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A DYNAMIC ANALYSIS OF ENTRY RATES
IN THE GLOBAL PERSONAL COMPUTER INDUSTRY

By

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ABSTRACT

A DYNAMIC ANALYSIS OF ENTRY RATES IN THE GLOBAL PERSONAL COMPUTER INDUSTRY

By

Ayşegül Özsomer

This dissertation inverstigates institutional, environmental, and organizational factors that influence entry rates into the global personal computer industry. It also explores how the nature and intensity of these relationships change over time. The study relies on density dependence and population dynamics models. Variables analyzed include: *de facto* standardization, number of firms in the industry, number of prior entry and exits, and duration of existing firms' participation in industry. Entry rates are also analyzed at the subpopulation level. The population is divided into: (1) U.S. versus foreign vendors; and (2) geographical specialists versus global generalists. The nature of interdependence between these subpopulations is inverstigated.

Data on the complete life history of the industry is used. The instantaneous rate of entry is estimated using maximum likelihodd estimation. The effect of density, prior entries and prior entries were found to be curviliniar and significant. Prior entries increase entry rates while prior exits lower entry.

The presence of U.S. firms is found to increase entry of both other U.S. and foreign firms. Foreign firms, on the other hand, seem to generate competition for both subpopulation. Hence, U.S firms expand the market while foreign firms compete for existing market share. Predatory competition is found betwee global generalists and geographical specialists. Generalists expand at the expense of specialists, whereas,

specialists do not create competition for generalists. At the regional level, outside the U.S. market is found to decrease entry into the global marketplace. The emergence of an industry standard is found to be a critical factor affecting entry. Before *de facto* standardization, density increases new entry through legitimizing the industry. After standardization, however, density decreases entry because of intense competition. Hence, *de facto* standardization is an institutional variable with significant effects on entry rates.

to my father, Erdogan Özsomer

and

my mother, Ülkü Özsomer

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CHAPTER ONE

INTRODUCTION

1.1 Motivation for the Study

Within the last decade increased attention has been devoted to studying international industries as distinct competitive environments (Bartlett 1987; Doz 1980; Porter 1986; Pralahad and Doz 1987). Much of this work was spurred on by Pralahad's (1975) and Doz's early examinations of integration and responsiveness and Porter's (1980) identification of distinct industry types. Researchers have classified industries as being either `multidomestic' or `global'. Multidomestic industries are characterized by competitive forces that are constrained structurally by country. Hence, national competitive environments are isolated and competition can be analyzed in much the same way as domestic competition (Morrison and Roth 1992). In contrast, global industries have been characterized as a series of linked domestic industries where structural forces combine to produce a single competitive arena which transcends national competitive environments (Porter 1986:12). To compete more effectively in a global industry, businesses may need to dramatically change their patterns of competitive behavior (Douglas and Craig 1989; Ohmae 1985; Pralahad and Doz 1987).

Competition in a global industry exposes businesses to an `interdependent' competitive environment where strategic actions taken in one country affect competitive situations in other countries (Hout, Porter and Rudden 1982). Global competition characterized by such international market and competitive interdependencies results from a combination of tangible and intangible asset flows (Bartlett and Ghoshal 1987; Hamel and Pralahad 1985; Teece 1986). Tangible asset flows can be represented by intra-industry trade (Kotabe 1989, 1990; Porter 1986) involving the transfer or movement of component parts and finished goods across national borders, and by cross-subsidization of operations in one market by financial resources generated in another (Hamel and Pralahad 1985). In a similar way, intangible assets link international markets through movements of proprietary technologies, management skills, and other firm-specific skills. Market interdependencies result when a competitor that internally integrates tangible and intangible asset flows compels other competitors to respond in the same way or risk a loss of competitiveness both at home and foreign markets (Porter 1986).

Against this background, global industries witness continuous change in the population of organizations over time. New organizations enter while existing ones grow and decline at varying speeds. Some firms merge or are acquired by others. Although each of these processes are important elements of the evolution of industries over time, international marketers and organizational theorists have shown relatively little interest in the creation of new organizations in such an environment.

The phenomenon of organization births or more specifically the act of creation itself may be contingent on the social, environmental and organizational setting from which the firm emerges (Pennings 1982). Furthermore, the entrepreneurial act of birth involves a commitment to a location that constrains the firm geographically. Decisions at the time of founding, such as location of incorporation, selection of geographical markets to serve, the choice of technologies to adopt, and industry role to play as a technological leader or follower, impart a distinct and enduring posture toward the firm's environment. Viability in global industries might be a function of those early acquired characteristics and their compatibility with the environment. Although it is true that firms change and adapt to their environments, initial conditions at the time of founding can have effects that last throughout the history of the firm. Furthermore, population demographics and social organizational factors continue to affect founding rates of new organizations. It is, therefore, desirable to understand the environmental, organizational and institutional processes that foster or inhibit organizational births throughout the life histories of global industries.

If we could understand these processes, we could answer questions such as: How do social, environmental, and organizational factors affect the creation, and therefore entry into a highly volatile, high-technology global environment? How does the existing population of firms affect entry rates? How do dynamics of the population such as prior entries and deaths affect entries? How are the relationships between population dynamics and entry rates affected when technology standards emerge?

If we knew the answers to these questions, then we could predict when the viability of an organization in a global industry is improved or threatened by the entry of new firms. We could, for example, predict if a U.S. PC vendor facilitates entry of foreign firms by legitimizing the industry or technology. We could also predict how populations of firms pursuing different geographic diversification strategies (generalists versus specialists) affect the creation of firms in the same or different populations. We could determine the nature of competition, whether multidomestic or global, by the existence of significant effects of population density on entry rates. Furthermore, we could explore and understand the effects of industry standards on entry rates. The literature on global competition has paid little attention to these issues.

Why is it important to understand the underlying processes that affect entry rates? Why is it important to understand if a new firm intensifies competition, thereby decreasing the viability of existing firms, or legitimizes the industry thereby increasing the viability of incumbents? Rate of entry into an industry is known to shape the industry structure. If new entry creates competition, incumbents would benefit from erecting entry barriers. If, on the other hand, new entry promotes mutualism or legitimation, incumbents should, in fact, lower entry barriers and promote new entry through their technology, marketing and management strategies. Hence, understanding processes affecting entry and exploring the extent to which it is affected by social, environmental, and organizational factors could have significant managerial and policy implications.

The process of new entry and the industry structure effects created thereof, seem even more critical in high-technology industries with volatile entry. This is because national competitiveness of major industrial regions (e.g., European Community) and countries of the Triad are dependent on effective competition in such high-technology industries.

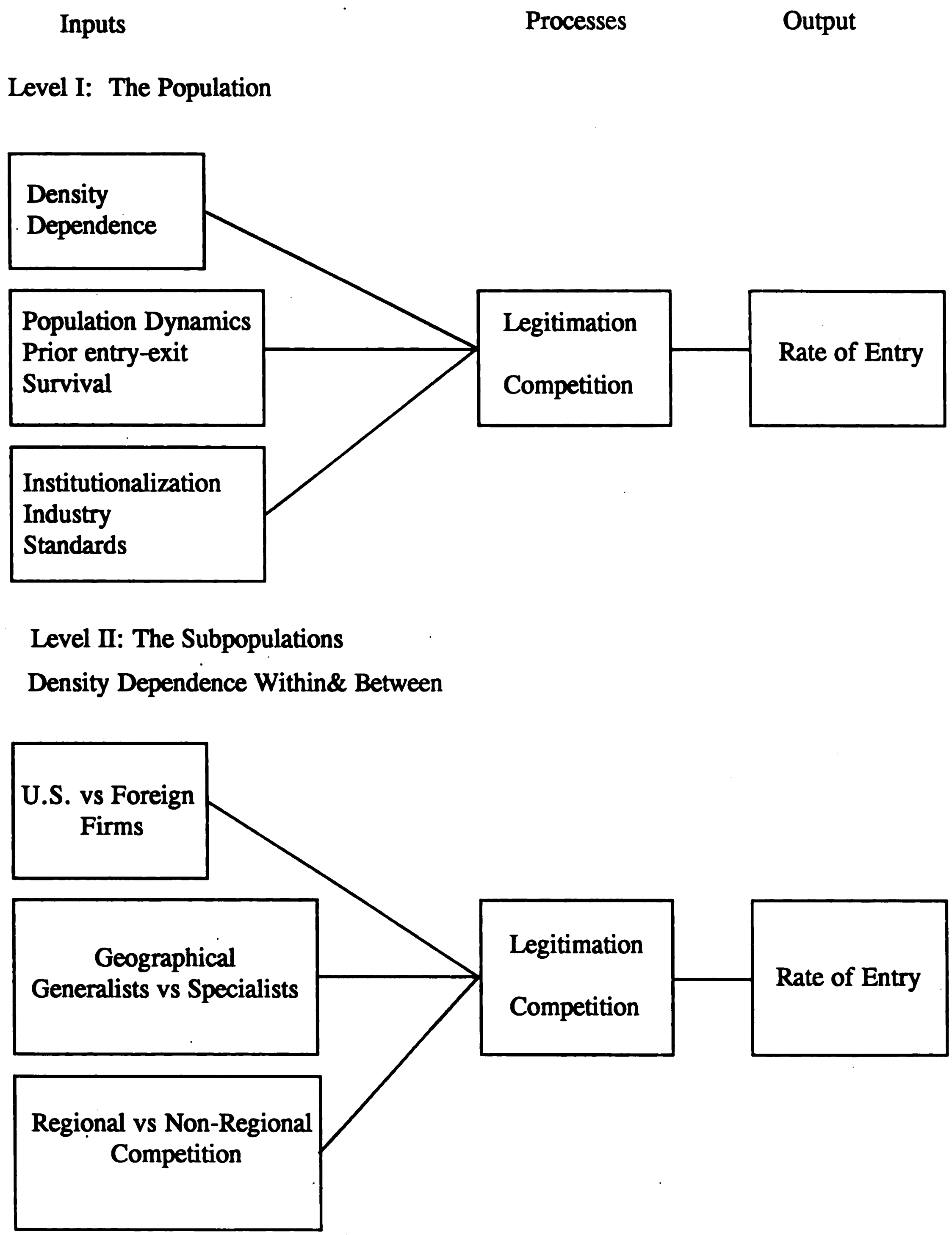
With these issues in mind, this study investigates social, environmental, and organizational factors that influence entry rates into a global industry-- the personal computer industry. It also explores how the nature of these relationships change over time. The study relies on density dependence and population dynamics models of organizational ecology. A conceptual framework is presented in Figure 1.1. This framework highlights factors expected to influence entry rates: population or subpopulation density, population dynamics, and institutionalization. The organizational ecology (OE) approach is adopted both as an operational method and as part of the theoretical framework.

The remainder of this chapter is organized into five sections. The first briefly discusses the uniqueness of the personal computer industry and why it offers an excellent context for the study of underlying processes affecting entry to a global industry. The second highlights the scope while the third reviews the purpose of the research. The fourth discusses the expected contribution of the research from both a managerial and academic perspective. The final section gives an overview of the organization of the dissertation.

1.2. Characteristics of the Global Personal Computer Industry

Competition in the computer industry in general and the personal computer segment in particular, is truly global in nature. First, major competitors like IBM, Fujitsu, NEC and Compaq are involved in national market share battles and are using their financial and marketing ability in one market to cross-subsidize their battles in others (Hamel and Pralahad 1985). The battle is not simply for world volume but also for the cash flow to support new product development, investment in core technologies, and worldwide distribution. IBM, for example, has generated 68% of its consolidated cash flow from its European operations in 1989 (IBM Annual Report, 1989) and a significant portion of the cash generated has gone to R&D efforts.

Second, major players in the computer industry have the distribution and brand positions in key foreign markets, particularly in the Triad, which enable cross-subsidization and world-scale volume. Third, home country vulnerability, which refers to the risk of loosing national market share if global leadership is not pursued, is a major



* ———— denotes a relationship

Figure 1.1
Dynamic Analysis of Entry Rates in the Global PC Industry

threat for companies operating in this industry. Besides, the world's top computer manufacturers are players from the Triad world. In 1989, Japanese manufacturers led by Fujitsu, controlled 23% of the global sales (Fortune, March 9 1992). Another 14% of world sales was controlled by European manufacturers while the share of U.S. based manufacturers was 45%. These figures alone suggest that considering only the U.S market would be looking to less than half of the picture. Hence, the global nature of the computer industry necessitates the analysis of entry rates at the global level.

In addition to the global nature of competition, the high level of R&D investment in sophisticated technologies and the frequency of major technological innovations places the computer industry among the leading technology-driven industries. All such industries share certain characteristics:

1. A rapidly changing technological environment in which products are sold. For example, the discovery of semiconductors and their use in microcomputers by Apple and Commodore changed the industry structure in favor of new entry.

2. Global competition in many areas of product discovery, development, and commercialization.

3. High investments in R&D, both absolutely and as a percentage of sales. For example, IBM invested 16% of its sale revenue in R&D and engineering in 1989 (Annual Report).

4. A higher proportion of technical professionals in the work force, such as scientists, engineers and technologists, compared to other industries.

5. A highly volatile environment characterized by high entry and exit rates (may apply more to the introduction and growth stages of the industries).

The unique characteristics of the global computer industry in general and the personal computer segment in particular raise a variety of questions which have yet to be addressed in the literature. One question of particular interest to this study is: Why are entry rates into the PC industry so volatile?

1.2.1 Volatile Entry into the Global PC Industry

Entry rates into the global PC industry have been very volatile (Figure 1.2). The emergence of the industry in 1977 has quickly attracted a fair amount of new entry. The relative ease of manufacturing PCs with parts from various suppliers and the outstanding successes of early entrants motivated entrepreneurs to enter the industry.

The industry witnessed the most dramatic influx of new entry in 1984. Approximately, 35% of all entries between 1977-1992 took place in 1984. Such an environment brings certain questions to mind: What are the underlying mechanisms that determine this volatility of entry? Are the underlying mechanisms the same for different subpopulations that exist in the industry?

What is the type and level of interdependence between subpopulations in reference to entry? Are relationships competitive, mutualistic or predator-prey type?

The analysis of global competition in a high technology setting is assuming an increasing importance in the strategic management literature and practice (Douglas and Craig 1989; Ohmae 1985; Porter 1985,1986,1990). The global personal computer industry provides an excellent setting to study entry rates and the underlying social, environmental, and organizational processes.

1.3 Scope of Research

In industries where competition is global three groups of variables become of

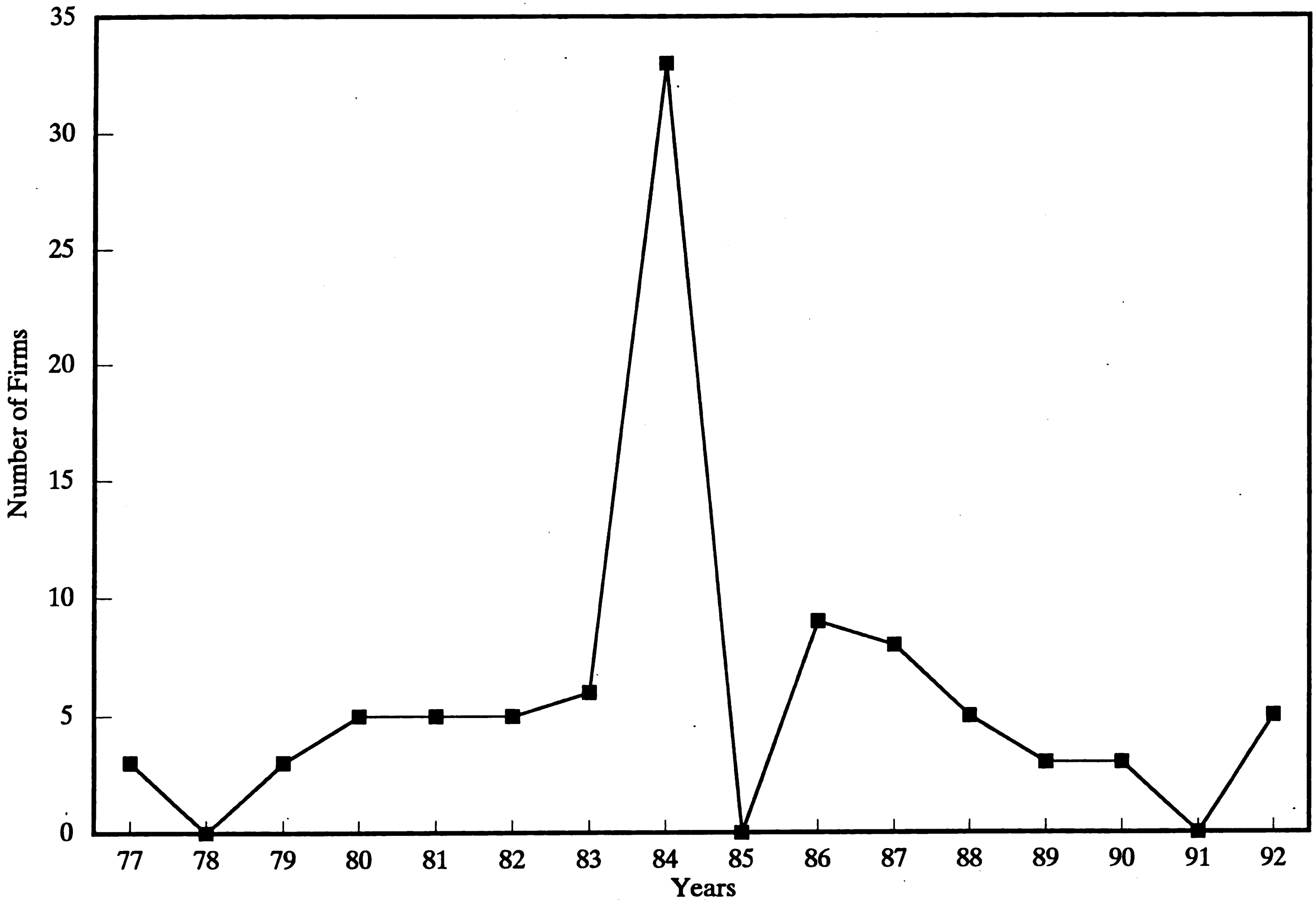


Figure 1.2
Volatile Entry in the Global PC Industry

critical importance in studying entry rates: (1) population density, (2) population dynamics, and (3) institutionalization.

First, the number of existing firms and the relationship between them (e.g competition versus legitimation) makes population density a critical factor. This is becausepopulations change over time as a result of the opposing factors of legitimation and competition (Hannan and Freeman 1986). Entry rates into an industry will be dramatically affected whether legitimation or competition is at work.

The second critical variable arises from the expectation that the dynamics of the population can affect the volatile pattern of organizational entry. Entries over time may be explained by effects of prior entries and exits on the availability of resources (Delacroix and Carroll 1983).

Third, the process of institutionalization can influence the nature and intensity of new entry. In industries where compatibility issues are relevant, the emergence of an industry standard and the institutional position attained thereof can have significant influences on entry rates. Hence, rate of entry into an industry can be expected to vary in the periods before and after the establishment of an industry standard.

Other organizational and environmental factors are also expected to affect entry rates. In high-velocity environments, where there is continuous dynamism and volatility, overlaid by sharp and discontinuous technological change (Bourgeois 1985; Bourgeois and Eisenhardt 1988), R&D outlays of incumbents can deter entry by working as entry barriers. However, the strengths of the entry barrier erected by R&D expenditures of existing firms will depend on the imitability of technology. When solutions known to work, in this case technologies, are easy to mimic, research intensity is not expected to have significant influences on entry rates (DiMaggio and Powell 1983).

Other functions such as marketing, distribution and advertising can also be used by incumbents to deter entry.

To capture the underlying processes regarding entry rates discussed above, three sets of variables are considered in this research:

(1) population density, that is, the number of firms in the industry;

(2) population dynamics variables of prior entries and exits;

(3) institutionalization as achieved through establishment of an industry standard.

Population density is disaggregated into subpopulation densities of:

(1) US market density versus global market density;

(2) density of US based firms versus foreign based firms;

(3) densities of geographical specialists versus generalists;

(4) densities of technological leaders versus followers.

1.4 Level of Analysis

A dynamic analysis of organizational entry rates necessitates an evolutionary process approach to the problem. Evolutionary studies focus on cumulative changes in structural forms of populations of organizations across communities, industries, or society at large (Aldrich 1979; Hannan and Freeman 1977). As in biological evolution, change proceeds in a continuous process of variation, selection and retention (Van De Ven 1992). The environment selects those forms best suited to the resource base of the environment in which the firm operates (Hannan and Freeman 1979).

This study views organizations as proactive, purposeful entities that can be distinguished from each other in terms of strategies they pursue, markets they choose to enter, and technologies they choose to adopt. Firms that choose to concentrate their efforts on single geographic markets are expected to differ from firms that compete on a global basis in all critical markets. U.S. based firms, due to their traditional roles as technology leaders and innovators, are different from many foreign firms who enter and thrive in the industry with strategies based on imitation. Such differences in firm strategies pursued can be used as a base of grouping firms into subpopulations.

The proactive decisions made by existing firms not only affect the performance of existing firms but also shape the history of the industry by affecting entry and exit rates. Hence, not only does the environment select those that best fit the resource requirements, as suggested by the OE approach, but firms themselves can also affect and change the requirements of the environment by affecting the rate of new entry. But the effect of the environment can be different for different groups of firms and different groups can affect the environment at varying levels. For example, U.S. based firms can have greater influence on the industry through their technological innovations. Foreign based firms, on the other hand, may be more vulnerable to environmental selection pressures due to their more imitative and reactive strategies. Furthermore, geographically specialized firms may create less direct competition and therefore enhance entry into the industry. Geographical generalists, on the other hand, may create intense competition by using up the resource base and therefore deter entry.

Such a situation seems to necessitate analyses at two levels: (1) the population; and (2) the subpopulations. The effects of population density, prior entries and exits, and emergence of an industry standard is analyzed at the population level. The effects of base of incorporation, extent of geographical diversification, technology role assumed (e.g., technological leadership versus followership) and the interaction between the global and the regional U.S. market is analyzed at the subpopulation level.

1.5 Purpose of Research

This dissertation is concerned with investigating the waves of entry into a high-technology industry. The objective is to identify critical social, environmental, and organizational variables that affect entry rates. The interdependencies between subpopulations in relevance to base of incorporation, geographical diversity achieved, technological leadership attained, global-regional competition and their influences on entry rates are also investigated. The personal computer industry is chosen as the environment to study entry rates.

Within this context, the study focuses on the following research issues:

(1) In industries characterized by global competition and compatibility standards, what are critical social, environmental and organizational factors that influence entry rates?

(2) Which group of factors, population density or population dynamics, have stronger effects on entry rates?

(3) Since subpopulations exist in the PC industry what is the nature of interdependence between these subpopulations?

1.6 Expected Contribution

The contribution of this dissertation is based on answering the questions posed above. The dissertation attempts to investigate the fluctuations in entry rates witnessed over the history of the global PC industry. Based on prior works of organizational ecology (OE) researchers (e.g Carroll and Hannan 1989; Hannan 1976; Hannan and Freeman 1977; 1989) this study attempts to make the following contributions: (1) extending the application of population ecology framework to a global industry context, (2) identifying critical factors that influence entry rates into an industry, (3) develop a conceptualization and quantification of interdependencies between subpopulations in reference to base of incorporation, extent of geographical diversification, and extent of technological leadership, and regional-global competition, (4) conceptualization and quantification of the level of "globalization" through an analysis of cross-subsidization, (5) a shift in research focus from domestic to global industry settings, and (6) a shift in research focus from cross-sectional or truncated longitudinal studies to complete life-history studies.

1.7 Justification for Single-Industry Focus

The research approaches a single industry, the global personal computer industry, from an international marketing perspective. The observed lack of inter-industry transmission of technical know-how seems to make know-how and technology, in large part, industry and product specific (Sahal 1981). Furthermore, the emergence and development of an industry is the result of activities of firms that share a mutual awareness of belonging to a common enterprise or industry (DiMaggio and Powell 1983). Hence, industry specific studies avoid the problem of multiple industry research which tend to compress strategically useful information by averaging across distinctly different industries.

1.8 Organization of the Research

This dissertation is organized in three parts as described in the "road map" in Figure 1.3.

