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Disagreements, Spinoffs, and the Evolution of Detroit as the Capital of the U.S. Automobile Industry

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The agglomeration of the automobile industry around Detroit, Michigan is explained using a theory in which disagreements lead employees of incumbent firms to found spinoffs in the same industry. Predictions of the theory concerning entry and firm survival are tested using data on the origin, location, and years of production of every entrant into the industry from 1895 to 1966. The geographic concentration of the industry is attributed to four early successful entrants and the many successful spinoffs they spawned in the Detroit area and not to conventional agglomeration economies benefiting co-located firms, as featured in modern theories of agglomeration. Implications of the findings regarding firm strategy are discussed.

Key words: economics; econometrics; organizational studies; econometric dynamics
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1. Introduction

Between 1900 and 1930, Detroit experienced nearly unparalleled growth for a large city, growing six-fold from a population of 305,000 to 1,837,000. There was no secret formula behind this growth. It was fueled by the concentration around Detroit of the automobile industry, which by 1929 was the largest industry in the United States (Davis 1988, p. ix). Initially firms entered the automobile industry throughout the eastern seaboard and the Midwest, but by 1909, Detroit was the center of the industry. It consolidated its position in the next 10 years as Detroit-area firms dominated the production of the leading makes of automobiles. After 1909, the industry went through a prolonged and severe shakeout of producers, evolving to be an oligopoly dominated by three famous Detroit-based firms, General Motors, Ford, and Chrysler.

Although industries are typically agglomerated geographically, it is rare to be as concentrated around one region as automobiles (Ellison and Glaeser 1997). Unraveling the causes of the extreme shakeout and concentration of the auto industry around Detroit thus promises to shed light on one of the driving questions of the burgeoning literature on economic geography, namely what forces contribute to the agglomeration of industrial activity. Numerous explanations have been advanced for the concentration of the automobile industry around Detroit. Some emphasize Detroit's low-cost access by water to raw materials and major markets for autos and Detroit's many small machine shops and skilled laborers available to supply the industry (Rae 1980). Coupled with increasing returns to scale, a reasonable assumption given the oligopolistic structure that emerged in the industry, one has the main ingredients of the Krugman et al. (Krugman 1991, Fujita et al. 1999) theory of agglomeration. Other explanations emphasize factors making Detroit's initial entrants especially capable competitors. Coupled with positive externalities associated with knowledge spillovers and more developed input markets (Rae 1980, Tsai 1997), one has the main ingredients of agglomeration theories featuring externalities and path-dependent processes (Arthur 1988). Indeed, the auto industry has been a kind of litmus test of competing theories of agglomeration, but no consensus has emerged for the concentration of the industry around Detroit, reflecting deficiencies in all the proffered explanations (Tsai 1997).

The purpose of this paper is to develop and test a new explanation for the agglomeration of the automobile industry around Detroit. It features the phenomenon of employees of incumbent firms leaving to start their own automobile firms, denoted as spinoffs. A theory of spinoffs based on disagreements developed by Klepper and Thompson (2006a, b) is used to explain spinoffs. Disagreements arise because incumbent management has a limited ability to recognize employees with superior ideas and/or abilities. When the disagreements are severe enough, employees leave to found spinoffs. The performance of firms is determined by the quality of their employees, hence better firms are more likely to experience disagreements that lead to spinoffs and to spawn better

performing spinoffs. Coupled with the chance location of four of the most successful early entrants in the Detroit area and the tendency of firms to locate close to their geographic roots, it is shown how the spinoffs process alone can account for the tremendous agglomeration of the automobile industry that occurred in the Detroit area.

The implications of the theory regarding the rate at which firms spawn spinoffs and the performance of their spinoffs are tested using data on the origin, location, and performance of every entrant into the industry from its commercial inception in 1895 through 1966. The findings suggest that the agglomeration of the automobile industry around Detroit was primarily the byproduct of the process underlying spinoffs and not conventional agglomeration economies benefiting all firms located in agglomerated regions. To the extent these patterns explain agglomerations more broadly, they suggest that strategically locating in an agglomerated area will not be beneficial and might even be harmful. Other implications of the theory regarding the effects of spinoffs on their "parents" are also discussed.

The paper is organized as follows. In §2, the history of the industry is reviewed. In §3, the forces leading to the concentration of the industry around Detroit are described, and various implications of the theory are laid out. In §4, the data and variables used to test the theory are presented. In §5, predictions of the theory regarding the rate and location of spinoffs are tested, whereas in §6, the predictions of the theory regarding the performance of firms are tested. In §7, implications of the findings are discussed.

2. History of the Industry

Smith (1968) compiled a list of every make of automobile produced commercially in the United States from the start of the industry in 1895 through 1966. He lists the firms that manufactured each make, their location, the years they manufactured the make, and any reorganizations and ownership changes they underwent. Smith's list of makes was used to derive the annual number of entries, exits, and manufacturers of automobiles, which are graphed in Figure 1 for the period 1895–1966.[1]

The number of entrants grew steadily from 1895 to 1907, peaking at 82 in 1907. Entry remained high for the next 3 years and then dropped sharply. It averaged 15 firms per year from 1911 to 1922 and became negligible after 1922, with only 15 firms entering from 1923 through 1966. After the first few years, the industry exit rate exceeded 10% for many years, and by 1910, the number of exits overtook the number of entries. Except for the 2-year period 1919–1921, the number of firms fell steadily from 1909 to 1941, dropping from a peak of 272 in 1909 to 9 in 1941.

Figure 1 Entry, Exit, and Number of Firms

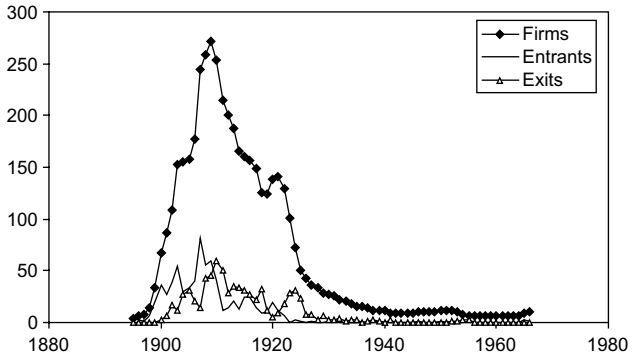
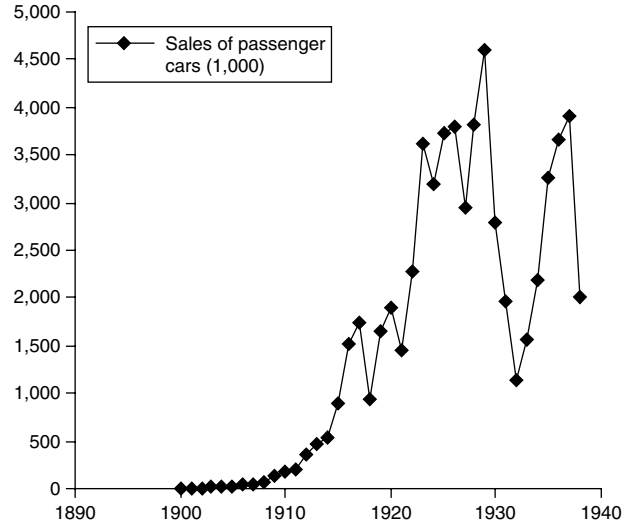


Figure 2 presents the annual number of passenger cars sold from 1900 to 1938 (Federal Trade Commission 1939, pp. 22–23). Entry largely preceded the growth of the industry. Although there were 155 automobile producers in 1904, they collectively produced only 22,419 cars. Subsequently the total number of cars sold increased by an average of 35% per year from 1904 to 1909, but still only 127,731 cars were sold in 1909, when the number of firms peaked at 272. After 1909, the number of firms declined steadily but sales grew to over 2 million cars by 1922, indicating that the shakeout of automobile producers was not driven by developments on the demand side.

