population ecology is that of *niche width* (Freeman and Hannan, 1983), defined as the degree to which an organization spreads its resources broadly across the environment in hopes of balancing its risks ('Generalism') or concentrates on exploiting a narrow segment in an attempt to earn a high return ('Specialism'). Niche width is thus a measure of the strategic scope of a firm. Niche width and the distinction between *r-strategists* (early entrants) and *K-strategists* (later entrants) combine to form the population ecology strategic typology (Brittain and Freeman, 1980; Freeman and Hannan, 1983).

The concept of niche width also has implications for appropriate subfield entry strategies. Specialist firms tend to be smaller organizations with relatively limited capital and less experience. In order to achieve success, they typically avoid competition based on scale and other economies and rely, instead, on first-mover advantages such as capturing technological leadership (Lieberman and Montgomery, 1988) or control of attractive locations (Prescott and Visscher, 1977). Generalist firms are typically established organizations that possess a broad range of skills and resources. They tend to have greater breadth in product lines, a larger customer base, wider geographic coverage and are often larger in size than Specialists (Carroll, 1985). Due to their size and commitment to current technologies, Generalists often possess a good deal of structural inertia (Hannan and Freeman, 1977) that prevents them from responding as quickly as Specialists in exploiting new market opportunities. Generalists, however, often rise to market leadership by leveraging superior operating efficiencies and scale economies (Lambkin and Day, 1989).

This acknowledgment of differences in the scope of the firms in the environment is the only true firm-specific factor considered in the population ecology framework. Thus, population ecology differs substantially or even conflicts with the increasingly popular resource-based view of the firm (Peteraf, 1993). Under the resource-based view, a firm develops, protects, and leverages its own relatively unique *strategic assets* while attempting to imitate or eliminate the strategic assets of competing firms (Amit and Schoemaker, 1993; Barney, 1991). From this perspective, these firm-specific assets are the key determinants of performance differentials in the industry. Therefore, the resource-based view suggests that firms are better able to determine their destiny than is a population ecology perspective on market dynamics.

In the population ecology framework, we expect that firms with narrow niche widths (Specialists) will be better able to apply their resources in a focused effort to achieve successful entry into an emerging technical subfield. Firms with more of a Generalist strategy will be better suited to later subfield entry in which they may draw upon their broader experience and skill base to achieve economies and succeed in a 'follower' capacity. We expect, then, that:

Hypothesis 2: Niche width will moderate the relationship between subfield entry and performance so that (a) for firms characterized by a greater degree of Specialism, early entry will be positively *associated with performance; and (b) for firms characterized by a greater degree of Generalism, early entry will be* negatively *associated with performance.*

Density dependence

Another potential moderating factor of the subfield entry—performance relationship suggested by the population ecology view—is based on the principle of *density dependence*. According to this concept, competitive dynamics will change as the density of the competitor population increases. As the population in an environment grows, members compete for increasingly scarce resources allowing only those best suited to the contingencies of the environment to survive (Hannan and Freeman, 1977; Lambkin, 1988). In an organizational setting this suggests that, as density rises, competitive pressures increase and competition becomes increasingly direct. This creates growing pressure on firms to diversify, particularly into those areas in which they can leverage existing skills and resources (Chatterjee and Wernerfelt, 1991).

A new technical subfield may emerge regardless of the population density of the macroenvironment.[1] While diversification is often *driven* by stagnant or declining markets, new technical subfields may emerge even during the early development stages of the macroenvironment. The question arises: What is the appropriate strategic response for a firm that is facing minimal competition in its primary market yet is presented with a potentially lucrative opportunity to enter an emerging subfield?

In a low-density environment (with minimal competitive intensity), firms that are first-movers into an emerging subfield will likely be those with strategic assets (Amit and Schoemaker, 1993) and distinctive competencies (Prahalad and Hamel, 1990) that make them best suited to succeed in the subfield. In contrast, if a subfield emerges within a high-density macroenvironment, firm entry may be driven by sheer survival motives. In this highly competitive situation, earlier entrants are less likely to have a meaningful advantage over later entrants. In fact, earlier subfield entrants may be at a disadvantage since they must absorb unique costs associated with market pioneering such as research and development, buyer education, and infrastructure development (Lieberman and Montgomery, 1988; Teplensky *et al*., 1993). This discussion suggests that the performance consequences of subfield entry are moderated by the population density of the macroenvironment. Therefore:

