The Geography of Organizational Knowledge

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Abstract

The evolution of the geographic distribution of producers in the television receiver and automobile industries is analyzed. Both industries experienced sharp shakeouts and evolved to be oligopolies, suggestive of increasing returns. The television receiver industry was initially concentrated regionally but evolved to be more dispersed over time. In contrast, the automobile industry was dispersed initially but evolved to be heavily concentrated around one city, Detroit, MI, that initially had no producers. Neither pattern conforms to theories that portray agglomerations as being beneficial to the firms that populate them. An alternative theory is developed and tested to explain the geographic evolution of the two industries. Firms are assumed to differ in terms of their initial competence at the time of entry, which shapes their long-term performance. They acquire their competence from firms in related industries and prior entrants into the new industry. The location and performance of entrants in both industries is analyzed, and it is shown how differential importance in the two sources of competence plays a critical role in explaining the contrasting evolution of the geographic structure of the two industries.

[Key words: Competence, Geography, Spinoffs]
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Steven Klepper

I. Introduction

Why do industries agglomerate geographically? What factors condition the extent of industry agglomerations and where they occur? These questions have attracted a great deal of theoretical and empirical attention in the burgeoning field of economic geography. It is generally believed that if agglomerations were better understood, significant insights would be forthcoming regarding international trade and economic growth.

Similar to modern trade and growth theories, the most popular theories of agglomerations feature increasing returns to scale. They can be external to firms, arising from such factors as knowledge spillovers and thicker labor markets (Henderson [1974, 1988]). Alternatively, they can be internal to firms, which coupled with transportation costs can give rise to location-specific externalities (Fujita et al. [1999]). In either case, firms in agglomerated areas have lower costs. Consequently, firms have an incentive to locate close to each other and, once formed, agglomerations should persist.

The theories have been tested by examining their consistency with the spatial variation in wages and labor productivity, spatial variation in industry employment, production, and innovation, and the evolution of the size and structure of cities. Hanson [2000] ably reviews the empirical literature, noting the limited power of prior empirical analyses to get at the key issues. He suggests that "empirical modeling of the dynamics of industry agglomeration is clearly an area where more work is needed." The purpose of this paper is to take up this charge by examining the evolution from birth to maturity of the geographic and market structure of two U.S. industries, automobiles and television receivers, that followed revealing paths.[1]

Both industries were initially populated by many firms but then experienced sharp shakeouts and evolved to be oligopolies. This is suggestive of increasing returns. But

[1] For a related effort on the spatial dynamics of employment in the U.S computer industry, see Beardsell and Henderson [1999].

neither industry evolved geographically the way the popular theories suggest. Television firms were initially heavily concentrated in three big cities, New York, Chicago, and Los Angeles, but over time the fraction of firms outside these cities increased markedly and the industry ended up dispersed throughout the Northeast and Midwest. In contrast, automobile firms were initially dispersed throughout the Northeast and Midwest, but the industry evolved to be extremely concentrated around one mid-size city, Detroit, that initially had no producers. The main purpose of this paper is to develop a new theory of geography to explain these patterns.

The theory combines the model in Klepper [2002a] of how the market structure of new industries evolves with a heriditary theory of organizational competence. Firms begin with different organizational competence that conditions the productivity of their R&D. Dynamic scale economies associated with R&D lead to a shakeout and evolution of an oligopolistic market structure, with the most competent early entrants dominating the industry. Entrants acquire their competence from their pre-entry experiences. The most competent diversify from related industries, are founded by high-level employees of firms in related industries, or are founded by high-level employees of prior entrants into the new industry. More competent firms in the new industry or related industries breed more competent "offspring," hence they are more fertile and breed more competent entrants. Social and economic forces induce entrants to locate geographically close to their origins. Consequently, at any given moment the number and quality of a region's entrants into a new industry depends on its stock of firms in related industries and the quality of its prior entrants into the new industry.

These two factors—the stock of prior entrants and firms in related industries—shape the location and regional performance of entrants into the new industry and thus how the geographic structure of the new industry evolves. In many ways, the theory is a variant of the Heckscher-Ohlin model of trade. Instead of focusing on the traditional inputs of production, which are increasingly mobile, organizational knowledge is identified as the key immobile resource giving rise to comparative advantage. Coupled with increasing returns associated with R&D, the theory provides an account of the evolution of both the market and geographic structure of a new industry.

The different ways the geographic structure of the television and automobile industries evolved is attributed to the differential importance of the two key sources of organizational knowledge in the two industries. Television firms faced similar organizational challenges to radio firms, and as a result experience in radios was the dominant determinant of a tv entrant's competence (Klepper and Simons [2000]). Entry into the industry was heavily concentrated in New York, Chicago, and Los Angeles because the radio firms were heavily concentrated in these three cities. The leading radio firms, though, were much less concentrated geographically than radio firms overall, and because they came to dominate television manufacturing the geographic concentration of the industry declined over time. In contrast, many of the challenges faced by automobile firms were novel, and new firms founded by employees of the leading incumbents were competitive with firms coming out of the most closely related industries of carriages and wagons, bicycles, and engines (Klepper [2002b]). Firms in these related industries were considerably more dispersed than the radio producers. Consequently, entry was initially more dispersed geographically than in televisions. While none of the early entrants located in the Detroit area, the first great firm in the industry, Olds Motor Works, located near Detroit, and three of the other great firms, which were related to Olds via subcontracting, soon entered nearby. Together, these four firms unleashed a juggernaut of employee startups that propelled Detroit to become the automobile capital of the United States (Klepper [2002b]).

The theory allows for differences in entry by region, but attributes these differences entirely to the stock of prior entrants and firms in related industries and not to characteristics of regions, such as their distance to buyers and suppliers, or to spillovers between firms. Furthermore, it attributes all differences in the regional performance of firms to differences in their backgrounds. These predictions are tested by assembling data for the two industries on the location and background of each entrant and the regional stock of firms in related industries. Consistent with the theory, the number and quality of firms in a region in related industries influenced the entry of both diversifying firms and new entrants. In televisions, new firms were consistently outperformed by the diversifiers, and the entry of new firms was not related to the number of incumbent firms in a region. In contrast, in automobiles firms founded by employees of the leading incumbent firms performed as well if not better than the diversifiers, and entry of such firms was closely related to the number and quality of incumbent producers in a region. These patterns gave rise to differences across regions in firm performance. Firms located in the most agglomerated area performed distinctly well in automobiles but fared poorly in televisions. In both instances, though, this was primarily due to regional differences in the backgrounds of firms and not the regions in which they were located.

The paper is organized as follows. In Section II, the nature of the evolution of the market and geographic structure of the two industries is reviewed. In Section III the theory is presented and implications of the theory for the two industries are derived. These implications are tested in Section IV for televisions and Section V for automobiles. The findings are discussed in Section VI, which also contains concluding remarks.

II. Evolution of the Television Receiver and Automobile Industries

The evolution of the automobile and television industries was analyzed in Klepper [2002a, 2002b] and Klepper and Simons [2000]. In this section, the evolution of the market and geographic structure of the two industries is reviewed using data for all producers on their location and dates of entry and exit.[2]

Beginning with the television industry, Figure 1 presents the annual number of U.S. entrants, exits, and producers from the start of the industry in 1946 through 1989. A total of 177 firms entered the industry. Entry was concentrated in the first few years of the industry. It peaked in 1948 and by 1956 was negligible. The number of firms peaked at 105 in 1949 and then steadily declined. Approximately 30 firms were left in the industry at the end of the 1960s when international competition, initially from Japan, began. In 1969 the top two firms, RCA and Zenith, accounted for 39% of the U.S. sales of black and white and 48.5% of the sales of color tvs and the four-firm concentration ratios in the two markets were 61% and 65.5% respectively. The number of firms continued to decline after the 1960s, and by 1989 firms outside the U.S. dominated the industry and only three U.S. producers were left.

[2] See Klepper and Simons [2000] and Klepper [2002a, 2002b, 2002c] for all data sources and procedures.

Entry was heavily concentrated around New York, Chicago, and Los Angeles, which together accounted for about 15% of the U.S. population at the start of the tv industry. Table 1 reports the percentage of the entrants in each city. New York had 44% of the entrants, Chicago 15%, and Los Angeles 14%,[3] with the rest of the entrants scattered throughout 17 other states and the rest of New York, Illinois, and California. Figure 2 presents the annual percentage of U.S. television firms in New York, Chicago, and Los Angeles for the 1946-1989 period. New York initially contained over 50% of the firms. Over time this percentage declined, reaching 20% around 1970 and then zero by the latter part of the 1970s. Firms were slower to enter in Los Angeles, but it too followed a similar progression. The percentage of firms in Los Angeles peaked around 20% in the mid 1950s and then declined, reaching zero around the mid 1970s. Of the three cities, only Chicago maintained its share of firms. Chicago accounted for 25% of the firms through 1980, after which the percentage of firms in Chicago increased sharply as the number of firms dwindled from eight to three. Thus, from around the mid 1950s until 1980, the percentage of firms in the three cities in total declined from around 70% to 25%.

The output of the leading firms in the industry was less concentrated regionally than the firms themselves, but it followed a similar evolution. In 1954-1956, three of the leading firms, Admiral, Zenith, and Motorola, were in Chicago, and they jointly produced 34% of the output of the leading producers. New York had Emerson and DuPont, which jointly produced 8.6% of the output of the leaders, and Los Angeles had Hoffman and Packard Bell, which produced 3.9% of the output of the leaders. In 1959 the same three Chicago firms produced 37.6% of the output of the leaders, Emerson and Olympic in New York produced 8.3% of the output of the leaders, and Hoffman in Los Angeles produced 1.2% of the output of the leaders. In 1972, when color television dominated the industry, the same three Chicago firms (with Motorola under foreign ownership) accounted for 35.6% of the color sales of the leaders and no New York or Los Angeles

[3] Firms were classified in each of these cities if they were located within 25 miles of the city. Only four (minor) firms moved in or out of the three cities, and they were classified based on where they spent the majority of their years.

firm was among the industry leaders.[4] The other leading U.S. firms, which included RCA, GE, Philco, Sylvania, Magnavox, and Westinghouse, were scattered through the east and midwest, so that over time the industry became increasingly dispersed geographically.