Part I includes the Preliminary Framework and includes Chapter 1, Chapter 2, and Chapter 3. Chapter 1 provides an introduction to the dissertation, by motivating the need to study waves of entries and interdependencies between social, environmental, and organizational variables. The chapter also provides a framework for analysis. Finally, the chapter defines the research questions that this dissertation will address.

Chapter 2, includes a description of the global PC industry. A historical overview of the operating environment of the industry is presented. The emergence and development of an industry takes place through a process of learning that is context dependent, bottled up in an industry setting (Sahal 1981). Hence, knowledge of the industry is necessary to understand how various variables affect entry rates and how and why these effects change over time. Chapter 3 provides a review of two streams of research in the population ecology tradition: (1) density dependent population models, and (2) population dynamics models. This chapter concludes with a complete statement of research questions.

In Chapter 4, the research design and methodology is presented. The chapter begins with a presentation of variables used in the study and an identification of the data sources. Research hypotheses are also developed in this chapter.

Part II presents the findings of the dissertation. Chapter 5 discusses the findings from the statistical analysis. The second chapter in this part, Chapter 6, summarizes the findings and points out their relevant implications and contributions to researchers and practitioners. Limitations of the study and suggestions for future research are also outlined.

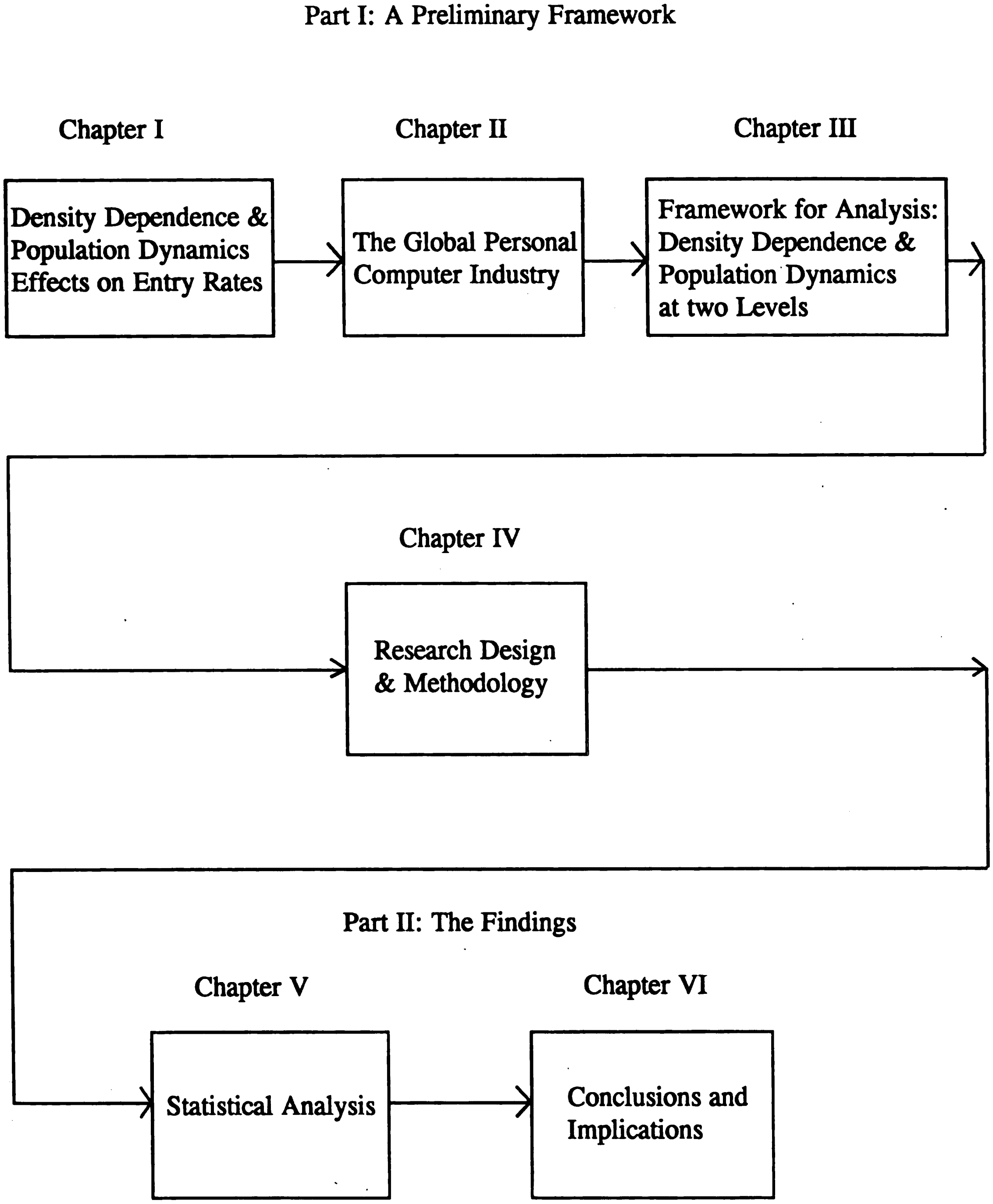


Figure 1.3
A Road Map for the Research

CHAPTER TWO

THE GLOBAL PERSONAL COMPUTER INDUSTRY

The Personal Computer, or the PC, has been one of the most successful product concepts introduced in the twentieth century. It has become a crucial component of today's office as well as of many homes and educational institutions. An important aspect of the competition that characterized the industry, at least in the early stages of the industry, concerned the legitimation of the PC and of the industry. The institutional development of the industry through efforts of industry standard establishment was also an important aspect of competition in the industry.

This chapter presents a historical description of the evolution of the industry, the pattern of entry and exits, the significant geographical markets, the competitive strategies followed by firms in the industry, and the nature of competition before and after the emergence of an industry standard.

2.1 Historical Evolution of the Global PC Industry-The `Old' and the `New' Industries

The history of the PC industry is a tale of two industries existing side by side, but with little in common. First, there is the `older' industry of traditional mainframe and minicomputer manufacturers including IBM, Unisys, Digital Equipment, Wang, Groupe Bull, and Olivetti. These companies prospered by exploiting proprietary hardware and operating system software technologies (Standard and Poor's Industry Survey, October 1987). As a result, the mainframe computer market of the 1970s and 1980s was highly fragmented, with each manufacturer dominating its particular niche. Mainframe and minicomputer manufacturers now agree that they were driven more by technology than by considerations of their user needs. Gross margins on these products were as high as 70 to 90 percent on mainframe computers.

The invention of the microprocessor, a new semiconductor that contained the heart of an entire computer on a single silicon chip, in late 1971 spurred the creation of a new computer industry. Datamation called Intel Corporation's first Central Processing Unit (CPU) chip, the most significant technological development of the 70s (Brock 1975).

Since players in the older industry failed to recognize the possibilities of the microprocessor, it was left to entrepreneurial startup companies, such as Apple and Commodore, to exploit the new technology.

The first PC, introduced in 1977, posed little apparent threat to the established computer manufacturers. Early PCs were weak and limited - more toys than business machines and were no competition for mainframes. Advances in microprocessor technology, however, have allowed PCs to become increasingly powerful. As a result, the share of PCs of the worldwide information technology market has increased from 11.5% in 1984 to 16.5 in 1992; while the share of minis and mainframes has decreased drastically from 28.5% to 13.5 during the same period (Standard & Poor's Industry Surveys, 1991).

2.1.1 The `New' Industry: A Consumer Market

The single distinguishing feature of all PCs is that the CPU is contained on one tiny silicon semiconductor chip or microprocessor. Microcomputers or PCs are basically single-user systems. In its simplest configuration, a PC system consists of the following: a standard typewriter keyboard, a video monitor, and a body housing the hard drive and the disk drives. A printer can be incorporated to the system to print the output from the PC. See Figure 2-1 for a simple diagram of such a system, and how the components work together.

2.2 Personal Computing-A Historical Overview

The first PC was introduced by Apple Computer founders Steven P. Jobs and Steve Wozniak in 1976. The product was assembled with semiconductors, plastic and metal parts, and electromechanical subassemblies purchased from independent suppliers. Most of the parts were standard with a few (power supplies and integrated circuits) built to Apple specifications. By 1980, Steve Jobs' Apple Computer Corp. had grown to a $117 million company and its multicolored apple logos were beginning to be seen in the large corporations where IBM's mainframes had dominated (Annual Reports; Standard & Poors Industry Surveys)

The commercially available microprocessors attracted startups like Commodore and Tandy as well as entry into the industry by existing electronics and mainframe manufacturers such as Hewlett-Packard, Atari, Texas Instruments, Sharp and NEC among others. By 1981 total worldwide sales passed the $2 billion mark. The period from 1977 to 1981 was one of "Product Concept Competition" where there was lots of experimentation with different product concepts and technologies.

2.2.1 IBM's Entry into PC Industry: Towards Legitimation

Extremely high growth rates of the PC market and the stunning progress of Apple and the other PC manufacturers attracted the leader of the mainframe industry, IBM, into the PC market. IBM's Chairman John Opel, approved a crash program and sent a team of 13 engineers to Boca Raton, Fl., to design the first personal computer.

The team at Boca Raton was given one year to develop a product that could compete with the *Apple II.* In order to meet the deadline, the team turned to outside suppliers for key hardware and software (Standard & Poors Industry Surveys, October 1991). They used Intel's 8088 microprocessor for the hardware and Microsoft was selected to provide the machine's operating system. On August 12, 1981, IBM introduced its first PC. Although the first IBM PC was considered an unexciting product, IBM managed to take the market leadership position away from Apple in 1982 (Standard & Poor's Industry Survey, June 1985).

IBM's entry into the PC industry was a critical development because it signalled the legitimacy of the new industry to both existing firms and potential entrants. IBM's adoption of an operating system *incompatible* to that of existing Apple computers started a period of "Industry Standard Competition". New entrants were faced with a major decision: Whether to manufacture PCs that were compatible to IBM machines or to Apples or whether to adopt a completely different technology.

The first IBM PC used predominantly off-the-shelf components. With the major innards of the PC readily available, new firms had little difficulty coming up with IBM compatible machines, usually at lower prices. By 1984, IBM compatible PCs had reached a worldwide unit market share of 26.4 % up from 13.7 % in 1983 while the share of Apple PCs declined from 3.7% worldwide unit market share in 1983 to 2.8% in 1984. PCs using other types of central processing units (e.g., UNIX among others) had still 80% worldwide market share but were loosing ground very rapidly to IBM compatible PCs.

Figure 2.1
Components of a Personal Computer System

Table 2-1 presents the shares of IBM compatible, Apple compatible and other types of CPUs. Table 2-1 shows the IBM compatible versus non-compatible 68XXX family unit sales. The graph helps visualize the dramatic increase in the sales of IBM compatible PCs.

In the PC market, compatibility was provided through "cloning". Clones are products that are nearly identical in design (Hariharan 1990). Clones are viewed as close substitutes, thus resulting in less differentiation between products. IBM clones provide as near as 100% compatibility with IBM PCs. They run with the same operating system and use most of the same software. IBM clone owners can interchange know-how, software and parts. IBMs and their clones are nearly identical in the eyes of the consumer and therefore may lead to more price competition. In fact, the very reason of the existence of IBM clone manufacturers is their capability in delivering products that are near "identical" in the eyes of the consumers at much more competitive prices than IBM.

By 1984, the PC industry had proven to be a rapidly growing industry with an average unit sales growth rate of 117% from 1981 to 1984 (Dataquest, PC Market Trends 1992). In addition, the industry characterized low entry barriers due to generally easily imitated technology, a need for high similarity between PCs to obtain hardware and software compatibility, and consumers not inclined to consider a major break from their present technology due to high switching costs (Bridges *et al.).*

This environment was conducive to an influx of firms manufacturing IBM compatible PCs. As a result, 1981 through 1984 witnessed rapid entry into the industry that made up nearly 65% of total entries that occurred throughout the life of the industry, 1977-1992 (Dataquest Inc.). Most minicomputer and mainframe companies had entered the industry by 1984 and entries such as AT&T, Compaq, Digital, Epson, Fujitsu,

Table 2.1
Global Market Shares of PC's by Microprocessor Type, 1983-1992

Year	IBM Compatible (80XXX family)	Apple Compatible (68XXX family)	Other Unix
1983	13.70	3.69	85.93
1984	26.39	2.81	70.80
1985	38.91	3.56	57.53
1986	51.47	5.72	42.81
1987	62.89	10.27	26.84
1988	67.92	11.45	20.63
1989	73.92	11.64	14.44
1990	84.69	12.41	2.90
1991	85.78	13.46	0.76
1992	86.55	12.98	0.47

Source: Dataquest, Inc. 1992

Note: Market shares are computed based on worldwide unit sales.

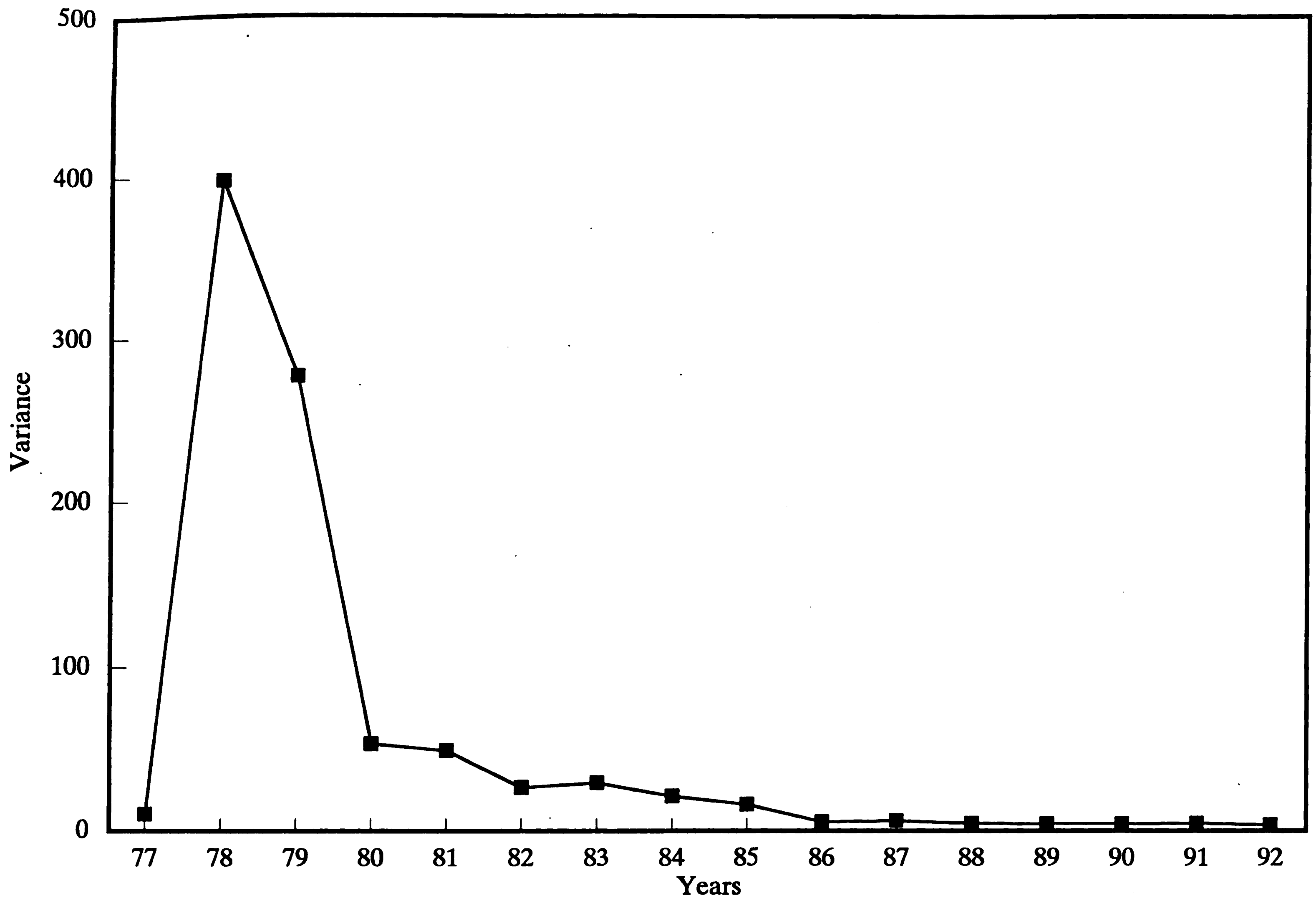


Figure 2.2
Variance of Global Shipment Market Shares

Hewlett-Packard, Kaypro, Leading Edge, NCR, Olivetti, Panasonic, and Sanyo manufactured mostly IBM compatible machines by utilizing off-the-shelf parts and non-proprietary PC technology. By the end of 1984, there was general agreement in the industry that the Industry Standard Competition resulted in favor of IBM compatibility and the *de facto* standard was IBM compatibility (Dataquest Inc., various years; Standard & Poors Industry Surveys, various years).

2.2.2 Intentifying Competition in the PC Industry

The establishment of a *de facto* standard shifted competitive pressures towards market share and profit battles. This new phase that the industry entered can be named: Market Performance Competition. Together with giant firms with substantial resources such as IBM, AT&T, Hewlett-Packard, and Tandy among others, the industry hosted dozens of minor players in the market. However, with computer prices declining rapidly (See Table 2-2), new products being introduced at a dizzying speed, and declining growth rate in the industry made the nature of competition in this stage different from the previous stages. (See also Figure 2.2).

IBM's second generation PC, the PC AT, introduced in 1984 was the standard for clone makers to copy. Both newly entering PC manufacturers and incumbents were rushing to market with competitive IBM compatible PC AT like products, just as they had rushed PC clones to market after 1981 when the IBM PC was fast becoming the industry standard (Standard & Poor's Industry Surveys, June 1985).

At this Market Performance Competition Stage, the spectacular growth in unit sales witnessed in the previous stage (average growth rate 117%) appeared to be moderated. From 1985 through 1992, the industry sustained an average worldwide unit sale growth of only 12% (Dataquest Inc.). Some years, in particular 1987, proved to be very problematic for firms in the industry with a *negative* growth rate of 14.8%.

Meanwhile, the variance of PC manufacturers' worldwide unit market shares were declining over the years (See Figure 2-2). The variance, which was 16.6 in 1985, had declined to 4.3 in 1989 and to 3.8 in 1992. Increased competition was decreasing the average difference in market share between firms in the industry. This meant that no longer a single firm sold as much as 70-80 percent of total PCs.

Figure 2-2 also reveals a stabilization of the market share variance in both the worldwide market and U.S. market starting in 1986. After 1985, which coincides to the year after de facto standardization, the market share variance did not fluctuate exhibiting an average of 4.91 through 1986-1992.

The densely populated IBM compatible group, the slowing industry growth rate, and increasing production capacity of big players like IBM, created intense competitive pressures for IBM clone manufacturers. The increasing number of firms in this group, which had worked as a signal of the legitimacy of the IBM technology and standard in the previous stage, now generated cut-throat competition within the clone population. The clone makers traditionally relying on manufacturing PCs at lower prices (and to some extent upgraded characteristics), were having hard time competing solely on the basis of price, as price cuts were led by IBM.

As a result the industry witnessed the first exits of firms in 1985. In the following years of the Market Performance Competition Stage, the number of firms exiting the industry almost equaled the number of entries, stabilizing population density throughout

Table 2.2
Retail Prices of Selected Personal Computers, Various Years

Year	Model	Price ($)
1981	IBM PC	2,235
1984	IBM PC	1,995
1983	IBM PCXT	4,995
1984	IBM PCXT	3,895

Source: Standard and Poor's Industry Surveys, June 1985 this period.

2.3 The Evolution of Key Markets

In this section, the key markets in the PC industry and the relationship between the U.S., Western European, and Japanese markets are described. Together, these three markets constituted 88 % of the worldwide unit PC sales in 1990, and 86% in 1992 (Dataquest Inc.). There are some salient differences between the U.S and the Japanese markets in that, in Japan, approximately 50 % of the market is dominated by NEC, a Japanese manufacturer. NEC, uses a different operating system and different microprocessors which are incompatible to both IBM and Apple technologies. In Europe, U.S firms face a set of European competitors such as Groupe Bull and Olivetti, with major European presences and brand recognitions. Besides, Groupe Bull, has active governmental support due to public ownership. Although key players and the competitive intensity were different in these three markets, there is evidence of high levels of competitive interdependence which showed an ever increasing trend throughout the history of the PC industry.

2.3.1 The U.S. Personal Computer Market

In 1977, there were three PC manufacturers in the world and all were American firms. Apple, Commodore, and Tandy together had shipped 47,000 PC units in that year (Dataquest Inc.). Demand for their products was faster than they had imagined. As a result, production backlogs were attracting consumer electronics companies to diversify into the PC industry. By 1980, Hewlett-Packard, Texas Instruments, and Atari had entered the market. In 1980, the industry leader Apple controlled 27% of the market, and was closely followed by Tandy and Commodore with 21 and 20 percent market shares, respectively (Dataquest Inc.).

The presence of key semiconductor manufacturers such as Intel and Motorola, and the emergence of software manufacturing companies led by Microsoft, generated a continuous flow of new hardware and software in the U.S. market for PC manufacturers to utilize. This infrastructure of suppliers, together with the openness of the U.S. consumer and scientist to new products, enabled demand for PCs in the U.S. market to grow rapidly. In 1983, six million PCs were sold in the U.S alone. Table 2.3 presents the number of PCs sold in the U.S. market and the U.S. market's share of worldwide PC sales for various years.

2.3.2 The Role of U.S. Personal Computer Manufacturers

U.S PC manufacturers played the role of "technological leaders" in the industry. The use manufacturing were moving quickly down the learning curve in first generation PCs and continuously introducing new products. Competitive strategies of these firms were primarily determined by changes in semiconductor and software technologies (Ungson 1990). The size and the advanced infrastructure of the U.S semiconductor, software, and PC markets, concentrated in the small and densely populated Silicon Valley enabled the quick diffusion of technology and spill-overs between competing firms. Furthermore, the size of the U.S. PC market enabled investments in R&D to be recovered quickly.

Industry pioneers like Apple, and Commodore were entrepreneurial startups

Table 2.3
PC Sales in the United States, various years

Year	Units Sold [a]	US Market's Share of World Market	Non-US Market's Share of World Market
1983	6,199	55.73	44.27
1984	7,768	51.64	48.36
1985	6,072	41.29	58.71
1986	6,814	45.23	54.77
1987	8,391	50.32	49.68
1988	9,616	50.45	49.55
1989	9,330	43.75	56.25
1990	9,849	41.72	58.28
1991	10,183	40.75	59.25
1992	11,106	38.85	61.15

Source: Dataquest Inc., 1992

[a] Units sold are in thousands.

thriving on continuous innovation and upgrading. There was a continuous race between scientists in these firms to come up with better technologies and innovations. Sometimes, the rivalries were at the personal level as well as firm level. The continuous flow of scientists from early entrants to newer firms seemed to facilitate this personal rivalry. Hence, U.S firms offered continuous innovations in price/performance through leading edge technological advances.

As several firms worked on leveraging their own semiconductor technology (for example, IBM) others worked on enhancements in the user interface (for example, Apple with the Macintosh user interface). These technological leaders opened the roads of technology for others, mostly foreign PC vendors, to follow.

Technological leadership has given U.S firms the opportunity to dominate the industry and determine the future of it. This proactive technological leadership strategy has enabled six U.S firms to be among the top ten PC vendors while there were two Japanese firms and only one European firm in the top ten (See Table 2-4). The dominance of U.S vendors has increased even further in 1992 with eight out of the top ten being U.S. based.

2.3.3 The European Personal Computer Market

The first European PC vendor, Sinclair, entered the market in 1980. This U.K based company sold 35,000 of the total 40,000 units sold in Europe in 1980 (Dataquest Inc.). The European market for PCs was the second largest PC market. In 1990, approximately 34% of worldwide unit sales had taken place in Europe. Although the growth rate has been slow throughout the eighties compares to other regions of the world, in 1992 the share of the European market was still around 26% of world unit sales

(Dataquest Inc.).