Hypothesis 3: The population density of the macroenvironment will moderate the relationship between subfield entry and performance so that (a) in a low-density *macroenvironment, early subfield entry will have a* positive *impact on performance, and (b) in a* high-density *macroenvironment, early subfield entry will have a* negative *impact on performance.*

We expect that the principles of density dependence will apply to the subfield's evolution as they do to the macroenvironment. After a technological breakthrough or other innovation spawns a new subfield, a phenomenon that is, in effect, a microcosm of the macroenvironmental growth and development process should ensue. In other words, pioneers will enter the subfield and attempt to capitalize on first-mover advantages to earn economic rents (Stigler, 1987). In the early stages of subfield evolution, direct competition will be minimal and entrants will earn superior profits. If the subfield develops into an attractive opportunity, the density of the subfield will increase, resulting in increasing competitive intensity. At some point, this growing level of competition should minimize or nullify any first-mover advantages in the subfield, perhaps even producing an environment that favors more efficient later entrants. Thus, we expect:

Hypothesis 4: Prior entrants to the subfield in a given market will moderate the relation-

[1] We use the term 'macroenvironment' to refer to the larger competitive population within which the subfield emerges. In this study, we examine the emergence of the ATM subfield within the macroenvironment of the banking industry.

ship between subfield entry and performance so that (a) when a smaller proportion of competitors have entered the subfield, early subfield entry will have a positive *impact on performance, and (b) when a larger proportion of competitors have entered the subfield, early subfield entry will have a* negative *impact on performance.*

Imitability and ease of entry into the subfield

In a population ecology view, competition ensues when two entities occupy the same resource space, that is, when they come into competition for the same resources. The ease with which firms can enter a subfield directly affects the population of the resource space and, thus, the level of competition for available resources. *Imitability* is the extent to which a firm's subfield entry can be replicated by competitors, including the costs and resources required for that replication (Barney, 1989, 1991; Dierickx and Cool, 1989a, 1989b; Mansfield, Schwartz, and Wagner, 1981). In the case of subfields that are *not* highly imitable due to the difficulty of acquiring necessary technology, assets, or skills (e.g., satellite launch, supercomputer development, patentable processes), competitors will strive to be first to market. Here, first entrants may earn reputation, buyer loyalty, and other advantages that allow them to outperform the competition for some time (Gilbert and Newberry, 1982). At the other extreme, a highly imitable subfield (e.g., 1-hour photo developing) produces no sustainable performance advantage for early entrants and may, in fact, force first-movers to incur costs that are not borne by later entrants (Mansfield *et al*., 1981). In this situation, an incumbent will often benefit from delaying entry (Mitchell, 1989).

The ATM subfield presents an interesting context for the study of the imitability of subfield entry due to the variance in regulations regarding mandatory network sharing that existed across regional markets. In many regional markets, banks could enter and grow their ATM networks somewhat artificially through government-mandated network sharing with other banks. This mandatory sharing was instituted primarily in response to antitrust fears (Violano and Van Collie, 1992). In these markets, a new entrant with even no machines of its own would be able to provide the same effective geographic coverage and service level for its customers as the largest entrenched competitor in the market. In other markets, proprietary (single bank) systems were allowed, producing an environment in which subfield entry was more difficult to imitate.

We expect that in nonregulated markets the development of proprietary ATM networks would represent a significant barrier to imitation. Later entrants would be at a severe disadvantage as they would be forced into heavy expenditures to match the service levels provided by entrenched competitors. However, in those regions where the linking of ATMs between banks was mandated, competitor's entries could be imitated with relative ease. In fact, later entrants might gain an advantage in this example due to pioneers' absorption of extraordinary costs such as network software development (Mitchell, 1989). This specific case illustrates the basic population ecology principle that:

Hypothesis 5: The imitability of the subfield will moderate the relationship between entry and performance so that (a) for subfields that are not *highly imitable, early entry will have a* positive *impact on performance, and (b) for subfields that* are *highly imitable, early entry will have a* negative *impact on performance.*

METHOD

Data

The data consist of several variables for over 3500 banks during the early stages of the evolution of the ATM subfield (the years 1971–79). Cash-dispensing machines were first available in the late 1960s although it was not until the early 1970s that ATMs as they are generally understood today became available. Most industry competitors regard the ATM as primarily a cash dispenser which also offers additional services such as providing account balances, accepting deposits, transferring funds between accounts, and allowing for the purchase of other instruments such as traveler's checks. The range of services provided through these machines has been steadily increasing.