The automobile industry also experienced a sharp shakeout and evolved to be an oligopoly, similar to televisions. Figure 3 presents the annual number of U.S. entrants, exits, and producers in the industry from the start of the industry in 1895 through 1966. A total of 725 firms entered the industry. In contrast to televisions, initially entry increased for a number of years and peaked at 82 in 1907. It remained high for the next two years and then dropped sharply, but it continued to be nonnegligible until the early 1920s, after which entry dried up. It took 14 years before the number of firms peaked at 272 in 1909. Subsequently the number of firms fell sharply, and by 1941 only nine firms were left. The top two firms, Ford and General Motors, accounted for 38% of the output of the industry in 1911. This increased to over 60% in the 1920s, and by the 1930s Ford, General Motors and Chrysler produced over 80% of the output of the industry.

In contrast to televisions, entry was quite dispersed geographically. Table 2 reports the number of entrants in the 11 states with the most entrants. These states, which included all the major markets in the east and midwest, accounted for 90% of all the entrants and about 55% of the U.S. population around the start of the industry. Unlike tvs, though, where three cities accounted for 73% of the entrants, the top three states only accounted for 44% of the entrants, and the entrants were dispersed over multiple cities within each state. Over time, though, the industry became heavily concentrated around one city, Detroit, Michigan. Figure 4 presents the annual fraction of automobile producers based within 100 miles of Detroit[5] from the start of the industry through 1941, when only nine firms were left. Through 1901 69 firms entered the industry, but no firm entered in the Detroit area. After the entry in the Detroit area of Olds Motor Works in

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[4] The 1954-1956 and 1959-1960 data are from Datta [1971, p. 295] and the 1972 data are from Levy [1981, p. 98].

[5] The 100-mile distance was chosen to reflect movement and branching of firms within approximately a 100-mile distance of Detroit. Eleven of the 725 entrants moved in or out of the 100-mile region, and they were classified as in the region if they spent the majority of their years producing there.

1901, the fraction of firms in the Detroit area rose steadily into the mid 1910s. It then fell back a little but after 1920 it rose again, to over 50% by 1941.

The shift of the industry toward Detroit was much more dramatic than these figures reflect. Figure 5 reports the annual number of leading makes of automobiles produced by firms based in the Detroit area over the period 1901-1928, during which the total number of leading makes that were listed each year was typically between 14 and 18. In 1915, when approximately 20% of the automobile firms were located in the Detroit area, firms based in the Detroit area produced 13 of the 15 leading makes. The Detroit-area firms were comparably dominant in 1928, producing 15 of the 18 leading makes, and this continued thereafter. With the leading makes typically accounting for over 80% of the output of the industry, by 1915 Detroit had truly become the automobile capital of the United States.

Thus, both the television and automobile industries experienced sharp shakeouts and evolved to be oligopolies, but their geographic structure evolved quite differently. Klepper [2002a] developed a model to explain the common market structure evolution of the two industries. The model is now extended to address the evolution of the geographic structure of the two industries.

III. Model

The model in Klepper [2002a] is first presented. The driving force in the model is R&D. R&D lowers a firm's average cost, which is specified as $c_{it} = c_t - a_i g(r_{it})$, where c_{it} is the average cost of firm i in period t, c_t is a cost component in period t common to all firms, a_i is the productivity of the firm's R&D, r_{it} is its R&D in period t, and g(.) is such that $g' > 0$ and $g'' < 0$ for all r_{it} to reflect diminishing returns to R&D. Firms are assumed to costlessly imitate all innovations in the prior period, which is modeled as $c_t = c_{t-1} - \max_i\{a_i g(r_{it-1})\}$. The firm's R&D productivity a_i is assumed to be fixed over time.

Firms grow in each period subject to a cost of growth that reflects the costs of attracting new customers and assimilating the additional labor and capital needed to grow. The cost of growth is denoted as $m(\Delta q_{it})$, where Δq_{it} is the absolute growth of the firm's output in period t and m(.) is assumed to be such that $m'(0)=0$, $m' \geq 0$ and $m'' \geq 0$ for all $\Delta q_{it} > 0$.

The industry demand curve is fixed over time. Firms take the price in each period, p_t, as given, where price clears the market. They choose r_{it} and Δq_{it} to maximize their profits in period t:

$$\Pi_{it} = [p_t - c_t + a_i g(r_{it})]\,(q_{it-1} + \Delta q_{it}) - r_{it} - m(\Delta q_{it}).$$

If $\Pi_{it} \geq 0$ the firm remains in the industry; otherwise it exits. Firms also incur random cost shocks due to such factors as capital shortages, management failures, and the like that temporarily inflate their average costs. If the cost shock exceeds the firm's profit per unit of output from production, $p_t - c_t + a_i g(r_{it})$, then it exits.

In each period there is a new stock of potential entrants. They enter if their R&D productivity a_i is sufficiently great that $\Pi_{it} \geq 0$, where $q_{it-1} = 0$ for potential entrants and Δq_{it} is their size at entry. The competence of entrants, reflected in their R&D productivity, is determined by a heriditary process. The competence of firms diversifying from related industries depends on their competence in the related industry and the transferability of that competence into the new industry. If the firm is new, its competence similarly depends on the competence of the firms where its founders worked, the transferability of that competence into the new industry, and the prior positions of the founders. Diversifying firms are assumed to locate close to their base and new firms are assumed to locate close to the prior employers of their founders to maintain social ties and exploit localized knowledge of capitalists, potential employees, suppliers, etc. For the same reasons, firms are assumed not to move their base locations over time.

The average competence of diversifying firms is assumed to be greater than the average competence of new firms by dint of their organizational experience and complementary assets. If the organizational challenges in the new industry are novel, some new firms may be able to achieve the competence of the leading diversifiers; otherwise diversifiers will dominate the industry. Three types of new firms are distinguished. The first, called experienced entrepreneurs, are founded by heads of firms in related industries. The second, called spinoffs, are founded by high-level employees of incumbent firms. The third, which is a residual category called inexperienced firms, are founded by capitalists with little experience relevant to the new industry and by lower-level employees of firms in related industries. When the organizational challenges in the new industry are novel, inexperienced firms will not be competitive with diversifiers because of their lack of relevant experience, but the best experienced entrepreneurs and especially the best spinoffs, who have experience in the new industry itself, may have competence comparable to the best diversifiers. Incumbent firms can breed multiple spinoffs, and the most competent spinoffs come from the most competent incumbents. Thus, when organizational challenges in the new industry are novel, leading incumbent firms can profoundly affect regional entry and firm performance, which is a theme that is developed further below.

Regardless of the competence of diversifying and new firms, the nature of the returns to R&D built into the model implies that the new industry will experience a shakeout and evolve to be an oligopoly (cf. Klepper [2002a]). Larger firms earn a greater return from R&D because they have a bigger output over which they can apply the cost reductions from R&D. Earlier entrants have more time to grow and thus all else equal are larger. Consequently, they always perform more R&D. More competent firms also perform more R&D because of the greater productivity of their R&D. Firms that conduct more R&D have lower costs and greater profits, which makes them less likely to exit due to an adverse cost shock or decline in price. So eventually the most competent early entrants take over the industry. But initially their growth is limited by the costs of growth. This allows other firms to enter. Price must exceed the average cost of all incumbent firms to enable them to earn sufficient profits from production to cover their R&D and costs of growth. With m'(0) assumed equal to zero and price exceeding average cost, it is profitable for all incumbent firms to expand. The cost of growth function is assumed to be such that incumbent growth is sufficient to cause $p_t - c_t$ to decline over time. This raises the minimum R&D productivity needed for profitable entry, and eventually $p_t - c_t$ declines to the point where entry is no longer profitable even for the most competent potential entrant. At this point entry ceases but exit continues due both to firms drawing adverse cost shocks and profits being compressed by decreases in price. Thus, the industry experiences a steady decline in the number of producers—a shakeout—and it evolves to be an oligopoly dominated by the most competent early entrants.

The model also provides an account of the evolution of the geographic structure of shakeout industries. The ultimate geographic structure of shakeout industries is determined by the location of the most competent early entrants. If their locations differ from the locations of entrants generally, then the geographic structure of the industry will change over time. The model has distinctive implications regarding the location of different types of entrants. Let p_{irt} denote the probability that an entrant in period t of type i will locate in region r, where i denotes the four types of entrants distinguished in the theory: diversifiers, experienced entrepreneurs, spinoffs, and inexperienced entrants. Both diversifiers and experienced entrepreneurs in a region arise from firms in their region in related industries. They require a sufficiently high competence to be able to enter profitably. Their competence depends on their competence in their original industry and the transferability of that competence into the new industry. Therefore, p_{irt} for diversifiers and experienced entrepreneurs depends only on the number and quality of firms in related industries at time t in region r relative to other regions. Analogously, the number and quality of incumbent firms in the new industry at time t in region r relative to other regions determines p_{irt} for spinoffs. Inexperienced entrants are a mixture. Some are started by capitalists with little relevant experience in the new industry while others are started by lower-level employees of firms in related industries. If the capitalists need experienced employees in the new industry to help guide their firms, then the same factors that condition p_{irt} for spinoffs—the number and quality of incumbent firms—determine p_{irt} for inexperienced firms. Presumably the number and quality of firms in related industries determine the number of inexperienced firms founded by lower-level employees of related firms. Thus, the determinants of p_{irt} for inexperienced firms are a combination of those for the other three types of entrants.

The implications of these predictions for the location of entrants depends on the key sources of organizational knowledge. In televisions, Klepper and Simons [2000] identified the entrants that diversified from the radio industry, but it was not possible to trace the origin of the other entrants, which were largely new firms. They found that entrants that diversified from the radio industry consistently outperformed the other entrants. Moreover, the leading radio firms consistently outperformed the other radio diversifiers. This suggests that the radio diversifiers had greater competence than the other entrants[6] and that opportunities for new entrants were limited. Only the best new entrants would then have been able to enter. This rules out the inexperienced firms. Spinoffs require the prior entry of their parents and thus on average enter later, which in the model is disadvantageous. Thus, it might be expected that experienced-entrepreneur entrants, particularly those emanating from the radio industry, would dominate entry by new firms. Then, the key determinant of p_{irt} for both diversifiers from the radio industry and the other entrants would be the number and quality of radio producers at time t in region r relative to other regions. It will be shown that at the start of the tv industry, radio producers were heavily concentrated in New York, Chicago, and Los Angeles, which would explain why entry in tvs was so heavily concentrated in these three cities. More generally, the following hypothesis will be tested:

<u>T1</u>: For all entrants, p_{irt} is positively related to the number and quality of the radio firms at time t in region r relative to other regions, which is the only determinant of p_{irt} for the diversifiers and the primary determinant for the other entrants.