Historically, Alcatel, Amstrad, and Olivetti have been the major European players. Alcatel exited in 1991 (Dataquest Inc., 1992). Amstrad, on the other hand, has not been able to sustain its initial successes in the PC industry. The company was among the top ten PC vendors ranked by revenue in 1987 (Dataquest Inc., 1992). However, by 1991 Amstrad has fallen below the top 25. Olivetti, on the other hand has been able to retain its position in the top ten by ranking sixth in 1987 and seventh in 1991. By concentrating its efforts in one geographical market, Europe, Olivetti has been able to retain high sales volumes.

Newer and stronger European PC vendors have emerged in recent years. Groupe Bull, the largest among these has been able to become a first tier global competitor through the acquisition of Zenith Data Systems in 1989. It ranked fifth in worldwide revenues in 1991.

2.3.4 The Role of European PC Manufacturers

After experimenting with alternative technologies and standards in the earlier years of the industry, European vendors generally have adopted IBM compatibility. Historically, they have not been very successful in the U.S. market and are almost nonexistent in the Japanese market. However, through geographical specialization, they have been able to dominate the European market. As technological adopters, they introduce new technologies (e.g. PCs with 486 microprocessors) after technological innovators have already done so. Hence, European firms have generally played the role of technological followers and geographical specializers in the PC industry. Table 2-5 shows the years of introduction of the latest technologies of selected European and U.S. firms.

Table 2.4
Nationality of Top 10 Vendors in the Global PC Market

1992		1991		1990	
Firm	Nationality	Firm	Nationality	Firm	Nationality
IBM	U.S.	IBM	U.S.	IBM	U.S.
Apple	U.S.	Apple	U.S.	Apple	U.S.
Compaq	U.S.	Commodore	U.S.	Compaq	U.S.
NEC	Japan	NEC	Japan	NEC	Japan
Commodore	U.S.	Compaq	U.S.	Commodore	U.S.
Dell	U.S.	Packard Bell	U.S.	Compaq	U.S.
Packard Bell	U.S.	Atari	U.S.	Toshiba	Japan
Toshiba	Japan	Toshiba	Japan	Tandy	U.S.
AST	U.S.	Tandy	U.S.	Epson	Japan
Tandy	U.S.	Groupe Bull	Europe	Atari	U.S.

Source: Dataquest, Inc.

Table 2.5
Years of Microprocessor Adoption of Selected U.S. & European Vendors

Firm	Microprocessor Type	
	80486SX	804486DX
European		
Amstrad	1992[a]	1992
Apricot	1992	1990
Bull	1991	1990
Olivetti	1991	1990
Phillips	1992	1991
United States		
AST Research	1991	1989
IBM	1991	1989
Tandon	1991	1990

Source: Annual Reports, various years.

[a] The years given are based on the year the company introduced a PC with the corresponding microprocessor.

2.3.5 The Japanese Personal Computer Market

Traditionally, dominated by Japanese vendors, the market had reached 2.5 million units in 1989, and 3.3 million units in 1991 (Dataquest Inc.). Revenues total about $10 billion in 1992 (Wall Street Journal, October 19, 1993).

Japanese vendors were quick to see the potentials of the fast growing PC market. Early entrants were diversifications from the mainframe industry and cross-overs from consumer electronics. NEC was an early entrant in 1979. The company immediately assumed market leadership in Japan and has retained this position ever since. Sharp and Sord's entry in 1980 was followed by Fujitsu, Epson, Matsushita, and Toshiba (Dataquest Inc.).

Due to the Japanese language and alphabet, there has been lots of experimentation with alternative hardware and software technologies in Japan. NEC's technology became the leading de facto standard, although other firms like Fujitsu, Sharp, Sord and Epson used other hardware technologies. Table 2-6 shows the market shares of the top PC vendors in Japan for the last couple of years. NEC's strong brand name, together with a strong network of loyal retailers, has made the Japanese market difficult to enter for U.S. firms with the exception of IBM.

Recent advances in microprocessor speed and capabilities has opened the Japanese market for U.S. vendors. The Intel 486 chip operates efficiently in Japanese and Japanese software for IBM compatible machines is finally developing. Hence, Compaq successfully entered Japan in late 1992 and Dell in early 1993 (Wall Street Journal, October 19, 1993).

The entry of other IBM compatible PC vendors has significant implications for the establishment of industry standards in the Japanese market. The increasing number

Table 2.6

PC Shipment Market Share of Vendors in Japan

Vendor	Home Country	1989[a]	1991	1992
NEC	Japan	36.2	53.0	53.0
Fujitsu	Japan	5.3	8.0	9.8
Apple	U.S.A	1.4	5.4	8.3
Toshiba	Japan	7.3	7.9	7.6
IBM	U.S.A	6.4	6.9	6.1
Seiko-Epson	Japan	6.7	7.7	5.7

Source: Wall Street Journal, October 19, 1993.

Note: The figures for 1989 refer to the share of the Asia/Pacific market.

of firms selling IBM compatible PCs in Japan is expected to increase the legitimation of IBM compatibility in Japan. This legitimation, in turn, is expected to lead to a long waited clarification of competing PC technologies in Japan.

2.3.6 Industry Standard Competition in Japan

The entry of new firms manufacturing IBM compatible PCs in Japan has rejuvenated a long existing war among alternative PC technologies. The standard that is challenged is NEC's de facto standard that enjoyed 53% of the market in 1992. Fujitsu, with approximately 10% share of the market has its own technology incompatible to NEC, IBM, or Apple. With new players on the IBM compatible league, the dominance of NEC in Japan can be challenged and finally the Japanese market can be open to global competition. Fujitsu's recent adoption of IBM standard (Wall Street Journal Oct 19, 1993), could mean a critical step in establishing "global" de facto standardization in the PC industry.

2.4 The Globalization of the PC Market

Some trends in the PC industry are increasing the globalization of the industry at a very fast pace. First, the establishment of a *de facto* standard in the U.S. market is facilitating the establishment of a standard in other critical markets around the world. U.S. firms from different markets are increasingly using their resources and experiences from one market in cross-subsidizing market share battles in others.

Morrison and Roth (1992) use the identification of global players and global brand names as two criteria to identify industries as global. According to their argument, if the same players compete with each other in leading world markets then there is evidence for

Table 2-7

Top Four Firms and Their Market Shares in Key Markets, 1990, 1992

U.S.	1990	MS	1992	MS	Japan	1990	MS	1992	MS
	IBM	14.18	Apple	12.20	Asia/ Pacific	NEC	41.84	NEC	38.00[a]
	Apple	10.90	IBM	11.68		Toshiba	12.85	Apple	7.53
	Tandy	4.60	Compaq	5.13		IBM	7.25	IBM	5.00
	Compaq	4.29	PackardBell	4.64		Fujitsu	5.58	Fujitsu	3.67
Western Europe	Commodore	13.85	Commodore	15.16	Rest of World	Commodore	9.73	IBM	9.96
	IBM	13.30	IBM	15.04		Epson	5.10	Aces	4.24
	Atari	6.81	Apple	9.07		Compaq	4.04	Apple	3.46
	Apple	5.09	Compaq	8.39		Toshiba	3.17	AST Res.	3.00

Source: Dataquest Inc., various years.

[a] The market share figure refers to 1991.

globalization. Converging markets and technologies are transforming the PC industry into a global one where global competitors and brand names dominate the markets worldwide.

The top four firms and their market shares in four regions for 1990 and 1992 are shown in Table 2-7. Competitive positions in key markets seem to be highly interdependent. In 1992, IBM and Apple, consistently appear in the top four in all the regions. Furthermore, Compaq is among the top in the two largest markets, U.S. and Europe. Hence, there is strong evidence that the same firms compete effectively for market share in all the regional markets. Furthermore, competitive positions in one market seems to be affected by positions in others. The global positions of these firms are further supported by their global brand names such as IBM/PS2 and Apple Macintosh. Their image as technological leaders in the industry also enhance their global market shares. To conclude, the PC industry can be classified as global where key markets are dominated by the same firms.

A close look at Table 2-7 shows that in Western Europe and Japan, Commodore and NEC, respectively enter the top four, although they do not do as well in the rest of the world. These firms have positioned themselves more aggressively in these regions only. Commodore, has been forced to concentrate its efforts in the European market where it enjoys high brand recognition and loyalty. Its continuous loss of market share in the U.S. market has forced Commodore to become a geographical specialist. NEC, on the other hand, is positioned very strongly in the Japanese market. This is mainly due to its development and commercialization of an operating system suitable for the Japanese alphabet. The need for a different hardware and software for the Japanese market has worked as an entry barrier for many U.S. and European firms (with the exception of IBM) into the Japanese market. Entry was further inhibited by the very limited developments in software to deal with the complex nature of the language.

The existence of firms like Commodore and NEC and their outstanding success in certain regions, reveal the presence of geographical specialist strategies together with global strategies in the personal computer industry.

Conclusion. The presence of the same PC vendors in top positions in key markets reveals the existence of global players competing with global strategies in the global PC industry. The industry has exhibited an increasing level of globalization in recent years. However, there is also evidence of geographical specialists existing together with global firms. The PC industry seems to host two types of firms: (1) global firms pursuing global strategies, and (2) geographical specialists thriving for regional dominance through concentrated efforts.

CHAPTER THREE

REVIEW OF THE LITERATURE

This chapter reviews the literature relevant to organizational entry. The two approaches used to study entry in organizational ecology are discussed, namely: (1) density dependent explanations to entry, and (2) population dynamics explanations to entry. The discussion is extended to density dependent and population dynamics explanations of cross-population effects. The purpose of this review is present the state of knowledge in both streams of research. The review will also present a synthesis of the empirical literature.

3.1 Organizational Ecology

Organizational ecology (OE) focuses on the study of organizational diversity (Singh and Lumsden 1990). It investigates the effects of social, environmental, and organizational conditions on (1) the rates of creation of new organizations, (b) the rates of mortality of organizations, and (c) the rates of change in organizational forms (Singh and Lumsden 1990). The evolutionary dynamics of environmental and organizational processes and their influences on organizational births and deaths are central issues. In contrast to the prevailing emphasis on adaptation in the study of organizations, OE emphasizes the role of selection processes.

OE theorists see organizations as subject to inertial forces resulting from both internal and external arrangements (Hannan and Freeman 1989). The dynamics of diversity of a population is dependent on the rate at which new and diverse organizations are created and the rate at which organizations of various types disappear. The formation of new (kinds) organizations and the disappearance of existing types are central to the process of diversity in the world of organizations. Thus, entry and exit rates constrain the dynamics of diversity and the speed of organizational evolution. Entry and exit rates are expected to vary in response to changes in density and environmental conditions that affect carrying capacities (Hannan and Freeman 1989).

3.2 Density Dependence of Founding and Mortality Rates

3.2.1 Description

Much of recent research in organizational ecology (OE) is based on Hannan's (1986) model of density dependence in organizational founding and mortality rates. This model is used by sociologists and organizational researchers to understand and evaluate the nature, sources and intensity of competition. Operationally, researchers have studied competition and mutualism using the `density dependent' founding and mortality model (Barnett and Carroll 1987; Carroll and Hannan 1989; Delacroix, Swaminathan and Solt 1989). The model permits entry and exit rates to vary according to the number of organizations in the population.

Hannan (1986) formulated founding and mortality rates in an organizational population as a function of opposing processes of legitimation and competition. *Legitimation* of an organizational population means its organizational form acquires a "taken for granted" or institutionalized character (Hannan and Carroll 1992). *Competition* refers to constraints arising from the joint dependence of multiple organizations on the same set of finite resources for building and sustaining organizations. *Density* refers to the number of firms in the population.

In explaining population growth, Hannan (1986) argued that population density captures both legitimation and competitive forces. According to this model, at low levels of density reflecting the early development of an organizational population, the legitimation process will dominate. This occurs because new organizational forms have difficulty in gaining access to capital and in getting their products accepted and supported by customers, suppliers and other related parties (Carroll and Wade 1991; Hannan and Freeman 1989). The population acquires legitimacy through increased numbers. As the number of organizations increases, thus making the level of density higher, entrepreneurs, the capital market and other related parties such as government institutions begin to see the form as viable. This perceived viability prompts more entrepreneurs to adopt the form in founding new organizations as well as the barriers to the capital markets to fall. Hence, an increase in the number of firms will increase founding rates and reduce mortality rates.

Carroll and Wade (1991) describe the continuation of the dynamics succinctly in that "As the population expands further, legitimacy gains diminish; the population has achieved a "taken for granted" or institutionalized character and there are no further returns to expansion by numbers (p.273)". At this point competition rather than legitimacy increases as the size of the population expands. When a population approaches its carrying capacity, competition intensifies further as now there are more firms competing for the same critical resources. This intense level of competition discourages potential entrepreneurs and the founding rate declines. Additions to the number of firms at this stage also result in higher mortality rates.

3.2.2. Convergence of Ecological and Institutional Research

Organizational ecology and the institutional approach to organization (Meyer and Rowan 1977; Meyer and Scott 1983) were initially seen as separate theoretical views. More recent studies, however, suggest convergence of the two theories (See Singh and Lumsden 1990 for a discussion). Legitimacy and the role it plays in organizational dynamics has been one area of convergence between population and institutional research (Singh and Lumsden 1990).

The theory of institutionalization states that legitimacy affects population change through external institutional support which reduces selection pressures on organizations. The isomorphism of an organization with the institutional environment enhances legitimacy and so provides greater access to resources, which reduces mortality rates and increases entry rates. Institutional theorists define isomorphism as a constraining process that forces one unit in a population to resemble other units that face the same set of environmental conditions (DiMaggio and Powell 1983).

At the population level, the trend toward isomorphism suggests that organizational characteristics are modified in the direction of increasing compatibility with environmental characteristics (DiMaggio and Powell 1983). In contrast to Hannan and Freeman (1977) which argue that non optimal forms are selected out of a population, some institutional theorists emphasize adaptation but not in the sense that managers' actions are necessarily strategic in a long range perspective (DiMaggio and Powell 1983). They believe that a lot of managerial behavior takes place at the level of "taken for granted assumptions" (p.149) rather than conscious strategic choices (DiMaggio and Powell 1983). The theory of isomorphism, as described by institutional theorists addresses not the psychological states of actors but the structural determinants of the *range* of choices that actors perceive as rational or prudent. This fits very well with organizational ecology explanations of legitimation of form. When an organizational form is legitimized, entrepreneurs are expected to adopt that form that has been generally accepted in the industry. In the PC industry, the establishment of an industry standard around IBM compatibility has legitimized that technology and has limited the range of technological choices available to entrepreneurs. This limitation in range and legitimation of IBM compatibility has generated a flow of new entries manufacturing IBM compatible products.

Whether the process of selection or adaptation is at work at the population level, the two schools of thought converge in treating legitimation as the underlying process that links density to changes in organizational entries and exists. Hence, the institutional theory provides additional support for the underlying processes that work in density dependent models.

Consistent with Hannan's model, this study advocates that the evolution of organizational populations and competition within and between those populations can be best studied by examining how density, population dynamics, and institutionalization processes influence the rates at which new organizations are created.

3.2.3. Studies Using Density Dependent Founding Model

Compared with the extensive literature on organizational mortality, there are fewer studies on organizational entry in the OE literature. [For an excellent review of empirical research on organizational mortality, see Singh and Lumsden (1990).] The limited number of studies on founding may be partly due to conceptual and methodological peculiarities of studying founding (Delacroix and Carroll 1983).

Founding (or entry) rates pertain to attempts and the absence of attempts to create firms, while failure rates pertain to existing organizations (Hannan and Freeman 1988). Failure rates depend on properties of individual firms such as age and size as well as on population characteristics such as density (Barnett 1990; Hannan and Freeman 1989). In studying founding rates, since there is no organization prior to founding, the population itself needs to be treated as the level of analysis. (Hannan and Freeman 1988).

In an empirical test of his theory, Hannan (1986) found support for the nonmonotonic relationship expected between density and founding rates. Density had a nonmonotonic effect on founding rates, the effect being first positive and then negative. In more complex models that controlled for prior density and births, Hannan and Freeman (1987) found strong support for the model. Since, then several other studies have found patterns of density dependence that agree with the nonmonotonic density dependent model. These studies and the populations studied are summarized in Table 3-1.

Studies in highly volatile, high-tech industries have reported findings that do not support the model. Hannan and Freeman's (1989) analysis of rates of entry into the U.S. semiconductor industry revealed a monotonic positive effect of density on the rate. A possible explanation for this finding is that the semiconductor firm population as a whole could be well below its carrying capacity at all times, and therefore a growing population created entry opportunities. In other words, the time frame of the study (1947-1984) may not have been long enough to get beyond the growth stage in the industry. Although Carroll and Hannan (1989) state that studies which include the entire history of an industry have found results consistent with the model, it is useful to test the theory in other populations.

Table 3.1[1]
PRIOR STUDIES ON ORGANIZATIONAL ENTRIES

Approach	Population	Results	Reference
Density dependence	US national labor unions	+ +	Hannan '86
	US national labor unions	+ (industrial unions)	HRF '87
	US semiconductor (1947-1984)	+ - (monotonic + effect)	HRF '89
	Independent local telephone companies in Iowa (1900-1917)	+ +	Barnett & Carrol '87
	Medical diagnostic imaging industry (1959-1986)		Mitchell '87
	American brewing industry (1633-1988)		Carroll & Swamingathan '89
	Nine newspaper population	+ +[2] (American Soc. Review)	Carroll & Hannan '89
	US brewing industry (1633-1988)	+ +[3] (complete data set) + + (only 19th and 20th century data analyzed)	Carroll & Swaminathan '91'92
	US brewing industry (1975-1990)	+ +[4]	
	US brewing industry	+ +	

[1]Adapted from Singh and Lumsden '90.

[2]Strong support for founding, but the mortality model holds for large populations.

[3]Density effects remain strong after isolating the effects of legality issues pre- and post-prohibition periods.

[4]Non-monotonic relation found for brewpubs and microbreweries.

Furthermore, density dependent models have not included variables such as firm strategies regarding geographical diversification, and technological leadership. Some population demographics variables, namely, the densities of firms relative to their bases of incorporation may also affect entry rates. Density dependent models may be very sensitive to model specification error (Barnett 1990). Both the direction and significance of density dependence have been shown to change when organizational, environmental, and characteristics of the population other than density are controlled for (Barnett and Amburgey 1990). Hence, it should be desirable to test the density dependent model in another industry by incorporating such variables.

Conclusion. The density dependent model of organizational founding has been strongly supported, with the exception of the results from the U.S. semiconductor industry. Testing this model in another young, high-tech industry, namely the global PC Industry by incorporating strategic and population demographic variables could help explain the inconsistent findings. To eliminate possible period specific biases, an observation window which covers the industry's entire history is used. This leads to the following propositions pertaining to the global PC industry:

Proposition (1): The relationship between density and organizational entry is nonmonotonic. The relationship is positive at low levels of density and becomes negative at higher levels of density.

3.3 Population Dynamics of Organizational Founding

3.3.1. Description

A second approach to the study of organizational founding within the OE tradition comes from Stinchcombe's (1965) influential work on the motivations and environmental factors conducive to founding. Stinchcombe argues that the conditions prevailing at a given moment in time put their stamp on new organizations, and due to the inertial properties of organizational structure, these characteristics at the time of founding persist as long as the organizations survive. If this argument is true, diversity in organizations at any moment in time reflects variations in founding conditions.

A significant period when density is not yet a mitigating factor on founding is the interval during which a population or industry is being created to take advantage of newly created resources such as a new technology (Brittain and Freeman 1980). The period of initial industry creation usually witnesses large numbers of organization founding with success for some kinds of firms (e.g. PC clone makers) more a function of timely arrival than their ability to outperform other forms. Hence, the manner in which organizational forms (or firms) first appear and become common is highly relevant not only for the initial stages of a new industry but also has significant implications for the whole life-cycle of the industry. Prior history of organizational founding and growth can affect organizational entry rates as individuals leave one organization and enter another (Brittain and Freeman 1980).

In another study in the Stinchcombe tradition Pennings (1982) related organizational birth frequencies to attributes of urban ecology and the abundance of socioeconomic resources. The most important predictors of organizational birth were occupational and industrial differentiation, the size of the industry, the availability of venture capital, and to a lesser extent, the presence of universities.

According to Delacroix and Carroll (1983) the cyclical patterns of organizational founding over time can be explained by the effects on resource availability of prior foundings and prior failures. The effects of prior entries and exits might operate both through material processes and subjective evaluations of events by potential entrepreneurs. The establishment of a new firm in an industry either indicates the availability of resources or it is interpreted as a sign of resource availability. Hence, each new entry encourages the entry of others. Since each birth uses up resources, the process by which entries trigger entries may outstrip resource availability (Delacroix and Carroll 1983). Entrepreneurs may tend to overreact to births and collectively overshoot the carrying capacity of the environment. Hence, a very high entry level should have a negative effect on the frequency of subsequent entries. The cyclical behavior of entry can be fitted well by a quadratic function of entries in the prior period (Hannan and Freeman 1989). A nonmonotonic effect of prior entries on current entry rates is believed to prevail.

In terms of prior exits, when an existing organization dies, some resources are freed, which could be used to create new organizations. An upper limit exists to this positive effect of prior failures on current entry, since an even larger number of deaths would signal a hostile environment to potential entrepreneurs. Consequently, a very high level of exit should depress the level of subsequent entries (Delacriox and Carroll 1983; Hannan and Freeman 1989). This effect would lead to a curvilinear relationship between prior exits and current entry rates.

Mitchell (1991) identifies another factor affecting entry rates into an industry: the length of existing firms' participation in the industry, referred to as survival. Survival as a population dynamics variable, signals the performance of existing firms or incumbents. Although survival may be weakly correlated with market share and profitability (Mitchell 1991; Schaffer 1989), survival potential is of interest to potential entrepreneurs in their decision to enter an industry or not. Long periods of industry participation or survival would encourage potential entrepreneurs to create new organizations by signalling a fertile niche. But as the survival period increases further, the core of the market will be exploited by existing firms, discouraging further entry. The effect of survival on entry rates is expected to prevail even after controlling for the number of firms in the industry.

Conclusion: Density and population dynamics arguments together explain the waves of founding in the history of organizational populations. It is important to model density and population dynamics variables together, because population dynamics effects can be related to both density dynamics and changes in density levels (Singh and Lumsden 1990; Tucker, Singh, Meinhard and House 1988). When the two are modeled together there is some evidence that density dependence effects are stronger than population dynamics effects. It should be useful to study the generalizability of these results.

The theoretical and empirical findings on the relationship of population dynamics variables and founding rates yield the following propositions:

Proposition 2: There is a nonmonotonic relationship between prior entries and exits and current organizational entry rates.

Proposition 2(a): There is a positive relationship between prior entry and current organizational entry rates, but the relationship becomes negative at high levels of prior entries.

Proposition 2(b): There is a negative relationship between prior exists and current entry rates, but the relationship becomes positive at high levels of prior exits.

Proposition 2(c): There is a positive relationship between survival and entry at lower duration of survival of incumbents: but the relationship becomes negative at higher duration of survival of incumbents.

Proposition 2(d): Density dependent effects on entry rates are stronger than population dynamics effects.

3.4 The Organizational Ecology of Strategic Groups

A strategic group (SG) is a grouping of organizations in the same industry which pursue similar strategies with similar resources (Hatten and Hatten 1987; Porter 1980). Analyzing strategic groups in an industry or population enables investigation of interactions and relationships between groups that industry-level research tends to compress by averaging across distinctly different firms. If firms in an industry can be readily classified into several meaningful groups, then industry micro-structure might be analyzed in much the same way that industry structure typically is. From this perspective, strategic group analysis is very similar to subpopulation level research of the OE tradition. Actually, the use of models from organizational ecology have been successfully applied to the study of strategic groups. [See, for example, Carroll and Swaminathan (1992) for an American Brewing Industry application.]

Caves and Porter (1977) used the theory of mobility barriers to analyze strategic groups. Mobility barriers can be generally expressed as either absolute costs of movement from one group to another, or as the operating or variable cost penalty relative to incumbents that the entrant must face (McGee 1985; Hatten and Hatten 1987). At the heart of strategic groups theory is the idea that there are `rigidities associated with change' (Oster 1982).