The development of the ATM allowed banks to effectively circumvent state banking restrictions and provide nationwide banking services for their customers. This benefit resulted primarily from the development of shared networks such as Cirrus and Plus. Most experts agree that ATMs also produced a significant per transaction cost savings for banks. In 1983, Citibank estimated that its average, fully allocated cost per ATM transaction was less than $0.60, compared to a cost of over $1.20 per teller transaction. Interestingly, despite this per transaction savings, little net savings resulted for most banks since the average number of weekly transactions per customer increased significantly in the ATM environment. Finally, while many banks installed ATMs in the hopes of expanding market share, this benefit does not seem to have generally materialized. It appears that ATM expenditures had the primary effect of merely allowing banks to maintain their market share (see Kirkman, 1987).

The first part of the data comes from a representative survey conducted by the Federal Deposit Insurance Corporation (FDIC) of over 3500 banks that adopted ATMs during the 9-year period. From this we ascertained the number of banks that entered the ATM subfield in each year. It is important to note that these data pertain to the first decade of the evolution of this market so that the timing of entry reflected pioneering tendencies by banks. Conventional wisdom from this industry suggests that most of this period (1971–76) represented the 'birthing phase' of this market and was marked by the 'pioneering use of ATMs by the early adopting banks' (Violano and Van Collie, 1992: 83).

The entry data were then merged with data on firm and market characteristics maintained by the Federal Reserve Board in the Report of Condition and Income and the Summary of Deposits. These sources contain summary information for all commercial banks in the United States. These data enabled us to determine the characteristics of the 739 entrants and 2944 nonentrants (as of 1979) for each of the 9 years under consideration, leading to a combined cross-section/time series data set consisting of 33,147 observations. In particular, for each bank we could determine the information shown in Table 1.

The variables in the data base pertained to both firm-specific and market factors. Two measures of performance were used. Return on assets (ROA) is the predominant measure of financial performance in the commercial banking industry and has been used extensively in the strategy literature (McKee, Varadarajan, and Pride, 1989). ROA has the advantage of permitting comparison across firms of varying size. Further, 'ROA is the most meaningful financial indicator in the banking industry and is the indicator most closely watched by bank analysts and bankers themselves' (Reger, Duhaime, and Stimpert, 1992: 195). In order to improve the reliability of our findings, a second performance measure, net income (NI), was used.

Both ROA and net income have the advantage of being indicators of overall firm performance. Most examinations of the consequences of market entry have measured brand-level performance and have neglected to consider the entry's overall impact on the firm (e.g., Urban and Star, 1991). We felt more encompassing measures such as ROA and net income allow a more appropriate consideration of all the consequences of subfield entry or nonentry on the firm. SIZE is the bank's total asset size.

The timing of entry (ENTRY) reflects pioneering tendencies. The data in this study pertain to the early development stages of the subfield. Since only 12% of banks had entered the subfield by the end of the period studied (the year 1979), we refer to all banks entering the subfield during the period studied (1971–79) as 'early entrants.' Those not entering during the period of study are considered later entrants as virtually all banks have, to date, entered the ATM subfield. Further, the ENTRY variable captures differences between those pioneers entering in the early years of the data period and those entering in later years within the period of study.

In order to capture the concept of niche width (SPEC), we defined the bank's degree of specialization on a Specialist/Generalist continuum in terms of its product mix. Specialists had a higher ratio of demand deposits to total deposits while Generalist banks had more diversified portfolios and lower values in the mix variable. This mix of deposits is a meaningful indicator of niche width. Firms with a larger percentage of nondemand deposits ('Generalists') place greater emphasis on commercial and retail loans, letters of credit, and other financial products and services. Specialists concentrate more on the core areas of savings and checking accounts which comprise demand deposits. In effect, the SIZE and SPEC variables mirror the asset and liability sides, respectively, of the banks' balance sheets. Population density (DENS) indicates the number of banks operating in each banking market.