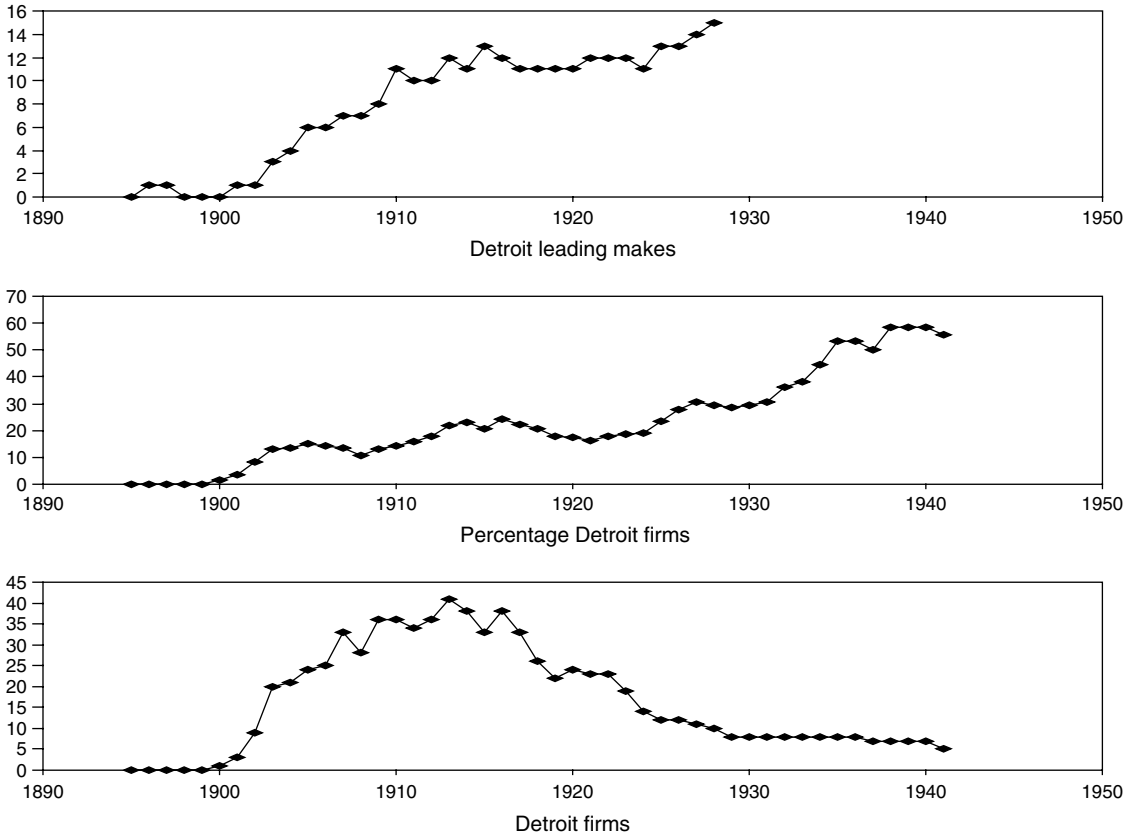
Not surprisingly given the drastic decline in the number of firms, the industry evolved to be a tight oligopoly dominated by three firms, General Motors,

Figure 2 Annual Sales of Passenger Cars, 1900–1938



[1] Entry and exit dates are based on the first and last year of commercial production of all makes of a producer. Mergers and acquisitions were treated as continuations of the firm whose name was retained, or in the case of mergers the largest firm involved, with the other firms treated as censored exits in the econometric analysis.

Figure 3 Location of Firms Around Detroit



Ford, and Chrysler,[2] all of which were based in Detroit, Michigan. The industry was not, however, originally concentrated around Detroit. The annual number of firms and the percentage of all firms located in the Detroit area[3] from 1895 to 1941, when the number of firms reached a trough of 9, is presented in the bottom two panels of Figure 3. In the first 6 years of the industry, 1895–1900, there were 69 entrants. Packard Motor Car Co. (nee Ohio Auto Co.) entered in 1900 and moved to Detroit in 1903, but otherwise, no manufacturer was located in Detroit until Olds Motor Works in 1901. Subsequently, the number of firms in the Detroit area rose, reaching a peak of 41 in 1913, 4 years after the peak in the number of firms in the industry. The number of Detroit-area firms subsequently declined along with the decline in the total number of automobile producers. After the entry of Olds Motor Works in 1901, the percentage of firms in the Detroit area rose to 15% by 1905, then fell back in the next 4 years after which it increased to 24% by 1916. It fell again in the next 8 years or so, after which it climbed to over 50% by 1935.

The concentration of activity around Detroit was actually considerably greater than the percentage of firms based in the Detroit area. The editors of the magazine *Automobile Quarterly* compiled an annual list of the leading makes of American automobiles beginning in 1896 based upon production figures by make (Bailey 1971). Through 1900, at most six total makes are listed, with 14 or 15 makes listed from 1905 to 1924 and 18 makes listed by 1928, after which nearly all the makes were manufactured by firms based in the Detroit area. The annual number of makes manufactured by Detroit-area firms for 1896 to 1928 is plotted in the top panel of Figure 3. The one make listed for the Detroit area in 1896 and 1897 reflects one experimental car made by Ford and Olds, respectively, in these 2 years. The first listing of a Detroit-area firm that produced more than one car was Olds Motor Works in 1901, when it was credited with the

[2] General Motors was formed in 1908 as a merger of a number of firms, with its most prominent components, Buick, Cadillac, and Olds Motor Works, dating back, respectively, to 1903, 1902, and 1901. Ford Motor Company entered in 1903. Chrysler Corporation emerged in 1924 through the efforts of Walter Chrysler, ex-president of Buick, to reorganize two of the leading firms in the industry that had merged after falling on hard times, Maxwell Motor Corporation, which dated back to 1904, and Chalmers Motor Co., which dated back to 1906.

[3] In addition to Detroit, the Detroit area was defined to include the following locations in Michigan, all of which are within approximately 100 miles of Detroit: Adrian, Chelsea, Flint, Jackson, Marysville, Oxford, Plymouth, Pontiac, Port Huron, Sibley, Wayne, and Ypsilanti. The boundaries of this region were chosen to reflect multiple locations of some of the firms within the region.

manufacture of 425 cars. Olds was the only firm in the Detroit area listed as one of the (nine) industry leaders in 1901. Subsequently, the number of makes manufactured by Detroit-area firms increased through 1915, when it reached 13 (out of 15 makes listed), and then reached 15 (out of 18) by the end of the period in 1928. With the leading makes accounting for well over 80% of the total industry output after 1910, firms in the Detroit area dominated the industry by the mid-1910s. Fourteen separate firms in the Detroit area populated the ranks of the industry leaders in the decade 1911–1920, and Detroit-area firms continued to dominate the industry for the next 45 years.

3. Theory

A model of the evolution of new industries was used in Klepper (2002) to explain the evolution of market structure in automobiles and three other industries that experienced extreme shakeouts and evolved to be oligopolies, tires, televisions, and penicillin. The model features increasing returns to scale, which are associated with technological change. It also features heterogeneity among entrants in their technological capabilities. It predicts that earlier entrants and those with better pre-entry experience survive longer and ultimately dominate the industry, which accorded with the firm survival patterns in the four industries.

The model has little structure regarding entrants. It simply assumes that in every period a new set of potential entrants arises, where the entrants are heterogeneous in terms of their technological capabilities. To explain the agglomeration of the industry around Detroit, one aspect of entry, by spinoffs, is specified in more detail. A theory of spinoffs developed by Klepper and Thompson (2006a, b) is exploited. The theory depicts spinoffs as the result of strategic disagreements within firms.

In the theory, decision makers receive information in each period about how their firm should proceed. The firm initially hires decision makers with the same strategic views and so they all have a common prior belief about the decisions the firm should make. But over time they receive different information based on differences in their positions in the firm, expertise, and backgrounds. Their information is unbiased, so that on average it reflects the best course of action for the firm. But the information is also noisy. Each decision maker communicates his information to the other decision makers in the firm. If the variance of the noise in the information of each decision maker is the same and is recognized as such, then each decision maker gives equal weight to the information of all members of the firm, including himself, when deciding on the best course of action for the firm. Then all decision makers want to pursue the same course of action and no disagreements occur. But suppose one decision maker has superior information, in the sense that the variance of the noise of his information is less than everyone else's, but only he recognizes this. Only he will appropriately weight his information more than everyone else's in deciding on the best course of action for the firm, and a disagreement will occur. If the disagreement is large enough to overcome the cost of starting a new firm, he will leave to start his own firm. The spinoff exploits the views of others in the parent firm and so overlaps with the parent, but also pursues novel ideas and thus differentiates itself from its parent. The departure of a talented employee also weakens the parent firm.