Caves and Porter (1977) have noted that firms in an industry are typically heterogeneous, but this heterogeneity is limited because firms frequently show structural similarities with some but not all other firms in the industry. Porter (1979) explicitly refers to strategic groups competing viably with each other in the same competitive arenas. However, this view can be regarded as an unnecessary restriction on the application of the group concept (Hatten and Hatten 1987). In fact, studies of the American brewing industry (Hatten, Schendel and Cooper 1978; Schendel and Patton 1978) found that some groups were composed of firms actively competing not against each other but *against other market members classified in different groups*.

In line with Hatten and Hatten (1987), this study regards the requirement of rigidities associated with change and the issue that groups have to be formed from companies which competed with each other in the same competitive arenas to be unnecessarily restrictive. In this study, a group is regarded as simply a tool to help us explore the interactions between subpopulations more aggressively and exhaustively.

The application of OE models to the study of strategic groups requires laying the foundation of certain assumptions. First, entry rates are used as the dependent measure (rather than performance). Second, group interdependencies are examined with density dependent models (Carroll and Swaminathan 1992). Third, *organizational form* can be used as the basis on which organizations get sorted into fairly persistent strategic groups. By this view, organizational form means much more than the formal structure of the organization. It includes all factors that define a populations's niche including especially environmental factors.

Based on the definition of groups adopted in this study, and using organizational form as the basis to sort firms into groups, firms in the global PC industry are disaggregated first into U.S. based versus foreign based firm subpopulations and second into geographical specialist versus global generalist subpopulations. In the next two sections the theoretical and empirical implications of organizational ecology of strategic groups in the global PC industry is presented.

3.4.1. Interactions Between Sub-Populations

Just as the addition of an organization to a population affects entry and exit rates in that population, the addition of an organization to a competing population may also affect these rates. The only distinction is whether the effect occurs within a population or across the boundary between populations (Hannan and Freeman 1989).

In a useful extension of the density dependent founding and mortality model, density is disaggregated to detect whether specific types of organizations generate competition or mutualism. For example, Hannan and Freeman (1989) disaggregated the density of national labor unions into craft and labor unions in order to model competition among and between these sub-populations. Their results generally found that increasing density of industrial unions strongly depressed the founding rate of craft unions and vice versa. The same researchers disaggregated the population of semiconductor manufacturers into independent and subsidiary firms (Hannan and Freeman 1989). They found the number of independent firms to have a positive and significant effect on the entry rates of subsidiary firms. Independent firms were found to provide support for subsidiary firms, thus evidencing mutualism between populations. The cross-effect of the subsidiary population on the independent population, on the other hand, revealed a nonmonotonic effect. Increasing numbers of subsidiary firms initially increased rate of entry of independent firms; but, as the density of subsidiary firms increased at higher levels, the entry rates of independent firms dropped off rapidly.

In a study of the early telephone industry, Barnett and Carroll (1987) disaggregated the population into mutually owned and commercially owned telephone company populations. They showed that mutual and commercial companies operating in the same geographic area were symbiotically related. Barnett (1990) used type of technology, more specifically transmission and power technologies, as the basis for disaggregation. Carroll and Swaminathan (1992), disaggregated the density of American brewers into mass producers, the microbrewery and the brewpub, in order to model competition among and between these groups.

3.4.2 Interactions between U.S. and Foreign Based Groups

It seems reasonable to expect that the entry of firms into an industry might result in an expansion of the market, a diversion of demand from incumbent firms, or a combination of the two (Mahajan, Sharma, and Buzzell, 1993). Entry of a new firm might expand total market volume especially when the new entrant introduces significant innovations in product concept or design. Historically, U.S. firms have been technological leaders in the industry, continuously expanding the market by new product introductions and improvements. Hence, U.S. and foreign based firms are expected to differ significantly on the level of their technological innovativeness. Technological innovativeness is defined as the ability to generate significant returns from new products.

Technological innovativeness of U.S. based firms may attract new buyers and lead to accelerated market growth and expansion (Mahajan *et.al* 1993). This market expansion might also create opportunities for incumbents to appeal to new potential buyers, thus making the general market environment more attractive to new entry. Hence, the density of U.S. firms is expected to have a positive effect on entry into the industry.

Not all firms in industries rely on innovativeness and speed to market for survival. When organizational technologies are poorly understood, or when the environment creates uncertainty, organizations may model themselves on other organizations (DiMaggio and Powell 1983). Such mimetic behavior can yield a viable solution with little expense. Firms relying on imitative strategies will attempt to appeal to the potential buyers of technological leaders by adopting the same technologies. In this case, foreign firms as technological followers, market established products and attempt to divert U.S. vendors' potential buyers through promotion and/or price reductions. Hence, foreign based firms are expected to intensify competition in a market, thereby making the industry less attractive to new entry.

When there are few foreign companies or me-too strategists in an industry, entry rates of followers can increase because niches left unattended by U.S. firms motivate entrepreneurs to imitative entry. However, there is a ceiling to this positive density effect. When there are too many foreign firms, the niches left by leaders are already exploited and returns to imitation decline. Thus, entry rates are expected to decrease beyond the carrying capacity of the industry for imitators.

Based on the preceding discussion, the global PC industry is expected to host two main groups of firms pursuing different technology strategies: (1) The population of U.S. based PC vendors, and (2) the population of foreign based PC vendors. U.S. based firms such as Apple, IBM, and Compaq compete for price/performance leadership through leading-edge technological advances such as products using the most advanced microprocessors. These technology platform companies are first to market state-of-the-art PCs. AST Research, and IBM, for example, introduced their first PC using a 486DX

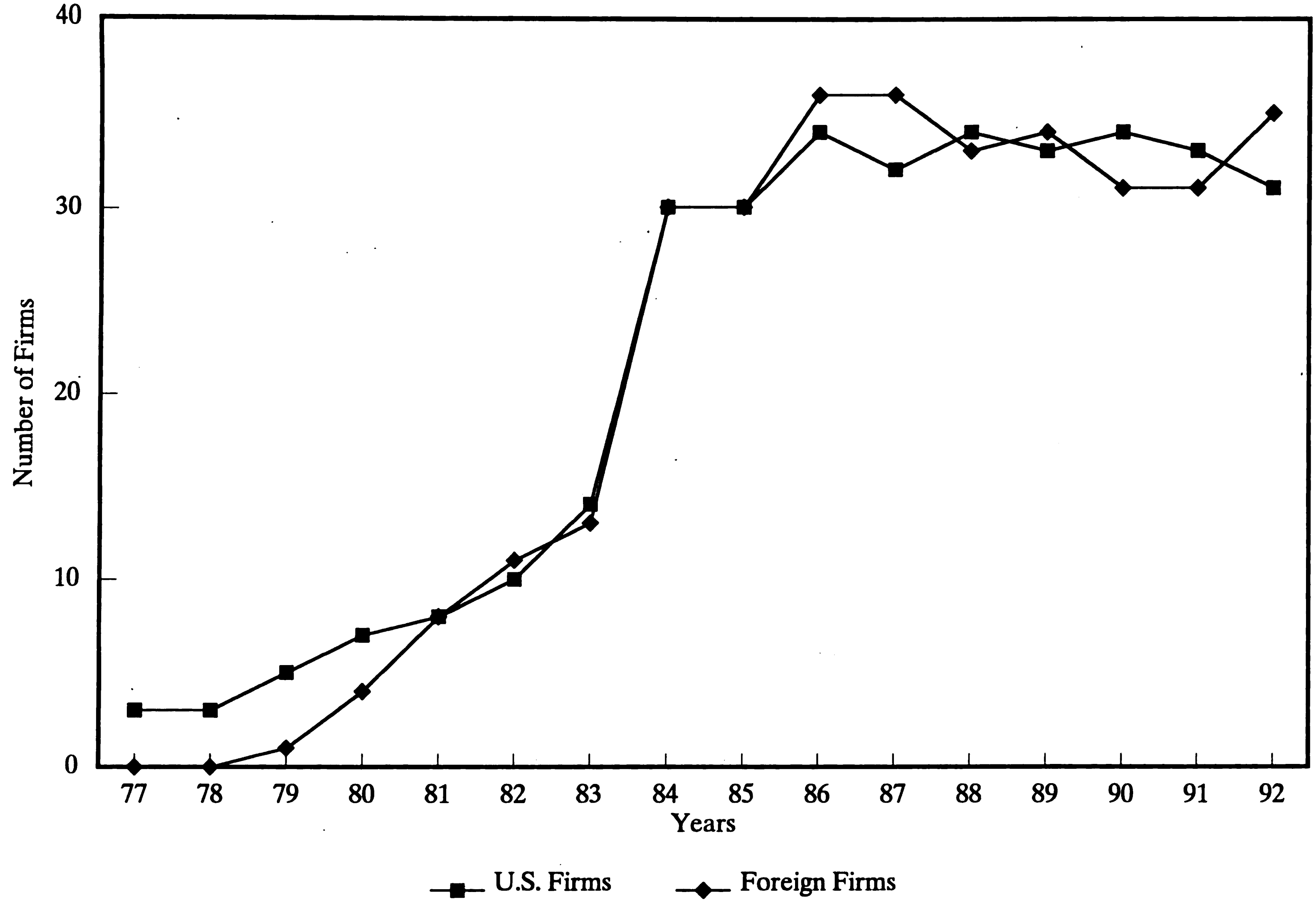


Figure 3.1
Number of U.S. and Foreign Firms in the Global PC Industry

microprocessor in 1989. Amstrad, on the other hand, generated 50 percent of its 1991 revenue from PCs using old technology processors like the 80XX and 80286 families (Dataquest 1992). Commodore also relies too long on older technologies.

The distribution of U.S. and foreign based firms included in this study over the 1977-1992 period is presented in Figure 3.1. An analysis of Figure 3.1 shows that, the number of U.S. and foreign based firms have been very close to each other over the life history of the industry. Although U.S. firms have outnumbered foreign firms in every year up to 1981, after that year foreign firms have caught up. So Figure 3.1 shows that U.S. based firms have not been able to sustain the dominance in numbers that they had in the beginning years of the industry. Hence, there must be some underlying processes that lead to these changes.

What is the relationship between U.S. based and foreign based firms? Do they compete with each other or do they create an environment conducive to new entry by firms from both populations?

Conclusion. These empirical studies illustrate that complex interdependencies exist between organizational subpopulations. Furthermore organizational interdependencies can exist at several levels: between individual organizations, between subpopulations of organizations, and between communities of organizations (Carroll and Wade 1991). By analyzing the entire population of PC manufacturers we implicitly assume that U.S. and foreign manufacturers experience similar processes (that is interdependencies exist only at the population level). But, U.S. and foreign firm populations may affect each other's founding rates and each population may be affected differently by population dynamics and environmental factors. For example, U.S. vendors could have driven the expansion of the PC market by first legitimizing foreign vendors and then competing with them. If so, U.S. and foreign firm populations should be analyzed as separate subpopulations rather than together as a single population of PC vendors. The preceding discussion leads to the following propositions:

Proposition 3(a): There is a positive relationship between the density of U.S. firms and entry rates of both U.S. and foreign firms. The relationship becomes negative at higher levels of U.S. firm density.

Proposition 3(b): There is a negative relationship between the density of foreign firms and entry rates of both U.S. and foreign firms. The relationship becomes positive at higher levels of foreign firm density.

3.5 Geographical Specialists versus Global Generalists

3.5.1. Geographical Diversification

An increasing number of firms are pursuing international market diversification to achieve economies of scope and synergies. Research on international market diversification has found a positive relationship between the intensity of international market operations and profitability (Rugman 1979). The cross-market transfer of tangible assets, particularly financial resources, is expected to enhance performance in key markets (Hamel and Pralahad 1985).

Although the effects of geographical diversification on survival and performance have received increasing attention, the international marketers have shown relatively little interest in the effects of diversification on entry rates. This study attempts to fill this gap by investigating the effects of geographical diversification or specialization strategies of incumbent firms on the entry rates of newcomers.

3.5.2 The Population Ecology of Diversification

The essence of organizational ecology to the treatment of groups is to view them as separate, possibly interdependent, populations of organizations (Carroll and Swaminathan 1992). As discussed earlier, organizational form is used to define subpopulations. In this view, organizational form is determined by the degree of geographical diversification. More specifically, geographical specialism or generalism can be used as the basis to form groups. In ecological terms, the level of specialism or generalism is an issue of niche width (Hannan and Freeman 1977; Freeman and Hannan 1983). When a niche is broad-based and organizations can survive on a variety of different resources, the population is composed of generalists. When organizations depend on a narrow range of resources, they constitute a specialist population.

Hannan and Freeman (1977) view generalism and specialism as opposite ends of a continuum with wide ranges corresponding to generalism and narrow ranges corresponding to specialism. This continuum describes an organization's breadth of geographical markets served, variety of technologies used, variety of products produced or all three. Based on this definition, generalism is an organizational attribute representing the range of clientele, services, and funding sources that an organization deals with (Aldrich 1979). A specialist organization has a very circumscribed, narrow geographical niche, whereas a generalist offers a broad range of products to a geographically dispersed clientele (Wholey and Huonker 1993).

Questions about within- and between-group interdependence among generalist and specialist firms in the global PC industry can be modelled using density dependent founding models (Carroll and Swaminathan 1992).

3.5.3 Generalist and Specialist Subpopulations in the Global PC Industry

As discussed in Chapter 2, for the last nine years or so, the global PC industry has experienced consolidation. While market share positions among top tier vendors (e.g. Apple, IBM, Compaq) remained fairly stable, exits of vendors controlling fractional amounts of the market have been significant.

Throughout the history of the industry, mainly two distinctive organizational forms have existed. The first of these, *geographic-niche suppliers* are companies that focus their sales regionally-often on selected vertical markets (Dataquest, PC Market Trends 1992). Key examples of such geographical specialists are Groupe Bull, Olivetti and Commodore in Europe and Nec in Japan. The second, *global generalists*, are firms that concentrate their capacities in ways that exploit the global market. Given these fundamental differences in geographical diversification strategies, the two organizational forms thus define strategic groups in the global PC industry.

PC vendors of each organizational form also face different strategic challenges. Generalists compete on a global basis for large market shares. This segment of the industry is recently enjoying newly found manufacturing and distribution efficiencies. The specialists, by contrast, target their products for regional markets. They are facing accelerated price competition and problems in maintaining regular access to distribution channels.

If geographical specialists and global generalists constitute distinctive organizational forms in the OE sense, then generalists and specialists should each experience separate processes of legitimation and competition governed by the prevalence of numbers of each form (Carroll and Swaminathan 1992).

Carroll (1985) proposed that competition among generalist organizations in a population to occupy the center of the market (or the central market-U.S.) frees peripheral resources that are most likely to be used by specialist members of the population after controlling for firm size. This hypothesis implies that, in concentrated markets with few large generalists, specialists may be able to exploit more of the available resources without engaging in direct competition with larger global generalists. Carroll (1985) referred to the process generating this outcome as resource partitioning. The resource partitioning explanation yields the prediction that increased density of global generalists decreases the entry rate of generalists and increases the entry rates of geographical specialists. In other words, generalists create global competition for each other while during this process they free some local markets for geographical specialists.

The case of Commodore can be used to illustrate this point. Commodore can be considered a geographical specialist through its heavy reliance and concentration in the European market. Commodore generated 75 and 84% of its revenue from Europe in 1990 and 1991, respectively (Annual Reports). It's 11.8 % market share of the European PC market makes Commodore the second largest PC vendor in Europe second after IBM (Annual Reports). Commodore's success can be attributed to concentrating its capacities on a limited geographical area. Hence, as geographical generalists like IBM, NEC, Compaq and Apple compete with each other for global market share, Commodore is concentrating in the European market. Hence, the propositions are:

Proposition 4(a) : There is a positive relationship between the density of generalists and entry rates of specialists.

Proposition 4(b) : There is a negative relationship between the density of generalists and entry rates of generalists?

3.6 Regional Competition versus Global Competition

Researchers have classified industries as being either `multidomestic' or `global' (Bartlett and Ghoshal 1987; Hamel and Pralahad 1985; Yip 1989). In a global industry, important characteristics like consumer needs, minimum efficient scale, and context of competitive strategy are defined not by individual national environments, but by the global economy (Bartlett and Ghoshal 1987; Levitt 1983). This makes global industries a series of linked domestic industries where structural forces combine to produce a single competitive arena which transcends national competitive environments (Porter 1986:12). The scope of competition is on a global level, even if manufacturing takes place on a local-for-local basis. In contrast, multidomestic industries are characterized by competitive forces that are constrained structurally by country and competition can be analyzed in much the same way as domestic competition (Morrison and Roth 1992).

Competition in a global industry exposes businesses to an `interdependent' competitive environment where actions in one country affect competitive intensity in another. Hamel and Pralahad (1985) describe the process of cross-subsidization as the essence of global competition. An aggressive competitor can use the cash flow generated in its home market(s) to cross-subsidize an attack on the home market(s) of foreign based competitors. A defensive competitor can retaliate not in its home market where the attack was staged, but in national markets where the aggressor firm is most vulnerable. The existence of such global competitive interaction requires a level of analysis that considers interactions at the regional level.

3.6.1. Organizational Ecology Approaches to Regional and Global Competition

In studying interdependencies between geographical markets population density is disaggregated according to regions. Carroll and Wade (1991) disaggregated density according to geographic location to investigate whether the effects of competition are stronger for the population defined at a local geographic level than for a national population. They found that the addition of an organization to a population had a greater competitive impact on the failure rate at the local level. For the rural brewery population, they found the density of urban breweries to first drive the expansion of the market for beer by first legitimating rural breweries and then competing with them. The same findings hold for founding of urban breweries. Baum and Singh (1992, 1993), in analyzing the rates of founding and failure of day care centers showed that the intensity of competition between centers increased with geographical proximity and overlap in the ages of children served.

3.6.2. An Alternative Explanation to Interactions Between Regional and Global Markets

An alternative explanation to the effects of density on organizational entry comes from the discussion of cross-subsidization presented in 3.5. By analyzing interactions within and between regional markets we implicitly assume that the process of cross-subsidization is captured by density dependence. In other words, when number of firms increases, competition is created not only because more firms are competing for the same limited resource base, but the flow of tangible and intangible assets across markets generates uneven competitive pressures in regional and global markets. If an entry to a regional market decreases entry at the global market level, high levels of competitive interdependence is found to exist. This signals the existence of cross-subsidization. Such a finding can be interpreted as the flow of tangible and intangible assets from one region to another (Teece 1987). If the regional population has a later "starting" date than does the larger population defined at the higher (global) level, competitive effects through cross-subsidization can be more pronounced even at earlier stages of the industry history (Carroll and Wade 1991). In other words the legitimation process expected to take place at early stages of the industry can be replaced by competition generated through cross-subsidization by incumbent firms.

Conclusion. A different level of analysis, one at the regional market level, can explain fluctuations in entry rates to geographical markets more robustly. Significant interdependencies between regional and global markets are expected in the global PC industry. When analysis is conducted at the regional as well as the population levels, the effects of some population dynamics variables are expected to change.

The process of cross-subsidization is presented as an underlying source of high interdependencies. Cross-subsidization manifests itself as increased intra-population competition. When an addition to the population of organizations in the regional market creates significant effects (positive or negative) on global entry support for the existence of cross-subsidization is generated. When cross-subsidization is found to exist, there is evidence that the industry is global (rather than multi-domestic where no significant effects of regional density on global founding is expected).

Extending the preceding discussion to the PC industry, generates the following propositions. The cross-subsidization explanation is addressed in proposition 12, whereas proposition 13 addresses the legitimation-competition explanation:

Proposition 5 : There is a negative relationship between regional market density and entry rates to the global PC market.

3.7 The Population Ecology of Industry Standards

Over the history of a population organizations become more and more homogeneous. In the initial stages of their life cycle, organizational populations display considerable diversity in approach and form (DiMaggio and Powell 1983). Once the field becomes well established, however, there is an immense push towards homogenization. Both OE and institutional theorists agree that the concept that best captures homogenization is *isomorphism*. Hannan and Freeman (1977) argue that isomorphism can result because non-optimal forms are selected out of a population of organizations or because organizational decision makers learn appropriate responses to adjust their behavior accordingly. As mentioned before, much of empirical research in OE focus on the selection process.

It is argued here that the emergence of an industry standard creates immense pressures toward homogenization in organizational populations. When an industry standard is established (by competition, the state, or the professional) organizations are forced to become more similar to each other.

In the next section the concept of industry standards is defined. Both the OE and institutional theory approaches are reviewed within the industry stages of the global PC industry.

3.7.1. Definitions of Key Terms

Compatibility: Webster's defines compatibility as "the capability of components to function together". Products are called compatible when their design is coordinated in some way, enabling them to work together (Farrel and Saloner 1987). The term compatibility is used to 1) characterize the ability of components to function together, and 2) the capability of products to work with the same set of complementary products. If two products A and B function together with the same set of complementary products, and are substitutes for the consumer, then products A and B are *compatible substitutes* When product A is designed so that it will function together with product X, products A and X are *compatible complements* (David and Bunn 1987). Hariharan (1990) illustrates the use of these definitions with the following examples:

1) a VHS format and a VHS format tape are compatible complements;

2) an IBM PC and a COMPAQ PC are compatible substitutes.

Technological Compatibility Choices: There are three types of compatibility choices that firms face (Gabel 1987). These are 1) Multi-vendor compatibility, 2) Multi-vintage compatibility, and 3) Product line compatibility.

Multi-vendor compatibility is said to exist when multiple vendors conform to or adopt the same compatibility standard. In other words, products made by these vendors will all function with the same set of complementary products. In the PC industry, most IBM compatible machines although made by different vendors will run most of the same software.

Multi-vendor compatibility does not imply that the quality or performance across compatible machines is identical Hariharan (1990).

Standard: Webster's defines a standard as "something that is established by authority, custom or general consent as a model or example to be followed".

A related term industry standard is also used in the dissertation. An industry standard is a model, specification or design that has a dominant market position in the industry for its product class (Hariharan 1990). For example, IBM compatibility is an industry standard in the PC industry (Hergert 1987).

Vendor standards become industry standards only when they earn a dominant share of the market. Not all vendor standards become industry standards. For example, the 68XXX family of microprocessor technology adopted by Apple since 1977 did not become an industry standard due to the existence of other vendor standards. Apple compatible Pcs were able to reach a cumulative market share of 17% worldwide in 1992 (Dataquest Inc. 1992).

When a vendor standard earns a dominant share of the market after winning the battle in the market place, it is termed a *de facto* standard. In some cases, it may be clear ex-ante who will lead the standardization battle: often a vendor with a large market share. For example, IBMs leadership in setting the *de facto* standard in Pcs presumably drives from a common expectation that, as in other computer markets, IBM would have a large market share (Farrell and Saloner 1987). On the other hand, industry standards may also be picked by committees.

3.7.2. The Population Ecology of Industry Standards in the Global PC Industry

Organizations compete not just for customers and resources, but also for institutional legitimacy. As discussed in chapter two, the target in phase two of the industry life cycle is setting the standard. This means competing for obtaining institutional legitimacy for the technology of the firm.

Choice of technology is an important decision managers have to make especially when they compete in industries where standards and compatibility between products are important. In an number of prominent industries such as telecommunications, computing and consumer electronics compatibility or incompatibility are critical issues (Gabel 1987, p.vi):

> The extent to which products are standardized and compatible can affect industry structure (through the number of competitors and the relationship between producers of complementary products), industry conduct (by shifting competition away from product differentiation...), and performance (by the effect on product diversity, economies of production and service, and network externalities).

In industries characterized by global competition and compatibility standards, when there is no industry standard that one or more firms have already adopted (Phase 1 in Table 3-2), relative positions of firms in the industry may be quite different from the case where there exists at least one vendor standard. In the PC industry, for example, early market evolution saw the emergence of innovators who quickly attained market leadership when an industry standard had not yet been established. Prior to 1980, Apple, Tandy, and Commodore jointly held 89% market share. The industry changed dramatically when IBM introduced its PC. By 1984, IBM had 29 % of world market and 36 % of U.S. market share (Dataquest Inc., 1984). Conformance to the IBM standard was viewed by many competitors as a key element of future viability. In this case, the choice facing other firms was whether they should offer a product that is compatible with IBM Pcs or not.