Table 1. Data base variables

Construct	Operationalization	Definition
Performance (return on assets)	LOG (ROA_t)	Log of return on assets
Performance (net income)	NI_t	Net income after taxes
Firm size	$SIZE_t$	Total bank assets ($ millions)
Entry timing	$ENTRY_t$	Entry timing as measured by years elapsed since entry to the ATM subfield[a]
Niche width (strategic scope)	$SPEC_t$	The product mix of each bank, as indicated by the ratio of demand deposits to total deposits and indicating the firm's position on the Specialist/Generalist continuum
Population density	$DENS_t$	The number of banks in a given banking market
Prior entrants	$PRIOR_t$	The percentage of competitors in a given market that have entered the ATM subfield in the previous year
Mandatory sharing	$SHARING_t$	A dummy variable indicating whether sharing of ATMs with other banks in the market was mandated

[a]Since the technology was commercialized in 1971, a firm entering in 1974, for example, was coded as 0,0,0,1,2,3,4,5,6 for the 9-year panel ending in 1979. Similarly, for firms entering in the first year (1971), the entry variable was recorded as 1,2,3,4,5,6,7,8,9 while for censored observations (nonentrants) it was recorded as zero for the entire panel. Thus, $ENTRY_t$ is time varying, even after differencing. An alternative measure to capture early vs. late entry was also tested, wherein firms entering in the first 2 years were coded as above while all other entrants were coded as zero. After differencing this has the effect of coding early entrants as 1 and later (and non-) entrants as zero. The impact of entry in this model was qualitatively identical: earlier entrants outperformed later entrants, thereby reinforcing the earlier conclusion. We do not report these results in order to conserve space.

PRIOR captures the proportion of market competitors that have entered the ATM subfield. Finally, SHARING reflects the presence or absence of regulations mandating the sharing of ATMs with competing banks.

The study of the performance consequences of subfield entry has a significant methodological advantage over traditional market entry studies. This advantage involves the identification of relevant *nonentrants* to the subfield. In most market entry studies, nonentrants cannot be effectively identified or studied. For example, if we were considering entry into the greater banking industry, potential entrants could conceivably come from financial services firms, insurance companies, or from a host of other industries. In the context of studying the ATM subfield, however, the macroenvironment of the banking industry represents the pool of most likely entrants to the subfield so we can examine the characteristics of entrants as well as nonentrants to the subfield, an important strategic and methodological consideration (Mitchell, 1989).

Models

The econometric methodology we employ provides several benefits over previous market entry and ecologically based studies. Specifically, we: (a) use longitudinal data at the micro level (combined cross-section/time series); (b) use data from both entrants *and* nonentrants to the subfield; (c) overcome several limitations of previous studies using the Profit Impact of Market Strategy

(PIMS) data base; and (d) control for unobservable factors that may have an impact on profitability such as managerial skill and luck.

Our longitudinal analysis has several advantages over traditional, cross-sectional studies including the capability to assess the stability of phenomena over time, the simplification of complex phenomena, and the ability to test a wider range of hypotheses than in cross-sectional analysis (Tuma and Hannan, 1984: 12–13). Most importantly, dynamic analysis is necessary in order to effectively study phenomena associated with evolutionary aspects of strategy.

The use of data from both entrants *and* nonentrants to the subfield is a significant advantage as it overcomes the sample selection bias of most previous market entry research (Mitchell, 1989). When subject firms are selected so that they are not independent of the outcome variable of interest, biased empirical findings may result (Winship and Mare, 1992). This nonrandom selection exists in studies of the characteristics of market entrants that fail to consider characteristics of nonentrants (e.g., Robinson, Fornell, and Sullivan, 1992). In this study, we include firms that exhibit a range of entry strategies as well as nonentrant firms.

Despite the breadth of strategy research drawn from the PIMS data base (e.g., Lambkin, 1988; Robinson, 1988; Robinson and Fornell, 1985; Vanhonacker and Day, 1987), several potential shortcomings of this source have been identified. These issues include bias in firms' self-reporting of pioneer status (Srinivasan, 1988), a bias towards larger firms (Buzzell and Gale, 1987), and general questions over the generalizability of PIMS-based findings to other settings (cf. Kerin *et al*., 1992). Given the range of strategy research spawned by the PIMS-based Lambkin (1988) study, in particular, it is important that we assess the validity of PIMS-based findings in other research contexts.