Klepper and Thompson (2006a) show that the better the (unrecognized) information of the decision maker, then the more likely a disagreement will arise that leads to a spinoff, the greater the expected performance of the spinoff, and the greater the expected past performance of the parent firm, which in part reflects the views of the better informed decision maker. Therefore, the better the firm then the greater its expected rate of spinoffs and the better the expected performance of its spinoffs. Firms are assumed to be formed of like minded individuals with the same initial view about the best course of action for the firm; hence, initially there is no chance of a disagreement leading to a spinoff. As employees subsequently receive different signals, the chance of a disagreement leading to a spinoff rises. As signals accumulate over time, asymptotically all employees learn the best course of action for the firm. So after a certain point the chance of a disagreement leading to a spinoff must decline (Klepper and Thompson 2006a). Therefore, spinoffs are more likely when a firm is middle aged—the probability of a spinoff initially rises and then falls with the age of the firm. More informed decision makers with the least influence in the decision-making process are most likely to form spinoffs because their views will differ most from the firms due to their lower influence on the firm's choices. Therefore, any development that lowers the decision making influence of a more informed decision maker will increase the chance of a spinoff. One such development is an acquisition, which typically shifts decision making influence toward new owners. Consequently, Klepper and Thompson (2006a) conjecture that the probability of a spinoff will be higher around the time a firm is acquired.

The theory takes on special significance when coupled with the tendency of firms to locate close to their geographic roots, which has been widely observed and whose motivation will be discussed later. For spinoffs, it implies they will locate close to their parents. With better firms expected to have more and

Table 1 Hypotheses

1. Better-performing firms had a higher spinoff rate.
2. Better-performing firms spawned better-performing spinoffs.
3. Spinoffs performed better than the average firm.
4. Spinoffs located close to where their parents were located.
5. Olds, Cadillac, Ford, and Buick/GM were among the leading firms in terms of number of spinoffs, and their spinoffs performed distinctly well.
6. Spinoffs accounted for a greater percentage of entrants in the Detroit area than elsewhere.
7. Spinoffs in the Detroit area performed better than spinoffs elsewhere whereas other firms performed comparably in the Detroit area and elsewhere.
8. Once the parental heritage of spinoffs is accounted for, spinoffs and firms generally performed comparably in the Detroit area and elsewhere.

better spinoffs, a buildup of superior firms around successful early entrants will occur. Spinoffs do not merely divert output from their parents, but pursue novel ideas. Consequently, regions with superior firms will expand their total output, contributing to an agglomeration of economic activity without any resort to conventional agglomeration economies that benefit all co-located firms. In automobiles four of the most successful early entrants, Olds Motor Works, Cadillac, Ford, and Buick, were located close to each other in and around Detroit, in large part due to the influence of Olds Motor Works.[4] Consequently, based on Klepper and Thompson's theory it would be expected that these four firms would disproportionately spawn more and better quality spinoffs, which in turn would spawn more and better quality spinoffs, and so forth. This would lead to a buildup of leading firms in the Detroit area and more generally cause the industry to be agglomerated there.

This explanation for the agglomeration of the industry around Detroit has a number of testable implications. They are listed in Table 1. The first three hypotheses are predictions of Klepper and Thompson's model of spinoffs. The fourth hypothesis is implied by the general tendency of all firms to locate close to their geographic roots. The rest follow from Hypotheses 1–4 coupled with the early location of Olds, Cadillac, Ford, and Buick in the Detroit area. These four firms should have been among the leaders in terms of number and quality of spinoffs. If they unleashed a spinoff juggernaut, then spinoffs should have accounted for a greater percentage of the entrants in the Detroit area than elsewhere. Furthermore, spinoffs in the Detroit area should have performed well because of their heritage, and in the absence of any agglomeration economies, the other types of entrants should have performed comparably in the Detroit area and elsewhere. Last, once the heritage of spinoffs is controlled, spinoffs and more generally all firms should have performed comparably in the Detroit area and elsewhere.

Some of these claims contrast with the implications of conventional theories featuring agglomeration economies, as noted above, and thus will serve as especially useful tests of the theory. Other implications of Klepper and Thompson's model of spinoffs that are not addressed by conventional agglomeration theories or other theories of spinoffs will also provide a useful test of the theory.

4. Backgrounds of the Firms

To test the various claims, the spinoffs and their parents must be identified. It is also useful to distinguish other types of firms, such as ones that diversified from other industries, to use as benchmarks to evaluate the performance of the spinoffs. Two sources are used to identify the backgrounds of firms: Smith (1968) and the *Standard Catalog of American Cars* (Gunnell 1992, Kimes 1996). Smith identifies firms that produced other products before automobiles, but has no information about the backgrounds of startups. In contrast, the *Standard Catalog* is a unique resource that contains a brief history for every firm listed in Smith (1968). Reconstructing founding conditions is daunting, but for most of the firms, the *Standard Catalog* is quite informative about their founding. For a small number, though, the *Standard Catalog* lists only the initial officers and not the founders, or it lists the founders but indicates little about their backgrounds. Occasionally other sources were consulted, but it was rare for these to be informative. Consequently, for a small number of firms little information was available to classify them, and they were put into the residual category, as noted below.

The first step in classifying firms according to their background was to identify firms that diversified into automobiles from other industries. This was complicated by the presence of many entrants with very similar but not exactly the same names as preexisting firms in other industries. A few of these firms may

[4] Olds entered in 1901 and soon became the first firm in the industry to sell over 1,000 cars in a year. By 1904 it was selling over 5,000 cars. Olds had been a successful producer of steam and gasoline engines, but like most of its counterparts, it subcontracted the production of nearly all of its parts. Its orders were on an unprecedented scale, which provided invaluable experience to its subcontractors. It subcontracted the two most important components of its car, the engine and transmission to two Detroit machine shops, Leland and Faulconer and the Dodge Brothers. Leland and Faulconer was instrumental in the success of Cadillac, which was started in 1902. Ford was founded in 1903 and its success was largely attributable to the Dodge Brothers, who as Ford's main production arm enabled Henry Ford to overcome production problems that plagued his two earlier startups. Buick, which also entered in 1903 and rose into the ranks of the leading firms after it came under the control of William Durant, was originally financed by the Briscoe brothers, who were sheet metal manufacturers that supplied Olds with radiators, gas tanks, and fenders.

have changed their names when they diversified into autos, but more often they seemed to have been new firms. Typically they were founded by the head of the preexisting firm with the similar name, with many of the same stockholders as the preexisting firm. A number of new firms were also founded by individuals who previously headed bicycle firms. The bicycle industry was consolidating around the start of the automobile industry, and many firms either sold out to combines or exited bicycles and then started automobile firms. Thus, there were many entrants into the automobile industry that had a clear heritage but were new firms. To distinguish these firms from ones that diversified into automobiles, a separate category, called experienced entrepreneurs, was established. Experienced entrepreneurs were new firms headed by someone who previously headed an active or recently sold off firm in another industry. Diversifiers, which were called experienced firms, were preexisting firms that entered the automobile industry by adding automobiles to their product line.

All firms that were listed in Smith as producing another product prior to automobiles were classified as experienced firms. Twenty-five additional firms on Smith's list were identified from the *Standard Catalog* as entering from another business, most often carriages and wagons. These firms were also classified as experienced firms, yielding a total of 120 experienced firms. Firms were classified as experienced entrepreneurs if in the *Standard Catalog* at least one of their founders was identified as the head of a named firm that was active or had recently been sold. This yielded a total of 108 experienced entrepreneurs. The *Standard Catalog* was used to identify the main prior product produced by each experienced firm and experienced entrepreneur.

Firms were classified as spinoffs if at least one of their founders had worked for or founded, or both, an automobile firm in Smith's list. It was generally straight forward to identify the founders from the descriptions in the *Standard Catalog*, but when it was unclear whether a featured experienced automobile man was actually a founder, the firm was inclusively classified as a spinoff. In total, 145 spinoffs were identified.