In automobiles, Klepper [2002b] was able to classify entrants into the four categories distinguished in the theory and to identify the industry from which the diversifiers and experienced-entrepreneur entrants originated. The theory implies that p_{irt} for diversifiers and experienced entrepreneurs depends only on the number and quality of firms in industries related to automobiles at time t in region r relative to other regions. The spinoffs performed as well as the diversifiers and experienced entrepreneurs,[7] and there were many spinoff and inexperienced entrants. Consequently, in contrast to televisions, the number and quality of incumbent firms at time t in region r relative to other regions would also be an important determinant of p_{irt}, in particular for the spinoffs and secondarily inexperienced firms. As noted earlier, the first great firm in the industry

[6] The technological and marketing challenges facing tv firms were similar to those faced by radio firms. In both industries, RCA was the lead innovator. It licensed all its innovations, and firms used RCA's and their own innovations to improve their products. They also devoted considerable effort to lowering cost via process innovation. The radio diversifiers used their experienced radio R&D employees to guide their R&D in tvs and they used their radio distribution networks to sell tvs. All told, their experience in radios appears to have given them a substantial competence advantage in tvs (Klepper and Simons [2000]).

[7] Many of the organizational challenges faced by the automobile firms were novel. Plants were much larger and the pace of technological change much faster than in industries related to automobiles like carriages and wagons and bicycles. As a result, the advantages of diversifying entrants were more limited

was Olds Motor Works, which entered near Detroit. It was influential in the location nearby of three of the other great firms in the industry, Cadillac, Ford, and Buick. As a result, Detroit had an unusual concentration of high quality incumbents that led to a high rate of spinoff entry around Detroit. More generally, the following hypothesis will be tested:

A1: The number and quality of firms in related industries at time t in region r relative to other regions positively influences p_{irt} for diversifiers and experienced entrepreneurs and secondarily the inexperienced entrants, while the number and quality of incumbent producers at time t in region r relative to other regions positively influences p_{irt} for spinoffs and secondarily inexperienced entrants.

The model also has distinctive implications regarding the survival of firms in each region. Let h_{irt} denote the hazard of exit of firms of type i in region r at time t. In the model, h_{irt} is a function of the time the firm entered and its R&D productivity, which is determined by its competence, and is unrelated to the region in which the firm located. If regions differ in the backgrounds of their firms and firm backgrounds are not controlled, then the model implies h_{irt} will vary across regions. This turned out to be the case in both televisions and autos. Consider first televisions. Entrants were heavily concentrated in New York, Chicago, and Los Angeles because the radio firms were concentrated in those three cities. Nearly all the leading radio firms, however, were not located in New York or Los Angeles. Consequently, the entrants in New York and Los Angeles were less competent than the entrants in Chicago and elsewhere, which explains why the percentage of tv firms in New York and Los Angeles declined over time and the industry became less concentrated geographically. More generally, the following two hypotheses will be tested:

T2: h_{irt} is higher for entrants in New York and Los Angeles than Chicago and elsewhere.

T3: Conditional on the time of entry and firm backgrounds, h_{irt} does not differ across regions.

In automobiles, firms in related industries were dispersed over a number of states, which contributed to diversifiers and experienced entrants being more dispersed than in

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than in tvs, and new firms, both experienced entrepreneurs and particularly spinoffs from the leading tvs. The early success of Olds Motor Works, Cadillac, Ford, and Buick led to a high rate of distinctly competent spinoffs in the Detroit area, who in turn bred more spinoffs of distinct competence. Therefore, due to their superior parentage, spinoffs in the Detroit had lower hazards than spinoffs elsewhere. Other types of entrants were not more competent in Detroit than elsewhere, but because spinoffs constituted a high percentage of the entrants in the Detroit area, the hazards of entrants in the Detroit area were lower than the hazards of entrants elsewhere. This explains why the percentage of firms in the Detroit area increased over time and the industry became increasingly concentrated around Detroit. More generally, the following two hypotheses will be tested:

A2: h_{irt} is lower for entrants in the Detroit area than elewhere.

A3: h_{irt} is lower only for spinoffs and not other kinds of entrants in the Detroit area, and if the backgrounds of the parents of spinoffs are controlled, h_{irt} does not differ across regions for spinoffs or other types of entrants.

A number of the hypotheses contrast with implications of the leading theories of geography and thus provide discriminating tests of the alternative theories. The leading theories imply that entry of all types of firms is greater in regions with more and better incumbent producers, either because of spillovers or locational advantages that draw firms to these regions and affect their performance. In contrast, the number and quality of incumbents is predicted to affect only the spinoffs and secondarily inexperienced firms in automobiles. The leading theories also predict that the hazards of all types of entrants are lower in agglomerated areas, which includes New York, Chicago, and Los Angeles in televisions and Detroit in automobiles. In contrast, television firms in New York and Los Angeles are predicted to have higher hazards and in automobiles the lower hazard of Detroit firms is predicted to be confined to spinoffs, and in both industries regional differences are predicted to vanish once the backgrounds of entrants are fully controlled.

IV. Televisions

Predictions T1-T3 are tested in this section, with predictions A1-A3 tested in the next section. Prediction T1 is tested first using a conditional logit model for p_{irt}. Four

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incumbents, were competitive with, if not superior to, the diversifying entrants.

regions are distinguished: New York, Chicago, Los Angeles, and a residual category that includes the rest of the U.S. The model is

$$p_{irt} = \exp(\underline{x}_{irt}'\underline{\beta})/\Sigma_r \exp(\underline{x}_{irt}'\underline{\beta}),$$

where $\underline{x}$ is a vector of explanatory variables and $\underline{\beta}$ a vector of coefficients. The explanatory variables include features of the regions, which are allowed to have different effects for different types of entrants.

The first specification includes one explanatory variable, which is the percentage of radio producers in each region, denoted as Radiofirms. Entry was heavily concentrated in the early years of the tv industry, and so Radiofirms was based on firms producing radios in the years 1945-1948. Klepper and Simons [2000] identified 266 radio producers in this period. Table 1 reports the percentage of the producers in each region. New York had 33% of the radio producers, Chicago 15%, Los Angeles 7%, and the residual category 45%. Thus, 55% of the radio producers were in the three cities that accounted for 73% of the television entrants, suggesting that the initial geographic concentration of the tv industry was directly related to the geographic structure of the radio industry. The estimates of the model, which are reported in Table 3, support this. The coefficient estimate of Radiofirms is positive and significant at the .01 level, confirming that regions with more radio producers had more tv entrants. The model was reestimated without the residual category (and the entrants into the residual category) to test whether the results might have been an artifact of grouping all the entrants outside of New York, Chicago, and Los Angeles into one category. This had little effect on the coefficient estimates, which was also true of subsequent specifications, as would be expected if the model were properly specified.[8]

Among the 177 entrants into tvs, 58, or approximately one-third, diversified from the radio industry. Nearly all located where they were based in radios, which no doubt contributed to the relationship between p_{irt} and Radiofirms. Hypothesis T1 predicted that the stock of radio producers in a region would affect both diversifiers from radios and the

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[8] Indeed, outside of New York, Chicago, and Los Angeles, no other area contained a sizable number of tv or radio firms, so it seems likely that the effects of Radiofirms on the location of the entrants would be even stronger if the residual category were somehow disaggregated.

other entrants. The distribution of the radio diversifiers and other entrants across the four regions is reported in Table 1. To test whether both types of entrants were affected by the number of radio producers in the region, Radiofirms was allowed to have a separate effect for entrants diversifying from radios, denoted as Diversifiers, and all other entrants, denoted as Other. The coefficient estimates of Radiofirms for both groups of entrants reported in Table 3 are positive and significant at the .01 level, indicating that regions with more radio firms not only had more entrants diversifying from the radio industry but also more of other entrants, consistent with prediction T1. The coefficient estimate for the entrants diversifying from radios is over twice as big as the coefficient estimate for the other entrants, which is consistent with the number of radio producers in a region having a more direct effect on diversifiers than startups.

Hypothesis T1 also predicts that entry depends on the competence of the radio producers in a region as well as their number. The competence of radio firms in region r was measured by the average size of the radio firms in the region, denoted as Q_r, divided by the average size of all radio firms, denoted as Q. This was interacted with Radiofirms to test whether the effect of the number of radio firms on entry depended on the competence of the firms. The interaction term, which is the product of Radiofirms and Q_r/Q, equals the percentage of the total output of the radio industry accounted for by firms in each region, denoted as RadioQ. These percentages are presented in Table 1. They were computed based on a list of the 1940 sales of the top 16 radio firms, which jointly accounted for over 90% of the sales of the industry (McLaurin [1949]). New York firms had 11% of the output of the leaders, Chicago 38%, Los Angeles 0%, and the residual category 51%, reflecting that all but one of the top 16 radio producers was located outside of New York and Los Angeles. The interaction term RadioQ was added as an explanatory variable and it was allowed to have a separate effect for the radio diversifiers and the other entrants.

For the radio diversifiers, the coefficient estimates of Radiofirms and RadioQ reported in Table 3 are both positive and significant respectively at the .05 and .10 (one-tailed) levels. Consistent with hypothesis T1, both the number and competence of the radio firms positively influenced entry of the entrants diversifying from the radio industry. Indeed, the leading radio firms were much more likely to enter tvs than the other radio producers (Klepper and Simons [2000]), consistent with the theory. Regarding the other entrants, the coefficient estimate of Radiofirms was positive and significant at the .01 level but the coefficient estimate of RadioQ was negative and significant at the .01 level. The latter estimate, which was not predicted, implies that regions with a greater number of less competent radio firms attracted more of the other entrants. Table 1 confirms this. New York and Los Angeles, which together had only one of the leading radio producers, accounted respectively for 53% and 18% of the other entrants versus only 26% and 5% of the radio diversifiers. All but two of the top 16 radio firms entered tvs, and they may have discouraged or even prevented their employees from starting their own tv firms through devices like noncompete covenants. Consequently, New York and Los Angeles may have had a disproportionate number of radio employees with the freedom to start their own tv firms, which could explain the concentration of the other entrants in these two cities.

