FIRST-MOVER ADVANTAGE AND THE SPEED OF COMPETITIVE ENTRY, 1887–1986*

RAJSHREE AGARWAL
University of Central Florida

and

MICHAEL GORT
State University of New York at Buffalo

ABSTRACT

This paper examines historical changes in the duration of the interval between the commercial introduction of a new product and the time when entry by later competitors begins. A priori reasons are examined why the duration of this interval in the U.S. economy may either expand or contract. Data for 46 major product innovations, however, show a systematic tendency for the interval identified above to contract over the last century. The average time span was almost 33 years at the turn of the century and has declined to 3.4 years for innovations in 1967–86. Empirical evidence suggests this change resulted largely from a lowering of absolute cost advantages of first movers through easier transfer of knowledge and skills across firms and was also facilitated by the growth of markets.

HISTORICAL accounts tell us how, at the turn of the twentieth century, competing firms in the infant phonograph record industry relied heavily on secrets to protect their property rights in innovations. Engineers at the Columbia Phonograph Company worked behind locked laboratory doors. Even patenting a device was considered tantamount to advertising it. Would such a strategy be equally effective in the same industry today?

Investment in innovation is driven by expectations of transitory monopoly returns that innovations are supposed to yield. There have always been two strategies to protecting these monopoly returns. The first relies on patents, the second on developing innovations in secrecy and getting to the market first. How effective the second approach is depends upon how long one can expect to stave off competitive entry in a market one has pioneered. Have there been historical changes in how long the first mover's advantage can be effectively preserved? It took 33 years for imitators to enter the phonograph industry in the late nineteenth century and only 3 years for rapid entry for an innovation in a successor industry, compact disc players. Is this a typical phenomenon? Is the decline in the duration of the interval prior to competitive entry consistent over time, or is the above simply an instance of anecdotal evidence?

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We start by examining the advantages of first movers in terms of the entry barriers present for later entrants. Are there a priori reasons or empirical evidence for expecting historical changes in obstacles to entry?

I. Historical Changes in Factors Leading to Entry Barriers

As a starting point, let us use Joe Bain's classification.[1] He identified three main sources of entry barriers: those arising from (*a*) economies of scale and sunk costs, (*b*) absolute cost advantages, and (*c*) product differentiation advantages. The initial analysis by Bain has been extended by others to include patent protection and other government restrictions to entry, the effects of advertising, control of scarce resources, and restrictions on the speed of information flow. In addition, recent researchers have also stressed the importance of technology lock-ins and path dependence as forces that increase market entrenchment of first movers. We consider historical changes in each of these factors in this section.

A. Economies to Scale and High Sunk Costs

Bain considered economies of scale and high sunk costs to be two important sources of entry barriers. The role of high sunk costs was further developed by William Baumol, John Panzar, and Robert Willig in their theory of contestable markets.[2] Further, high sunk costs act as entry barriers in industries characterized by capital-intensive technologies. As argued by George Stigler, however, for scale economies to serve as entry barriers, one needs to assume that the relevant market demand is insufficient to permit later entrants to attain minimum efficient scale given the presence of incumbent firms with sunk costs in the market.[3] An alternative formulation of the same issue is that the problem arises not merely from the aggregate size of the market for a product but from the time it takes for a new entrant to gain a share of the market consistent with minimum efficient scale. This time interval may be prolonged only by the gradual consumer acceptance of the brands of new entrants.

Viewed in this way, there are reasons why barriers to entry arising from economies of scale and high sunk costs have eroded over time. Market demand has expanded more rapidly because of an increase in the potential market size, quicker dissemination of information across consumers, and increases in consumer income. Peter Golder and Gerard Tellis report on a historical decline in the time taken for diffusion of product information among consumers.[4] In ad-

[1] Joe Staten Bain, Barriers to New Competition, Their Character and Consequences in Manufacturing Industries (1956).

[2] William J. Baumol, John C. Panzar, & Robert D. Willig, Contestable Markets and the Theory of Industry Structure (1982).

[3] George J. Stigler, Barriers to Entry, Economies of Scale and Firm Size, in The Organization of Industry 67 (George J. Stigler ed. 1968).

[4] Peter N. Golder & Gerard J. Tellis, Will It Ever Fly? Modeling the Takeoff of Really New Consumer Durables, 16 Marketing Sci. 256 (1997).

dition, over the last century, and after World War II in particular, there has been a reduction of effective geographical distance through improvements in transportation and an increasing globalization of markets. Firms enter foreign markets more easily. There has been considerable discussion in marketing literature on the positive relation of globalization of markets to increases in the diffusion rate of products across consumers, at home and abroad. Since returns to innovation and imitation are associated with market size, this raises the incentive to both innovate and imitate, thus decreasing the delay in competitive entry.