The parent of each spinoff was identified based on the prior firm where the principal automobile founder of the spinoff worked. If there were multiple automobile founders that had worked at different firms, then one was identified as the most influential founder based on the description in the *Standard Catalog*, and his prior employer was designated as the parent. Most founders of spinoffs seemed to have worked for only one prior automobile company, but when a prior employer to the parent could be identified, that firm was designated as the secondary parent of the spinoff. In a few cases individuals were involved in rapid succession in two spinoffs after long-term employment in one firm. In these cases, the long-term employer was designated as the parent of both spinoffs.[5]

The rest of the 352 firms that were not classified as experienced firms, experienced entrepreneurs, or spinoffs were lumped into a residual category of inexperienced firms, reflecting their limited prior knowledge regarding automobiles. Most of these firms were founded by wealthy capitalists with little knowledge of automobiles or by lower-level employees of firms in related industries.

Classifying firms into categories requires rules. Every effort was made to avoid systematic biases in the classifications, but inevitably rules create artifactual cases. With 725 entrants and 145 spinoffs, though, it seems doubtful that this would systematically bias the findings.

5. Spinoffs

An econometric model of the rate at which automobile firms spawned spinoffs is specified to test various predictions about the spinoff process. Nearly all the spinoffs entered between 1899 and 1924, and so the analysis is restricted to this period. Each firm's history is broken into annual intervals from the year before its date of entry[6] (or 1899 if it entered earlier) through 1924. The observations of all firms are pooled and an ordered logit is estimated of the factors influencing the probability of a firm having one, two, or three spinoffs in each year t.

To test whether better firms had higher spinoff rates, three explanatory variables are constructed to reflect the quality of a firm in year t: the total number of years the firm produced automobiles, a 1–0 dummy equal to 1 if the firm had been among the production leaders of the industry in year t or the preceding 5 years, and a 1–0 dummy equal to 1 if the firm had been the number one or two producer in year t or the preceding 5 years. The total years of production is a conventional measure of a firm's

[5] This included the two 1907 spinoffs of Alanson Brush of Cadillac, Brush Runabout and Oakland, and the two 1911 spinoffs of William Durant of General Motors, Little Motors and Chevrolet Motors. Howard Coffin and Roy Chapin of Olds Motor Works also founded two spinoffs in close succession, E. R. Thomas-Detroit Co. in 1906 and Hudson Motor Car Co. in 1909. They were joined in the founding of Hudson by two other long-term employees of Olds, Roscoe Jackson and George Dunham, and Olds was classified as the parent of both E. R. Thomas-Detroit and Hudson.

[6] The firm's entry date is its initial year of commercial production in Smith (1968). Some firms were organized before this date, and in two instances spinoffs entered in the year prior to the first year of commercial production of the parent firm. To accommodate this, the analysis was started in the year prior to each firm's initial year of commercial production.

overall performance whereas the other two variables reflect the firm's performance at or just before year t. To test whether the firm spinoff rate first rises and then falls with experience, the number of years of production of automobiles through year t and its square are included as explanatory variables. To test whether spinoff rates are higher around the time of acquisitions, a 1–0 dummy equal to 1 for firms that were acquired by another auto firm between years $t-2$ and $t+1$ and a comparable 1–0 dummy equal to 1 for firms acquired by non-auto firms between years $t-2$ and $t+1$ are included.[7] Both are based on listings of ownership changes in Smith (1968). Separate variables are included for acquisitions by auto and non-auto firms to test whether they have different influences on the spinoff rate, as some studies of other industries suggest (Brittain and Freeman 1986, Stuart and Sorenson 2003).

Additional explanatory variables were included to control for other factors that might influence the spinoff rate. A 1–0 dummy equal to 1 for firms that produced in year t and a 1–0 dummy equal to 1 for firms that did not produce in year t but had ceased producing less than 5 years earlier were included to test whether the spinoff rate declined after firms ceased producing automobiles. A variable equal to the number of non-spinoff entrants divided by the number of firms averaged over years $t-2$, $t-1$, and t was included to test whether conditions affecting non-spinoff entry also affected the rate of spinoffs, with a 3-year average used to reflect general conditions bearing on entry at time t.[8] Last, a 1–0 dummy equal to 1 for firms located in the Detroit area in year t was included to test whether the high rate of firm formation in the Detroit area resulted in a better infrastructure to support entry of all kinds, including spinoffs. The percentage of all entrants that entered in the Detroit area rose markedly through 1916, increasing from 10% in 1895–1904 to 14% in 1905–1909 and 29% in 1910–1916. In contrast, after 1916 only 12% of the remaining entrants located in the Detroit area. Accordingly, a 1–0 dummy equal to 1 for firms located in the Detroit area in year t for years after 1916 was also included as an explanatory variable to test if the spinoff rate of Detroit firms declined after 1916.

The estimates of the coefficients of the variables and three constant terms quantifying the thresholds for one, two, and three spinoffs are reported in Table 2.[9]

Table 2 Coefficient Estimates of the Ordered Logit Model

Variable	Coefficient estimate
Constant 1	−6.6851 (0.3615)***
Constant 2	−9.7128 (0.5174)**
Constant 3	−11.6736 (1.0608)***
Dummy—producing	1.1763 (0.4652)***
Dummy—≤5 yrs. notprod.	1.3865 (0.4131)***
Years of production if producer	0.1772 (0.0648)***
Years of prodution^2 if producer	−0.0065 (0.0030)**
Total years produced	0.0133 (0.0077)**
Production leader	0.7605 (0.3343)**
Numbers 1 or 2 producer	0.6789 (0.3951)**
Acquired by auto firm	0.9551 (0.3440)***
Acquired by non-auto firm	0.8468 (0.2616)***
Non-spinoff entry rate	0.9258 (0.5239)**
Detroit area	1.2079 (0.2279)***
Detroit area after 1916	−1.1251 (0.4008)***

Note. Standard errors in parentheses.
*Significant at the 0.10 level (one-tailed). **Significant at the 0.05 level (one-tailed). ***Significant at the 0.01 level (one-tailed).

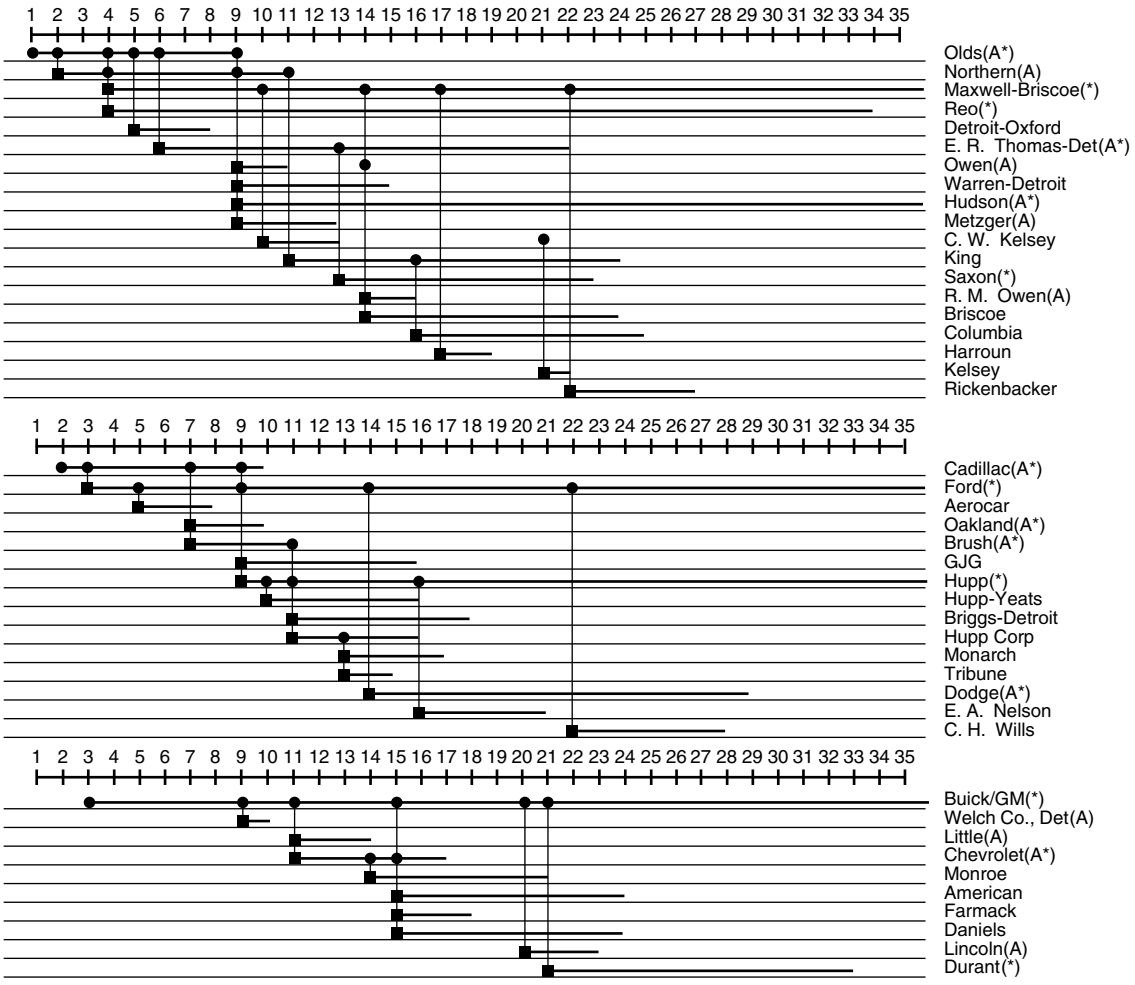
The estimates largely conform with expectations. The probability of a spinoff is significantly greater in years firms were producing. It is also significantly greater for firms that had ceased producing within the last five years (relative to firms that had ceased producing over five years ago, the omitted reference category). For producers, the coefficient estimates of the number of years of production and its square are positive and negative, respectively, with both significant. The estimates imply that the probability of a spinoff rises until age 14, which is well within the age range of the more successful firms, and then declines. The probability of a spinoff is significantly greater around times that firms were acquired by either auto or non-auto firms. It is also significantly greater in years with a higher non-spinoff entry rate. In terms of the critical variables for the theory, the probability of a spinoff each year is significantly greater for firms that produced longer. It is also significantly greater for firms that were among the production leaders in the contemporaneous or prior 5 years, and significantly greater still for firms that were the number one or two producer in this same time period. Thus, as predicted in Hypothesis 1 in Table 1, firms that performed better had higher annual spinoff rates. Last,