The entry of IBM into the industry and the subsequent establishment of an industry standard was followed by the birth of approximately 350 firms (Sullivan 1984), which started an intensely competitive stage (Hergert 1987). Thus emergence of an industry standard can have significant effects on the dynamics of entry rates into the

Table 3.2
Phases in the Evolution of an Industry

		Years
	Phase I:	
Defining a Viable Product Concept ↓	Competition in Product Concepts and in Developing Technologies	1977-1980
Developing technologies to deliver functionalities ↓	"Product Concept Competition"	
Formation of Technology groups ↓	Phase II:	
	Competition for Setting the Standard	1981-1984
Establishing Industry Standards ↓	"Industry Standard Competition"	
Market Expansion	Phase III:	
	Competition for Profits and Market Share	1985-1992
	"Market Performance Competition"	

Adopted from Hariharan 1990

industry (Hannan and Freeman 1977).

3.7.3 Phases in the Industry Life Cycle, Standards and Entry

An industry standard shifts the competitive criteria or `target' of the population, thereby exacerbating disequilibrium and producing new types of organizations. For example, in the initial phase of the industry characterized by Product Concept Competition (Table 3.2), the `target' seems to be developing viable product concepts and technologies. In phase two, the `target' is setting the standard. Industry Standard.

Competition is characterized by fierce competition between technology groups (Hariharan 1990). The more firms adopting a given technology, the higher the likelihood of that technology to become a *de facto* standard. Hence, firms are motivated to make their technologies easily accessible through licensing, joint manufacturing, and non-proprietary practices. This new environment is expected to generate a new wave of entry.

Entry is further facilitated if imitation is relatively easy and firms can simply follow the leaders (Carroll 1993). A symbiotic relationship is expected between firms in the industry and new entries where existing firms are dependent on new entries to adopt the technology and legitimize it and new entries are dependent on existing firms for available technologies. As the technology spreads, a threshold is reached beyond which adoption provides legitimacy rather than improve performance of the adopter (Meyer and Rowan 1977). Hence, rate of entry into an industry is expected to be positively related to density in the Industry Standard Competition phase.

The environment in phase two will favor imitative, me-too strategies rather than innovative strategies which decreases the heterogeneity of firms (Carroll 1993). The process leading to increased homogeneity is the desire of both existing firms and new entries to rely on tried solutions. As organizations try to outperform each other and change, the aggregate effect of individual change is to lessen the extent of diversity in the field (DiMaggio and Powell 1983).

Since a *de facto* standard emerges after winning the battle in the market place, the emergence of the standard is a continuous process. Hence, phase two includes the periods before and after the emergence of an industry standard when competition between technology groups is most intense.

When *de facto* standardization occurs, a new environment is created, in which new opportunities emerge and existing ones disappear. This stage of the industry is called: "Performance Competition Phase". Now legitimacy is obtained for the form (technology), and the standard itself becomes a powerful force that leads organizations to become more similar to one another.

In phase three, as the industry is populated with similar organizations that depend on the same resource bases, entry rates start to decline because supply of resources needed to build new organizations (such as computer engineers, entrepreneurs, venture capital) are depleted and the carrying capacity of the industry is reached. In this phase, the environment is much less diverse, as there is less experimentation with alternative technologies, processes, and structures. The `target' is now increasing efficiency within the domains of the standard technology. Technological progress is `competence enhancing' (Tushman and Alderson 1986) as it proceeds incrementally down an uncertain but directed trajectory according to an accepted standard (Dosi 1982). The level of uncertainty in this phase is much less than the first two stages. The source of uncertainty also shifts as uncertainty in market demand becomes a more critical factor in `performance competition.'

<u>Conclusion.</u> Industry standards create powerful forces that influence the nature and rate of entry into an industry. The relationship between rate of entry and density can change before and after adoption of an industry standard.

Proposition 8: There is a positive relationship between density and entry rates in "Product Concept" and "Industry Standard Competition" phases of an industry. The relationship between density and entry becomes negative at the "market share competition" phase.

3.8 <u>Conclusion</u>

The preceding discussion centered on identifying density dependent, population dynamics, environmental and institutional variables that influence organizational entry rates and proposed relationships among them. The purpose of this chapter was to provide the theoretical framework, namely density dependent models for studying organizational founding. A summary of the research propositions is provided in Table 3-3. In the next chapter, a discussion of the specific hypothesis to be tested will be addressed.

Table 3-3
Research Propositions

Proposition 1:	The relationship between density and organizational entry is nonmonotonic. The relationship is positive at low levels of density and becomes negative at higher levels of density.
Proposition 2:	There is a nonmonotonic relationship between prior entries and exits and current organizational entry rates.
Proposition 2(a):	There is a positive relationship between prior entry and current organizational entry rates. The relationship becomes negative at high levels of entry rates.
Proposition 2(b)	There is a negative relationship between prior exits and current entry rates. The relationship becomes positive at high levels of prior exits.
Proposition 2(c):	There is a positive relationship between survival and entry at lower duration of survival of incumbents. The relationship becomes negative at higher duration of survival of incumbents.
Proposition 2(d):	Density dependent effects on entry rates are stronger than population dynamics effects.
Proposition 3(a):	There is a positive relationship between the density of U.S. firms and entry rates of both U.S. and foreign firms. The relationship becomes negative at higher levels of U.S. firm density.
Proposition 3(b):	There is a negative relationship between the density of foreign firms and entry rates of both U.S. and foreign firms. The relationship becomes positive at higher levels of foreign firm density.
Proposition 4(a) :	There is a positive relationship between the density of generalists and entry rates of specialists.
Proposition 4(b) :	There is a negative relationship between the density of generalists and entry rates of generalists.
Proposition 5 :	There is a negative relationship between regional market density and entry rates to the global PC market.

Table 3.3 (cont.)

Proposition 8:	There is a positive relationship between density and entry rates in "Product Concept" and "Industry Standard Competition" phases of an industry. The relationship between density and entry becomes negative at the "market share competition" phase.

CHAPTER FOUR

HYPOTHESES AND RESEARCH DESIGN

This study examines the impact of industry standards, geographic market diversification, and source of competition on entry rates into the global PC industry. The research questions addressing these relationships were presented in Chapter 3. This chapter reviews the research design used and the measurement of the dependent variable, rate of entry, and the set of organizational and environmental level independent variables. The data used in the study and the sources are discussed. The statistical hypotheses are then presented and the chapter concludes with a discussion of the models and analysis to be used.

4.1 Variables Used in the Study

4.1.1 Defining Vital Events

In this section, vital events in the life histories of most PC manufacturers in the global PC industry are defined. This means obtaining information on the timing of a series of `vital events' such as organizational entry, exit, and survival.

4.1.1.1 Organizational Entry

The process of beginning of an organization is a distinctive social activity which consists of a set of subprocesses such as initiation, resource mobilization, legal establishment, social organization, and operational start-up (Hannan and Freeman 1989). However, not all organizing attempts are successful in establishing an operating organization and it is difficult to decide when an organizing attempt actually begins

(Delacroix and Carroll 1983). Hence, in this study the definition proposed by Delacroix and Carroll (1983) is used: "... organizational birth (entry) is defined as the creation of an operating entity that acquires inputs from suppliers and provides outputs to a given public (customers, clients, patients, etc. (p.276)" This measurement definition assumes that the first appearance of a product or service signals the birth date of the organization. The number of organizational entries in a given period will reflect both the level of organizational attempts and the relative success of these attempts.

Dataquest Inc., the source for our data tracked entries and exists from the global PC industry. Industry analysts contacted reported high confidence in the accuracy of Dataquest data. Figure 4.1 shows the number of PC vendor entries per year. The figure shows a very volatile entry history, marked by periods of extremely high entries. These peaks coincided with changes in the technological environment in the industry, in particular establishment of an industry standard.

4.1.1.2 Organizational Exit

Deciding on the time of mortality for an organization is complicated by `lingering death' or `living death' cases (Bourgeois and Eisenhardt 1987). Besides, there are at least four generic kinds of organizational mortality: disbanding, absorption by another organization, merger, and radical change in form (Hannan and Freeman 1989).

The case of merger raises the most important conceptual question. In this, we use the approach adopted by organizational ecology researchers and use the way the organization presents itself to the outside world as the key. When two firms merge, if an organization with a new name is created, we consider the two merging companies as exits and the new entity as an entry. Hence, an exit is defined as the last year a company is listed in any of the data sources.

Entry and exists were checked with supplementary sources from another market research firm (International Data Corporation), and various industry surveys e.g Standard and Poor's, Computerworld, Computerland. Figure 4.1 shows the exits from the global PC industry.

4.1.2 Population Density

Density is defined as the number of PC vendors worldwide at the start of each year (Barnett 1990), which is also equal to global density. Figure 4.2 shows the density of PC vendors over time. It is useful to bear in mind the relationship expressed by Tucker *et al* (1990):

$$\text{density}_t = \text{density}_{t-1} + (\text{entries}_{t-1} - \text{exits}_{t-1})$$

4.1.2.1 U.S. Based Versus Foreign Based Subpopulation Densities

Companies were grouped as North American, Japanese, European, and Rest of World based on their place of incorporation. If a company was owned by Japanese investors but was incorporated in the U.S. it was considered a U.S. company. For example, Corona is owned by Daewo but is incorporated in the U.S., so it was considered a U.S. company. Similarly, Headstart is a division of Phillips (Europe) but is considered a U.S. company for the same reasons.

To calculate the density of foreign firm subpopulation, European, Japanese and firms incorporated in the rest of the world is summed at the beginning of each year. Firms incorporated in North America are also included in the U.S. number although the number is too small to warrant any different approach.

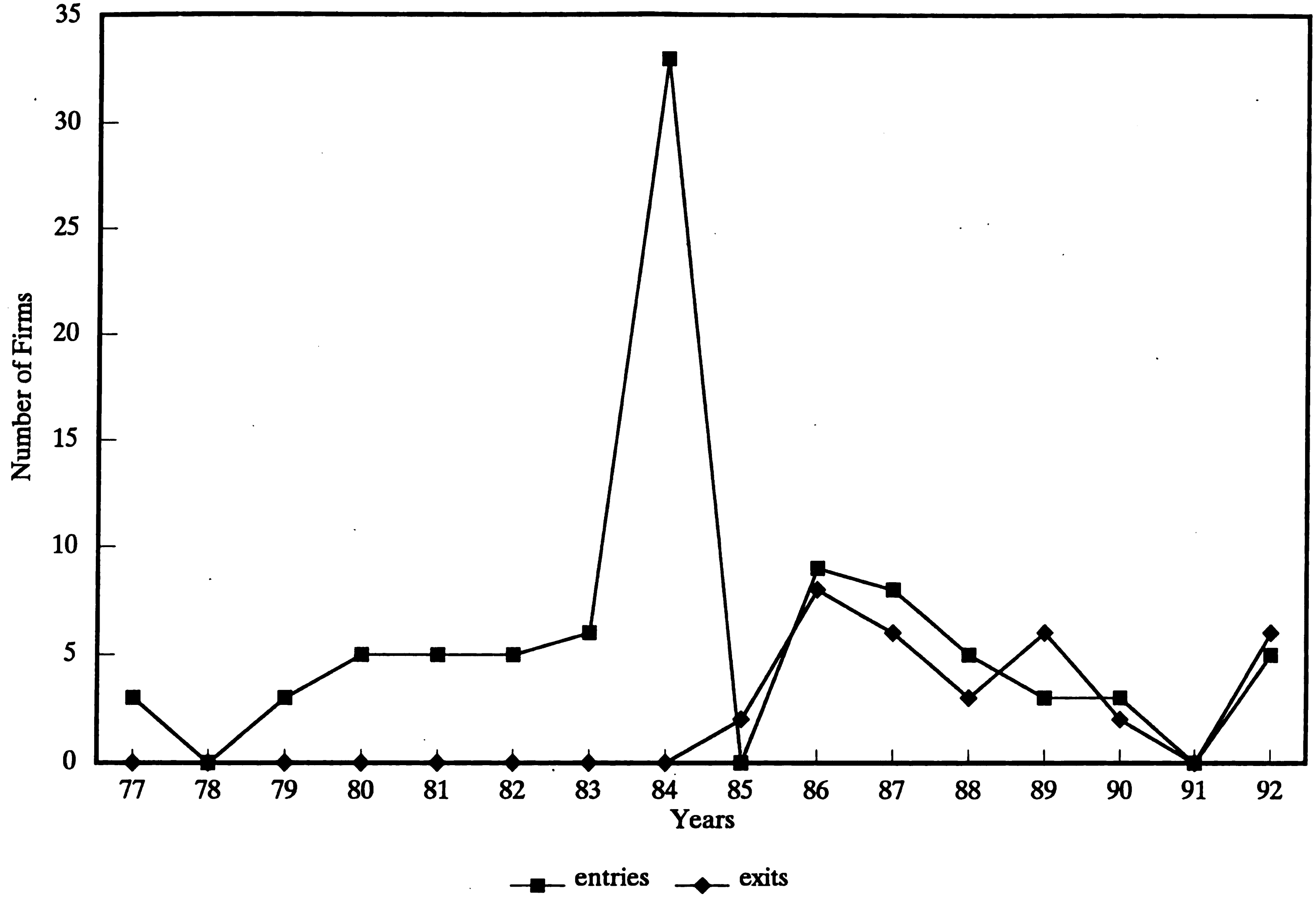


Figure 4.1
Prior Entries and Exits in the Global PC Industry

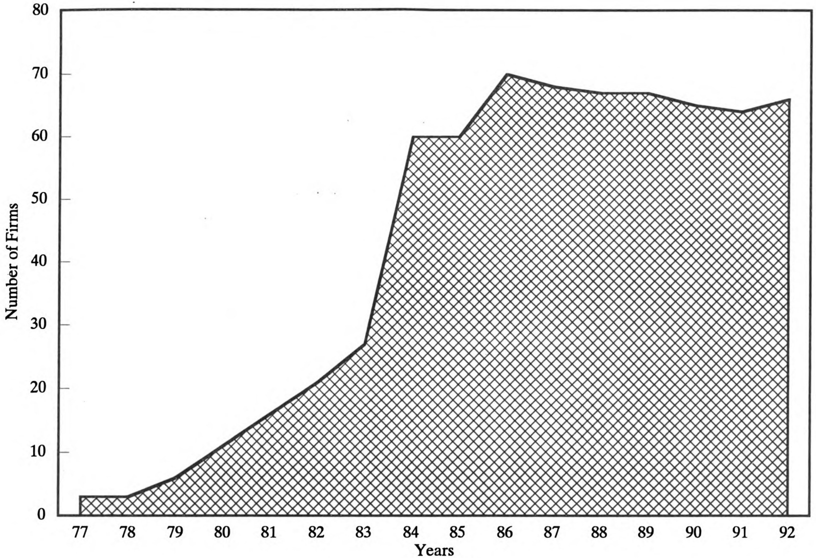


Figure 4.2
Global Density of PC Vendors

4.1.2.2 Regional Versus Global Market Subpopulation Densities

Regional density is defined as the number of firms operating in the North American market at the start of each year. North America (particularly the U.S.) is selected as the key market or subpopulation for the study because it accounts for 55, 47, and 44 % of the computer industry revenues for 1984, 1989 and 1992, respectively. Cash flows generated in the U.S. market are very critical for global competitors' market share battles worldwide. Being the single biggest market makes the U.S. a critical competitive environment for both U.S. and foreign PC manufacturers.

4.1.2.4 Geographical Specialist Versus Global Generalist Densities

PC unit sales and revenues are recorded for each company in each of the North American, European, Japanese, and Rest of World markets. A firm is classified as a geographical specialist if it generates more than 60 percent of revenues from any one single market. Otherwise, the firm is classified as a global generalist. This is done for every firm throughout its life history in the industry.

For a change in firm strategy to be recorded, the condition has to prevail for at least two consecutive years. In other words, for a generalist firm to become a specialist it is necessary for more than 60 percent of revenue to be generated from a single market for two consecutive years. If the firm has one year of high revenues from a single market surrounded by fragmented sales, the firm was still considered a generalist in the year when it exceeded the 60 % threshold. This procedure was adopted to capture continuation expected in firm strategies and to avoid re-classification based on industry shortages of specific products.

Densities of generalists and specialists are defined as the number of firms in each of these subpopulations at the start of each year.

4.1.3 Population Dynamics Variables

In this section, variables pertaining to population dynamics are explained.

4.1.3.1 Prior Entries and Exits

The number of entries and exits in the year prior to the observation year are recorded at the PC population level.

4.1.3.2 Survival

Survival is computed as a separate variable by subtracting the year of entry from the year of each observation (Barnett 1990). There will be a survival variable for each year for each firm. This variable is equivalent to organizational age.

Next is a presentation of organizational and environmental variables which are used as controls in the models. It should be noted that not all variables are used.

4.1.4 Organization Level Variables

Organizaional level variables were used to test differences between subpopulations such as U.S. versus foreign firms and geographical specialists versus global generalists.

4.1.4.1 Technological Innovativeness

Worldwide unit PC sales and revenues by microprocessor type for each company is recorded for each year between 1987-1992. Two measures of new product sales are computed. Sales from PCs with the most advanced microprocessor, the 486 chips, are computed for every year for 1990 through 1992. The new chip was introduced in 1989 and 1990 is the year when it was used in new PC shipments.

Newsales486$_{(1990,91,92)}$ = (Worldwide Unit Sales from 486SX & 486DX microprocessor PCs)/(Total Worldwide Unit Sales).

Another measure of a firm's historical technological innovativeness was calculated by using the same approach to the sale of PC with 386 chips. The 386 chip was introduced in 1986. The first PCs with 386 chips were introduced in 1987. Hence, for every firm, 386 PC unit sale ratios were calculated for 1987 through 1989.

Newsales386$_{(1987,88,89)}$ = (Worldwide Unit Sales from 386SXSL & 386DX microprocessor PCs)/(Total Worldwide Unit Sales).

4.1.4.2 Organization Size

Size is measured by worldwide revenues in Million dollars.

4.1.4.3 R&D Intensity

R&D intensity is measured by the R&D to sales ratio for every year between 1987-1992. R&D as a percent of sales is used because this measure deflates for size and controls for heteroscedasticity (Hambrick, MacMillan, and Barbosa 1983). A separate variable as change in R&D (year to year changes in R&D intensity) is recorded to minimize the probability of autocorrelation.

4.1.4.4 Marketing Intensity

Two measures are used to measure marketing intensity. First, marketing and selling expenditures (excluding advertising) as a percent of total sales is calculated for the years 1987-1992. Second, advertising expenditures in the U.S. market are recorded for the years of 1977-1992. These two measures are expected to capture the marketing intensity of the firms in the population.

4.1.5 Environmental Variables

4.1.5.1 Industry Size

Industry size is computed in terms of PC unit shipments for the years 1977-1992. Industry size is the summation of company shipments in units for each year for the total population. These figures are presented in Figure 4.3.

4.1.5.2 Industry growth rate

Growth rate is computed as a separate variable using percent change in industry size from year to year.

4.1.5.3 Industry Concentration

Market share variance is also computed for each year for the total population, to capture the effects of industry concentration. Market share variance plus the reciprocal of density is the Herfindahl-Hirshman concentration index (Barnett 1990).

4.1.5.4 Industry Age

Industry age is calculated by subtracting 1977, the year of the start of the industry, from the observation year.

4.1.5.5 Market Saturation

Market saturation is measured using the installed base of Pcs worldwide, a cumulative measure of all PCs sold since the inception of the industry up to the year of observation.

4.1.5.6 De Facto Standardization

The evolution of the PC industry is separated into three distinct phases in relation to the intensity and nature of competition (See Table 3.2). These there phases are : Product Concept Competition (1977-1980), Industry Standard Competition (1981-1984),

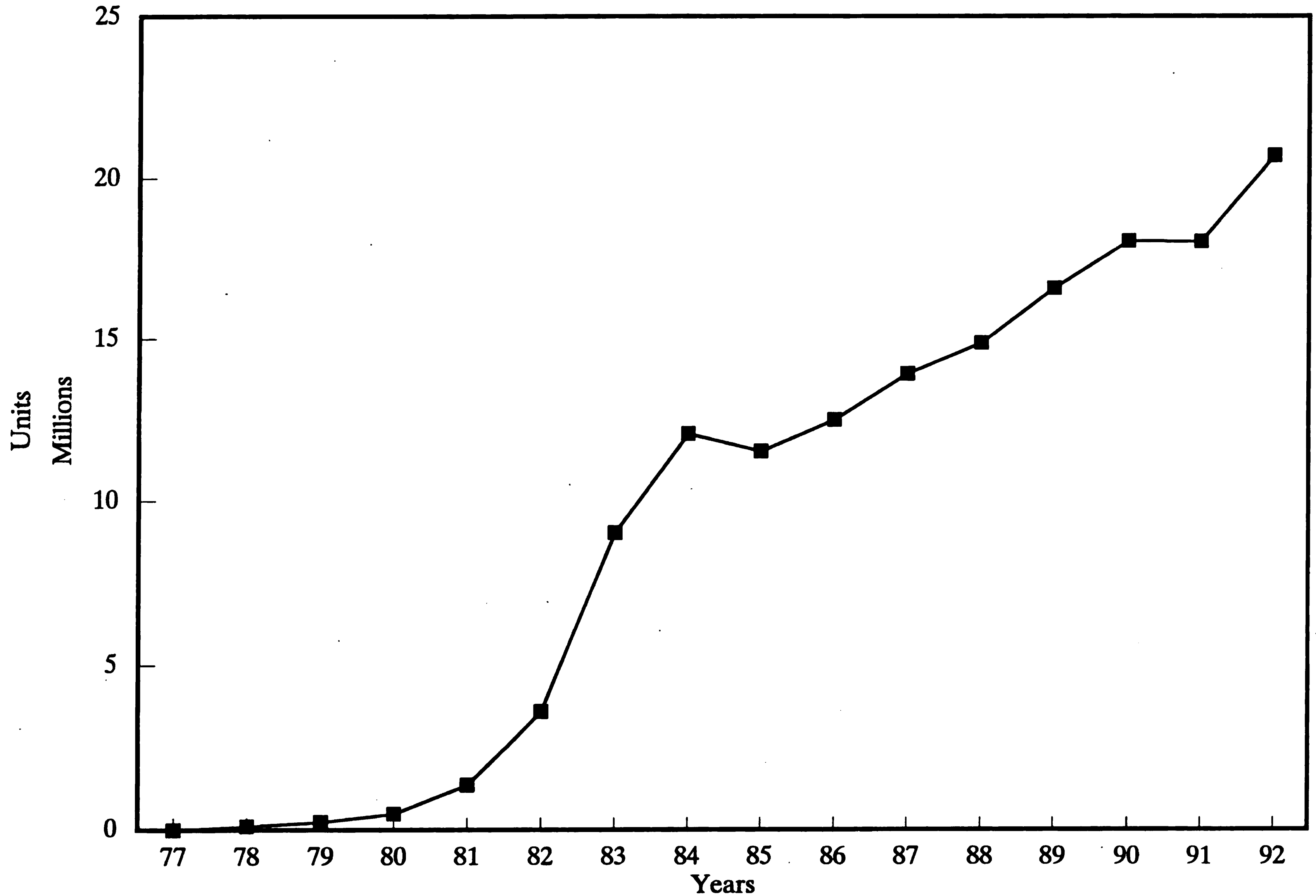


Figure 4.3
PC Industry Size: Unit Shipments to the World

Performance Competition (1985-1992). Hence, these periods are used to investigate the effects of *de facto* standardization on entry rates into the PC industry.

4.1.6 Performance Variables

Financial accounting indicators, financial measures, and market success indicators are used to measure performance.

4.1.6.1 Global Market Share

Global market share is determined by dividing the firm's total worldwide PC unit sales by total worldwide PC unit sales volume. Global market share is also calculated by using revenue figures.

4.1.6.2 Profitability

In an approach similar to Caves and Ghemawat (1992), income statement data is used to estimate profitability of PC manufacturers. To adjust for market share differences, each firm's pretax income is weighed by company's share of industry revenues for each year (Pretax income X worldwide market share in dollars). This measure seems appropriate in that it captures both sales, market share and operational efficiency in a single item. A total description of the measures used in the study is presented in Table 4.1.

4.2 Data Sources

The data collection process emphasized a longitudinal approach, where the entries and exits of firms in the industry, the survival periods of existing firms, number of firms in industry are traced over time as the industry evolves. Hence, these data were collected as a time series.