Finally, Itami (1987) proposes that so-called 'invisible assets' such as consumer data, brand equity, corporate culture, and management skill are the true sources of comparative advantage. Yet, in very few instances has organizational research considered these unobservable factors that may influence a firm's success. As described by Jacobson:

> The role of unobservable factors such as management skill and luck is largely ignored or thought unimportant in [studies of organizational success]. But these factors can be postulated, if not expected, to have far-reaching influences on business performance and other strategic factors … Further, studies that fail to control for a firm's invisible assets are unlikely to assess accurately the influence of observed strategic factors on business performance (1990: 74–75)

In addition to explicitly studying several key strategic variables of interest, the methodology employed here controls for these unobservable factors. The importance of controlling for unobserved heterogeneity stems from the fact that it is impossible to collect data on all the factors that are likely to impinge upon firm performance. This is particularly important in strategic research since many or most factors relevant to firm strategy are inherently unobservable (for example, luck) (Jacobson, 1990). In the context of our study, it would be reasonable to expect that unobservable factors such as managerial style and the strategic orientation of a firm would have a significant impact upon performance, while being contemporaneously correlated with the observed predictors of performance such as market entry (for example, because risk averse managers are likely to delay entry). It is critical therefore to control for the effects of these unobservables, and one way of doing it is to use a serial correlation model (Boulding, 1990; Erickson and Jacobson, 1992; Jacobson, 1990), usually specified as:

$$\pi_{i,t} = X_{i,t}\beta + \epsilon_{i,t} + \alpha_i \tag{1}$$

$$\epsilon_{i,t} = \epsilon_{i,t-1}\rho + \nu_{i,t} \tag{2}$$

Here, $\pi_{i,t}$ represents profits of firm I in time t; $X_{i,t}\beta$ represents the vector of observable covariates that affect profits; α_i is the firm-specific fixed effect that is invariant over time; and $\epsilon_{i,t}$ represents the error term. This specification leads to the following model:

$$\begin{aligned}\pi_{i,t} &= \pi_{i,t-1}\rho + X_{i,t}\beta - X_{i,t-1} \\ &\beta\rho + \nu_{i,t} + \eta_i\end{aligned} \tag{3}$$

where $\eta_i = \alpha_i(1 - \rho)$ and is the firm-specific fixed effect that is invariant over time. Note that this model represents a 'structural' model where the dependent variable is influenced by both the observables (X) and the unobservables (ϵ). The fact that the unobservables are autocorrelated implies that the structural equation will be characterized by serially correlated residuals. The lagged values of $\pi_{i,t}$ are informative because they help to predict the effect of the autocorrelated unobservable variables (Jacobson, 1990).

It should be noted here that the specification in Equation 1 is referred to as the fixed effects model since α_i is a firm-specific, time-invariant constant and represents the effects of all unmeasured, stable characteristics of firms. An alternative specification known as the random effects model assumes that some of the omitted variables leading to the error term will represent factors peculiar to both the individual firms *and* the time periods whereas the other variables will reflect individual differences that tend to affect the observations for a given firm in a systematic fashion over time. Choosing between the random effects and the fixed effects model is possible by means of the Hausman test (Hausman, 1978), although some researchers have questioned the use of the random effects model for nonexperimental data (Allison, 1994). In our case, however, the substantive results do not hinge on this choice.

RESULTS

A variety of models were calibrated to examine the relationship between the timing of subfield entry and firm performance. We present two sets of results: (a) Table 2 contains the results of calibrating the fixed effects and random effects serial correlation models for the two performance measures; and (b) Table 3 contains the random effects models for the two performance measures with the time-specific period effects. While the latter does not permit us to control for serially correlated errors, it does allow us to control for time trends. Since the relatively few time periods in our data set (nine) are likely to inhibit our ability to effectively test for the effects of serial correlation, we focus on the models presented in Table 3 (Models 5–8) for the purpose of interpreting the coefficients. We note, however, that the substantive results regarding the key hypotheses are similar in both the models presented in Tables 2 and 3. In all cases, the choice of fixed vs. random effects was governed by the Hausman test and we report only those models that were determined to be appropriate for the data based on this test.

From Models 5–8 in Table 3 we find a strong impact of subfield entry on firm performance. For example, Model 7 demonstrates that Net Income increases by approximately \$95,000 1 year after entry, representing an increase of 12% over the 1971 mean for this measure. When viewed in light of the fact that our data pertain to early entrants in the subfield, this provides strong support for Hypothesis 1.

Among the hypothesized moderating relationships, Hypothesis 2 posited that competitors' degree of Specialism or Generalism (i.e., their niche width) would moderate the entry–performance relationship. No support was found for this hypothesis. For both measures, the interaction was nonsignificant (see Models 6 and 8 in Table 3). In order to better interpret this result, we speculated that a correlation between niche width and firm size may exist and be problematic. A negative correlation between these two variables would indicate that larger firms tend to be Generalists. Our results show this not to be the case. We found very low, nonsignificant correlation between SPEC and SIZE (on average, –0.02 over the 9-year period). The relationship between Specialism/Generalism and size effects has been particularly ambiguous in ecological research (cf. Wholey and Britain, 1986) and is clarified somewhat through this analysis.