B. Advertising and Product Differentiation

Traditionally, following and expanding on Bain's original argument on product differentiation, scholars have alleged that advertising increases entry barriers by raising the absolute cost advantages of incumbent firms and by increasing capital requirements for entry. Richard Schmalensee, argued, however, that the mere presence of advertising is not sufficient to lead to restrictions on entry.[5] In the models developed by Schmalensee, uncertainty about product quality and differences in consumer experience with the competing brands lead to inequality in consumer acceptance between incumbent firms and later entrants, thereby leading to entry barriers. To the extent that advertising can be used by potential entrants to increase consumer information about quality and offer choices in price-quality combinations, advertising can in fact lead to a decline in the barriers to entry.

William Comanor and Thomas Wilson review the literature on the effects of advertising on competition.[6] They find that arguments about advertising limiting or enhancing competition rest on the direction of the effects of advertising on demand elasticities. Competition is limited if advertising results in the relevant demand becoming less elastic or lowers cross elasticities; barriers to entry decline if advertising results in higher price elasticities and higher cross elasticities of demand. Theoretically, Comanor and Wilson view both results as plausible. They depend in part on the relative importance of persuasive versus informational advertising. The empirical results on the issue are mixed as well, as indicated in the above survey, and there are substantial differences in how the various statistical results should be interpreted. In particular, there has been much controversy over the alleged positive relation between advertising and market concentration, with Lester Telser attributing such correlation to statistical and methodological flaws.[7]

Over the last century, technological advances in media and communication

[5] Richard Schmalensee, Product Differentiation Advantages of Pioneering Brands, 72 Am. Econ. Rev. 349 (1982); Richard Schmalensee, Brand Loyalty and Barriers to Entry, 40 S. Econ. J. 579 (1974).

[6] William S. Comanor & Thomas A. Wilson, The Effect of Advertising on Competition: A Survey, 17 J. Econ. Literature 453 (1979).

[7] Lester G. Telser, Another Look at Advertising and Concentration, 18 J. Indus. Econ. 85 (1969).

have resulted in dramatic increases in advertising channels, that is, in a reduction in the costs of advertising relative to the audience it reaches. As noted above, advertising can increase brand-name recognition of first movers and hence impede entry. Alternatively, it facilitates the dissemination of information on price and quality by new entrants. Equally important, a reduction in the effective cost of advertising (relative to audience size) raises the growth rate of demand in new markets, thereby creating market space for new entrants and, as a result, accelerating entry.

C. Absolute Cost Advantage

Bain attributed barriers to entry in the form of absolute cost advantages to management skills, to advantages in production techniques, to ownership of scarce inputs, and to differences in capital costs. Differences in costs based on production techniques arise from patents, trade secrets, or learning by doing. Marvin Lieberman and David Montgomery attribute first-mover advantages and barriers to entry to technological leadership and buyer switching costs.[8] In John Sutton's analysis of endogenous sunk costs resulting from advertising or research and development (R&D) outlays, first-mover advantage depends upon the returns to such outlays.[9]

Erosion in a first mover's technological leadership and in the value of proprietary information should increase with improvements in mechanisms for interfirm diffusion of technology. These, in turn, may follow from greater workforce mobility, research publication, reverse engineering, plant tours, and other forms of informal communication.

Each of these factors has probably grown in importance over time. First, workforce mobility has risen, given improvement in transportation and faster diffusion of information about job opportunities. Second, the population of firms in manufacturing has grown considerably over the last century.[10] Thus, the number of potential entrants in a new market drawn from this population should have increased accordingly. Third, much the same effect can be expected from the growth in scientific and technical personnel produced by universities (a growth documented by the National Science Foundation's data on degrees awarded in science and engineering). As the population of trained personnel grows, the speed of transmission of technical knowledge can be expected to rise. Fourth, there has been a rise in the mobility of managerial and technical personnel across firms. This increases the transfer of knowledge and skills relevant to entry. For example, average job tenure in 1983 with a single employer for managerial and professional labor was only 4.8 years. And despite a rise in the median age of

[8] Marvin B. Lieberman & David B. Montgomery, First Mover Advantages, 9 Strategic Mgmt. J. 41 (1988).

[9] John Sutton, Sunk Costs and Market Structure (1991).