Most of the archival data comes from Dataquest, a market research and consulting company specializing in the computer industry. The rest is collected from various published sources such as annual reports and 10-K reports, Ward's Business Directory, Moody's Industrial News Report and Standard and Poor's Industry Surveys. Advertising expenditures and number of brands advertised in the U.S. market come from LNA/ARBITRON Multi-Media Service Annual Publications. Financial measures like Pretax Income Margin, Return on Assets, and Gross Margin come from the Compaq/Disclosure data base.

4.3 Data

This study analyzes organizational entries into the PC industry from the inception of the industry in 1977 until the end of the observation period in 1992. Such a *dynamic* analysis of how entry rates change over time necessitates the use of event-history data. When the "time paths" of change in a categorical dependent variable is analyzed, the analysis is said to be *dynamic* (Tuma *et al* 1979). To generate event-history data, for each organization, the timing and sequence of entry and exit are recorded to the year of the event (Tuma 1979; Tuma and Hannan 1984). To enable a better understanding of dynamic analysis of entry rates, a description of event-history analysis is presented.

4.3.1 Event-History Analysis

Event-history data gives the number, timing and sequence of change in a categorical dependent variable (Tuma *et al* 1979). The advantage of event history analysis is that it takes account of both the occurrence and timing of an event while estimating the effects of exogenous factors (Schoonhoven, Eisenhardt and Lyman 1990). Hence, event-

Table 4.1
Measures Used in the Study

VARIABLES	MEASURES	DATA SOURCES
Vital Events & Organizational Age		
1. Entry date		Dataquest
2. Exit date		Dataquest
3. Prior entries	$Entry_{t-1}$	Dataquest
4. Prior exits	$Exits_{t-1}$	Dataquest
5. Survival	Observation year - entry year	
Population density (1977-1992)	$Density_t$ = $density_{t-1}$+($entries_{t-1}$ - $exits_{t-1}$)	
Subpopulation level measures:		
1a. US based firm density	$USDensity_t$ = $Usdensity_{t-1}$+($USentries_{t-1}$ -$USexits_{t-1}$)	
1b. Foreign " "		
2a. Geographical generalists	single market revenue ratio < 60 % for at least 2 consecutive years	
2b. Geographical specialists	single market revenue ≥ 60 % for at least 2 consecutive years	
3a. Regional market density	US market density	Dataquest
3b. Non-regional market density	Global density - US market density	Dataquest

Table 4.1 cont.

VARIABLES	MEASURES	DATA SOURCES[1]
Organizational level variables:		
Technological leadership		
1. $Newsales486_{(90,91,92)}$	Worldwide unit sales from 486SX & 486DX PCs/Total worldwide unit sales	
2. $Newsales386_{(87,88,89)}$	Worldwide unit sales from 386SXSL & 386DX PCs/Total worldwide unit sales	
Industry level variables:		
Global market size, 1977-1992 (population mass)	Σ (firm unit shipments to the world)	
Market share variance	Herfindahl-Hirshman index	
Institutionalization	Year of industry standard establishment	

[1]All data is from Dataquest.

history data is very rich and allows models to be estimated that other types of temporal data (i.e., panel data, experimental data, change data) would not allow for (Tuma 1979; Tuma et al. 1979).

Organizations that enter the industry are said to experience an "event," making a transition between the two possible states, moving from a non-existent state to the state of having entered the industry. A hypothetical event history of a PC vendor is given in Figure 4.4.

Using the same logic, data is used to construct an event history for each PC vendor in the form of a sequence of time periods, or "spells," separating each event (Amburgey, Kelley, and Barnett 1993; Barnett 1990; Hannan and Freeman 1989). Each spell between the firms non-existence, entry and exit is broken into yearly spells. This procedure generates 672 cases for analysis. A fragment of the data used in the analysis is presented in Figure 4.5.

There are three possible states or destinations at the end of a spell. A firm may "enter" or start to exist. A firm may fail or die before the end of the spell. A firm may also continue to exist or survive at the end of each spell. If when the observation period ends in 1992 the firm continues to exist (survive), the spell is "right-censored." In this study, thirty five percent of the cases are censored on the right.

Since the data covers an observation window starting from the beginning of the industry in 1977, the analysis is not expected to suffer from left censoring, which occurs when some organizations in a population are already in existence at the beginning of the period under study (Amburgey *et al.*1993). Tuma (1979) calls data that covers the complete history of the population the "ideal case."

Figure 4.4
A Hypothetical Event History

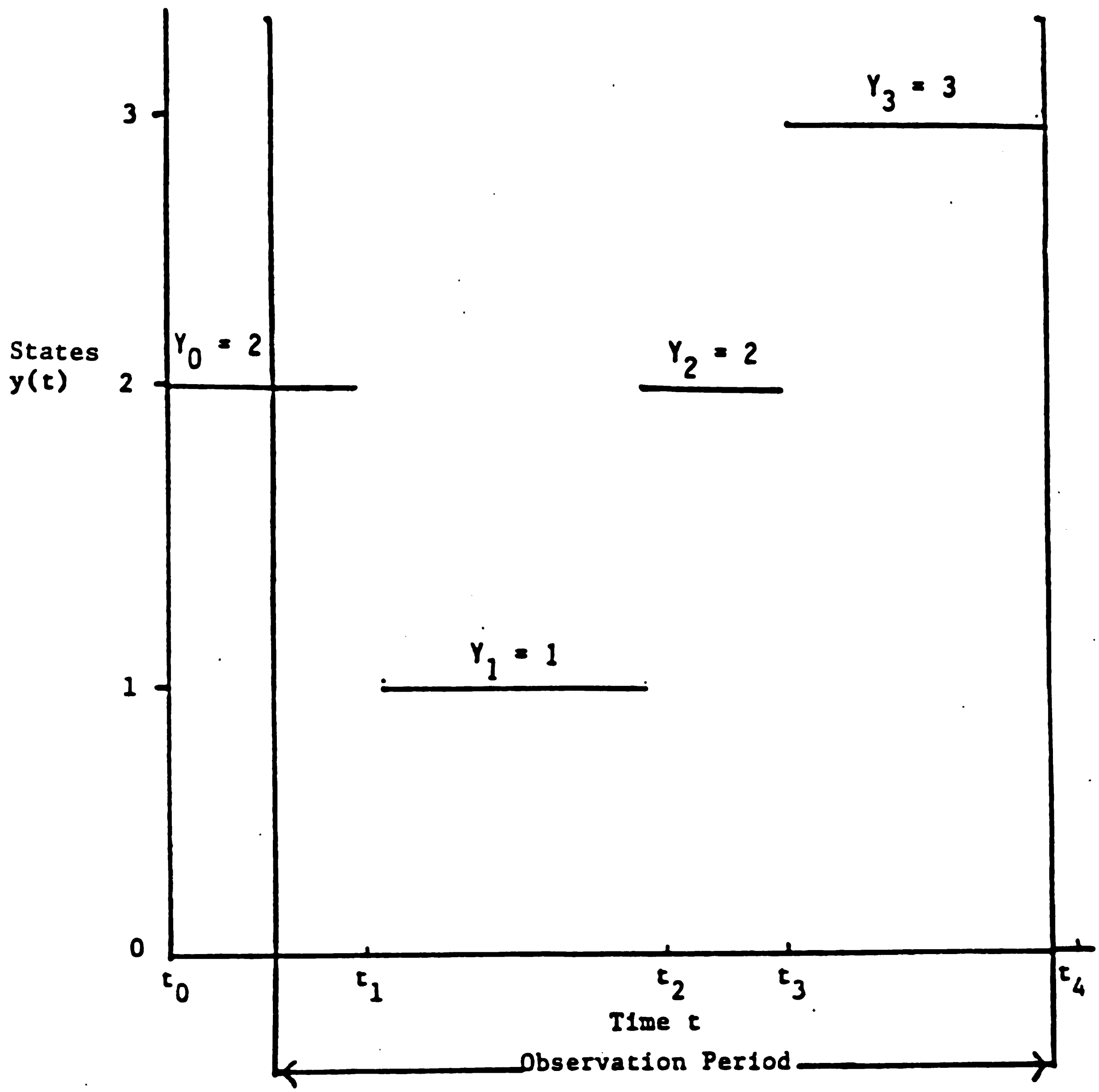


Figure 4.5
Fragment of the Event History Data

```
                                              ending state
[redacted]16339.6912824918033331   4.76 591  4 90 4  -starting
0016542.2511257218064061   4.52 490  4 89 4   state
0016744.89 9474816600023   4.32 389  4 88 4
0016744.89 8153514883955   4.78 288  4 87 2
0016846.24 6788313937480   6.41 187  2 86 1
0026339.6912824918033331   4.76 291  4 90 2
0026542.2511257218064061   4.52 190  2 89 1
0036744.89 9474816600023   4.32 289  3 88 2
0036744.89 8153514883955   4.78 188  2 87 1
0046339.6912824918033331   4.76 591  4 90 4
0046542.2511257218064061   4.52 490  4 89 4
0046744.89 9474816600023   4.32 389  4 88 4
0046744.89 8153514883955   4.78 288  4 87 2
0046846.24 6788313937480   6.41 187  2 86 1
0056339.6912824918033331   4.76 891  4 90 4
0056542.2511257218064061   4.52 790  4 89 4
0056744.89 9474816600023   4.32 689  4 88 4
0056744.89 8153514883955   4.78 588  4 87 4
0056846.24 6788313937480   6.41 487  4 86 4
0057049.00    99912516574  5.75 386  4 85 4
0056036.00    99911546368 16.56 285  4 84 2
0056036.00    99912090861 21.68 184  2 83 1
0066339.6912824918033331   4.761091  4 90 4
0066542.2511257218064061   4.52 990  4 89 4
0066744.89 9474816600023   4.32 889  4 88 4
0066744.89 8153514883955   4.78 788  4 87 4
0066846.24 6788313937480   6.41 687  4 86 4
0067049.00    99912516574  5.75 586  4 85 4
0066036.00    99911546368 16.56 485  4 84 4
0066036.00    99912090861 21.68 384  4 83 4
006277.29     999 9056267 30.01 283  4 82 2
006214.41     999 3611486 27.19 182  2 81 1
0076339.6912824918033331   4.76 891  4 90 4
0076542.2511257218064061   4.52 790  4 89 4
0076744.89 9474816600023   4.32 689  4 88 4
0076744.89 8153514883955   4.78 588  4 87 4
```

Values of several population, organizational and environmental covariates such as market share variance, market size, industry and organizational age that are associated with each spell are updated at the beginning of each year.

4.4 Research Hypotheses

In chapter three several research propositions were presented. In this section, specific corresponding research hypotheses are developed. Table 4.2 presents these hypotheses.

4.4.1 Density Dependence and Entry Rates

As described in section 3.2, the density dependent model of organizational ecology permits organization entry and exit rates to vary according to the number of organizations in the population.

Organizational density can affect entry rates through several processes. High tech industries are populated with scientific personnel and require more technical skills than conventional capital intensive industries (Ungson 1990). Besides, knowledge about technologies and processes involved are often available only to "insiders," that is to those already participating in such organizations (Hannan and Freeman 1989). A rapidly changing technological environment together with continuous dynamism and volatility inhibits essential features of the organization structure and strategy from being codified. In such environments, existing organizations are the only training grounds for new organization builders. The organizational population can be viewed as the pool of potential entrepreneurs (Carlton 1978). The high visibility of `spin-offs' in areas such as the Silicon Valley has increased awareness of the potential of existing firms to produce new firms (Carroll 1993). When the number of existing organizations in an industry is small, the founding rate is depressed as a result of the absence of potential organization builders. The greater the population, the bigger the pool of potential entrepreneurs and, therefore, the higher the birth level.

The PC industry supports this explanation in that many of the start-ups throughout the evolution of the industry were initiated by computer scientists leaving existing firms. For example, the two founders of Apple Computer, Steve Jobs and Steve Wozniak were previously employed by Atari and Hewlett-Packard, respectively (Thompson and Strickland 1984). Hence, the first empirical question as whether the rate of entry has a pattern of density dependence.

4.4.2 Density Dependence in Entry Rates through Legitimation and Competition

According to density dependent models, population density is a very critical variable because it is believed to capture both legitimation and competitive forces (Hannan 1986). Legitimation and competition, in turn, are the underlying processes that influence entry rates. The theory of institutionalization (Meyer and Scott 1983) also provides support for the relationship between density and legitimation. Institutionalization meant that certain forms attain a "taken for granted" character. Hence, the simple prevalence of a form tends to give it legitimacy. When numbers are small and legitimacy is not established, founding an organization can be more difficult because venture capitalists might be reluctant to invest in uncertain technologies and industries. Besides, small numbers deter the emergence of support services such as market research and specialized consulting firms (Pennings 1982). Overall, legitimation of an industry which is achieved through greater numbers of firms in that industry, increases entry rates.

The second underlying process of the model, competition, is expected to influence entry rates at high levels of density. (Hannan and Freeman 1977; 1989). Contrary to legitimation, competition within a population induces a negative relationship between density and entry rates. Given a limited level of resource availability that determines the carrying capacity (Hannan and Freeman 1977), the more the competitors, the smaller will be potential gains from entering the industry at a given level of demand. Fewer resources are available and markets are packed tightly in densely populated industries. Therefore, high density implies strong competitive interactions within populations dependent on limited resources such as capital, technical personnel, suppliers, and place, etc. As density grows relative to the carrying capacity, supplies of potential organizers, members, and resources become exhausted. Moreover, existing firms respond to increasing competitive pressures by erecting new entries.

Based on the preceding discussion, entry rate is expected to rise initially due to legitimation of the industry, the firms and the technologies and then the rate falls with greater density due to increased competition for the same resources in the environment. If this proposition is true we can infer that legitimization increases the entry rate up to the carrying capacity of the industry, after which competition decreases the rate of entry. That is, a non-monotonic density dependence is expected in founding rates.

Hypothesis 1. Entry rates of PC vendors will increase and then decline (nonmonotonic inverted U-shape) as the density of PC vendors increases.

4.4.3 Population Dynamics and Entry Rates

A second approach to the study of entry rates in the OE tradition concentrates on the effects of population dynamics variables on entry rates. Two population dynamics variables are used in this study: (1) prior entries and exits, and (2) length of participation in industry or survival.

4.4.3.1. Prior Entries and Exits

Prior entry and exit rates were found to influence current entry rates by Delacriox and Carroll (1983). This effect is tied to the release and consumption of limited resources by prior activities of exit and entry. Prior exit rates are expected to have a nonmonotonic effect on current entry rates in that an even larger number of deaths would signal a hostile environment to potential entrepreneurs and deter entry. High prior entries would signal that opportunities are favorable but potential entrepreneurs are also expected to respond to market saturation. Hence, prior exits and entries are expected to have a nonmonotonic effect on current entry rates:

Hypothesis 2(a). Entry rates of PC vendors will increase and then decline (nonmonotonic inverted U-shape) as the number of prior entries increases.

Hypothesis 2(b). Entry rates of PC vendors will increase and then decline (nonmonotonic inverted U-Shape) as the number of prior exits increases.

4.4.3.2 Survival

As mentioned in chapter 3, long periods of survival of industry participants would signal a fertile niche to potential entrepreneurs (Mitchell 1991). Again, a nonmonotonic relationship is expected between survival and entry rates, because as the survival period of existing firms increases further, the core of the market will be exploited by incumbents discouraging further entry. Longer survival periods of existing firms may enable firms to create entry barriers and establish an oligopolistic industry structure.

Hypothesis 2(c). Entry rates of PC vendors will increase and then decline as survival periods of existing firms increases.

When density and population dynamics variables are modeled together, density dependent effects on entry rates are expected to be stronger than population dynamics effects.

Hypothesis 2(d). Density dependent effects on entry rates will be stronger than population dynamics effects.

4.4.4 Competition Between U.S. and Foreign Firms

U.S. and foreign firms were observed to play different roles in the emergence, development and growth of the PC industry. Historically, U.S. firms have been central to the emergence and early take-off of the industry. In 1979, two years after the industry's inception, the three companies that started the industry (Apple, Commodore and Tandy) still controlled 81.5 percent of worldwide revenues. These firms were very influential at defining the viable product concept thus shaping the industry for other U.S. and foreign firms to come.

The influence of U.S. firms on the industry evolution continued and even accelerated once IBM entered the industry in 1981. This was due to IBM's success in establishing its technology as the industry standard which affected both U.S. and foreign firm practices in particular regarding technologies adopted and R&D decisions made. Establishment of an industry standard created an entry frenzy by reducing the level of uncertainty in the industry.

To summarize, with continuous technological innovations and new product introductions, U.S. firms have motivated and facilitated entry of foreign firms by legitimizing the industry. The entry of large U.S. computer manufacturers like IBM, Digital Equipment, and Hewlett-Packard and their high advertising expenditures aimed at `educating the consumer' regarding the nature and uses of PCs, have accelerated this legitimation process further. The immense increases in demand for PCs has increased the carrying capacity of the industry and facilitated entry.

Furthermore, U.S. technology platform companies such as IBM and Apple provide technological leadership and support for foreign firms. IBM's liberal approach to technology proprietorship through open systems architecture generated an entry frenzy in 1984 dominated by foreign clone makers (Computerworld Dec 31, 1984). Hence, there seems to be evidence of mutualism between the populations of U.S. and foreign PC vendors, where increases in the number of U.S. firms will increase foreign firm entry rates.

The relationship between foreign firm entry rates and U.S. population density is expected to be non-monotonic. Once the industry is legitimized and is sufficiently populated, additional entries intensify competition because now there are more companies using the same resource base (Hannan and Freeman 1977;1988;1989). Hence, increasing numbers in the U.S. subpopulation initially increases the rate of entry of foreign firms;

but, as the density of U.S. firms increase at higher levels (of density), the entry rate of foreign firms will drop. In other worlds, at lower levels of U.S. firm densities the cross-effect of the U.S. population on the foreign population is mutualistic. At higher levels of U.S. firm densities, however, mutualism is replaced by competition.

Within subpopulation effects of entry rates are expected to follow the same nonmonotonic relationship for the reasons outlined in section 4.4.2.

Hypothesis 3(a). Entry rates of both foreign and U.S. firms will increase as the density of U.S. firms increases. The relationship is negative at high levels of U.S. firm density.

Hypothesis 3(b). Entry rates of both foreign and U.S. firms will decrease as the density of foreign firms increases. The relationship becomes positive at high levels of foreign firm density.

4.4.5. Geographical Specialists versus Global Generalists

In chapter three, the population of PC vendors was grouped into two populations based on the level geographical diversification achieved. Geographical specialists relied on a narrow geographical base for their sales, whereas global generalists had a broader geographical base.

The resource partitioning explanation suggests that the strategic group of generalists create competition for each other while leaving unattended niches. These niches, in turn, are populated by specialists. Hence, a mutual relationship is expected to exist between generalists and specialists while within subpopulation relationships are competitive.

Hypothesis 4(a). The entry rates of generalists will decrease as the density of generalists increases; and will increase as the density of specialists increases.

Hypothesis 4(b). The entry rates of specialists will increase as the density of generalists increases and will decrease as the density of specialists increases.

4.4.6 Regional versus Global Competition

When competitive forces are constrained structurally by country or market, competition is localized and increases in number of firms in one market is expected to create intramarket (within subpopulation) competition rather than intermarket (between subpopulations) competition. However, when high levels of interdependencies exist between markets, as is the case in global industries, the density of one population is expected to affect entry rates in the other. The nature of this interdependence can be investigated by looking at the number of firms in the U.S. market and its effects on the global PC market as a whole.

If higher densities in the U.S. market first increase and then decrease entry rates into the U.S. market, but do not have a significant effect on entry rates to the global market, then there is evidence for regional (localized) competition. If, on the other hand, higher densities of firms in the U.S. market increase and then decrease founding rates in the global market, then there is evidence for global competition.

The practice of cross-subsidization by firms in the PC industry, particularly in R&D, flow of products and finances, strongly suggests that the industry is global. Hence, significant inter-market (between populations) effects on entry rates are expected.

Another reason for expecting high interdependencies is that when competition in regional market increases, firms are motivated to enter into other markets (Root 1987). As a regional market is populated, there is incentive to explore foreign markets. This expectation is further supported by the attractiveness of the growing non-U.S. market (Porter 1985). As the non-U.S. market's share of the worldwide industry size increases, firms will be more motivated to enter non-U.S. markets to secure a share of this growing market. Table 2.3 reveals the increase in the non-U.S. market's share of worldwide unit sales from 44.27 % in 1983 to 61.15 percent in 1992. Hence, the higher density in the U.S. market is expected to cause greater entry into global markets. As the density in both the regional and global market increases, competitive intensity increases, thus causing entry rates to decline.

Hypothesis (5). Entry rates of PC vendors into the global market will increase and then decline (nonmonotonic inverted U-Shape) as the density of firms in the U.S. market increases.

4.4.7 Organizational size

In investigating interactions between populations, a critical variable to consider is firm size. Organizations of different sizes in a population use different strategies and structures (Hannan and Freeman 1977; 1989). Large and small-sized organizations, though engaged in similar activities and operating in the same geographic markets, depend on different mixes of resources. This implies that organizations will compete most intensely with organizations of similar size (Baum and Mezias 1992). Hence it is necessary to control for the effect of size by including it in the model.

4.4.8. The Effects of Technology Standards: Period Effects

A critical event that marks the history of the PC industry is the emergence of a *de facto* standard around IBM technology by 1984. In chapter three, the expected relationships between entry rates and density before, during and after *de facto* standardization was explained in detail. In phase two, the target is industry standard establishment. The greater the number of firms adopting the standard, the higher the legitimation of the form. hence, a positive relationship between density and entry rates is expected.

In phase three, the direction of the relationship changes. Now the target is higher market share and profits. Furthermore, since there are more firms relying on the same limited resource base (because of the industry standard firm homogeneity is higher) each addition to the population creates competition. Hence:

Hypothesis (6). Rate of entry into the PC industry is positively related to density in phase two; but the relationship becomes negative in phase three.

4.4.9 Environmental Controls

Measures of installed base of Pcs over the years (market saturation), industry growth rate, industry concentration, and industry age could be added to control for variance due to such industry and environmental variables. There are 38 cases of exits and 94 entries over the life of the industry. Hence, non-survivors seem to be underepresented in the data set.

4.5 Description of RATE

The study of change in categorical (or nominal) variables --that is variables whose possible values are unordered and countable-- has often interested researchers in several fields. Examples of such variables include the ruling political party in a nation, the structural type of a firm (e.g., whether it is a subsidiary or an independent firm, and of course entries and exits in an industry.

RATE is designed to estimate parameters in various continuous-time, stocastic models of change in categorical variables (Tuma 1979). The models in RATE allow change in a categorical variable to depend on observed exogenous and endogenous variables.

RATE can be used with one of two types of data: (1) event-history data, which record the time and sequence of particular kinds of changes, or (2) change data, which record the nature of the first change that occurred in some time interval, but not the exact time of this change (Tuma 1979).

RATE implements Maximum Likelihood (ML) estimation of parameters. Tuma (1979) selected ML over more commonly used least squares method for two main reasons. First, ML estimators are asymptotically consistent, efficient, and normally distributed under fairly weak regulatory conditions on the probability distribution function of the random variable. Therefore, given a sufficiently large sample size, ML estimation ordinarily give good estimates of parameters in a model--as long as assumption of the model are met. Second, ML estimation allow censored observations to be used in estimating parameters, thus avoiding biases that result from deleting such cases (Tuma 1979). RATE also implements partial likelihood (PL) estimation of parameters.

4.6 Model

The hypotheses are tested using parametric models of organizational entry. An organization entry can be considered an instance of an "arrival process", which is one kind of point process. The rates of entry and of the other types of events (exit and survival) were assumed to be a loglinear function of the variables. This form is usually preferable to the linear form because it constraints transition rates to be nonnegative, as required by fundamental probability assumptions (Tuma 1979). The model assumes that the instantaneous rate of transition from a state j (state of being non-existent) to a state k (entry) at time t depends on a vector of variables X (which may include previous history) in the following way (Tuma 1979):

$$r_{jk}(t) = \exp(\beta X),$$

where *X* is a vector of variables, β is a vector of parameters indicating the effects of the variables on the rate of transition. The vector of variables X describe characteristics of the member population such as density, population dynamics variables, and various organizational and environmental variables. By assumption, neither the vector of variables *X* nor the vector of parameters β may vary over the observation period of one year. However, the value of the variables are updated at the beginning of each year.