The results of Hypothesis 3 showed that population density does moderate the relationship between subfield entry and performance, although the result is significant for only one of the two performance measures. The interaction term is negative and significant for Net Income and suggests that early subfield entry has a positive impact on performance only in banking markets characterized by low density. For example, from Model 8 we see that entry has a negative impact once the population density exceeds 264 banks (= 145/0.549). To put these results in perspective, we note that the average market consisted of 73 banks (S.D. = 100, minimum = 2, maximum = 408 banks). Hypothesis 4 was also supported. The percentage of prior entrants into the ATM subfield did moderate the relationship between entry timing and performance. Entry had a positive impact on performance only when less than 68% of all the banks in the market had entered the subfield. Finally, in Hypothesis 5 we proposed that the imitability of the subfield entry would moderate the entry–performance relationship. In support of

Table 2. Impact of subfield entry on firm performance

Variable	Hyp. tested	Random-effects Model 1 (main effects)[a]	Random-effects Model 2	Fixed-effects Model 3 (main effects)	Fixed-effects Model 4
Performance measure		Log (ROA)	Log (ROA)	Net income	Net income
		β (S.E.)	β (S.E.)	β (S.E.)	β (S.E.)
Constant		4.445 (0.004411)	4.436 (0.004458)	–	–
ENTRY	H_1	0.01863**** (0.000803)	0.037321**** (0.003355)	97.747**** (13.68)	109.88** (56.82)
SPEC	–	–0.47692**** (0.009660)	–0.46346**** (0.009744)	490.38*** (198.5)	603.27*** (200.9)
DENS $\times 10^{-3}$	–	0.082676**** (0.01554)	0.073779**** (0.01580)	197.83 (980.7)	1732.9* (1024.0)
PRIOR	–	0.54405**** (0.008215)	0.59253**** (0.008611)	829.56**** (141.7)	797.86**** (149.9)
SHARING	–	0.081138**** (0.001905)	0.081256**** (0.00200)	41.579 (30.92)	62.612** (32.59)
SIZE $\times 10^{-5}$	–	0.52193**** (0.074)	0.50348**** (0.074)	567940**** (1764)	568240**** (1765)
ENTRY ● SPEC	H_2	–	0.019302** (0.007691)	–	311.43** (132.0)
ENTRY ● DENS $\times 10^{-3}$	H_3	–	–0.013872* (0.007278)	–	–739.71**** (125.8)
ENTRY ● PRIOR	H_4	–	–0.11765**** (0.005885)	–	–234.94** (96.99)
ENTRY ● SHARING	H_5	–	–0.00507**** (0.001348)	–	–35.835* (21.73)
Fixed vs. random effects (Hausman test)		$\chi^2_6 = 0.0001$	$\chi^2_{10} = 0.0001$	$\chi^2_6 = 370.21$	$\chi^2_{10} = 391.38$

$*p < 0.10$; $**p < 0.05$; $***p < 0.01$; $****p < 0.001$

[a]The fixed-effects model was rejected in favor of the random-effects model since the Hausman test showed $\chi^2_{6\ \mathrm{d.f.}} = 0.0001$

this hypothesis, the coefficient of the interaction term shows that early entry is *relatively* much more profitable in markets that do not require mandatory sharing. For example, in Model 8 we see that net income for entry in the first year is on average $145,000 in markets without mandatory sharing but falls by $44,930 in markets which do mandate sharing.

Thus, with the exception of the niche width hypothesis (Hypothesis 2), the results support the