[7] Acquisitions are allowed to affect the spinoff rate 1 year before they occur, reflecting the general tendency for acquisitions to be consummated some time after they are arranged.

[8] Alternatively, this was controlled using year dummies, which had little effect on the estimates.

[9] The model was estimated as an ordered logit and also as a simple logit, with the dependent variable equal to 1 if a firm had one or more spinoffs in a year. This had little effect on the estimates. It was also estimated as a conditional logit, which effectively controls for firm fixed effects. This requires dropping all the firms from the sample with no spinoffs and dropping the variable total years of production of automobiles because it does not vary for a firm over time. A Hausman test comparing the coefficient estimates in the conditional logit with those based on the ordinary logit on the reduced sample and variable set could not reject the null hypothesis of the firm fixed effects equaling zero.

Figure 4 Spinoffs of Olds, Cadillac, Ford, Buick/GM



Notes. •—Year of a spinoff from a parent. ■—Entry year of spinoff. A—Firm exited by acquisition by an automobile firm. *—Car make produced by firm attained ranks of leading makes. ——Years of firm production through 1936.

the coefficient estimate for the Detroit-area dummy is positive and significant, implying that the spinoff rate was roughly three times larger for firms in the Detroit area than elsewhere.[10] It is almost completely offset by the negative coefficient estimate for the Detroit-area dummy after 1916, which is also significant. Thus, after 1916 the Detroit-area firms were not especially fertile, but before that Detroit-area firms spawned more spinoffs than expected based on their performance.

[10] The coefficient estimates can be interpreted in the conventional way as the derivative of the log odds ratio with respect to the explanatory variables, where the log odds ratio is the log of the probability of one or more spinoffs divided by one minus this probability (cf. Cox and Snell 1989, p. 159). Thus, $\exp(1.2079) = 3.346$ quantifies how much greater the odds ratio is for Detroit-area firms than firms located elsewhere. Since the annual probability of firms spawning one or more spinoffs is quite low, the denominator in the odds ratio is close to one, implying that the annual probability of a spinoff through 1916 was around three times greater for Detroit-area firms than firms located elsewhere.

Consistent with the estimates of the ordered logit model, Olds, Cadillac, Ford, and Buick/GM were the most prolific breeders of spinoffs in the industry, as predicted in Hypothesis 5 in Table 1. Olds and Buick/GM led the industry with seven spinoffs each whereas Ford and Cadillac had four spinoffs each, which tied them for third place with Maxwell-Briscoe, a descendant of Olds. A genealogical tree of the spinoffs descended from Olds, Cadillac, Ford, and Buick/GM is presented in Figure 4. Among the 12 firms in the Detroit area that made it into the ranks of the leaders after the entry of Olds, Cadillac, Ford, and Buick/GM, ten of them (identified in Figure 4) were descended from these four firms. The historical record of these spinoffs is sufficiently rich to reconstruct the impetus for their formation. Consistent with the theory, strategic disagreements were common in Olds, Cadillac, Ford, and Buick/GM, and their leading spinoffs were largely formed as the result of such disagreements (Klepper 2006).

The leading spinoffs of Olds Motor Works are illustrative. Ransom Olds himself left Olds Motor Works and formed Reo after a dispute about precision manufacturing with the Smiths (father and son), who owned a majority of Olds' stock and were centrally involved in its management. Two of Olds' top production and marketing employees, Roy Chapin and Howard Coffin, subsequently left Olds to form E. R. Thomas-Detroit after the Smiths endorsed a new car they wanted to produce but then reneged at the last moment. Subsequently they left E. R. Thomas-Detroit to co-found Hudson after the new head of the company, Hugh Chalmers, allowed them to develop a new car in a separate venture that he helped finance but subsequently traded his stock for their holdings in E. R. Thomas-Detroit. Ford and the Dodge Brothers, the most successful spinoff of Ford, had similar histories. Henry Ford was forced out of his second startup, which evolved into Cadillac, after he was unwilling or unable, or both, to move his company into production, and the Dodge brothers left to form their own company over Ford's unwillingness to renew his commitment to them as his main production arm. Cadillac's two main spinoffs, Brush Runabout and Oakland, were also formed as a result of a dispute involving Alanson Brush, a key innovator in Cadillac, concerning the use of his patents. Last, Buick/GM's two main spinoffs, Chevrolet and Durant Motors, were formed after William Durant, the founder of GM, was twice ousted from GM due to differences of opinion about his ambitious acquisition strategy and his integration (or lack thereof) of the acquisitions into GM. At Chevrolet he developed a small car to compete with the Model T, which continued efforts he had initiated at GM but were abandoned after his departure.

Nearly all the spinoffs descended from Olds, Cadillac, Ford, and Buick/GM located in the Detroit area, reflecting the general tendency of spinoffs to locate close to their parents, as predicted in Hypothesis 4 in Table 1. Of the 145 spinoffs, 110 located within 100 miles of their parents, with 50 of the 61 spinoffs whose parents were located in the Detroit area also locating there. Consequently, as predicted in Hypothesis 6 in Table 1, spinoffs accounted for a disproportionate share of the entrants in the Detroit area—37% of the spinoffs located there versus 9% of the experienced firms and entrepreneurs and 11% of the inexperienced firms. Expressed alternatively, spinoffs accounted for 48% of the entrants in the Detroit area versus 15% of the entrants elsewhere.

6. Firm Performance

The rest of the hypotheses in Table 1 that remain to be tested pertain to the performance of firms. The metric of performance that can be constructed for all firms is the total years they produced automobiles. Accordingly, the analysis focuses on the determinants of the annual firm hazard of exit.