[10] Historical data on establishments from the U.S. Department of Commerce, Bureau of the Census, Historical Statistics of the United States (various years), clearly points to such growth.

engineers, which should have increased the average length of service, the average number of years engineers have been on the same job declined by 16 percent from 1983 to 1998.[11] Fifth, this is reinforced by the growth in the number and importance of scientific journals and trade publications that communicate information relevant to new entry.

Finally, the effects of market globalization include entry by foreign firms. Our data show not only that the presence of foreign firms in the product markets has been steadily rising over the years but that both the first movers and early competitors in products such as video cassette recorders, compact disc players, and video games have consisted predominantly of foreign firms. This broadens the resource base necessary for entry and renders it less likely that first movers can maintain exclusive control of the human capital and intellectual property rights needed for competitive entry.

D. Technology Lock-in and Path Dependence

Some authors in recent years have stressed the importance of path dependence in the evolution of technologies, for example, W. Brian Arthur[12] and Vernon Rutton.[13] Path dependence implies that future success is to a large extent dependent on past achievements, which results in increasing returns from following a particular path. Path dependence may then lead to market entrenchment if a variant of a new technology, produced by an innovator, leads to a cumulative advantage (increasing returns) over later entrants. This, it has been argued, could foreclose entry by producers of competing products even when the newer versions of a technology are superior, as a result of technology lock-ins and high switching costs.

Have there been systematic changes in the period of first-mover advantage over time? If so, how important are each of the above entry barriers, and their historical changes, in determining the lag before competitive entry ensues? This is the question we now examine.

II. Data

Accurate historical data on product life cycles are typically very difficult to obtain, hence the few empirical studies that are able to investigate systematically issues regarding new product markets. To test the hypothesis of a systematic decline in the years prior to competitive entry, we use data on 46 products (see

[11] Data obtained from the Current Population Survey conducted by the Bureau of the Census (various years). The information on job tenure is not available for years prior to 1983 in a manner that would allow consistent estimates of percent changes.

[12] W. Brian Arthur, Competing Technologies, Increasing Returns and Lock-in by Historical Events, 99 Econ. J. 116 (1989); W. Brian Arthur, Increasing Returns and the New World of Business, Harv. Bus. Rev. July-August 1996, at 100.

[13] Vernon W. Ruttan, Induced Innovation, Evolutionary Theory and Path Dependence: Sources of Technical Change, 107 Econ. J. 1520 (1997).

Appendix Table A1) that were introduced starting with the late nineteenth century and extending to 1986. The 46 products were chosen to allow substantial diversity by including a mix that covered consumer, producer, and military goods, as well as products that varied in both their capital and technological intensiveness.

The data were compiled mainly from the *Thomas Register of American Manufacturers* and supplemented by information from a variety of sources, including trade publications. The *Thomas Register*, which dates back to 1906, is used primarily by purchasing agents. Michael Lavin, in extensively describing various sources of business information, states that the *Thomas Register* is the best example of a directory that provides information on manufacturers by focusing on products.[1415] According to Lavin, "The *Thomas Register* is a comprehensive, detailed guide to the full range of products manufactured in the United States. Covering only manufacturing companies, it strives for a complete representation within that scope."

It is particularly important to note here that the data were developed originally for a project that focused on entry, exit, and survival of firms over the entire product life cycle. While choosing the products, we did not have any prior knowledge or expectation about the length of the initial monopoly interval for each product.

We began by identifying new product innovations by consulting various technical sources, scientific journals, chronologies, and encyclopedias of new innovations. Process innovations, or organizational and social innovations (such as the assembly line, supermarkets, and so on), were excluded since our focus was on new markets. To be included in the sample, a product innovation had to be deemed significant by experts in the field and result in entirely new product markets rather than improvements or subsections of existing markets.[16] As noted by Jerry Wind and Vijay Mahajan, "[O]nly a small percentage of all new products are 'new to world products'—about 10 percent of the now classic Booz, Allen and Hamilton survey of new products."[1718] Our choice of time period was limited to the turn of the twentieth century because the *Thomas Register* was first pub-

[14] The importance of imports in manufacturing has increased over the last few decades. The *Thomas Register* includes foreign manufacturers of the product if the firm maintains an office or distribution channel for its product in the United States. Foreign firms that operate plants in the United States are also included. Thomas Register of American Manufacturers (various years).

[15] Michael R. Lavin, Business Information: How to Find It, How to Use It (2d ed. 1992).

[16] For instance, *Consumer Reports* issued a special issue on products introduced between 1936 and 1986 that changed the lives of consumers (I'll Buy That! 50 Small Wonders and Big Deals That Revolutionized the Lives of Consumers: A 50-Year Retrospective (1986)), and our sample includes 12 of their 16 new product innovations. The other six could not be included because of a lack of consistency between the general product definition and the *Thomas Register* listing.