Next, the number of the tv producers in each region was added to test whether entrants were attracted to regions with more tv producers. This variable, which is denoted as Tvfirms, equals the percentage of the tv firms in the industry in the year prior to each firm's entry that were located in each region.[9] It was allowed to have separate effects for the radio diversifiers and other entrants. The coefficient estimates of Tvfirms for the two groups of entrants reported in Table 3 are small and insignificant, suggesting that the number of tv firms in a region had little effect on the entry of either the radio diversifiers or other entrants.[10] This was probed further by adding fixed effects for each region, which controls for unobserved regional characteristics that could influence both past and current entry. This had little effect on the coefficient estimates of Tvfirms. A measure of the competence of tv firms based on the output of the leading tv firms during the decade of 1950-1960 was also added as an explanatory variable, but its coefficient estimate was insignificant for each of the two groups of entrants. Thus, consistent with

[9] For entrants in the first year of the industry, 1946, Tvfirms was set equal to 25% in each of the four regions. In the later years of the industry, foreign firms entered into production in the United States, and these firms were included in the counts of tv firms in those years.
[10] The diversifiers entered in the first few years of the industry, which may have limited the extent to which they could have been influenced by prior entrants. Alternatively, the other entrants generally entered later than the diversifiers and so were more susceptible to being influenced by the location of incumbents.

hypothesis T1, the number and quality of incumbent tv producers in each region had little effect on the entry of either the firms diversifying from the radio industry or the other entrants.

To test hypotheses T2 and T3, a proportional hazard model of the form

$$h_{irt} = f(age_{irt})\exp(\underline{x}_{irt}'\underline{\beta})$$

was estimated. The variable age_{irt} is the age of the firm, $\underline{x}$ is a vector of explanatory variables, including firm backgrounds and time of entry, that affect the hazard proportionally at every age, and $\underline{\beta}$ is a vector of coefficients. The proportional hazards model is consistent with the theory assuming that the other entrants were equally competent and less competent than the diversifiers from the radio industry (Klepper [2002a]).[11] The model was estimated using the Cox partial likelihood approach, which obviates having to specify the form of the function f(.), with exits by acquisition treated as censored observations. The initial specification includes just three 1-0 locational dummies, denoted as New York, Chicago, and Los Angeles, which equal one for firms in the respective cities. The coefficient estimates are reported in Table 4. The coefficient estimates for New York and Los Angeles are positive and significant at the .01 and .05 levels respectively, reflecting a 86% and 76% higher annual hazard of firms in New York and Los Angeles than the residual category. The coefficient estimate for Chicago is negative but not significant at conventional levels, reflecting a 26% lower annual hazard for firms in Chicago relative to the residual category. As a group, the coefficient estimates are significantly different from zero at the .01 level. Thus, consistent with prediction T2, the performance of firms differed by region, with firms in New York and Los Angeles having higher hazards than firms in the other two regions.

The regional differences in firm hazards were predicted to arise from differences in the backgrounds of the firms in each region. The composition of the entrants was in fact quite different in the four regions. Only 19% and 12% of the entrants in New York and Los Angeles respectively diversified from the radio industry versus 54% of the entrants in both Chicago and the residual category, and only one of the New York and Los Angeles radio diversifiers was among the top 16 radio producers as of 1940. Figure

[11] Specification tests failed to reject the proportionality assumption for any of the explanatory variables.

6 conveys how this affected the hazards of the firms in each region. Kaplan-Meier survival curves indicating the natural log of the percentage of the survivors to each age are presented for the 14 radio producers in the top 16 in 1940 that diversified into tvs, the other 44 radio diversifiers, and the other 117 entrants.[12] The negative of the slope of each curve is the hazard of the group. The curves indicate persistent differences in the hazards of the three groups at all ages. Diversifiers among the top 16 radio producers had much lower hazards than the other radio diversifiers, who in turn had much lower hazards than the new entrants. Thus, without controlling for differences in firm backgrounds in each region, the New York and Los Angeles firms were destined to have higher hazards than the firms in Chicago and the residual category.

It was predicted in hypothesis T3 that regional differences in the firm hazards would go away once the backgrounds of the firms were controlled. This was tested by adding to the hazard model a 1-0 dummy, denoted as Radioproducer, equal to 1 for entrants diversifying from the radio industry and a 1-0 dummy, denoted as Top16radioproducer, equal to 1 for radio diversifiers in the top 16 radio firms in 1940. A 1-0 dummy, denoted as Entryby1948, equal to 1 for firms that entered in 1948 or earlier was also added to represent the effect of earlier entry on the hazard. The coefficient estimates for the three added variables are all negative and significant (at the .01 level for Radioproducer and Top16radioproducer and the .05 level for Entryby1948), as expected. The effects of the two radio dummies are particularly large, reflecting a 59% lower annual hazard for radio producers and a further 79% lower annual hazard for diversifiers among the top 16 radio producers. More important, the coefficient estimates of the three regional dummies are all much closer to zero than in the initial specification and are insignificant both individually and as a group. Thus, despite the extent to which tv producers were agglomerated in the three regions (no other comparably-sized area in the residual category contained a sizable number of tv producers), there were no differences in regional hazard rates once the backgrounds of firms were controlled, consistent with hypothesis T3.

[12] Acquired firms were treated as censored exits. A curve drops to the horizontal axis when the respective

V. The Automobile Industry

The data available to test the hypotheses are different in autos than tvs. Klepper [2002b] exploited information on the origins of all entrants to divide the 725 entrants into the four categories discussed in the theory: diversifiers, experienced entrepreneurs, spinoffs, and inexperienced firms, which contained 120, 108, 145, and 352 entrants respectively. The primary industry for each diversifier and experienced entrepreneur and the parent of each spinoff were identified. Unlike televisions, the diversifiers, and similarly the experienced entrepreneurs, came from a number of different industries. The two most common were carriages and wagons (C&W) and bicycles, which respectively accounted for 58 and 24 of all the diversifiers and experienced entrepreneurs. The technologies of both industries overlapped with automobiles, and entrants from these industries were among the best performers (Carroll et al. [1995], Klepper [2002b]). Although it was not possible to construct the roster of C&W and bicycle producers at the start of the automobile industry, the Census of Manufacturers reported the number and value of production of C&W and bicycle producers by state. These data are used to test hypothesis A1.

Analogous to tvs, a conditional logit model is estimated to test A1. The unit of analysis is the state, and the analysis is restricted to the firms that entered through 1925[13] and the 34 states and the District of Columbia with one or more producers. The initial specification of the model contains only two variables: the percentages of all C&W and bicycle producers in the state, denoted as C&Wfirms and Bikefirms. For each entrant, C&Wfirms is a weighted average of the percentage of C&W producers in the state in the two closest Census years (the Census was conducted every five years) to the year the firm entered, with the weights inversely related to the years between the Census year and the firm's year of entry. Bikefirms is the percentage of bicycle producers in the state in 1900. The industry was undergoing a sharp decline and consolidation at this point, and the state of the industry in 1900 was a better indicator of bicycle talent in a region than any of the subsequent Censuses.

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group survival rate falls to 1%.

[13] The 11 entrants from 1926 to 1966 are excluded because it is doubtful that they were influenced by conditions that prevailed at the start of the industry, which is the focus of the analysis.

Table 2 reports the value of production of C&W and bicycle producers in 1900 in the 11 states with the most automobile entrants.[14] These states, which accounted for 90% of the automobile entrants, also accounted for 81% of C&W and 99% of bicycle production in 1900. They were also among the most industrialized states in the U.S., containing many of the manufacturing firms servicing the C&W and bicycle industries that also had competence related to automobiles. Accordingly, it was expected that the number of automobile entrants in a state would be closely related to C&Wfirms and Bikefirms. This is borne out by the estimated coefficients of the two variables, which are reported in Table 5. Both coefficient estimates are positive and significant at the .01 level. They indicate that states with more C&W and bicycle production had more automobile entrants. Table 2 indicates that C&W and bicycle production was considerably dispersed over the 11 leading states, with Michigan fourth in C&W and ninth in bicycle production. This would explain why initially the industry was not very concentrated geographically and Detroit did not attract many early entrants.

Transport costs were significant for automobiles. If they were also an important influence on the location of firms, as featured in Fujita et al. [1999], then the states with more C&W and bicycle producers might have had more automobile entrants due solely to having larger markets. This was tested by adding to the model the state population, expressed as a weighted average of the percentage of the total population in the state in the two closest Decennial Census years. Population actually had a negative coefficient estimate and its addition only increased the magnitudes of the two coefficient estimates. Thus, the size of the state market does not appear to have affected the location of entrants, and population was not included in any of the subsequent analyses.

In the next specification, C&Wfirms and Bikefirms were allowed to have separate effects for diversifiers and experienced entrepreneurs from the C&W and bicycle industries respectively (denoted as C&Wentrants and Bikeentrants respectively) and all the other entrants (denoted as Other). The diversifiers and experienced entrepreneurs were grouped because the estimates were similar for these two groups when they were entered separately, which may partly reflect that the distinctions between the two groups

[14] These values were reported in Bureau of the Census [1908].

were sometimes blurred.[15] The coefficient estimates of both variables are positive and significant at the .01 level for both groups of entrants. Thus, consistent with hypothesis A1, states that had more C&W and bicycle producers had more diversifiers and experienced entrepreneurs from these industries and also more of the other entrants. Somewhat surprisingly, the coefficient estimates for C&Wfirms and Bikefirms are similar for the two groups of entrants. It seems more reasonable to expect that these variables would have a more direct effect on the entrants from the respective industry than other types of entrants, but the estimates suggest otherwise. This may largely be a reflection of that fact that states with more C&W and bicycle producers were more industrialized generally and thus had more candidates in other industries to enter or breed new entrants.

It was expected that states that had more competent C&W and bicycle producers would have more entrants, all else equal. Analogous to radio firms, the total value of production of C&W and bicycle production as reported in the Census was used to construct two variables, denoted as C&Wvalue and Bikevalue. These variables are equivalent to interactions of C&Wfirms and Bikefirms with the relative size of firms in the respective industries in each region, where the latter is a measure of the average competence of the firms in the region. Both variables were added to the prior specification and allowed to have separate effects for the two groups of entrants.