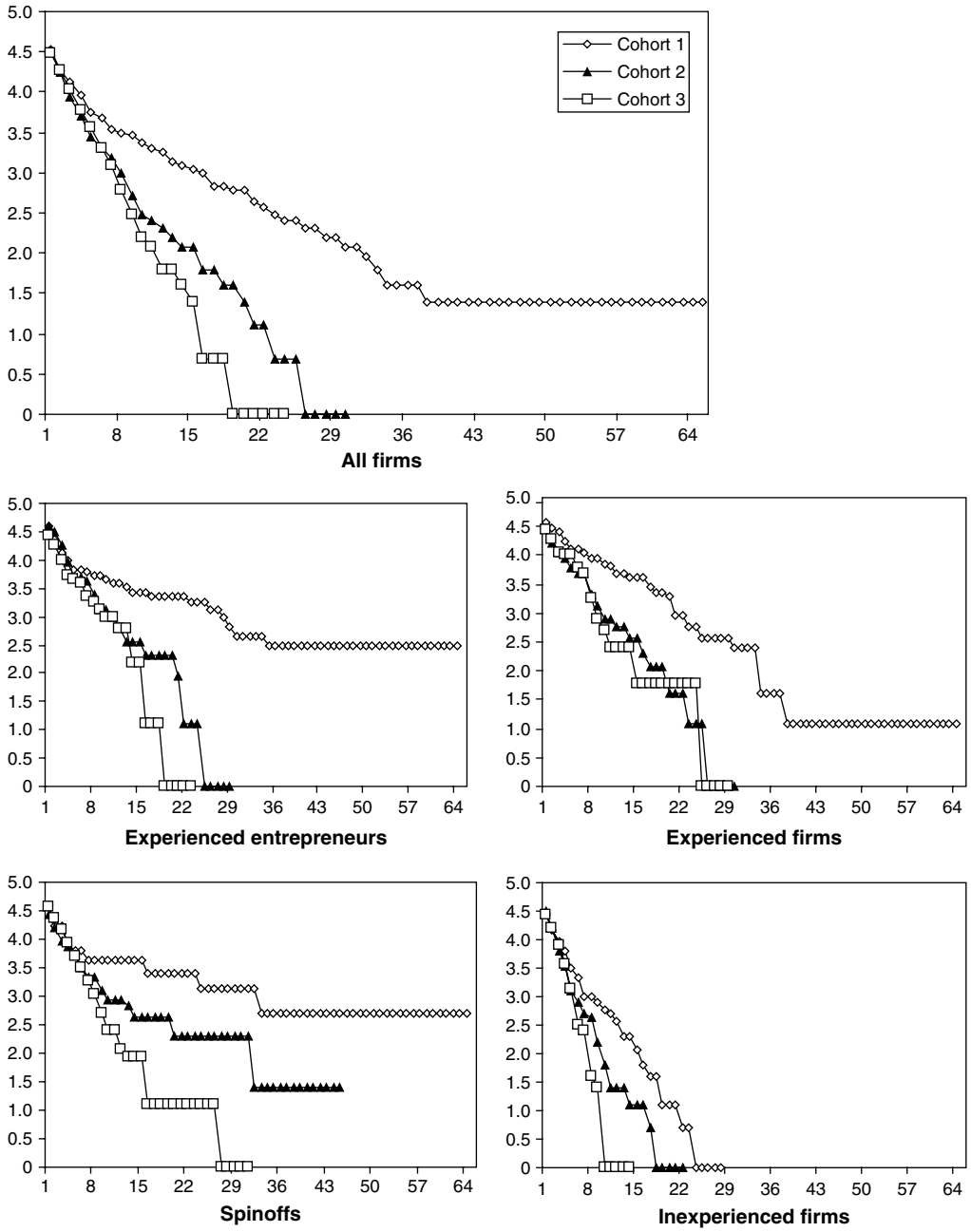
A benchmark model of the hazard of exit is constructed based on the model of shakeouts in Klepper (2002) that features the effects of firm backgrounds and time of entry on the hazard of exit. Experienced firms, experienced entrepreneurs, and spinoffs are expected to be better able than inexperienced firms to manage the process of technological change by dint of their prior experience. Accordingly, they are expected to have lower hazards of exit at every age than inexperienced firms. Time of entry conditions the size of firms at every age, which affects the hazard of exit by influencing the returns and thus effort devoted to technological change. Firm output was quite small through 1904 and then began to grow, especially after 1909. Accordingly, three entry cohorts were distinguished: 1895–1904, 1905–1909, and 1910–1966, which respectively contain 219, 271, and 235 entrants.[11] Figure 5 reports Kaplan–Meier survival curves for the three entry cohorts, both for all firms and separately for the experienced firms, experienced entrepreneurs, spinoffs, and inexperienced firms. Each curve plots the natural log of the percentage of entrants surviving to each age, with the negative of the slope of the curve at any age equal to the hazard at that age.[12] For the firms overall and each group separately, the survival curves overlap closely until about age seven and then separate sharply according to time of entry.[13] The survival curves for the three cohorts of inexperienced entrants are also much steeper at every age than the analogous survival curves of the other three groups of firms, reflecting a higher hazard of exit at every age for the inexperienced firms relative to the other three groups of entrants.

[11] Entry categories are arbitrary, but they obviate having to specify a functional form for the effect of time of entry on the hazard. Klepper (2002) divided the earliest entrants in the first cohort into two groups, but the earlier group did not have lower hazards than the next group of entrants at older ages, as would be expected if time of entry exerted a monotonic effect on the hazard. This may partly reflect the slow initial growth in output of the industry, which would have lessened the importance of very early entry. Also, there was considerable uncertainty early on about the best technology for engines, and a number of the early entrants adopted steam and electric engines, which appears to have limited their longevity. To check on the robustness of the findings to the definition of entry cohorts, the hazard model was also estimated using the four entry cohorts distinguished in Klepper (2002), but this had little effect on the findings.

[12] Firms that exited by being acquired are treated as censored exits. A survival curve drops to the horizontal axis when the survival rate for the entry cohort drops below 1%.

[13] Klepper (2002) provides an explanation for the delayed effect of time of entry on the hazard of exit.

Figure 5 Survival Curves by Time of Entry and Pre-Entry Experience



To capture these patterns, the hazard of firm exit at age t, $h(t)$, is modeled according to the Gompertz specification:

$$h(t) = \exp\{(\alpha_0 + \boldsymbol{\alpha}'\mathbf{x})t\}\exp\{\beta_0 + \boldsymbol{\beta}'\mathbf{z}\},$$

where $\mathbf{x}$ and $\mathbf{z}$ are vectors of covariates and the other terms are coefficients. The first exponential term allows the age of firms to affect the hazard rate monotonically. It also allows for the variables in $\mathbf{x}$ to condition how age affects the hazard. The second exponential term allows the variables in $\mathbf{z}$ to affect the hazard proportionally at all ages. Based on the descriptive results, variables reflecting the backgrounds of firms are included in $\mathbf{z}$ to allow them to affect the hazard proportionally at all ages. Also included in $\mathbf{z}$ are variables pertaining to whether firms were located in the Detroit area. Variables for the time of entry are included in $\mathbf{x}$ as well as $\mathbf{z}$ to allow them to affect the hazard differently at each age, as suggested by the descriptive results.

First, a benchmark model, denoted as Model 1, is estimated. Three 1–0 dummies equal to 1, respectively, for the experienced firms, experienced entrants, and spinoffs (the inexperienced firms are the omitted, reference category) are included in $\mathbf{z}$. Separate 1–0 dummies equal to 1 are also included in $\mathbf{z}$ for experienced