[17] Jerry Wind & Mahajan Vijay, Issues and Opportunities in New Product Development: An Introduction to the Special Issue, 34 J. Marketing Res. 1 (1997).

[18] Booz-Allen & Hamilton, New Product Management for the 1980s (1982).

lished in 1906.[19] Further attrition occurred while determining the consistency of the *Thomas Register* product listings with the definition of the product market. The annual volumes of the *Thomas Register* were then consulted to create a database that identifies the firms manufacturing each product in every year after the inception of the product.

We cannot claim that the sample is necessarily representative of all product innovations. Indeed, since the population of all product innovations has never been defined (let alone measured by anyone), there is no method available for drawing a representative sample. Our sample of innovations, however, does encompass a broad spectrum of important innovations in the past century. In fact, it undoubtedly represents a sizeable fraction of major product innovations, the absolute number of which is not large. And, as already noted, it was chosen for a study that investigated the survival of firms over the product life cycle, without reference to prior information on the duration of the interval before competitive entry. The sensitivity of the results to the choice of sample, in the context of an unknown population, is best judged by the consistency over time of our results. In addition, Section IV revisits the sample selection issue by presenting information on other products gathered from published studies that are tangentially related to the issue.

III. Results on Historical Change

As shown by Michael Gort and Steven Klepper, each new product market is associated with an interval of varying duration in which one firm, or at most a few firms, that was first in the commercial sale of the product occupies the entire market.[20] This is followed by an interval (or stage) in which imitators enter the market and challenge the position of the first movers. The boundary between the successive stages is identified statistically by a generalization of standard discriminant analysis. (The Appendix describes this methodology in detail.) Once the boundary is defined, we compute the number of years that the first interval, preceding entry by imitators, encompasses.

Table 1 gives the rate of decline in the duration over time. The results indicate that the duration has been shrinking at the rate of 2.93 percent a year. The R^2 of .53 and the strongly significant negative coefficient of time are sizable, but they probably understate the historical relation since there is no reason for assuming the relation in the duration of the first stage to time is continuous rather than episodic. Accordingly, we partitioned the period for which the data were developed into five periods of 20 years each and, second, into four periods, where the four-period partition explicitly maximizes the differences in the duration of

[19] Some products that were introduced in the late nineteenth century were added because reliable information was available on the time of product introduction and subsequent entry from reputable published sources.

[20] Michael Gort & Steven Klepper, Time Paths in the Diffusion of Product Innovations, 92 Econ. J. 630 (1982).

TABLE 1

RATE OF DECLINE IN DURATION OF INTERVAL PRIOR TO COMPETITIVE ENTRY

Variable	Estimate	t (p-value)
Intercept	59.12	7.50 (.0001)
Year of commercial introduction of product	−.0293	−7.20 (.0001)

NOTE.—Dependent variable: log (duration of interval prior to competitive entry). $R^2 = .53$; F-statistic (p-value) = 51.77 (.0001).

the first stage as a boundary-defining criterion for the comparative analysis of changes over time intervals. Both approaches yield very similar results, as shown in Table 2.

The results, regardless of how one divides the entire century by period, show a very large and consistent (in successive periods) decline in the duration of the interval before entry by imitators. The average time span for all products was almost 33 years at the turn of the century and had declined to 3.4 years for innovations in 1967–86. Note, in particular, that the decline is largest in the post–World War II period, the years during which there were dramatic advances in technology in both transportation (for example, increased use of air travel) and communication (for example, television). To test the significance of differences across time periods, we conduct both the F-test, which relies on the assumption of normality for its validity, and the nonparametric Kruskal-Wallis test[21] in case the assumption of normality is inappropriate for our data. Both the F-statistic and the Kruskal-Wallis test show that the differences across the periods were highly significant.

A test of the extent to which our results depend on a fortuitous selection of our sample is indicated by the variance in the duration of the interval to competitive entry. If the results depend on idiosyncrasies of our sample and the impact of a few outliers in our data, we would expect a large erratic variation over time in the dispersion across products in the duration of the relevant interval. In fact, however, Table 3 shows that the standard deviation declined over time roughly proportionally to the decline in the means. The coefficients of variation show remarkable stability whether the whole period is divided into two or four periods of equal length.[22]

[21] The Kruskal-Wallis test rank orders the observations and computes the following test statistic, where n is the number of observations, k is the number of periods, R_i is the rank of the ith observation, and n_i is the number of observation in the kth group. If the sample includes tied observations, a correction factor is applied to the above statistic, which is modified as $H^* = H/C$, where $C = 1 - \sum t^3 - \sum t / nn^2 - 1$ and t represents the number of ties for a given (tied) value and the summation is over all sets of tied values. The value of H^* is approximately chi-square distributed with $k - 1$ degrees of freedom.