Consider first the coefficient estimates of C&Wfirms and C&Wvalue. For the C&W entrants, the coefficient estimate of C&Wfirms is negative, but small and insignificant, while the coefficient estimate of C&Wvalue is positive, large, and significant at the .01 level. It appears that the number of C&W producers on its own had no impact on entry, but the competence of C&W producers critically determined entry for the C&W entrants. For the other entrants, the coefficient estimates of C&Wfirms and C&Wvalue are both positive and significant at the .01 level, although the latter is considerably smaller than the coefficient estimate of C&Wvalue for the C&W entrants. Thus, both the number and competence of the C&W producers affected the entry of the

[15] In some instances, the experienced-entrepreneur entrants had nearly the same name as their "parent" firm, reflecting considerable overlap in their stockholders and directors, and it was unclear the extent to which they differed from their parent firm (cf. Klepper [2002c]).

other entrants. These results are consistent with hypothesis A1. Alternatively, the addition of Bikevalue has little effect on the coefficient estimates of Bikefirms for the two groups of entrants. They remain positive and significant at the .01 level, while the coefficient estimate of Bikevalue is small and insignificant for both groups of entrants. The bicycle industry was declining sharply at the start of the automobile industry, and the failure of Bikevalue to affect entry may reflect that average firm size is not a good measure of competence in a declining industry.

In the next specification, the percentage of automobile producers in the state in the year prior to each firm's entry is added as an explanatory variable.[16] This variable, which is denoted as Autofirms, was allowed to have a separate effect for all the diversifying firms and experienced entrepreneurs, denoted as Diversifiers&Exp.Entrep, the inexperienced firms, denoted as Inexperienced, and the spinoffs, denoted as Spinoffs.[17] Based on hypothesis A1, Autofirms should not affect the entry of the diversifiers and experienced entrepreneurs and should have a greater effect on the spinoffs than the inexperienced firms. The estimates of Autofirms for all three groups of entrants are positive and significant at the .01 level, suggesting that Autofirms affected the entry of diversifiers and experienced entrepreneurs as well as the other two groups of entrants, in contrast to hypothesis A1. The ordering of the coefficient estimates of Autofirms for the three groups of entrants, though, is consistent with hypothesis A1. The coefficient estimate for the spinoffs is over twice as great as for the inexperienced firms, which in turn is greater than the coefficient estimate for the diversifiers and experienced entrepreneurs.

Part of the effect of Autofirms is likely to stem from unobserved state characteristics influencing entry, which would cause the location of current entrants to be related to the location of past entrants. Indeed, Autofirms can be thought of as a crude control for unobserved state effects. Note that its inclusion did not have much effect on the coefficient estimates of the C&W variables but it caused the coefficient estimates of

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[16] For the entrants in 1895, this variable was set equal to 2.86% for each of the 35 states. A few of the leading firms moved the state in which they were based during the years they produced automobiles. Moves of all firms were taken into account in the annual counts of the number of firms in each state.

[17] With controls introduced for spinoffs, the four C&W and Bike variables were constrained to affect entry for the "Other" entrants excluding the spinoffs.

Bikefirms to decline and become insignificant. This suggests that Bikefirms is a proxy for general state conditions affecting entry, as speculated earlier, but that C&W production directly influenced the location of automobile entrants. Unobserved state characteristics influencing entry can be controlled through state fixed effects. Fixed effects were entered for the eleven states listed in Table 2 that contained 90% of the entrants. This does not leave much independent variation in the C&W and bicycle variables to estimate their effects as the number of C&W and bicycle firms varies little across the other states or over time. In contrast, Autofirms does vary considerably over time, making it possible to separate the effect of incumbent firms on entry from unobserved state fixed effects.

The coefficient estimates of the non-state fixed effects are reported in the fifth column of Table 5. The (unreported) state fixed effects are all positive and significant at the .01 level. Not surprisingly, the coefficients of the C&W and bicycle variables are estimated with less precision. The coefficient estimates of C&Wvalue for the C&W entrants and the Bikevalue for the other entrants remain positive and significant (at the .05 level), but the other coefficient estimates of the C&W and bicycle variables are insignificant. The coefficient estimates for Autofirms for the three groups of entrants are considerably smaller, as might be expected if part of their estimated effects in the prior model was attributable to unobserved state characteristics. They also now conform completely with hypothesis A1. The coefficient estimate of Autofirms for the diversifiers and experienced entrepreneurs is insignificant while the coefficient estimates for the inexperienced entrants and the spinoffs remain positive and significant at the .01 level, with the coefficient estimate for the spinoffs over twice as big as the coefficient estimate for the inexperienced entrants.

The effect of Autofirms is probed further by including a variable denoted as AutoQ, which equals the percentage of the output of the leading automobile firms produced in each state.[18] This variable equals Autofirms multiplied by the average size of firms in each state relative to the average size of all firms. Thus, it serves as an

[18] AutoQ was constructed based on the data on the annual leading makes of automobiles (Bailey [1971]) that were used to construct Figure 5. The data begin in 1896, and for firms that entered in 1895, AutoQ was set equal to 2.86% for each of the 35 states.

interaction between Autofirms and the competence of the firms in each state, as reflected by their size. It is allowed to have a separate effect for each of the three groups of entrants. Hypothesis A1 predicts that AutoQ would have its greatest effect on the spinoffs and would not affect the diversifiers and experienced entrepreneurs at all. The estimates of this specification, which are reported in the last column of Table 5, conform with these predictions. The coefficient estimate of AutoQ is negligible and insignificant for the diversifiers and experienced entrepreneurs and for the inexperienced entrants, but is sizable and significant at the .01 level for the spinoffs, consistent with hypothesis A1. The inclusion of AutoQ causes the coefficient estimate of Autofirms for the spinoffs to drop sharply, indicating that the primary effect of Autofirms on the entry of spinoffs was concentrated in regions with more competent incumbent firms. By the mid 1910s Michigan was by far the state with the highest firm competence, accounting for about 25% of all the firms but over 80% of the output of the leading firms. The coefficient estimates thus suggest that spinoffs disproportionately entered in Michigan.

This is borne out by Table 2, which breaks down the entrants in each state into five categories: diversifiers and experienced entrepreneurs from the C&W industry, bicycle industry, and other industries, inexperienced entrants, and spinoffs. Michigan had more total entrants than any other state, but it accounted for only 19% of all the entrants. Michigan had a healthy number of entrants in most categories, but it stands out only in terms of the number of its spinoff entrants. It had 59 compared to the next highest state with 16 spinoffs. While spinoffs constituted only 20% of all the entrants, they constituted 44% of the entrants in Michigan. This was largely attributable to Olds Motor Works, Cadillac, Ford, and Buick, all of which were located in Michigan near Detroit. Olds entered in 1901 and soon was producing on an unprecedented scale. To cope with its large production it subcontracted a number of its parts, including engines. Two of its engine subcontractors, Leland and Faulconer and the Dodge Brothers, were instrumental in the success of Cadillac and Ford, and another one of its subcontractors initially financed Buick. Olds, Cadillac, Ford, and Buick were immensely successful and grew to be very large, and they were the four most prolific parents in the industry with 22 spinoffs. Their spinoffs were also very successful (Klepper [2002c]), in turn spawning 18 more spinoffs (Klepper [2002b]). All but nine of the 40 total spinoffs entered in the

Detroit area. Thus, consistent with hypothesis A1, incumbent firms profoundly affected regional spinoff entry.[19] This contrasts sharply with televisions.

Hypotheses A2 and A3 were tested using a parametric hazard model of the form:

$h_{irt} = \exp(\{\gamma_0 + \underline{\gamma}'\underline{z}\}age_{irt})\exp(\beta_0 + \underline{\beta}'\underline{x})$,

where $\underline{z}$ is a vector of variables that condition how age affects the hazard, $\underline{x}$ is a vector of variables that affect the hazard proportionally at all ages, γ_0 and β_0 are constant terms, and $\underline{\gamma}$ and $\underline{\beta}$ are coefficient vectors. Klepper [2002b, 2002c] found this form of the hazard fit well for automobiles with time of entry variables included in both $\underline{z}$ and $\underline{x}$ and firm background variables included in $\underline{x}$. This is consistent with the model if the maximum competence of the inexperienced entrants was less than the maximum competence of the other three groups of entrants and if within each group of entrants the later ones had greater average competence than the earlier ones due to the selection forces operating on entrants (Klepper [2002a, 2002b]).[20] To test hypothesis A2, an initial version of the model was estimated with only one explanatory variable, a 1-0 dummy denoted as Detroit that is equal to one for firms located in the Detroit area. This variable was included in the proportional term of the hazard (i.e., in the vector $\underline{x}$). The estimates of this model are reported in Table 6. Consistent with hypothesis T2, the coefficient estimate of the Detroit dummy is positive and significant at the .01 level. It implies that

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[19] The theory assumes better firms spawn more spinoffs because the spinoffs inherit their competence from their parents. Alternatively, better firms could spawn more spinoffs simply because they have a greater number of employees to start their own firms. If so, then the performance of spinoffs would not be related to the performance of their parents. This is tested in the analysis of the hazards of the automobile firms. It is worth noting here that the founders of the spinoffs were generally very high-level employees, most often either the head of the firm or its chief designer/engineer (Klepper [2002c]). It seems unlikely that the number of such individuals varied significantly across firms according to their size. Alternatively, better firms might have had more spinoffs because they had better top employees to start their own firms. It is hard to rule this out, but a number of successful spinoffs closely resembled their parents in terms of their initial cars and strategies, suggesting that the conjectured inheritance process was important. Two examples are discussed in Klepper [2002c].

[20] In the model firm price-cost margins decline over time, which raises the minimum competence required for profitable entry. Therefore, if the distribution of competence (i.e., R&D productivity) is the same for early and late entrants within each group of entrants (and is not degenerate), then the later ones will have higher average competence. This will counteract the effect of early entry on the hazard, and the earlier entrants will not necessarily have a lower hazard at young ages. The earliest entrants with the maximum competence eventually take over the entire industry, though, so at some point they must have a lower hazard than later entrants with comparable backgrounds. Therefore, the effect of early entry on the hazard may be greater at older ages, which is allowed for the in hazard by including the time of entry variables in $\underline{z}$ as well as $\underline{x}$.

entrants located in the Detroit area had a 32% lower annual hazard than entrants elsewhere.