Table 3 Coefficient Estimates of the Hazard Model

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	−1.5145***	−1.5376***	−1.5505***	−1.5537***	−1.5927***	−1.5926***
	(0.1046)	(0.1046)	(0.1036)	(0.1036)	(0.1003)	(0.1003)
t	0.0601***	0.0587***	0.0593***	0.0581***	0.0559***	0.0569***
	(0.0143)	(0.0141)	(0.0140)	(0.0139)	(0.0136)	(0.0136)
Detroit	−0.2928**	0.0163				
	(0.1297)	(0.1530)				
Experienced firms	−0.4146***	−0.4098***	−0.4135***	−0.4142***	−0.3892***	−0.3914***
	(0.1467)	(0.1467)	(0.1467)	(0.1467)	(0.1456)	(0.1456)
Experienced entrepreneurs	−0.5015***	−0.5360***	−0.5478***	−0.5496***	−0.5195***	−0.5222***
	(0.1524)	(0.1532)	(0.1527)	(0.1528)	(0.1513)	(0.1512)
Spinoffs	−0.5639***	−0.3917***	−0.2157*	−0.1410		
	(0.1217)	(0.1287)	(0.1525)	(0.1588)		
$C1$	−0.1505	−0.1522	−0.1324	−0.1272	−0.1002	−0.0976
	(0.1357)	(0.1350)	(0.1350)	(0.1350)	(0.1340)	(0.1339)
$C2$	0.0332	0.0152	−0.0025	−0.0035	0.0233	0.0260
	(0.1291)	(0.1291)	(0.1304)	(0.1306)	(0.1293)	(0.1292)
$C1 * t$	−0.0878***	−0.0852***	−0.0853***	−0.0839***	−0.0819***	−0.0832***
	(0.0162)	(0.0160)	(0.0159)	(0.0159)	(0.0156)	(0.0156)
$C2 * t$	−0.0490***	−0.0413***	−0.0331**	−0.0306**	−0.0308**	−0.0316**
	(0.0175)	(0.0176)	(0.0179)	(0.0179)	(0.0177)	(0.0176)
C, b, e firms	−0.4052**	−0.4145**	−0.4275**	−0.4272**	−0.4181**	−0.4199**
	(0.1928)	(0.1928)	(0.1929)	(0.1929)	(0.1927)	(0.1927)
C, b, e entrepreneurs	−0.2408	−0.2341	−0.2293	−0.2273	−0.2258	−0.2260
	(0.2023)	(0.2023)	(0.2023)	(0.2023)	(0.2023)	(0.2022)
Detroit spins		−0.7826***	−0.3695**	−0.2515		
		(0.2590)	(0.2211)	(0.2323)		
Years of parent production			−0.0090**	−0.0086**	−0.0099**	−0.0121***
			(0.0048)	(0.0048)	(0.0047)	(0.0041)
Parent no. 1			−0.9899**	−0.9541**	−0.6635	−0.9185**
			(0.5453)	(0.5482)	(0.6181)	(0.5288)
Secondary parent no. 1			−0.4373	−0.5541	−0.7432*	−0.7774**
			(0.4758)	(0.4837)	(0.4637)	(0.4616)
Spin reason				−0.3413*	−0.4642***	−0.4982***
				(0.2190)	(0.1969)	(0.1944)
Years of production $* D$					−0.0066	
					(0.0078)	
Log likelihood	−1,872.18	−1,867.58	−1,860.09	−1,858.82	−1,859.71	−1,860.08

Note. Standard errors in parentheses.
*Significant at the 0.10 level (one-tailed). **Significant at the 0.05 level (one-tailed). ***Significant at the 0.01 level (one-tailed).

firms and experienced entrepreneurs with backgrounds in the carriage and wagon, bicycle, and engine industries, which are the industries most closely related to automobiles. A 1–0 dummy equal to 1 for Detroit-area firms and 1–0 dummies equal to 1 for entrants in the first entry cohort (C1) and the second cohort (C2) are also included in **z**, with the cohort entry dummies also included in the vector **x**.

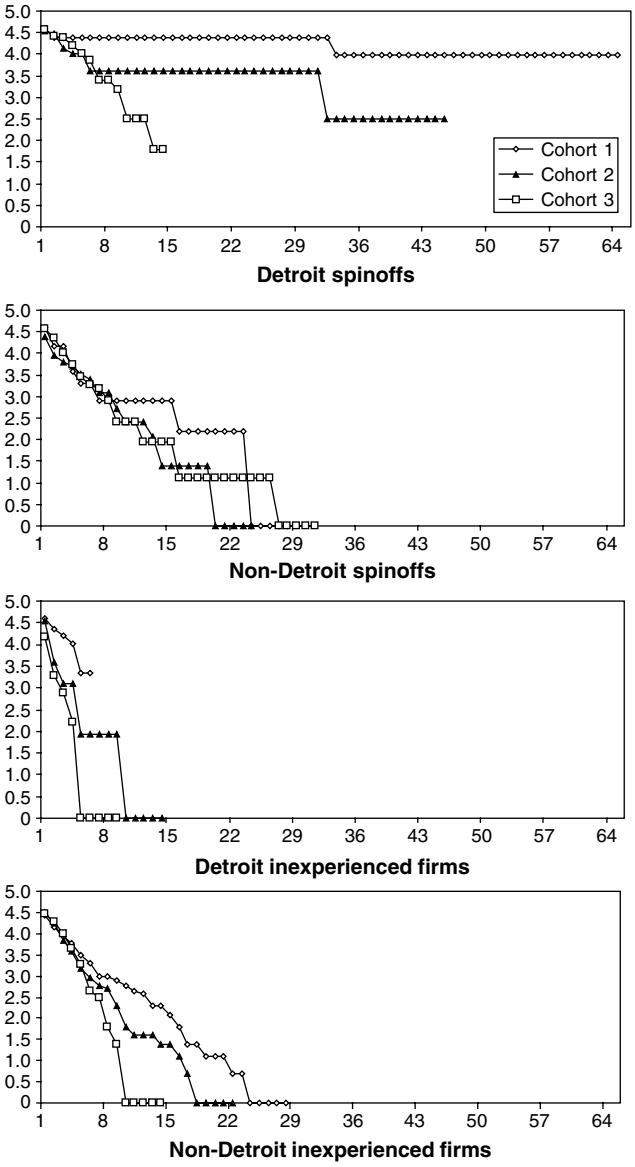
The estimates of Model 1 are reported in Table 3, with standard errors in parentheses and significance levels based on one-tailed tests. The coefficient estimates of the dummies for the three types of experienced firms are all negative, sizable, and significant, consistent with the graphs in Figure 5. They imply that the annual hazards of the experienced firms, experienced entrepreneurs, and spinoffs are 34%, 39%, and 43% lower than the inexperienced firms, respectively. Thus, consistent with Hypothesis 3 in Table 1, spinoffs performed distinctively. The coefficient estimates for the dummies for experienced firms and experienced entrepreneurs from the related industries of carriages and wagons, bicycles, and engines are also negative, with the former also significant, consistent with more closely related experience lowering the hazard. They imply a 33% and 21% lower hazard for firms in these industries relative to the other experienced firms and experienced entrepreneurs. The coefficient estimates of $C1 * t$ and $C2 * t$ are both negative and significant whereas those of $C1$ and $C2$ in the proportional term are small and insignificant. Consistent

with the descriptive results, this implies that at young ages different entry cohorts have similar hazards, but the hazards of the cohorts diverge with age according to the time of entry. The estimates imply that at age 15 the annual hazards of the first two cohorts of entrants are, respectively, 76% and 48% lower than the third cohort, with these percentages rising to 90% and 67% at age 25. Last, the coefficient estimate for the Detroit-area dummy is negative and significant, implying a 25% lower annual hazard for firms in the Detroit area.

Hypothesis 7 in Table 1 predicts that the superior performance of the Detroit-area firms should be confined to the spinoffs in the Detroit area. To test this, a dummy equal to 1 for spinoffs located in the Detroit area was added to Model 1. The coefficient estimate of this variable, reported in Table 3 under the column headed Model 2, is negative and significant, as predicted, implying a 54% lower hazard for the spinoffs in Detroit than elsewhere. More important, the coefficient estimate of the Detroit-area dummy is trivial and insignificant, suggesting that the lower hazard of Detroit-area firms was in fact confined to the spinoffs in the Detroit area. Accordingly, the Detroit dummy is dropped from subsequent specifications. Figure 6 illustrates how distinctive the performance of spinoffs in the Detroit area was. The top two panels present Kaplan–Meier survival curves for the three entry cohorts for spinoffs in the Detroit area and elsewhere, and the bottom two panels present the analogous survival curves for inexperienced firms, the second largest group of entrants, in the Detroit area and elsewhere. In all three entry cohorts, spinoffs in the Detroit area had much higher survival rates than spinoffs elsewhere, whereas if anything the patterns are reversed for the inexperienced firms.

Hypothesis 2 in Table 1 predicts that the heritage of spinoffs will affect their performance, and Hypothesis 8 in Table 1 predicts that the superior performance of the Detroit area spinoffs should be due to their heritage rather than being located in the Detroit area. To test these predictions, four variables measuring the performance of the parents of spinoffs were constructed: the total years the parents produced automobiles, a 1–0 dummy equal to 1 if the parent was ranked among the production leaders in the entry year of the spinoff or the preceding 5 years; a 1–0 dummy equal to 1 if the parent was the number one producer in the industry in the entry year of the spinoff or the preceding 5 years; and a 1–0 dummy equal to 1 if the secondary parent of the spinoff was the number one producer in the industry in the entry year of the spinoff or the preceding 5 years. The first dummy concerning whether the parent was among the production leaders added little explanatory power to Model 2 due to its high correlation with the years of

Figure 6 Survival Curves of Detroit and Non-Detroit Spinoffs and Inexperienced Firms



production of the parent, but the other two dummies had greater explanatory power and were included as covariates in **z**.[14]

The coefficient estimates of this model are reported under the column headed Model 3 in Table 3. Consistent with Hypothesis 2 in Table 1, the coefficient estimates of the three added variables are all negative and their joint effect is significant at the 0.01 level, with only the dummy for the spinoff's secondary parent not significant on its own. Furthermore, the coefficient estimate of the Detroit-area spinoff dummy is

[14] In contrast to the ordered logit analysis of the firm spinoff rate, when the two included dummies were broadened to encompass parents who were the number two producer, their explanatory power declined considerably.

reduced (absolutely) from −0.7826 to −0.3695, implying a 31% lower hazard for spinoffs in the Detroit area than elsewhere. Controlling for the heritage of the spinoffs also reduces the coefficient estimate of the spinoff dummy, as would be expected given the effect of the heritage of the spinoffs on the hazard.