[22] There are somewhat larger differences in the coefficients of variation if the entire period is divided into five 20-year intervals as in Table 2, but the number of observations are too small for meaningful analysis for two of the periods. The coefficients of variation, however, are very low for these two periods.

TABLE 2

HISTORICAL CHANGES IN DURATION OF INTERVAL PRIOR TO COMPETITIVE ENTRY, 1887–1986

Period of Commercial Introduction[a]	Number of Products	Mean Duration	Period of Commercial Introduction[b]	Number of Products	Mean Duration
1887–1906	4	32.75	1887–1906	4	32.75
1907–26	10	24.10	1907–29	13	23.85
1927–46	19	13.84	1930–45	15	12.60
1947–66	8	5.75	1946–86	14	4.86
1967–86	5	3.40			
F-statistic	9.86**		*F*-statistic	16.27**	
Kruskal-Wallis test statistic	25.97**		Kruskal-Wallis test statistic	28.47**	

[a] Divided into periods of 20 years each.
[b] Divided into four periods that maximized differences in duration of the relevant interval.
** Statistically significant at the .01 level.

IV. EVIDENCE ON OTHER PRODUCTS FROM RELATED STUDIES

Corroboration for the trends we observe in our data can be found in other published studies on product innovations and their diffusion over time, although the investigation of the initial monopoly interval in product innovations was not the central focus of these studies. Since the data requirements for tracking product life cycles and related issues are quite substantial, most of the papers reviewed here present anecdotal evidence for at most a few products. The cumulative evidence of all these papers, though, seems consistent with our finding of a generally declining trend in the monopoly interval of product life cycles.

James Utterback investigates several new product innovations in the context of the dominant design framework, and there is substantial overlap in his product categories and those reported here.[23] For the products not included in our sample, he reports that entry in early product markets (typewriters, automobiles, and electric lights) was "relatively slow," while competitors entered rapidly in products introduced later (transistors, disk drives, integrated chips, and electronic calculators). Long monopoly spans are also observed by Alfred Chandler for products introduced around the turn of the century (sewing machines, elevators, telephones, and cameras).[24] Conversely, case studies of more recent products show very short monopoly spans. For example, Barry L. Bayus, Sanjay Jain, and Ambar Rao investigate the personal digital assistant product market and report rapid entry of competitors within 2 years of its introduction.[25]

Bayus examines several product categories within the personal computer in-

[23] James Utterback, Mastering the Dynamics of Innovation (1994).

[24] Alfred D. Chandler, Jr., Scale and Scope: The Dynamics of Industrial Capitalism (1990).

[25] Barry L. Bayus, Sanjay Jain, & Ambar G. Rao, Too Little, Too Early: Introduction Timing and New Product Performance in the Personal Digital Assistant Industry, 34 J. Marketing Res. 50 (1997).

TABLE 3

COEFFICIENTS OF VARIATION IN DURATION OF INTERVAL PRIOR TO COMPETITIVE ENTRY

Years of Product Introduction	Number	Mean Duration	SD	Coefficients of Variation
1887–1936	26	21.85	12.86	.589
1937–86	20	6.50	3.83	.590
1887–1911	7	26.71	14.22	.532
1912–36	19	20.05	12.23	.610
1937–61	14	7.43	3.99	.538
1962–86	6	4.33	2.50	.578

dustry, and his data are consistent with very short monopoly intervals.[26] Finally, Golder and Tellis study 50 new product markets (of which nine overlap with the products in our study) in the context of market leadership and market pioneers and remark that the lag between pioneers and early entrants has declined dramatically from the pre– to post–World War II time period.[27] They report an average time lag of 19 years in the products introduced in the pre–World War II period and a lag of only 5 years in the products introduced in the post–World War II period. While their methodology and definitions are not strictly comparable to ours, their results, using largely an entirely different product sample, are remarkably consistent with those seen in Table 2.

The above studies cumulatively encompass more than 50 products not covered in our study and support our conclusion of a declining trend in the monopoly interval of the product life cycle. Thus, this decline is unlikely to be an accident of the products selected for our sample.

V. THE VARIABLES THAT DETERMINE CHANGE

We now turn to evidence that bears on the question of what changes in entry barriers produced the reported results. In Section I, we indicated that received literature focused mainly on (*a*) economies of scale and sunk costs, (*b*) advertising and product differentiation, and (*c*) absolute cost advantages. While direct measures of each of these are not available for most of the markets we examined in this paper, plausible conclusions can be drawn from the use of proxy variables.