The lower hazard of entrants in the Detroit area was predicted to be confined to spinoffs, which constituted a disproportionately large percentage of the entrants around Detroit. This was probed using Kaplan-Meier survival curves for four groups of entrants: 53 spinoffs in the Detroit area, 89 spinoffs elsewhere, 59 nonspinoff entrants in the Detroit area, and 513 nonspinoff entrants elsewhere. These curves, which reflect the natural log of the percentage of each group of entrants surviving to each age, are presented in Figure 7. The negative of the slopes of these curves reflect the hazard of the entrants at each age. The figure indicates that up to age 20, when only a few entrants were left in each group, the Detroit spinoffs had consistently lower hazards than the other three groups of entrants. With the exception of the two nonspinoffs in the Detroit area that survived beyond age 20, the Detroit spinoffs continued to have a lower hazard than the other entrants after age 20 as well.[21] Thus, there was virtually no difference in the hazards of Detroit firms and firms elsewhere except for the spinoffs, consistent with hypothesis A3.

It was predicted in hypothesis A3 that the differences in the hazards of the Detroit spinoffs and the spinoffs elsewhere would vanish if the differences in the competence of the spinoffs were controlled. This was tested in Klepper [2002b], which analyzed the principal factors influencing the hazards of the automobile entrants, including how the hazards of the spinoffs were related to various measures of the performance of their parents. Two variables representing the time of entry were included in both $\underline{z}$ and $\underline{x}$. These variables, denoted as Entry1895-1904 and Entry1905-1909, are dummy variables equal to 1 for firms that entered in 1895-1904 and 1905-1909 respectively, with the entrants in 1910-1966 treated as the reference group.[22] Dummy variables equal to 1 for diversifiers, experienced entrepreneurs, and spinoffs, denoted as Diversifiers,

[21] Neither of the two nonspinoffs in the Detroit area that survived until age 20 exited naturally (one exited by acquisition, which was treated as a censored exit). Consequently, the Detroit nonspinoff survival curve never dropped to the axis, whereas the other two groups also had long-term survivors but because they constituted less than 1% of the original entrants their curves drop to the axis.

[22] The time periods for the entry cohorts were chosen to balance the number of entrants in each cohort (Klepper [2002b]).

Experiencedentrepreneurs, and Spinoffs, were included in x. Additional dummies, denoted as Topdiversifiers and Topexperiencedentrepreneurs, were also added for diversifiers and experienced entrepreneurs from the C&W, bicycle, and engine industries, which were the three industries most related to automobiles.

The competence of the spinoffs was related crudely to their parents through three variables.[23] The main one, denoted as Yearsparentsurvived, is the number of years their parent survived.[24] The second, denoted as Parent#1, is a dummy equal to one if the spinoff's parent was the number one producer in the industry in the year of the spinoff's entry or the prior five years. The third, denoted Secondaryparent#1, is equal to one for spinoffs whose secondary parent (i.e., the firm the spinoff's founder worked for immediately before the parent of the spinoff if the founder had previously worked for at least two auto firms) was the number one producer in the industry in the year of the spinoff's entry or the prior five years. One other dummy variable, denoted as Spinstrategy, was included. It equals one for spinoffs whose strategy could be discerned from the historical record, which included spinoffs that were started due to a disagreement in the parent firm about strategy or innovation, the failure or imminent failure of the parent firm (or its automobile business), or the desire of the parent to market a new car through a separate organization to preserve its image.[25]

The estimates for three hazard models are presented in Table 6 to convey how the backgrounds and locations of firms conditioned their hazards. The first one adds to the initial specification all the variables except the four pertaining to the competence of the spinoffs. Thus, it controls for time of entry, whether a firm was a diversifier, experienced entrepreneur, or spinoff, and in the case of the diversifiers and experienced entrepreneurs, whether they came from the C&W, bicycle, or engine industries. The coefficient estimates all conform with expectations. The coefficient estimates of the time of entry variables are significant (at the .01 level) only in the interaction with age. They are both

[23] The latter two were chosen after experimentation with broader measures did not prove fruitful (Klepper [2002b]).

[24] For acquired firms that played an important role in their acquirer, this was set equal to the years their parent survived.

[25] The distinctive quality of these spinoffs is that they built on the expertise of their parents, which was expected to enhance their survival. Descriptions of the origins of the other spinoffs suggest they were less closely related to their parents, although in some instances the descriptions were too brief to be informative.

negative, indicating that earlier entry lowered the hazard at older ages. Firms that were diversifiers, experienced entrepreneurs, and spinoffs had 32%, 39%, and 45% respectively lower annual hazards than the inexperienced entrants,[26] and the annual hazards of the diversifiers and experienced entrants were respectively 36% and 24% lower still if they came from the C&W, bicycle, and engine industries. All of these effects are significant the .01 or .05 level with the exception of the last, which is significant at the .10 level (one-tailed). Furthermore, even after controlling for time of entry and firm background, the Detroit firms continued to have a significantly lower hazard.

The next specification adds a dummy variable, denoted as Detroitspinoff, equal to 1 for spinoffs located in the Detroit area. The coefficient estimate of this dummy is negative and significant at the .01 level, indicating that the spinoffs in the Detroit area had a 55% lower annual hazard than the spinoffs elsewhere. The coefficient estimate of the Detroit dummy is now trivial and insignificant, indicating that it was only the spinoffs in the Detroit area and not the other firms located there that had lower hazards. This conforms with the findings based on the survival curves in Figure 7 and with hypothesis A3..

The last specification drops the Detroit dummy and adds the four variables for the competence of the spinoffs. The coefficient estimates of these variables are all negative, as expected. They are jointly significant at the .01 level and are individually significant at the .05 level (one-tailed) or .10 level (one-tailed). Thus, spinoffs whose parents survived longer and had primary or secondary parents that were leaders of the industry survived longer. The estimates imply that if the parent survived 50 years or longer (a number of the Detroit parents survived longer than 50 years) then the spinoff had a 36% lower annual hazard, and the spinoff's annual hazard was further reduced by 59% and 50% respectively if its primary or secondary parent was the leader of the industry prior to its entry. Furthermore, spinoffs with a discernible strategy had a 31% lower annual hazard. Most important regarding hypothesis A3, the inclusion of the spinoff variables causes the coefficient estimate of the Detroit spinoff variable to drop absolutely from

[26] Furthermore, when the difference in the hazards of the inexperienced firms and the other three groups of

–0.7993 to –0.2480, with the estimate no longer significant. Thus, crude controls for the competence of the spinoffs and secondarily their strategies[27] largely account for the superior performance of the Detroit spinoffs and thus the Detroit firms generally, consistent with hypothesis A3.

VI. Discussion

The theory generated predictions that guided the exploration of where the entrants located and how their locations and backgrounds affected their performance. In both tvs and autos, diversifying and other entrants clustered in the regions with a greater number of producers in related industries, though not consistently in the regions with more competent producers in the related industries. In tvs, neither the diversifiers nor other entrants were attracted to regions with more and better incumbents. Consequently, the best performers did not congregate in any one region, and over time the industry became less concentrated geographically as two agglomerated regions with the less competent entrants declined. In autos, the diversifiers and experienced entrepreneurs also were also not attracted to the regions with more and better incumbents, but the spinoffs, which were an important force, clustered in the one region that by chance contained a number of the early leaders. By dint of their superior heritage, the spinoffs in this region performed distinctly well, causing the industry to become heavily agglomerated around the location of the early leaders.

These patterns generally conform with the theory. No doubt some of them, such as the clustering of the entrants in the regions with more producers in related industries, can also be explained by other theories. Two ways the industries evolved, though, seem particularly revealing. First, both the diversifiers and other entrants in tvs and the diversifiers and experienced entrepreneurs in autos (after controlling for unobserved characteristics of the leading states) were not attracted to the regions with more and better incumbent producers. Second, in both industries regional differences in the performance of firms were primarily attributable to regional differences in their pre-entry backgrounds

entrants was allowed to vary with age, the differences persisted with age (Klepper [2002c]).

[27] Even without the spinoff strategy variable, the coefficient estimate of the Detroit spinoff dummy is –0.3830, which is less than half its value without the controls for the competence of the spinoffs.

and not to characteristics of the regions, such as their concentration of producers. These findings suggest that locational advantages associated with agglomerations, such as thicker labor markets or the closeness of buyers and sellers, were not prominent in either industry. They also suggest that spillovers of ideas across closely located firms, which are featured in some theories of agglomeration, were also not prominent. Spillovers may have occurred in autos, but if so they occurred *within* and not across firms, with employees learning from their organizational experiences about how to establish their own firms.

In the absence of locational effects, the key factors shaping the performance of regions in the two industries were their stock of firms in related industries and in autos their stock of incumbent firms. The two industries differed fundamentally in the role played by incumbent firms as sources of subsequent entrants. As a consequence, their geographic structures evolved quite differently. It was conjectured that spinoffs were more prominent in autos than tvs because the challenges facing organizations were more novel in autos than tvs. Without detailed information about how firms in each industry were organized, though, it is difficult to go much beyond conjecture on this key matter.

The automobile and television industries were featured because sufficient information about them had been collected and the evolution of their geographic structure was provocative. Other studies suggest that the lessons from autos and tvs, particularly regarding spinoffs and agglomerations, apply more generally. Moore and Davis [2001] attributed the development of Silicon Valley primarily to spinoffs from semiconductor producers, with Fairchild Semiconductor playing a similar role to Olds Motor Works in automobiles. Sorenson and Audia [2000] found that agglomerations of footwear producers in the U.S. were perpetuated by a greater number of births in agglomerated regions, which they attributed to spinoffs. The tendency of better firms to breed more spinoffs and for spinoffs to perform distinctively, which was a key element of the agglomeration in autos, also characterized the spinoff process in the three industries where it has been analyzed extensively, lasers (Klepper and Sleeper [2000]), disk drives (Franco and Filson [2000]), and semiconductors (Brittain and Freeman [1986], Moore and Davis [2001]).