Table 3. Impact of subfield entry on firm performance with fixed period effects

Variable	Hyp. tested	Random-efects Model 5 (main effects)	Random-effects Model 6	Random-effects Model 7 (main effects)	Random-effects Model 8
Performance measure		Log (ROA)	Log (ROA)	Net income	Net income
		β (S.E.)	β (S.E.)	β (S.E.)	β (S.E.)
Constant		4.563**** (0.0039)	4.563**** (0.0039)	278.94**** (71.21)	245.31**** (71.88)
ENTRY	H_1	0.00666**** (0.0005)	0.00741*** (0.0025)	94.561**** (11.97)	145.17*** (50.05)
SPEC	–	–0.11963**** (0.008)	–0.12025**** (0.00845)	785.24**** (157.6)	785.50**** (158.3)
DENS $\times 10^{-3}$	–	–0.0669**** (0.0154)	–0.0673**** (0.0157)	–162.56 (254.9)	66.66 (258.7)
PRIOR	–	–0.00614 (0.00715)	0.00013 (0.00764)	286.62** (143.0)	333.12** (152.9)
SHARING	–	–0.00523**** (0.0015)	–0.00646**** (0.00164)	–112.17**** (31.45)	–82.914*** (33.09)
SIZE $\times 10^{-5}$	–	0.617**** (0.061)	0.621**** (0.061)	534250**** (1138)	534360**** (1139)
ENTRY ● SPEC	H_2	–	0.00155 (0.00572	–	143.33 (114.0)
ENTRY ● DENS $\times 10^{-3}$	H_3	–	–0.00253 (0.00541)	–	–549.96**** (108.2)
ENTRY ● PRIOR	H_4	–	–0.0103** (0.0045)	–	–211.79** (90.52)
ENTRY ● SHARING	H_5	–	–0.00252*** (0.00103)	–	–44.932** (20.75)
T1		–0.335**** (0.00218)	–0.335**** (0.0022)	–409.11**** (43.62)	–390.58**** (44.16)
T2		–0.343**** (0.00211)	–0.342**** (0.0021)	–391.41**** (42.44)	–374.18**** (42.94)
T3		–0.276**** (0.00207)	–0.276**** (0.0021)	–370.31**** (41.55)	–356.32**** (41.92)
T4		–0.190**** (0.00194)	–0.190**** (0.0020)	–396.56**** (39.24)	–385.67**** (39.46)
T5		–0.221**** (0.00184)	–0.220**** (0.0019)	–415.06**** (37.38)	–408.59**** (37.48)
T6		–0.181**** (0.00172)	–0.181**** (0.0017)	–406.20**** (35.01)	–404.97**** (35.02)
T7		–0.165**** (0.00164)	–0.165**** (0.0016)	–334.40**** (33.39)	–334.27**** (33.37)
T8		–0.113**** (0.00162)	–0.113**** (0.0016)	–168.19**** (32.92)	–169.62**** (32.91)

$*p < 0.10$; $**p < 0.05$; $***p < 0.01$; $****p < 0.001$

ecological view of subfield entry. These findings suggest several implications regarding the strategic dynamics and performance consequences of subfield entry.

DISCUSSION

Through technological advancements and other innovations, subfields emerge in many industries. When these opportunities arise, competitors must decide if and when they should enter. Since this study examined the evolution of only a single subfield, our conclusions concerning the proper competitive response to the emergence of a new subfield are limited. We can, however, make some observations based on our findings and speculate on several aspects of subfield dynamics that may be studied in future research:

1. *First-mover advantages do appear to exist in technical subfields*

While thoughtful and compelling arguments have been made supporting the view that not all firms should be pioneers in subfield entry (e.g., Lieberman and Montgomery, 1988; Kerin *et al*., 1992), or, perhaps, not even enter at all (Hannan and Freeman, 1977, 1984), our results show that legitimate first-mover advantages did exist in the subfield studied and translated into significant performance benefits. First, we found support for the hypothesis that, in the absence of any moderating effects, there is a significant relationship between early subfield entry and superior performance. As evidenced by the lack of significance for Hypothesis 2, the advantages of early entry held regardless of the firm's strategic scope.

The service-oriented nature of the ATM subfield makes this finding somewhat more noteworthy. Lieberman and Montgomery (1988) suggest that in services settings sustainable competitive advantages may be even more elusive than in product-oriented fields. If so, the early entry advantages found in this study are even more significant. It is possible that the inherently intangible nature of services may, in fact, make reputation building of paramount importance. This may magnify the significance of being first to market with a major service innovation.

2. *A firm's strengths and capabilities must be carefully matched with the evolutionary state of the subfield*

The results show that the dynamics of competition changed significantly depending on the portion of the competitive population that had entered the subfield. In relatively low-density subfields, the early entrants achieved superior performance. When a subfield became relatively saturated with competitors, the competitive dynamics changed and later entrants held an advantage. Consistent with the population ecology view, it appears that early in the subfield's development it was dominated by Specialist firms. Generalism became the dominant form as the number of entrants to the subfield increased and scale and other economies became the primary bases of competition (Lambkin and Day, 1989). Supplementary analysis supported this result by showing that SPEC decreased annually as the market evolved, marking the shift of the typical market participant from Specialism to Generalism. For strategists in r-Specialist firms, this suggests that constant reassessment of the competitive environment and movement into new, less populated niches is critical *before* competitive pressures intensify and the bases of competition change. In order to maintain their viability over an extended period of time, these firms must be able to execute a series of such well-planned strategic shifts.