We therefore turn to Table 4, which presents the mean duration before competitive entry in three successive intervals for products partitioned on the basis of several characteristics.[28] First, are they consumer or nonconsumer goods?

[26] Barry L. Bayus, An Analysis of Product Lifetimes in a Technologically Dynamic Industry, 44 Mgmt. Sci. 763 (1998).

[27] Peter N. Golder & Gerard J. Tellis, Pioneer Advantage: Marketing Logic or Marketing Legend? 30 J. Marketing Res. 158 (1993).

[28] The first two and last two periods in Table 2 are each combined since the number of observations in each category is too small for a meaningful analysis of variance.

TABLE 4

MEAN DURATION OF INTERVAL PRIOR TO COMPETITIVE ENTRY, BY PRODUCT CHARACTERISTICS

YEARS OF PRODUCT INTRODUCTION	MEAN DURATION							COEFFICIENT OF VARIATION: ALL
	Consumer	Nonconsumer	Technical	Nontechnical	High Capital Intensity	Low Capital Intensity	All	
1887–1926	26.50	26.67	27.00	26.14	25.38	28.17	26.57	.49
1927–46	15.83	12.92	14.00	13.40	13.62	14.30	13.84	.67
1947–86	4.88	5.00	4.67	5.25	4.60	5.00	4.85	.48
All	15.22	15.13	14.23	16.94	15.50	14.75	12.54	.82
F-statistic[a]	9.68**	6.48**	15.47**	3.69*	10.08**	7.16**	18.15**	

[a] Analysis of variance conducted for each product category to test homogeneity across the different periods. Not reported, but available on request, are the *F*-statistics for testing homogeneity for each period across each of the two subgroups within the three subcategories. All the latter *F*-statistics are not significant.

* Statistically significant at the .05 level.

** Statistically significant at the .01 level.

Second, are the products characterized by high or low technological intensiveness? Third, are they characterized by high or low levels of capital intensiveness (that is, capital-labor ratios)?

Before examining the relevance of each set of classifications from the standpoint of entry barriers, we report that the declines in the mean duration are systematic for each of the three sets of categories, and the mean durations across each set of two are roughly the same. Once again, this shows that the pronounced decline is not likely to be a function of sample selection. However one partitions the products, the results are much the same. This reinforces the conclusions already drawn on the basis of Table 3.

Turning to entry barriers identified above, let us first consider the distinction between consumer and nonconsumer goods. Product differentiation and advertising are likely to be far less important as determinants of sales of producer goods or goods purchased by the government than for the sales of consumer goods. The absence of difference in the decline over time in the duration of the interval prior to competitive entry for the two categories has, therefore, an important implication. It indicates that it is most unlikely that changes in product differentiation and advertising explain the observed results.

Second, consider the role of sunk costs. The higher the capital intensiveness, the greater the role of sunk costs should be as an entry barrier. Yet once again we find no significant difference in the pattern of decline over time in the period before competitive entry for products of high and low levels of capital intensiveness. We can thus largely eliminate the hypothesis that changes in the role of sunk costs are an explanation of the decline in the interval before competitive entry.

What about economies of scale or, more precisely, as discussed in Section I, the ratio of minimum efficient scale for new entrants to market size or, even more important, market growth? We have no hard evidence on changes in minimum efficient scale, but we do have evidence on market size and growth. The growth in population, the globalization of markets, as well as growth in their geographic scope within countries all mean larger size and faster initial growth from a zero starting point. Hence, the importance of minimum efficient scale as an entry barrier is reduced. Even if minimum efficient scale grew, higher market growth was at least a facilitating factor for entry.

Still another variable that needs to be considered is absolute cost advantage. Indeed, we consider this central to an explanation of the contraction of the interval before competitive entry. We have argued that there is evidence of a rise in the mobility of the labor force, and in particular of managerial and technical personnel, that facilitates the transfer of information and skills needed for entry. This transfer is further strengthened by the growth in the number and importance of scientific and trade journals. As the rate of diffusion of information rises, the role of knowledge as an absolute cost advantage and, hence, entry barrier diminishes. A somewhat surprising result was the fact that the decline in mean duration before competitive entry was very similar for goods characterized as

technical rather than nontechnical, as seen in Table 4. Apparently, the rate of transfer of knowledge and skills is a critical variable for both categories of products.