The theory is also able to address a number of prominent findings in the economic geography literature. Carlton [1983] and Rosenthal and Strange [2001] found that entry in an industry is greater in regions with more employment in the industry. This is readily explained by the spinoff process in the theory, as exemplified by autos. It can also be the result of diversifiers and new firms entering in the same regions, with the diversifiers entering first, which is illustrated by tvs. Dumais et al. [2002] found that lower hazard rates of establishments in agglomerated areas was the principal factor that contributed to agglomerations. This is consistent with the spinoff process in the theory, which predicts that agglomerations form and grow through the superior performance of spinoffs of superior firms, as illustrated by autos. Last, it has been found that across regions wages and residential prices are higher in more agglomerated areas. Greater concentrations of laborers in more agglomerated areas bid up housing prices, and then higher wages are required to attract the laborers to agglomerated areas. This equilibrium is consistent with the spinoff process in the theory, as the spinoffs in agglomerated areas are superior performers and thus can pay higher wages in equilibrium. The theory can also explain why agglomerations as extreme as automobiles are rare (Ellison and Glaeser [1997]). A number of circumstances are required that together are not likely, including the evolution of an oligopoly, spinoffs being competitive with diversifiers, and the concentration of early leaders in a narrow region.

While the theory can explain a wide range of findings, it leaves many questions unanswered. The theory assumes that firms have distinctive competencies that they inherit and that do not change over time, but it does not specify anything about the nature of the inheritance process or why firm competencies do not evolve over time. This makes it difficult to address why new firms were competitive in autos but not tvs. The theory features the role that spinoffs can play in the evolution of an industry's geographic structure, but it does not address why employees leave incumbent firms to start their own firms and how this affects their performance. The theory presumes that entrants locate close to their origins without spelling out why. For all of its shortcomings, though, the theory builds on certain phenomena that seem fundamental to geography. Firms tend to diversify into related industries (Scott [1993]), founders of new firms typically have prior experience in closely related industries (Cooper [1984]), and entrants do not stray far geographically from their origins (Cooper [1984]). Consequently, the fate of a region in a new industry must be closely related to its stock of firms in related industries, including earlier entrants in the new industry itself.[28] The theory simply elaborates how this process operates using the idea of organizational competence as its centerpiece.

While some scholars, such as Nelson and Winter [1982], have explored the functioning of organizational competence, this has not been a prominent area of research in economics. There is thus a long way to go toward developing a full-fledged theory linking geography with organizational knowledge. Much more needs to be known about how organizational competence affects firm performance and about the origins of organizational competence.[29] It was conjectured that organizations adapt their competence from one domain to another and others give birth to new ones, via their employees, that inherit their competence. Notions about birth and heredity are the staple of evolutionary theorizing but seldom have been applied in economics (Klepper and Sleeper [2000]). The evolution of the geographic structure of the television and automobile industries suggests that these ideas may have an important role to play in the understanding of regional economic growth and development.

[28] This is not to deny to the existence of other kinds of incubators, such as universities, in certain types of industries like biotechnology.

[29] See Helfat and Lieberman [2002] for a recent review of the literature on the origins of firm competence.

Table 1: Location of Television and Radio Producers

	177 Tv Entrants	58 Tv Entrants from Radio Industry	119 Tv Other Entrants	266 Radio Firms	Output of Top 16 Radio Firms
New York	44%	26%	53%	33%	11%
Chicago	15	24	10	15	38
Los Angeles	14	5	18	7	0
Elsewhere	27	45	18	45	51

Table 2: Automobile Entry by State for the Leading 11 States, Ordered by Population

State	Value Carriage Production 1900 (000)	Value Bicycle Production 1900 (000)	Total Entry	C&W Entry	Bicycle Entry	Other Industries Entry	Inexper-ienced Entry	Spinoff Entry
NY	12261	3842	98	8	8	19	48	15
PA	7958	1855	52	2	1	10	28	11
IL	8275	8960	70	6	0	19	39	6
OH	15616	4099	89	10	7	18	38	16
MO	5477	0	27	4	0	4	17	2
MA	5031	2715	55	0	2	13	36	4
IN	12661	2115	69	14	2	7	30	16
MI	11119	627	135	10	1	19	46	59
WI	6839	2795	20	4	1	6	7	2
NJ	2972	295	22	0	0	3	14	5
CT	2302	3672	17	0	2	4	8	3

Table 3: Coefficient Estimates Of Television Entry Model

(Standard Errors in Parentheses)

Variable	Specification 1	Specification 2	Specification 3	Specification 4
Radiofirms	.0228*** (.0052)			
Radiofirms-Other.		.0165*** (.0063)	.0484*** (.0088)	.0361** (.0149)
Radiofirms-Diversifiers		.0367*** (.0097)	.0246** (.0121)	.0203 (.0175)
RadioQ-Other			-.0361*** (.0062)	-.0314*** (.0075)
RadioQ-Diversifiers			.0132 (.0087)	.0144 (.0094)
Tvfirms-Other				.0101 (.0100)
Tvfirms-Diversifiers.				.0042 (.0128)
Pseudo R2	.0402	.0406	.1287	.1310
Log L	-235.52	-233.93	-213.79	-213.22

*** p ≤ .01, ** p ≤ .05, * p ≤ .10

Table 4: Coefficient Estimates Of Television Hazard Model

(Standard Errors in Parentheses)

Variable	Specification 1	Specification 2
New York	0.621*** (0.201)	0.320 (0.220)
Chicago	-0.294 (0.281)	-0.212 (0.287)
Los Angeles	0.532** (0.266)	-0.077 (0.270)
Radioproducer		-0.897*** (0.232)
Top16radioproducer		-1.554*** (0.506)
Entryby1948		-0.444** (0.197)
Log L	-672.43	-640.72

*** $p \leq .01$, ** $p \leq .05$, * $p \leq .10$

Table 5: Coefficient Estimates Of Automobile Entry Model

(Standard Errors in Parentheses)

Variable	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Spec. 5	Spec. 6
C&Wfirms	.1315*** (.0129)					
Bikefirms	.0660*** (.0069)					
C&Wfirms-C&Wentrants		.1206*** (.0298)	-.0105 (.0432)	.0284 (.0455)	-.0226 (.0630)	-.0378 (.0637)
C&Wvalue-C&Wentrants			.2219*** (.0268)	.1511*** (.0286)	.0768** (.0350)	.0620* (.0363)
Bikefirms-Bikeentrants		.1049*** (.0233)	.1096*** (.0376)	.0193 (.0412)	.0543 (.0535)	.0483 (.0543)
Bikevalue-Bikeentrants			-.0277 (.0404)	.0283 (.0409)	.0136 (.0480)	-.0063 (.0482)
C&Wfirms-Other		.1327*** (.0151)	.0704*** (.0176)	.0914*** (.0206)	.0580 (.0473)	.0381 (.0482)
C&Wvalue-Other			.1285*** (.0101)	.0570*** (.0127)	-.0323 (.0228)	-.0444* (.0025)
Bikefirms-Other		.0644*** (.0070)	.0513*** (.0138)	-.0235 (.0172)	-.0297 (.0395)	-.0384 (.0395)
Bikevalue-Other			-.0106 (.0104)	.0408*** (.0120)	.0622** (.0305)	.0446 (.0299)
Autofirms-Diversifiers&Exp.Entrep				.0748*** (.0106)	.0174 (.0112)	.0178 (.0129)
Autofirms-Inexperienced				.0918*** (.0088)	.0321*** (.0093)	0349*** (.0108)
Autofirms-Spinoffs				.1842*** (.0109)	.0711*** (.0014)	.0208 (.0223)
AutoQ-Diversifiers&Exp.Entrep						.0014 (.0047)
AutoQ-Inexperienced						-.0021 (.0042)
AutoQ-Spinoffs						.0165*** (.0058)
Pseudo R2	.1377	.1384	.1794	.2297	.2754	.2773
Log L	-2189.0	-2187.3	-2083.1	-1955.4	-1839.3	-1834.5

*** $p \leq .01$, ** $p \leq .05$, * $p \leq .10$

Table 6: Coefficient Estimates of the Hazard Model

(Standard Errors in Parentheses)

Variable	Model 1	Model 2	Model 3	Model 4
Constant	-1.6891*** (0.0506)	-1.4796*** (0.1048)	-1.5048*** (0.1050)	-1.5213*** (0.1039)
Age	-0.0289*** (0.0052)	0.0615*** (0.0144)	0.0599*** (0.0142)	0.0591*** (0.0140)
Detroit	-0.3804*** (0.1197)	-0.3054** (0.1306)	0.0033 (0.1531)	
Diversifiers		-0.3889*** (0.1480)	-0.3858*** (0.1480)	-0.3913*** (0.1480)
Experiencedentrepreneurs		-0.4879*** (0.1550)	-0.5262*** (0.1560)	-0.5426*** (0.1555)
Spinoffs		-0.5897*** (0.1226)	-0.4159*** (0.1295)	-0.1506 (0.1595)
Entry1895-1904		-0.1862* (0.1361)	-0.1850* (0.1355)	-0.1601 (0.1354)
Entry1905-1909		-0.0010 (0.1295)	-0.0169 (0.1296)	-0.0342 (0.1309)
Entry1895-1904*Age		-0.0888*** (0.0162)	-0.0860*** (0.0161)	-0.0843*** (0.0159)
Entry1905-1909*Age		-0.0496*** (0.0175)	-0.0414** (0.0177)	-0.0311** (0.0180)
Topdiversifiers		-0.4482** (0.1942)	-0.4548** (0.1941)	-0.4650** (0.1942)
Topexperiencedentrepreneurs.		-0.2707 (0.2047)	-0.2587 (0.2046)	-0.2498 (0.2046)
Detroitspinoffs			-0.7993*** (0.2632)	-0.2480 (0.2386)
Yearsparentproduced				-0.0090* (0.0049)
Parent #1				-0.8913 (0.5515)
Secondaryparent#1				-0.6938 (0.5371)
Spinstrategy				-0.3724* (0.2229)
Log L	-1908.38	-1849.58	-1844.91	-1835.96