The parameters of the model are estimated using Tuma's (1979) RATE program. RATE is preferred to other programs (i.e., nested regression analysis by SPSSX or SAS) because as mentioned before, it reduces right censoring bias by modelling the cumulative survival time of censored cases (Tuma and Hannan 1984).

RATE estimates the vector of parameters β by the method of maximum likelihood (ML). ML estimation begins with the observed data and iteratively calculates a set of coefficient parameters that best fits the data, that is, one that maximizes the probability density for the sample (Schoonhoven et al. 1990). The model can be tested at three levels.

4.6.1 Testing the Model

There are several kinds of statistical tests that can be performed. First, the effects of a variable on the rate of entry may be tested. Second, the statistical significance of a "set" of variables can be tested (Tuma 1979). The likelihood ratio test can also be used to assess the validity of the model.

4.6.1.1 Testing the Effects of a Variable

Testing the effects of a variable on the rate of entry into the PC industry involves the probability that this particular variable improves the predictive power of a given model more than would be expected on the basis of chance alone. If this probability is less than some value selected as the significance level, the variable is said to have a significant effect on the rate of entry.

The standard errors and F ratio of each estimated coefficient are used to check the significance of the effect of each variable on the rate of entry.

4.6.1.2 Testing the Effects of a Set of Variables

The statistical significance of a set of variables can be tested by the likelihood ratio test. This means testing the validity of the model containing all the estimated parameter coefficients by comparing the estimated model against a model (null) in which all coefficients equal zero. This test statistic is:

$W = 2[\ln L(b') - \ln L(b)]$,

where $L(b')$ is the likelihood for the model with a vector of estimated parameters b', and $L(b)$ is the likelihood for the null hypothesis, with all parameters equal to zero. The W statistic is chi-square distributed, with degrees of freedom equal to the number of variables. A high likelihood ratio statistic indicates that the model fits the data better than a model with no variables (Cox and Oakes 1984).

The models tested are hierarchically related. Therefore, they differ only by subsets of variables. The hierarchical nesting allows comparison of relative fit across models. This is done by calculating the difference in the log-likelihood ratio statistic and the difference in the degrees of freedom between two models and then comparing them to the chi-square distribution. If the difference statistic is significant at the difference in degrees of freedom, then the model with more variables is preferred because the additional variables provide a significant improvement in fitting the data. If, on the other hand, the difference between two models is not significant, the model with fewer variables is preferred because it is more parsimonious (Carroll 1983; Schoonhoven *et al.*; Tuma and Hannan 1984).

4.7 Conclusion

In this chapter, an overview of the variables used in the study was followed by a presentation of data bases used in the study. The chapter also included a discussion and presentation of research hypotheses. The next chapter will include results of the analysis of the models.

CHAPTER FIVE

RESULTS

This chapter is divided into three sections. First, results of population level analysis of density dependence and population dynamics are presented. Second, firms are categorized into (1) U.S. and foreign; (2) geographical specialists and generalists; and technological leaders and followers using the criteria discussed in chapter three. Third, the results of hypotheses testing interactions between subpopulations are presented.

5.1 Density Dependence or Population Dynamics

The empirical analysis of PC vendors in this section deals with three questions. (1) Does the entry rate depend on density, and, if it does, what is the nature of the dependence? (2) Does the entry rate also depend on the number of prior entries and exits? (3) Are density effects stronger than population dynamics effects of prior entry and exits?

Table 5.1 presents the estimates of the entry rate models for PC vendors. The coefficients shown indicate the estimated log-linear effects of variables on the instantaneous rate of PC vendor entry. For instance, the estimates for equation (1) yield the model

$$\lambda_{pc} = \exp(-6.1040 + 0.0966N_{pc} - 0.0823N^2_{pc}/100)$$

Where λ is the rate of PC entry and N_{pc} is PC density. The estimates can be readily transformed into rate multipliers.

Table 5.1
Models of Organizational Entry for PC Vendors[a]

Equation no.	(1)	(2)	(3)	(4)	
Constant	-6.1040	-5.2990		-5.2800	.22000
	(0.5513)	(0.2887)		(0.2370)	(0.00013)
PC Vendor Density	0.0966*				
	(0.0422)				
(PC Vendor Den.)^2/100	-0.0823*				
	(0.0450)				
Prior entry		-0.1365*			
		(0.0771)			
(Prior entry)^2/100		-0.9122*			
		(0.6400)			
Prior exit			-0.6685**		
			(0.1939)		
(Prior exit)^2/100			7.407**		
			(2.429)		
Survival				-28.01	
				(1364)	
(Survival)^2/100				165.0	
				(88660)	
Global market size	-0.2346*	-0.1135*		-0.4741*	-0.125*
	(0.0577)	(0.0176)		(0.0260)	(0.2027)
Likelihood Chi-square	42.98	56.96	49.55	337.33	
Degrees of freedom	3	3	3	3	
Number of entries	89	89	89	89	

* $p < .25$; ** $p < .10$; [a]Standard errors are in parentheses.

The estimates reported in equation (1) show that PC density has a significant inverted U-shape effect on the entry rate, thereby supporting the argument in hypothesis 1(b). The effects of density have the predicted signs: the first order effect, α, is positive and the second order effect, γ, is negative. It should be noted that the relationship between entry and density holds after controlling for global market size.

Density at the peak rate of entry can be calculated by taking the first derivative of the equation. When entry rate peaks, the density is $-\alpha/2\gamma$, which has a value of 58. This number is supported by observed values. When entries peaked in 1984, population density was 60. Hence, the model is able to give the correct density when entry rates peak within a range of rounding error.

5.1.1 Multiplier of the Entry Rate

The log-linear founding rate models reported in Table 5.1 assume that the effects of the covariates are multiplicative (Carroll and Swaminathan 1991). The effects of density on the entry rate (net of the effects of other covariates can be presented in terms of a multiplier of the unobserved baseline rate (Hannan and Freeman 1989:185-186, 206). Figure 5.1 plots the relationship between density and the entry rate of PC vendors over the period 1977-1991. In accordance with the density model, Figure 5.1 shows that this relationship has the shape of an inverted U within the observed range of density. The vertical axis is the *multiplier of the rate*. It is given by

$$\exp(.0966D - .0823D^2/100)$$

Table 5-2
T-Tests of Difference in Means Between Subpopulations

	U.S.$^{+}$		Foreign^{++}		
Variable	Mean	SD	Mean	SD	t- Value
Gross Margin	33.23	14.21	26.33	11.38	-4.08***
Sales & Adm.	23.39	8.61	18.84	7.47	-3.99***
Newsales (486SX & 486DX)	.032	.077	.011	.035	-3.08***
Newsales (386SX)	.119	.156	.072	.131	-2.22*
Global Unit Sales (000)	271	475	181	266	-2.52*
Global $ Revenue (0000)	407	692	289	467	-2.26*
Advertising Exp. (in U.S.)	5,813	10,706	1,115	1,536	-2.99**
Global Market Share	3.44	6.28	1.52	2.77	-3.69***
Firm Age	4.22	2.96	3.89	2.38	-1.33
	Geo. Generalist ^{0}		Geo. Specialist ^{00}		
	Mean	SD	Mean	SD	t- Value
Gross Margin	29.72	15.41	33.99	11.58	2.36*
Sales & Adm.					N.S.
Newsales (486SX & 486DX)					N.S.
Newsales (386SX)					N.S.
Global Unit Sales (000)	166	315	429	634	6.20***
Global $ Revenue (0000)	335	806	666	1275	3.65***
Advertising Exp. in U.S. (000)	4,532	10,832	7,991	13,036	1.92
Global Market Share	1.59	4.41	3.17	4.53	3.99***
Firm Age	4.46	3.12	5.50	3.41	3.92***

*p<0.05 *p<0.01 ***p<0.001 +N=310 ++N=286 ^{0}N=389 ^{00}N=212 where D (density) ranges from 0 to 70. The observed range is indicated by the vertical dashed line. At its maximum, when N≈58, the rate is 17.0 times larger than the rate at N=0. When density reaches the historical maximum of N=70, the multiplier equals 15.3. The estimates show that the rate of entry is higher in a PC population of 58 vendors than that of a population of 70 vendors, since 17.0 is larger than 15.3. The strength of density dependent competition at high density can be measured in terms of the ratio of the entry rate at maximum density (70) to the maximum entry rate at peak density (58). This ratio is approximately .90, indicating that the entry rate declines by 10 percent form its peak as density increases from 58 to 70. In other words, the entry rate when there were 58 vendors was 11 percent higher than it was at the historical high of density. These comparisons show that the rate rises sharply with increasing density in the lower range of [0,58] and drops very sharply with increasing density in the higher range (above 58), indicating that entry rates are very sensitive to density.

5.1.2 Population Dynamics Effects

In relation to testing population dynamics variables, namely the effects of prior entries on the rate of entry, equation (2) in Table 5.1 supports hypothesis 2(a). Prior entries have a significant non-monotonic inverted U-shape effect on rate of entry. The effect of prior exits on entry rates as seen in equation 3, however, is significant but U-shaped. The explanation seems to be that prior exits first decrease entries by signalling a hostile or unfavorable environment. After prior exits reach a certain level, too much resources is freed and become available for entrepreneurs in founding new organizations. Hence, entry rates start to increase. The findings support Hypothesis 2(b).

Table 5-2
T-Tests of Difference in Means Between Subpopulations

Variable	U.S.+ Mean	U.S.+ SD	Foreign++ Mean	Foreign++ SD	t- Value
Gross Margin	33.23	14.21	26.33	11.38	-4.08***
Sales & Adm.	23.39	8.61	18.84	7.47	-3.99***
Newsales (486SX & 486DX)	.032	.077	.011	.035	-3.08***
Newsales (386SX)	.119	.156	.072	.131	-2.22*
Global Unit Sales (000)	271	475	181	266	-2.52*
Global $ Revenue (0000)	407	692	289	467	-2.26*
Advertising Exp. (in U.S.)	5,813	10,706	1,115	1,536	-2.99**
Global Market Share	3.44	6.28	1.52	2.77	-3.69***
Firm Age	4.22	2.96	3.89	2.38	-1.33

	Geo. Generalist ⁰ Mean	Geo. Generalist ⁰ SD	Geo. Specialist ⁰⁰ Mean	Geo. Specialist ⁰⁰ SD	t- Value
Gross Margin	29.72	15.41	33.99	11.58	2.36*
Sales & Adm.					N.S.
Newsales (486SX & 486DX)					N.S.
Newsales (386SX)					N.S.
Global Unit Sales (000)	166	315	429	634	6.20***
Global $ Revenue (0000)	335	806	666	1275	3.65***
Advertising Exp. in U.S. (000)	4,532	10,832	7,991	13,036	1.92
Global Market Share	1.59	4.41	3.17	4.53	3.99***
Firm Age	4.46	3.12	5.50	3.41	3.92***

*p<0.05 *p<0.01 ***p<0.001 +N=310 ++N=286 ^{0}N=389 ^{00}N=212

Regarding survival, equation (4) shows that as survival periods of existing firms increase, entry rates first decline, then when survival periods have increased further, entry rates start to increase. This U-shaped relationship is opposite of the inverted U-shape that was predicted with hypothesis 2(c).

5.2 Identification of Subpopulations

Three groups of subpopulations were identified in the study. (1) U.S. and foreign based vendors; (2) geographical generalists and specialists; and (3) technological leaders and followers. Chapter three described the criteria used in developing these subpopulations. Table 5.2 gives the sizes of theses subpopulations and the t-tests of differences between means of selected variables. The significant t-values for all six variables suggest that U.S. firms generate more of their sales from technologically advanced products (newsales), have higher ratios of sales & administrative expenses, spend more on advertising, and on the average have higher worldwide revenues and unit sales.

There are significant difference between the other subpopulations as well. Specialists have lower gross margins than generalists. Generalists, on the average, have much higher worldwide revenues and unit sales. This classification suggests that generalists tend to be larger than specialists in size.

The significant differences between the subpopulations warrants the analysis of the data in terms of two populations.

Table 5.3
Models of Organizational Entry for U.S. Based PC Vendors[a]

Equation no.	(1)	(2)	(3)
Constant	-6.354	-7.658	-7.435
	(0.8214)	(1.266)	(1.290)
US firm density	0.1819*	0.6204*	0.7380*
	(0.1233)	(0.3500)	(0.3751)
(US firm density)^2/100	-0.3335*	-0.9673*	-1.1390*
	(0.2769)	(0.6391)	(0.6708)
Foreign firm density		-0.3014*	-0.4308*
		(0.2380)	(0.2707)
(Foreign firm density)^2/100		0.3632	0.5578*
		(0.4005)	(0.4451)
Global market size	-0.1805*	-0.2011*	-0.2099*
	(0.0806)	(0.0892)	(0.0922)
Global market share variance			-0.0039*
			(0.0037)
Likelihood chi-square	15.16	17.37	18.65
Degrees of freedom	3	5	6
Number of entries	47	47	47

[a] Standard errors are in parentheses.
* $p < 0.25$

5.3 Subpopulation Level Analyses

5.3.1 Density Dependence for U.S. and Foreign Firms

Table 5.3 gives the estimates of the entry rate models for the U.S. firm subpopulation. This table gives us information on: (1) whether the processes underlying density dependence differ by base of incorporation; and (2) the nature of competition between U.S. and foreign firms.

In equation (1) in Table 5.3, total population density is replaced by U.S. subpopulation density. This specification allows for the analysis of how the entry rate of U.S. vendors was influenced by the density of U.S. firms. Equation (1) provides support for the nonmonotonic relationship presented in hypothesis 3(a). The relationship has the same shape as the full-population estimates. The first order effect of U.S. firm density on U.S. firm entry rates is positive and the second order effect is negative. The rate rises with low-level increases in density but then declines with further increases at high levels of U.S. firm density. So there has been *intraform* competition within the population of U.S. firms, and the expected nonmonotonic pattern is evident in this subpopulation. U.S. firms have initially facilitated entry of other U.S. firms by legitimizing the industry. However, at higher levels of U.S. firms density, when density reaches approximately 30 U.S. vendors, they started competing with each other.

Equation (2) adds the cross-effects of foreign firm density to the model. The relationship between entry rates of U.S. firms and density of foreign firms is different, namely a U-shaped relationship exists. Foreign firms seem to generate competition for U.S. firms at lower levels of density. This is in line with the prediction that foreign firms do not expand the market with new product designs and specifications but rather create

Table 5.4
Models of Organizational Entry for Foreign Based PC Vendors[a]

Equation no.	(1)	(2)	(3)
Constant	-5.574	-9.004	-9.491
	(0.8324)	(1.4951)	(1.5690)
Foreign firm density	0.1598*	-0.3956*	-0.2346
	(0.1238)	(0.2347)	(0.2893)
(Foreign firm density)^2/100	-0.2045	0.8167*	0.5941*
	(0.2435)	(0.4134)	(0.4782)
US firm density		1.0120*	0.8776*
		(0.3734)	(0.4060)
(US firm density)^2/100		-2.0660*	-1.8980*
		(0.7390)	(0.7769)
Global market size	-0.2980*	-0.3468*	-0.3390*
	(0.0887)	(0.0111)	(0.0114)
Global market share variance			-0.0066*
			(0.0057)
Likelihood chi-square	29.73	38.51	39.76
Degrees of freedom	3	5	6
Number of entries	42	42	42

[a] Standard errors are in parentheses.
* $p < 0.25$

competition by sharing potential customers of incumbents. As the number of foreign firms increase, U.S. firm entry rate increases as well. The findings support Hypothesis 3(a). The findings also persist after global market size and market share variance are included in the model as reflected in equation (3).

Table 5.4 gives the estimates on entry rates for foreign based PC vendors. Equation (1) shows the prevalence of legitimation and competition at the *intraform* level. When the number of U.S. firms are not included in the analysis, foreign firms, first legitimize each other and then compete with each other. However, when the cross-effects of the U.S. subpopulation are included, the effect becomes an inverted U-spaded. Plus the effects of U.S. density on foreign entry rates are much higher than the effects of foreign density. Equation (2) supports the expectation that U.S. firms drive the expansion of the PC market by first legitimating foreign vendors and then competing with them. The dominant role of U.S. vendors in the industry seems to be supported by these findings. Equation (3) shows that the findings also persist when environmental covariates such as market size and market share variance are included in the model.

5.3.1.1 Hierarchical Nesting Models for U.S. and Foreign PC Vendors

Table 5.9 shows the results for likelihood ratio tests for all the models in the study that are hierarchically nested. An analysis of the models in Table 5.3 for the entry of U.S. based PC vendors shows that models (2) and (3) do not provide significant improvement over model (1). Hence, model (1) is preferred as the best fitting model for the sake of parsimony. The nonmonotonic effects of U.S. firm density explain the entry rates of U.S. vendors. This is in line with the theoretical expectations that, in general, U.S. firms have a dominant role in the industry and through their reactive strategies they determine entry rates of other U.S. vendors. The effects of foreign firms on U.S. firms is rather negligible. Although their effect on U.S. firms is competitive, this effect by itself does not explain entry rates of U.S. vendors. Hence, U.S. firms seem to be in an ecological community with foreign firms having only secondary effects on their entry rates.

When likelihood ratio tests for the models presented in Table 5.4 are conducted for the entry rates of foreign firms, the results are very different from the one for U.S. based vendors. Model (2) is a significant improvement in fit (8.79,df=2) over model (1). The inclusion of U.S. firm density improves the fit in predicting the entry rates of foreign based vendors. The inclusion of global market share variance in model (3) does not improve the fit significantly. Hence, model(2) is the best fitting model in predicting entry rates of foreign firms into the PC industry. The theoretical expectation that U.S. based firms are the industry drivers through legitimation holds through. The legitimation effects of U.S. firms on foreign firms imply that they cohere to form an ecological community with larger numbers of U.S. firms expanding the market and increasing entry rate for all companies.

5.3.2 Interactions Between Geographical Generalists and Geographical Specialists

Since generalists and specialists were shown to differ significantly on many variables in Table 5.2, it seems likely that the entry processes are different for the two subpopulations. This section investigates whether the entry rates differ by organizational form, namely the geographical diversification strategy adopted by companies. The section also analyzes whether there is competition within or between these subpopulations.

Table 5.5

Models of Organizational Entry for Geographical Generalists[1]

Equation no.	(1)	(2)	(3)
Constant	5.532 (0.923)	-5.315 (0.8148)	-5.824 (1.410)
Generalist Density	0.0842 (0.1726)	-0.9957 (0.5702)	-0.8870 (0.6256)
(Generalist Density)^2/100	0.0688 (0.5824)	1.998 (1.057)	1.734 (1.223)
Specialist Density		0.8320* (0.4283)	0.7997* (0.4355)
(Specialist Density)^2/100		-1.130* (0.5515)	-1.091* (0.5590)
Global Market Size	-0.2724* (0.1124)	-0.3161* (0.1230)	-0.3121* (0.125)
Global Market Share Variance			0.0020 (0.0038)
Likelihood Chi-Square	20.83	25.71	25.99
Degrees of Freedom	3	5	6
Number of Entries	25	25	25

[1] Standard errors are in paranthesis

* $p<0.05$

Table 5.5 reports parameter estimates and standard errors for various models of generalist entries. Model (1) presents the results of a baseline model with curvilinear effects of generalist density on generalist entries. The density of generalists seem to affect the entry rates of generalists. However, the parameters are much less than their standard errors and therefore the effect is not significant. In the model shown in column 2, including the density of specialists changes the direction of the first order effect of generalist density. This model fits the data better. Specialist density has significant nonmonotonic effect ont eh entry of generalists ($p<.05$). At lower levels of density, generalists create competition for each other, thus showing the existence of *within* group competition, whereas, specialists have a positive effect on the entry of generalists. At higher levels of density, the relationships are inverted. These relationship prevail after controlling for global market share variance. Thus, for generalist entry rates, the results shoed strong support for the nonmonotonic effects of specialist density but only weak support for the curvilinear effects of generalist density.

In Table 5.6, parameter estimates for models of specialist entry are presented. In all the models (1), (2), and (3), the nonmonotonic effects of specialist density on specialist entry rates is supported. The significant (p,.05) positive first order parameter, α, shows that specialists legitimize each other at early stages of the industry and the negative second order coefficient, γ, shows the start of competition with each other at higher levels of density.

In all models in Tables 5.5 and 5.6, the numbers of generalist in the market deter entry of both generalis and specialist firms. These consistent findings support the expectation that, in general, generalists create competition for *all* firms by depleting wide

Table 5.6

Models of Organizational Entry for Geographical Specialists[1]

Equation no.	(1)	(2)	(3)
Constant	-5.083 (0.4302)	-4.894 (0.5318)	-4.291 (0.6111)
Specialist Density	0.0149 (0.0494)	-0.4697* (0.2919)	-0.5067* (0.2944)
(Specialist Density)^2/100	-0.0288 (0.0849)	-0.6131* (0.3793)	-0.6581* (0.3830)
Generalist Density		-0.6249* (0.4133)	-0.7283* (0.4142)
(Generalist Density)^2/100		1.056* (0.7824)	-1.309* (0.7811)
Global Market Size	-0.1030* (0.0413)	-0.1112* (0.0471)	-0.1310* (0.0465)
Global Market Share Variance			-0.0041 (0.0032)
Likelihood Chi-Square	19.40	22.11	24.16
Degrees of Freedom	3	5	6
Number of Entries	65	65	65

[1] Standard errors are in paranthesis

* $p<0.05$

basis of resources, whereas, specialists enhance new entry by *all* forms.

5.3.2.1 Hierarchical Nesting Comparisons

Models in Table 5.5 are hierarchically nested. Therefore, it is important to find the model with the set of variables that improve the fit most. As explained in section 4.5.1.2 differences in *W* statistic and differences in degrees of freedom are used to find the best fitting model.

Table 5.9 presents the results of all hierarchically nested model comparisons in this study. Comparison of entry models for geographical generalists in Table 5.5 reveals that model (2) makes a significant improvement over model (1). When we add Global Market Share Variance in model (3), the model itself provides a better fit than the completely restricted null model (25.99, df=6), but it does not make a significant improvement in fit over model (2). Hence, model (2) is the best fitting model in explaining density dependent entry rates of generalists.

When likelihood ratio nesting comparisons are made for specialist entry for models presented in Table 5.6, model (3) shows a significantly better fit over both model (1) and model (2). Hence, Hence, entry rates for geographical specialists are best explained with nonmonotonic densities of both generalist and specialists. The nature of these effects, however, are different. Specialists initially increase entry rates by legitimating their own population, whereas, generalists create competition for specialists. The positive second order effect or generalists is positive (implying legitimation at higher levels) but nonsignificant.

Table 5.7

Models of Organizational Entry: Regional Density Dependence[1]

Equation no.	(1)	(2)	(3)
Constant	-5.472 (0.3419)	-4.979 (0.2706)	-4.961 (0.4934)
U.S. Market Density	0.0389 (0.0243)		-0.0264 (0.0527)
(U.S. Market Density)^2/100	-0.0890* (0.0383)		0.0273 (0.0656)
Outside U.S. Density		-0.0665 (0.0439)	-0.00382 (0.1906)
(Outside U.S. Density)^2/100		0.2242* (0.1034)	0.0837 (0.4588)
Global Market Size	-0.0733* (0.0212)	-0.1062*** (0.0208)	-0.1043** (0.0299)
Likelihood Chi-Square	49.15	54.25	54.50
Degrees of Freedom	3	3	5
Number of Entries	94	94	94

[1] Standard errors are in paranthesis

* p<0.05
** p<0.01
*** p<0.001

5.4 Regional versus Global Competition

This section investigates the question: Whether the processes underlying organizational entry differ by regional density versus outside region density.

Table 5.7 presents the parameter estimates and standard errors for the models tested. Model (1) supports the nonmonotonic density dependent founding model with positive first order and negative second order coefficients. Increased number of firms competing in the U.S. regional market actually increase the rate of entry to the global market place. Only the second order effect, γ, is significant (.0890, p,.05) indicating that significant competitive effects are created at higher levels of density.