A contrary effect raising absolute cost advantage for the first mover is, however, sometimes attributed to the increasing complexity of technology. It follows that the more technologically intensive the product, the more critical are the unique technological attributes of the product and the greater the probability of path dependence. Thus, technology lock-ins leading to market entrenchment should cause an increase in the quasi-monopoly interval, particularly for goods for which technology plays an important role. In contrast, our results point to acceleration of the erosion of market position by an innovator for all products in the sample and at a rate at least as high, if not higher, for technical goods. Thus, the results seem to support the view that forces of rapid information dissemination and reverse engineering have been gaining in importance over the adverse effects on entry of early technology lock-ins by first movers.

VI. Some Further Implications

Do our results mean that incentives for investment in innovation have also been declining? Not necessarily. As markets in the economy grow, the rewards per unit of time for a monopoly position grow commensurately. Four years of quasi-monopoly today may generate a larger aggregate return than 30 years at the turn of the century. And while the market shares of first movers may decline because of the speed of competitive entry, the absolute size of sales may be increasing. There is also considerable evidence that pioneers and first movers frequently retain the reward of a large market share long after they cease to have a monopoly position in the market. Buyer switching costs and network externalities, on the demand side, and learning by doing, scale economies, and setup and sunk costs, on the supply side, contribute to retention of market shares, as mentioned by Michael Katz and Carl Shapiro,[29] Dennis Mueller,[30] and William Robinson, Gurumurthy Kalyanaram, and Glen Urban.[31]

Nevertheless, the principal result of our study is that the magnitude of the first-mover advantage, which captures all the factors contributing to or attenuating entrenchment, appears to have been systematically declining over the last century in the United States. This bodes well for the future of competition.

It may also mean that in the future more emphasis will be placed by innovators on patent protection as compared to trade secrets and getting to the market as quickly as possible. In a recent paper, Samuel Kortum and Josh Lerner report a

[29] Michael L. Katz & Carl Shapiro, Technology Adoption in the Presence of Network Externalities, 94 J. Pol. Econ. 822 (1986).

[30] Dennis C. Mueller, First-Mover Advantages and Path Dependence, 15 Int'l J. Indus. Org. 827 (1997).

[31] William T. Robinson, Gurumurthy Kalyanaram, & Glen L. Urban, First Mover Advantages from Pioneering New Markets: A Survey of Empirical Evidence, 9 Rev. Indus. Org. 1 (1994).

remarkable increase in the rate of patenting in the United States since the mid-1980s.[32] Could this partly be a lagged response to evolutionary changes in the rate of competitive entry in new industries? Rational entrepreneurs may well have realized that one reason for the decline in the quasi-monopoly interval is the speed at which imitators gain access to the innovation-related information and, thus, rely on patents rather than trade secrets to protect their intellectual property rights.

VII. Conclusions

We have examined the forces that contribute to and attenuate entry barriers. While there are theoretical reasons for concluding that entry barriers in new markets have been both rising and falling, the empirical evidence leads to a far less equivocal conclusion. The rate of initial competitive entry in new markets has been rising rapidly and steadily over the last century, pointing to a weakening of entry barriers on net balance. We attribute this outcome largely to (*a*) increased mobility of skilled labor, (*b*) improvements in communication and, as a consequence, more rapid diffusion of technical information, (*c*) an increase in the population of potential entrants, and (*d*) growth in the absolute size of markets.

The results do not necessarily imply a reduction in the incentive to innovate but are consistent with a possible effect of the observed trends—that firms may increase their reliance on patenting rather than trade secrets.

APPENDIX

Procedure to Identify the Stage Prior to Competitive Entry

The procedure that we used to identify the interval prior to competitive entry is the same as the generalization of the standard discriminant analysis used by Gort and Klepper to separate the stages in the product life cycle.[33] To distinguish between stage I (monopoly returns interval) and stage II (start of competitive entry), we examined the data on annual net entry rates for each product. To determine the cutoff year for stage I, we first partitioned the series into three categories—the first and third categories contained the years in which the net entry rate clearly reflected stages I and II, respectively. The net entry rates of the T consecutive "in-between" years of the second category were then labeled $x_1, x_2, \ldots, x_T$. The problem was then to choose an optimal dividing year j such that observations $x_1, x_2, \ldots, x_j$ are classified in stage I and $x_{j+1}, x_{j+2}, \ldots, x_T$ are classified in stage II. This was accomplished by using a three-step procedure.