*** $p \leq .01$, ** $p \leq .05$, * $p \leq .10$

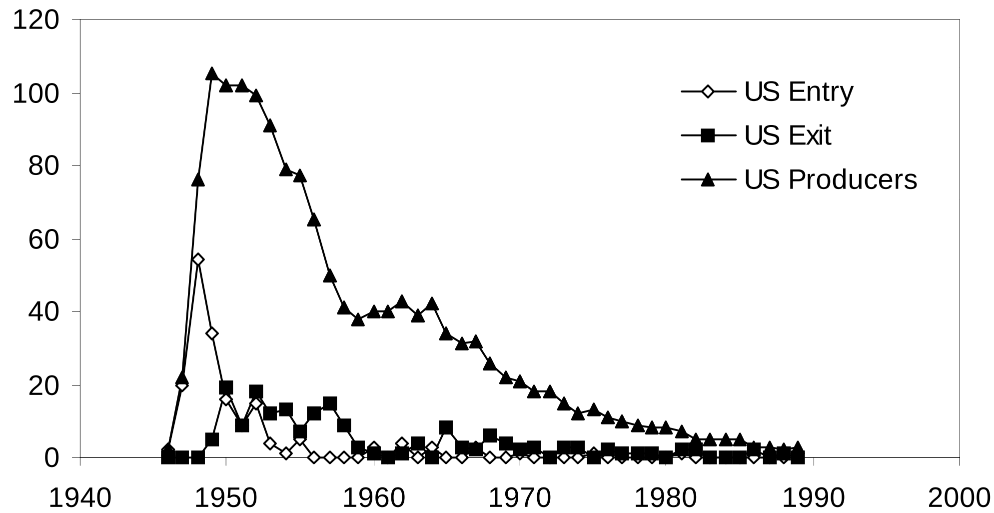

Figure 1: Entry, Exit, Number of Producers in Televisions, 1946-1989

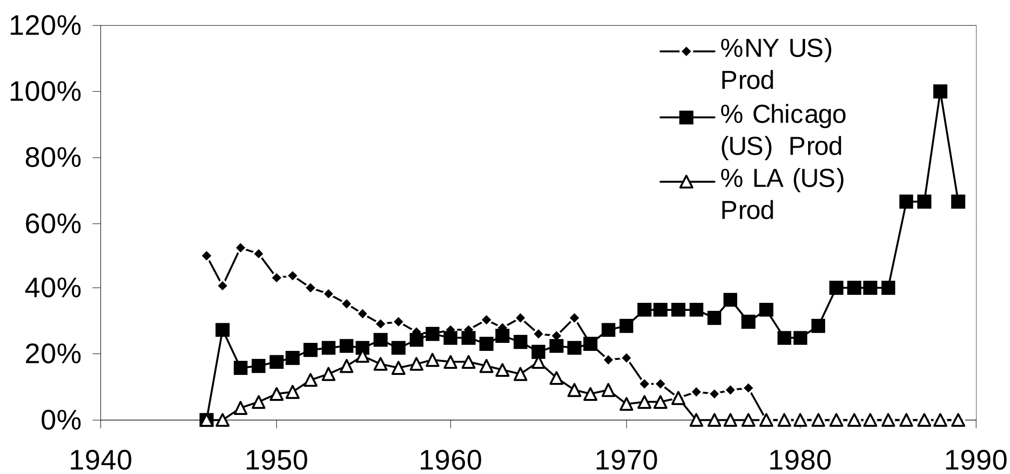

Figure 2: Percentage of Television Producers in New York, Chicago, and Los Angeles, 1946-1989

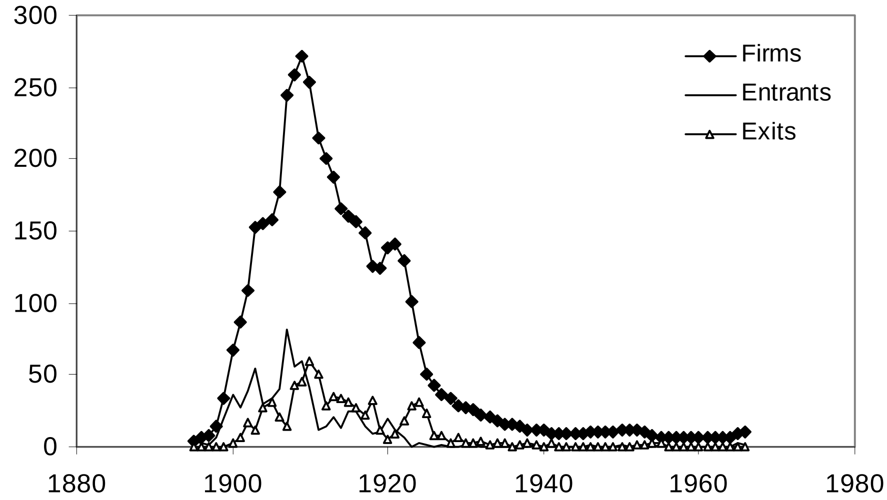

Figure 3: Entry, Exit, and Number of Producers in Automobiles, 1895-1966

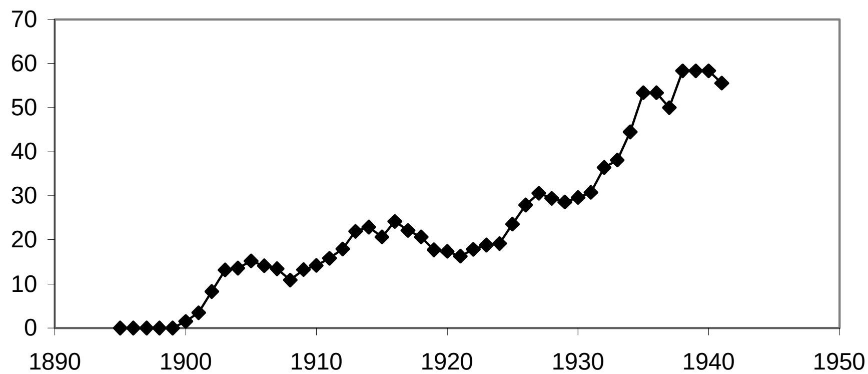

Figure 4: Percentage of Automobile Firms in the Detroit Area, 1895-1941

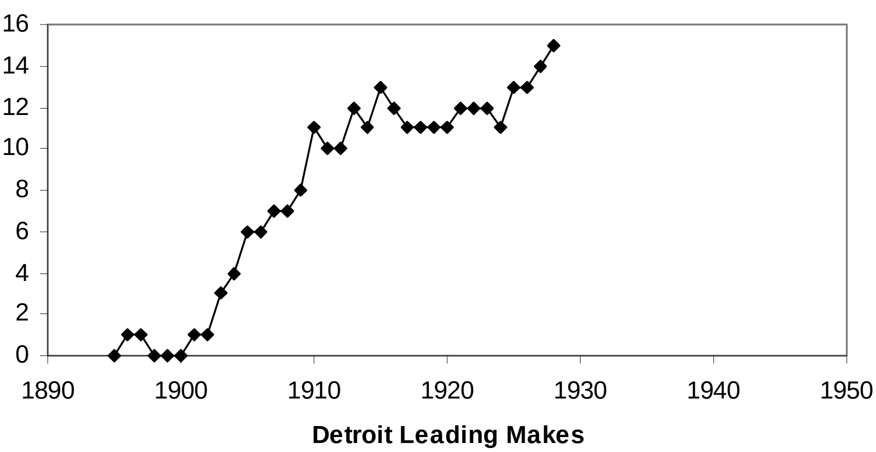

Figure 5: Number of Leading Automobile Makes Made by Detroit-Area Firms, 1901-1928

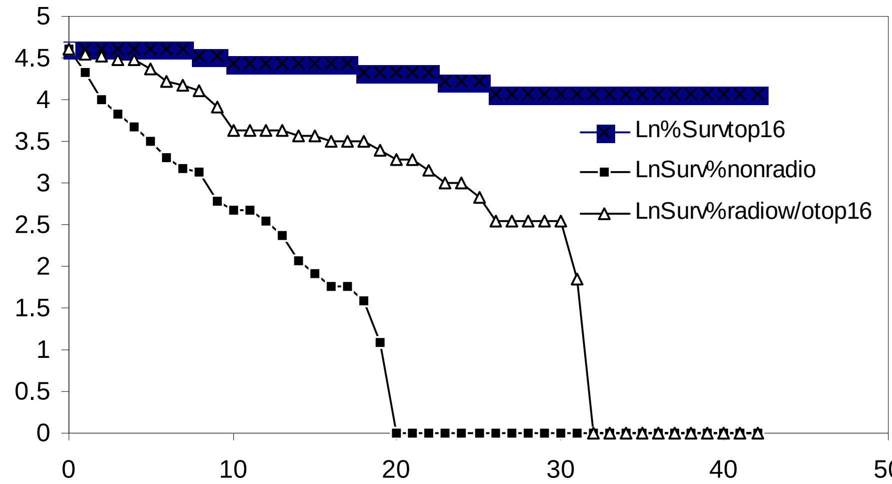

Figure 6: Log Survival Curves for Television Entrants

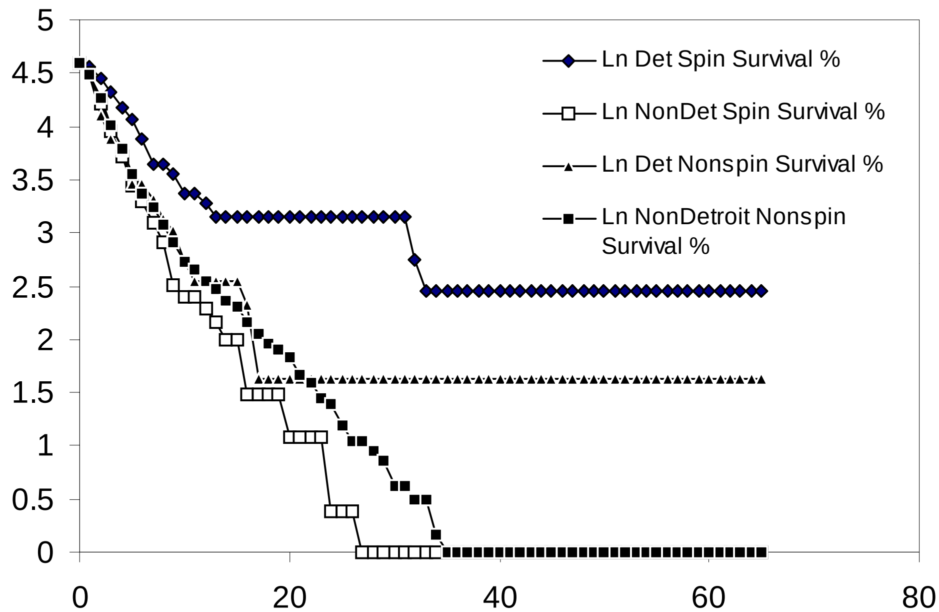

Figure 7: Log Survival Curves for Automobile Entrants

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