In model (2), the effects of density outside the U.S. region are investigated. This model seems to fit data better than the previous one as the coefficients are larger. Density outside the U.S. market has a negative first order effect on overall entry rates. Although the parameter is not significant, the nonmonotonic effect is supported. By these estimates, the number of firms competing in the non-U.S. regional market initially decrease the entry rates of PC vendors (-.0665), but after the number of PC vendors in the non-U.S. market reaches approximately 15, the effect becomes positive and significant (.2242, $p<.05$). The geographical markets of U.S. and non-U.S. regions initially are competitively related in that density increases outside the U.S. create global competition. However, when the non-U.S. markets reach a critical population level they facilitate global entry by legitimizing the regional market. The density outside the U.S. has a significant positive effect (.2242) on entry rates.

In model (3), densities in both the U.S. regional market and in the non-U.S. market are included simultaneously into the equations. Although individual parameters

Table 5.8

Density Dependence in Entry Rates: Effects of Industry Standards[1]

Equation no.	Period I & II (1)	Period III (2)
Constant	-4.365 (1.057)	116.00 (0.9418)
Density	0.0225 (0.2389)	-5.0420 (2.982)
$(\text{Density})^2/100$	-0.7266 (1.449)	4.4290* (2.330)
Global Market Size	0.3603 (0.5865)	-0.8263** (0.2434)
Global Market Share Variance	-0.0039 (0.0027)	0.5537** (0.1242)
Likelihood Chi-Square	5.60	78.19
Degrees of Freedom	4	4
Number of Entries	27	67

[1] Standard errors are in paranthesis

* $p<0.05$
** $p<0.01$

Table 5.9
Likelihood Ratio Tests for Models in the Study

Table #	Equation no.	*W*	DF	Significant Improvement
5.1	(1) & null	42.979	3	yes
"	(2) & null	56.959	3	yes
"	(3) & null	49.549	3	yes
"	(4) & null	337.326	3	yes
5.3	(1) & null+	15.165	3	yes
"	(1) & (2)	2.202	2	no
"	(2) & (3)	1.288	1	no
5.4	(1) & null	29.726	3	yes
"	(1) & (2)+	8.785*	2	yes
"	(2) & (3)	1.252	1	no
5.5	(1) & null	20.832****	3	yes
"	(2) & null+	25.710****	5	yes
"	(3) & null	25.992***	6	yes
"	(1) & (2)	4.878**	2	yes
"	(2) & (3)	0.28	1	no
5.6	(1) & null	19.405****	3	yes
"	(2) & null	22.113****	5	yes
"	(3) & null+	24.160****	6	yes
"	(1) & (2)	2.708	2	no
"	(20 & (3)	2.047*	1	yes
5.7	(1) & null	49.149****	3	yes
"	(2) & null+	54.24****	3	yes
"	(3) & null	54.50****	5	yes
"	(1) & (3)	5.35**	2	yes
"	(2) & (3)	0.25	2	yes
5.8	(1) & null	5.596*	4	yes
"	(2) & null	78.189****	4	yes

* p<25; ** p<.1; *** p<.01; **** p<.001
+ best fitting model

are not significant, the nonmonotonic effects of regional densities on global entry rates still prevail.

5.4.1 Hierarchical Nesting

Table 5.9 gives likelihood ratio comparisons for the models presented in Table 5.7. Model (3) in which the effects of both number of firms in the U.S. market and number of firms outside U.S. market are simultaneously included in the model proves a significant improvement (5.35, df=2) in fitting the data compared to model (1). However, model(3) does not provide significant improvement on model (2). Since, model (2) is more parsimonious, it is adopted as the best fitting model.

The number of firms operating outside the us market has a competitive effects on global entry rates. As number of PC vendors competing in markets other than the U.S. market increases, the entry rate declines.

5.5 Effects of Industry Standard: Period Effects

This section addresses the effects of institutionalization, namely the emergence of an industry standard, on entry rates. The objective is understanding the processes that underlie density dependence at different stages of the industry. The basic question is to explore the change in entry rates, if any, before and after an industry standard is established.

Table 5.8 shows parameter estimates and standard deviations for two periods. Model (1) presents the effects of density on entry rates for the "Product Concept and Industry Standard Competition Periods" of 1977-1983. Model (2) tests the same effects for the "Performance Competition Period" which starts in 1984 and is still going on in

1992.

The parameter coefficients in model (1) support the nonmonotonic effect of density on entry rates in the first two phases of an industry. The first order coefficient, α=.0225, is positive, implying legitimation of the industry by more entry at initial stages. The second order parameter, γ=-.7266, is negative, implying competition at higher levels of density. The parameter estimates are insignificant, however, as they are smaller than their standard errors. The expected signs of the parameters show that legitimation is the underlying process of density dependence in the first two stages of the industry.

Model (2), in Table 5.8 is the same as model (1) except that it includes the period after *de facto* standardization. This time, the first order coefficient, α, is negative (-5.042), supporting the expectation that once an industry standard is established, new entry intensifies competition. Nonmonotonic density dependence is shown as the sign of the second order coefficient, γ, changes to positive and is significant ($p<.05$). By these estimates, the number of PC vendors initially decreases entry rates of new PC vendors, but after the number of vendors reaches approximately 60, the effect becomes positive.

In period III, parameters for global market size (.8263, $p<.01$) and global market share variance (.5537, $p<.01$) become significant. This increase in effect sizes suggest that once the industry knows its standard and technological uncertainty is reduced, expansion in size of market becomes a critical factor in attracting new entry. Increased variance in market shares of incumbents become critical in affecting entry rates as well.

5.6 Conclusion

In this chapter, hypothesis related to density dependence, population dynamics, and institutionalization effects of *de facto* standardization are tested. The hypotheses tested and the results are presented in Table 5.10. Findings generally support the density dependent model of organizational entry at two levels of analysis: (1) the population, (2) the subpopulations identified in the study. Implications of these findings are discussed in Chapter 6.

Table 5.10
Hypotheses and Concordance

Hypothesis	Concordance
Density Dependence	
H1. Entry rates of PC vendors will increase and then decline as the density of PC vendors increases.	+ +
Population Dynamics	
H2a.Entry rates of PC vendors will increase and then decline as the number of prior entries increases.	+ +
H2b.Entry rates of PC vendors will decrease and then increase as the number of prior exits increases.	+ +
H2c.Entry rates of PC vendors will increase and then decline as survival periods of existing firms increases.	- -[1]
H2d.Density dependent effects on entry rates will be stronger than population dynamics effects.	
Density Dependence at the Subpopulation Level	
A. US - Foreign based firms	
H3a.Entry rates of US firms will increase and then decline as the density of US firms increases.	+ +
H3b.Entry rates of US firms will decrease and then increase as the density of foreign firms increases.	+ +[2]
H3c.Entry rates of foreign firms will decrease and then increase as the density of foreign firms increases.	+ +
H3d.Entry rates of foreign firms will increase and then decline as the density of US firms increases.	+ +

Table 5.10 (cont.)

Hypothesis	Concordance
B.Geographical specialists - Global Generalists	
H4a.Entry rates of generalists will decrease as the density of generalists increases.	+[3]
H4b.Entry rates of generalists will increase as the density of specialists increases.	+
H4c.Entry rates of specialists will increase as the density of generalists increases.	-[4]
H4d.Entry rates of specialists will decrease as the density of specialists increases.	-[4]
C.Regional - Global markets	
H5.Entry rates into the global market will decrease and then increase as the density of the US market increases.	- -[3]
Institutionalization - Industry Standards	
H6.Rate of entry into the PC industry is <u>positively</u> related to density in "Product Concept" and "Industry Standard" Competition Phases;	+ +[3]
the relationship becomes <u>negative</u> in the "Performance Competition Phase".	+ +

[1] First and second order effects of survival period were insignificant.
[2] Second order effect was in expected direction but insignificant.
[3] First order effect was in expected direction but insignificant.
[4] Results significant but opposite direction.

CHAPTER SIX

SUMMARY AND CONCLUSIONS

6.1 Discussion of Results

The three major research questions addressed in this research are:

(1) In industries characterized by global competition and compatibility standards, what are critical environmental, organizational, and institutional variables that influence entry rates?

(2) Which groups of factors, population density or population dynamics, have stronger effects on entry rates?

(3a) What is the nature of interdependence between subpopulations of: (1) U.S. and Foreign based firms; (2) geographical generalists and geographical specialists.

(3b) What is the nature of interdependence between regional markets, namely, the U.S. Market and the Outside U.S. Market.

The answers to each of these questions are presented below.

6.1.1 Density Dependence and Population Dynamics

This study found strong support of the model of density dependent organizational evolution. First, this study tested the model in a new industry which is volatile, young, and dynamic. Furthermore, the industry has much more spatial flexibility implying that the density dependent effects of the population could ba mitigated by spatial flexibilities. Hence, this study is the first application of the density dependent to a global industry. This finding, we believe gives further support to the processes of legitimation and competition that shape the evolution of organizational populations.

Second, by investigating a population of profit oriented organizations, the applicability of the model to business firms is enhanced. Hence, the theoretical boundary conditions proposed by Delacroix et al.(1989) are invalidated. The density dependent model of organizational entry seems to be valid for both profit and non-profit organizational populations.

The study found support for nonmonotonic population dynamics effects on entry rates. All of the three sets of dynamics variables had significant effects on entry rates.

6.1.2 Interactions Between U.S. and Foreign Firms

The major objective of this study was to investigate the interdependencies between subpopulations. The objective was to reveal the nature and intensity of competition within and between subpopulations. The change in this relationship over the history of the industry was also investigated. U.S. firms are the drivers of the industry. Their main role is the legitimation of the industry making entry easier for other U.S. firms as well as foreign ones. Competition created by other U.S. firms at higher levels of density have more effect on deterring entry than competition created by foreign firms. U.S. firms should pursue strategies that attract new entry by U.S. firms at initial stages of the industry. Their strategies, however, should target at erecting higher entry barriers for U.S. firms at later stages of the industry.

Foreign firms, on the other hand, should watch closely the subpopulation of U.S. firms. Initially, U.S. firms make entry easier through legitimation. However, in later stages strong competitive pressures are created by U.S. firms. Once, a critical number of Foreign firms is reached, they should erect strong entry barriers for U.S. firms.

6.1.3 Interactions Between Geographical Generalists and Specialists

This study found significant and complex interdependencies to exist between subpopulations of generalist and specialist organizations. Overall, specialists have a positive effect on entry rates of all organizations. Specialist density increases entry of generalists implying a symbiotic relationship. However, when the negative effect of generalist density on entry of specialists is considered, the nature of interdependence is shown to be of *predator-prey* type. Generalists are the predators and specialists are the preys in this complex relationship. The nature of the relationship within the generalist subpopulation is competitive, while the relationship within specialist subpopulation is symbiotic.

There are significant policy implications of this finding. Symbiotic effects of specialists on all types of organizations suggest that entry of specialists into such industries should be facilitated. In identifying national technology policies of nations, policy makers should view specialists as dynamic building blocks of industries. Policies should be devised that exploit the expansionary effects of specialists on industries. Preferential tax rates, access to venture capital and production equipment with favorable terms may be used to facilitate entry. Of course, these findings may apply only to high technology industries and caution in interpretation seems warranted.

6.1.4 Interdependencies Between Regional Markets: U.S. and Outside Region Markets

This study found that organizational interdependence can exist at several levels: between populations of organizations in different regions. To investigate if the markets of PC vendors in the us region are distinct from, but interdependent with, those PC vendors outside the U.S. region. The existence of interdependence would provide support for the cross-subsidization argument.

This study found that the density in the U.S. market generated more entry into the global market. However, the density in outside region market generated competition even at earlier stages of the industry. However, once a critical density outside the U.U. region is achieved, additional entries generate significant entry. This finding suggests the existence of some bottleneck regarding the number of firms the outside market can initially carry. More aggressive advertising and distribution strategies can increase the carrying capacity of the outside U.S. market. Once, the critical density is passed, however, higher density increases the entry rate.

A policy implication of this finding is that, initially governments or related institutions may want to support industry entry so that the hurdle can be overcome and positive legitimation benefits can be generated.

6.1.5 Effects of Institutionalization: Industry Standards

This study also investigated the effects of institutionalization, namely the emergence of an industry standard, on density dependent entry rates. The results show significant changes in the nature of density dependence before and after *de facto* standardization supporting theoretical expectations.

The density dependent legitimation-competition model is supported in the period before industry standard establishment. This is a large numbers game with larger populations increasing entry rates.

The effect of density on entry rates is just the opposite after *de facto* standardization. Increases in the number of firms create competition and decreases the rate on entry.

By including a measure of global market size, mass dependence in entry rates is explicitly modeled. This enables to test the sensitivity of density estimates to measures of population mass. Although mass dependence was modeled in all our analysis, only after *de facto* standardization its effect becomes positive and significant. Positive mass dependence may indicate the attractiveness of a growing industry particularly after the industry has decided on a standard and competition is intensified. When competition is created with every new entry, the only way to increase entry rates would be through a growing market. Hence, after *de facto* standardization, we see premium placed on market growth in attracting new entry. Industry growth may be achieved through extensive advertising and distribution as well as through reductions in prices. This finding is in line with the theoretical expectations of increased isomorphism (and therefor increased competition among more similar firms) through institutionalization (DiMaggio and Powell 1983). Note, however, that the competitive effect of density dependence on entry rates persist in spite of the mass-dependent effect, although the parameter is not statistically significant.

6.2 Research Limitations

The most significant limitation of the study is the focus on density dependence of only entry rates. Density effects on mortality rates and survival rates are not investigated. Density dependence predicts the critical events of both entry and exits. Density dependence od exit rates were not analyzed in this study because there were not enough (only 38) exists throughout the life history of the industry to estimate parameters. As the industry is showing signs of maturity in 1992 and particularly 1993, it should be feasible to test mortality models in the near future.

A second limitation relates to the number of firms in the population studied. Data on the vital events of entry and exit as well as other firm level variables are not recorded for the whole population of firms in the industry. Numerous number of firms that control approximately five per cent of the market are not traced by the market research firms specializing in the PC industry. Personal communication with industry analysts assured us that exclusion of these firms from the population would not constitute exclusion of critical information. These companies are on the fringes of the industry and they enter and exit with the speed of light. Therefore, they are not expected to generate any long lasting effects on population dynamics.

It is also believed that the longitudinal design of the study should make the effects of such systematic biases on parameter estimates noncritical.

A third limitation relates to the fact that changes in the technological environment, particularly occurrence and timing of competence disturbing and competence enhancing innovations (Tushman and Anderson 1986), are not included in the models. Since, both types of innovations are expected to influence entry rates through different processes (Abernathy and Utterback 1977), these variables need to be included in future research.

A fourth limitation stems from the fact that only one institutionalization variable, *de facto* standardization is included in the study. Other institutionalization variables such as the timing of establishment and size of industry association establishment, legal developments affecting the industry, and import and export regulations pertaining to components as well as finished PC can be included in the model.

6.3 Contributions of Research

6.3.1 Managerial Implications

It is of critical importance for incumbent firms to understand what are the underlying process that influence entry rates to an industry and to be able to predict rate of entry in the future.

Knowledge of entry rates and predicted population densities is is also necessary to develop firm strategies that should facilitate or deter entry depending on the legitimation or competitive effects generated by entry.

6.3.1.1 Managerial Implications of Density Dependence in Strategy Making

It is also important to know the density when entry rates peak. The industry of a firm may already have or may not have reached maximum density. Hence, if managers know when the rate of entry is expected to maximize and the corresponding number of firms at that time, they can devise medium and long term business and marketing strategies accordingly.

Figure 6.1 gives the predicted entry rates by the density dependent equations in Table 5.1. When previous year densities are input into the equations in Model (1), predictions are made for 1993 onwards. The model predicts that density of PC vendors will stabilize around 100. This stabilization will be in line with a sharp initial decline in entry rates after 1992 which is expected to level of after 1994. This analysis also reveals that the PC industry has already reached and passed its maximum in entry rates and unless a significant change occurs in the products and/or technologies, the industry will resemble mature industries with stable and low levels of entry and stabilized firm numbers. This type of early warning would be invaluable in decreasing the level of uncertainty in strategy making.

6.3.1.2 Managerial Implications for U.S. Firms

U.S. firms should continue their technological leadership role in the industry. Historically U.S. firms have led the emergence and development of the industry. The first PC manufacturers such as Apple, Commodore, and Tandy were U.S. firms. With continuous technological innovations and new product introductions, U.S. firms have acted as technological leaders in the industry. This aggressive technology strategy has enabled them to be the dominant subpopulation within the PC industry. Technological leadership eliminates the effects of competitive pressures generated by foreign firms, thus giving U.S. firms strategic flexibility.

U.S. firms should pursue non-proprietary technology strategies in regards to other U.S. firms, thereby facilitating new entry by U.S. firms. This is because of the symbiotic relationship that exists between U.S. firms. The success of early U.S. PC manufacturers help legitimize the industry. Hence, technologically innovative U.S. firms generate entry of U.S. firm entry. According to Apple's CEO John Scully, IBM's entry into the industry helped to "lend tremendous credibility to the PC (Computerworld Dec 24, p.47)". The entry of large U.S. computer manufacturers like IBM, Digital Equipment, Hewlett-Packard and their high marketing and R&D expenditures have accelerated this legitimization process further and have generated outstanding demand. As a result, the PC industry has been able to sustain an average growth rate of 93 percent in worldwide shipments from 1881 to 1985. The immense increase in the size of PC market has increased the carrying capacity of the industry and has facilitated entry of other U.S. firms.

However, too much legitimation may prove self destructive. When markets are too

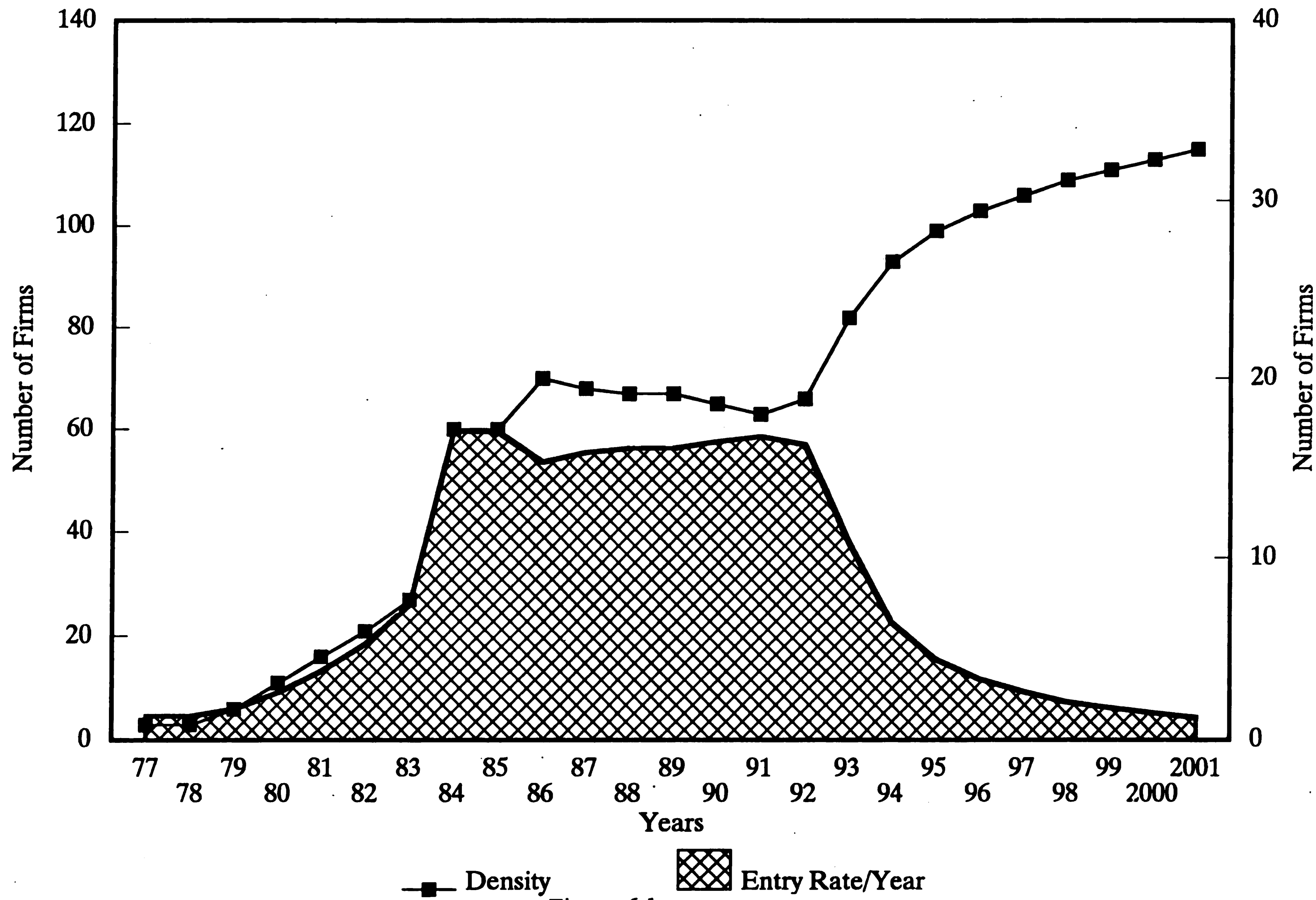


Figure 6.1
Estimates of Entry Rate and Density

populated and competition is generated strategies that lead to higher entry barriers are necessary. The case of Vobis, a German PC manufacturer is a good example. By importing parts from the cheapest sources, assembling them in Germany, and selling them at lowest prices, Vobis has become the market leader (19.4 market share) just after two years of its market entry. Escom, following the same strategy as Vobis, is already the fifth in the German market ahead of Apple. Us firms are now forced to pull their prices down in Europe as well. The challenge for U.S. firms is to continue their technological dominance, while at the same time, pulling costs lower. This is particularly relevant for the market leaders of IBM, Apple, and Compaq.

6.3.1.3 Managerial Implications for Foreign Firms

Foreign based vendors should review their technological role in the industry. Traditionally by acting as technological followers they have given up the dominant role in the industry. Hence, they are in a vulnerable position vis a vis the U.S. vendors. Especially at high levels of density, when legitimation effects of U.S. firms have changed to competition, foreign firms need to differentiate themselves from U.S. firms or pursue me-too strategies much more aggressively. The aggressive low cost strategies of Vobis and Escom have shown that followers can generate pressures on leaders if they pursue effective me-too strategies. This seems feasible despite the ecological dominance of U.S. firms.

6.3.1.4 Managerial Implications for Geographical Generalists

Generalists are in a symbiotic relationship with specialists. Therefore, generalists should not target their entry barriers to specialists. Generalists should monitor the actions of specialists for potential new developments. The increase in the number of specialists in the global PC (Dataquest Inc. 1992) industry can be viewed as a positive move for all the members in the population.

Generalists compete with each other. Hence, it is critical to erect entry barriers for generalists. Aggressive advertising, distribution, and pricing strategies in new and old markets could deter market entry of other generalist.

6.3.1.5 Managerial Implications for Geographical Specialists

Specialists should continue to concentrate their resources on single geographical market. However, this does not free them from competitive pressures generated by generalists. Successful strategies for specialists will mean outperforming generalists in the market served. This may mean intense price competition in some markets and aggressive advertising and/or distribution in others. The successes of pure specialists like Vobis and Escom in Germany, the world's third largest market, vis a vis generalists like IBM, and Compaq support this view.

If specialists become generalists, they will enter an unfriendly subpopulation with high competitive pressures. Thus sticking to the focal market seems to be a good strategy for specialists.

6.4 Future Research

As mentioned in section 6.2, an analysis of the processes underlying mortality and survival rates would be the next logical step. In both mortality and survival analysis, the unit of analysis would be the organization. This would enable the inclusion of firm strategies and performance measures into the models. Furthermore, the effects of marketing variables such as advertising, pricing and distribution could also be included.

It would be interesting to see the interactions between the subpopulations studied in respect to exit and survival.

Future research could also concentrate on the Triad markets and investigate interactions between the three. The challenge would be finding historical data relevant to each market.

This study can be supplemented by a case study of a variety of firms in the industry to validate the interactions that were found to exist by density dependent models. Although observations would generate only a point in time, it would enhance the credibility of the findings.

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