Step 1. For each $j = 1, 2, \ldots, T$, we computed

$$d_1(j) = \sum_{i=1}^{j} \frac{x_i}{j} \quad \text{and} \quad d_2(j) = \sum_{i=j+1}^{T} \frac{x_i}{(T-j)}. \tag{A1}$$

Step 2. The choice of the dividing year was limited to those values of j for which

[32] Samuel Kortum & Josh Lerner, Stronger Protection or Technological Revolution: What Is Behind the Recent Surge in Patenting? (paper presented at Carnegie-Rochester Public Conference, Bradley Pol'y Res. Center, Rochester, N.Y., April 1997).

[33] Gort & Klepper, *supra* note 20, at 21 & 22.

TABLE A1

DATA ON PRODUCTS IN STUDY

Product	Year of Introduction	Year of Competitive Entry	Technology Index	Capital Intensity	Consumer Index
Antibiotics	1948	1951	1	1	1
Artificial Christmas trees	1912	1962	0	0	1
Ball-point pens	1945	1955	0	0	1
Betaray gauges	1955	1961	1	0	0
Cathode ray tubes	1922	1941	1	1	1
Combination locks	1912	1930	0	1	1
Compact disc players	1983	1986	1	0	1
Computers	1935	1952	1	1	0
Contact lenses	1936	1976	0	0	1
Disposable diapers	1961	1970	0	1	1
Electric blankets	1911	1921	0	0	1
Electric shavers	1930	1936	0	0	1
Electrocardiographs	1914	1953	1	1	0
Freon compressors	1935	1941	0	0	0
Gas turbines	1936	1944	1	1	0
Guided missiles	1942	1954	1	1	0
Gyroscopes	1911	1952	1	0	0
Heat pumps	1953	1958	0	0	0
Laser printers	1980	1982	1	1	0
Microfilm readers	1929	1960	1	1	0
Microwave ovens	1967	1971	0	1	1
Nuclear reactors	1942	1954	1	1	0
Nylon	1939	1952	1	1	1
Outboard motors	1908	1913	1	1	0
Oxygen tents	1926	1942	0	0	0
Paints	1933	1945	1	1	1
Personal computers	1977	1982	1	1	1
Phonograph records	1887	1920	1	0	1
Photocopying machines	1940	1942	1	1	0
Piezoelectric crystals	1936	1941	1	1	0
Polariscopes	1906	1946	0	1	0
Radiant heating baseboards	1946	1951	0	0	0
Radiation meters	1949	1956	1	0	0
Radio transmitters	1922	1941	1	0	0
Recording tapes	1947	1951	1	0	1
Rocket engines	1944	1957	1	1	0
Shampoo	1898	1931	1	1	1
Smoke detectors	1932	1946	1	1	1
Styrene	1935	1954	1	1	0
Tampons	1912	1936	0	1	1
Telemeters	1928	1947	1	1	0
Television apparatus	1929	1948	1	0	0
Transistor radios	1954	1957	1	0	1
Video cassette recorders	1966	1975	1	0	1
Video games	1970	1973	0	0	1
Zippers	1904	1929	0	1	1

NOTE.—The distinction between producer and consumer goods is made by considering the type of good and by use of expert opinion. The products in the database are classified as technical and nontechnical on the basis of the study conducted by Paul Hadlock, Daniel Hecker, and Joseph Gannon (High Technology Employment: Another View, 144 Monthly Lab. Rev. 26 (1991)), who use the ratio of R&D employees to total personnel to distinguish between technical and nontechnical industries at the three-digit Standard Industrial Classification (SIC) levels. Capital-intensive and labor-intensive goods are classified on the basis of the capital-labor ratio of the four-digit SIC industries, and the ratios are derived from the Census of Manufactures for 1972 and 1987, the years in which most of the products were at the midpoint of their life cycle. Products in the study were classified as having a high capital-labor ratio if they were in the upper half of the industries on the basis of this ratio.

$$|d_1(j) - \mu_1| \leq \left| \frac{(\mu_1 - \mu_2)}{2} \right| \quad \text{and} \quad |d_2(j) - \mu_2| \leq \left| \frac{(\mu_1 - \mu_2)}{2} \right|, \qquad \text{(A2)}$$

where μ_1 and μ_2 represent the mean rate of net entry in categories 1 and 2. If there were no values of j satisfying (A2), then all observations were classified in stage I if $|d_1(T) - \mu_1| < |d_1(T) - \mu_2|$ and in Stage II otherwise.

Step 3. If there were multiple values of j satisfying (A2), then we selected the value of j from this set that maximized $|d_1(j) - d_2(j)|$.

Step 2 requires that the mean of the observations classified in each of the two stages is closer to the sample mean of the observations initially classified in those stages than in the alternative stage. Step 3 ensures that, among the classifications that would satisfy step 2, the classification that is chosen maximizes the difference between the means of the points classified in the two alternative stages.

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