One example of a firm that may be successfully executing such a strategy is Intel. For this company, each new generation of microprocessors represents a new technical subfield. Intel has increasingly found they must abandon production of earlier series of processors as more efficient 'clone' manufacturers enter the market. Their strategy is to stay in the subfield only as long as the population density is low, often in a state of actual or near monopoly. While this accelerating shifting of subfields (i.e., introducing new generations of processors) has caused some tension with major purchasers, it has produced a highly profitable era for the company (*Business Week*, 1995; Palmeri, 1994).

3. *The imitability of the subfield may dramatically influence appropriate entry strategies*

Our results show that in markets where entry to the ATM subfield was highly imitable, that is, those with mandatory sharing of networks between banks, any advantages to first-movers were effectively eliminated. In markets where proprietary systems were protected, however, early entry to the subfield resulted in a competitive advantage that provided significant performance benefits for early entrants. Differences in the regulatory environment significantly influenced the imitability of the subfield.

Although we cannot test the proposition in this study, it is quite possible that the development of the ATM subfield was effectively retarded in those markets where network sharing was mandated. In markets with mandatory sharing, few competitors would want to make a heavy investment in developing their ATM network since competitors would be able to 'free ride' on their developmental expenditures. In this regulated environment, early entrants would be at a disadvantage as they would bear a cost structure less competitive than that of later entrants (Mitchell, 1989). This may partially explain the remarkably slow development of the ATM subfield during the first decade of its existence despite clear service and cost advantages. In sum, variance in government regulations created two distinctly different types of competitive environments necessitating different actions and reactions to the emerging subfield.

CONCLUSIONS

Our results generally support population ecology as a valid conceptual model for the study of the performance consequences of subfield entry. The population ecology principles of density dependence (at both the macroenvironment and subfield levels), and the importance of the imitability of the subfield entry were all supported in this study. Niche width, which translates to a measure of the firm's strategic scope in an organizational setting, was not found to be a meaningful moderating variable. Regardless of the firm's strategic scope, early entry was associated with superior performance. One possible reason for this finding is our operationalization of the construct. Due to data limitations, our measure of niche width (SPEC) used a simple ratio of demand to total deposits. This measure may not have been sufficient to capture the nuances of the true niche width construct.

Our view of the strategic consequences of change (shown in Figure 1) helped reconcile the difficult inertia-based ecological perspective that all change will be resisted and produce negative results with the reality that change is often either forced upon a firm through environmental events or is necessary for ongoing competitiveness and survival. Future research should attempt to expand and further validate this framework. If supported, the model would increase the applicability of the ecological model to strategy research.

Our use of traditional financial performance outcomes in a study using a population ecology framework warrants further discussion. In past research, population ecology has generally been used to study organizational survival or failure rather than relative financial performance. As several authors have argued, however, organizational 'death' is only one of several possible outcomes predicted by this theory. For example, Aldrich (1979) and Lambkin and Day (1989) describe organizational *viability*, as measured by market share, as an important success measure within the population ecology framework. Therefore, our study extends population ecology research by demonstrating its validity with more traditional performance measures such as ROA and net income.

Finally, we point out that some strategy literature (e.g., Lieberman and Montgomery, 1988) has suggested that pioneering effects might be generated in an endogenous fashion. We leave to future research an assessment of the potential bias as a result of entry as an exogenous variable.

Technical subfields are an important area for strategy research and of great importance to managers. In particular, they often represent the chance to make competitive inroads and achieve advantage in an otherwise mature or even stagnant industry. In the relatively stable banking industry of the 1970s, the development of ATMs represented such an opportunity. Competitors' reactions to the emergence of this subfield produced significant performance differentials. For those banks that properly considered the density of their competitive market, the percentage of prior entrants to the subfield, and the regulatory environment, significant performance benefits were achieved. This setting does illustrate, however, the complex issues facing strategists with the emergence of a new technical subfield. As we have seen, population ecology seems to represent a valuable framework for improving our understanding of these phenomena. This study suggests that further research into subfield evolution and further consideration of the population ecology framework as a viable model for the study of dynamic strategic phenomena are warranted.

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