The role of the heritage of the spinoffs was probed further by adding to Model 3 a dummy variable representing whether spinoffs built upon the strategy of their parents. Although the historical record in the *Standard Catalog of American Cars* is too brief for many firms to discern whether they built upon the strategy of their parent firm, about 30% could be so distinguished. Included were the spinoffs that were formed as the result of a strategic disagreement with their parent firm. Although these firms distinguished themselves from their parents, they also borrowed from them as well (Klepper 2006), as Klepper and Thompson's theory would suggest. Also included were the numerous spinoffs that were founded by car designers after their parent failed or was about to fail. These firms typically produced similar cars to the parent firm, but were predicated on the idea that they could improve upon the strategy of their parent. Also included were a few spinoffs that were seemingly sponsored by their parent firm to produce a different but related car without affecting their parent's reputation.

The estimates of this model are reported under the column headed Model 4 in Table 3. The coefficient estimate of the added dummy is negative and significant, consistent with the idea that spinoffs that built upon the expertise of their parents had lower hazards. The addition of this variable further reduced (absolutely) the coefficient estimate of the Detroit-area spinoff dummy, which is no longer significant. Thus, crude controls for the heritage of the spinoffs largely explain the superior performance of the Detroit-area firms, consistent with Hypothesis 8 in Table 1. The coefficient estimate of the spinoff dummy in Model 4 is also smaller and insignificant, indicating that the superior performance of spinoffs was restricted to those with a distinctive heritage and that built on the expertise of their parents.

The absence of a Detroit-area effect is probed by dropping the dummies for spinoffs and spinoffs in the Detroit area and adding a variable interacting the years of production of the parent with the dummy for being located in the Detroit area. This makes it possible to test whether the effect of parental heritage was similar for spinoffs located in the Detroit area and elsewhere.[15] The coefficient estimates for this model are reported in Table 3 under the column headed Model 5. The coefficient estimate of the added variable is negative, suggesting that the longevity of the parent reduced the hazard more for Detroit spinoffs, but the estimate is insignificant and the main effect of years of production continues to be negative and significant. This suggests that background similarly affected the hazard for spinoffs in Detroit and elsewhere, as would be expected based on the theory. To gauge the effects of all the background variables, one last model, Model 6, was estimated without the interaction added to Model 5. The coefficient estimates of all four variables for the backgrounds of the spinoffs are negative and significant, along with nearly all the other background variables, confirming further the importance of pre-entry experience for firm performance.

[15] Analogous interactions were not added for the parent or secondary parent being the number one producer in the industry because all but one of the spinoffs with such parents were located in Detroit.

7. Discussion

The automobile industry was one of the earliest and most extreme examples of an agglomerated industry, yet the reasons for the agglomeration remain a puzzle. Tracing the heritage of all the entrants reveals that the puzzle is wrapped up in spinoffs from incumbent firms. Spinoffs were distinctive performers and accounted for the bulk of the firms that made it into the ranks of the leaders after 1903. The leading spinoffs were concentrated in the Detroit area, where spinoffs disproportionately entered. This was largely attributable to Olds Motor Works, Cadillac, Ford, and Buick/GM, which were responsible for most of the leading spinoffs, reflecting the tendency of better firms to have more and better-performing spinoffs. Indeed, the superior performance of firms in the Detroit area was largely due to the high quality of the spinoffs that located there, suggesting that it was the spinoff process and not any attributes of the Detroit area per se that caused the industry to be agglomerated there.

If spinoffs drove the agglomeration around Detroit, then they must have done more than merely diverted output from their parents. The spinoffs of the two dominant firms in the industry, Ford and Buick/GM, are illustrative. Ford's first successful spinoff, Hupp, entered in 1909. It produced a small, two-seater car powered by a four-cylinder engine. Sales of Hupp's car quickly attained the ranks of the top 15 and it remained between the tenth and fifteenth best seller for many years, with sales peaking at 129,020 cars in 1925 (Bailey 1971). Dodge Brothers, Ford's other leading spinoff, was even more successful. It produced a car that reflected the Dodge brothers' prowess as production experts—it was sturdy, reliable, and incorporated a number of distinctive features, such as the first all steel body. It was immediately popular, and by

1920, the year the Dodge brothers both died, the company achieved the number two position in the industry with sales of 141,000 cars. Neither firm seems to have had much effect on Ford's sales. Ford introduced the Model T in 1908, and it remained the number one producer in the industry through 1926, with its sales growing from 10,202 cars in 1908 to 501,462 cars in 1915 and 1,817,891 cars at is peak in 1923 (Bailey 1971).

The experiences of Buick/GM and its most prominent spinoff, Chevrolet, are similar (Klepper 2006). After William Durant was first ousted from GM, the Buick division abandoned the production of a smaller car that Durant had initiated to compete with the Model T. Chevrolet, which located in Flint, MI (part of the Detroit area), successfully developed such a car, which propelled it to tenth place in the industry in 1915 before it was combined with General Motors. Subsequently its sales grew tremendously and it ultimately displaced the Model T as the best seller in the industry with sales of 1,749,998 cars at its peak in 1927. In the same era, Buick's sales increased from 43,946 cars in 1914 to 255,160 cars in 1927 (Bailey 1971).[16]

Klepper and Thompson's (2006a) theory is consistent with these patterns and the various statistical findings regarding spinoffs. Other theories can also account for some of these findings. Cassiman and Ueda (2006) developed a model of spinoffs based on the idea that firms lack the capacity to pursue all the good ideas they generate in R&D. Their theory predicts spinoffs specialize in ideas that are less central to the mission of their parents, with better firms spawning better-performing spinoffs. No doubt automobile firms were limited in the projects they could pursue, but at the same time disagreements over management practices and core strategic issues seem to have been at the heart of a number of the leading spinoffs of the top firms. Burton et al. (2002) suggest that employees of top firms may have an easier time raising capital for their own ventures, which could also account for better firms having longer-lived spinoffs. This certainly may have enabled spinoffs of top firms to survive initial challenges, lengthening their average lifetime. But over time firms would be expected to develop their own sources of capital and initial capital advantages would be expected to decline in importance. But, the survival curves in Figure 5 indicate that spinoffs had lower hazards at all ages, not just young ages, suggesting that their superior performance transcended an initial capital advantage.

The theory does not incorporate agglomeration economies associated with technological spillovers and thicker markets for labor and specialized intermediates (Rosenthal and Strange 2004) that would have benefited all firms in the Detroit area. Indeed, once Olds, Cadillac, Ford, and Buick/GM located in the Detroit area, agglomeration economies alone could have accounted for the subsequent growth of the industry in the Detroit area. But if agglomeration economies were significant, why did inexperienced firms in the Detroit area perform better than their counterparts elsewhere? Eventually wages and prices were bid up in the Detroit area, as predicted by modern theories of geography, which conceivably could have eliminated any excess returns to locating there. But until that point, firms of all types should have performed better in the Detroit area if agglomeration economies were significant, and after that point firms of all types should have performed comparably in the Detroit area and elsewhere. However, Figure 6 indicates that spinoffs in the Detroit area had lower hazards than spinoffs elsewhere at all ages whereas inexperienced firms in the Detroit area had comparable hazards to inexperienced firms elsewhere at all ages. This suggests that it was not Detroit but the spinoffs located there that were distinctive and that drove the agglomeration there.

It is possible that agglomeration economies in the Detroit area were significant but only benefited spinoffs, perhaps because only they had suitable preentry backgrounds to benefit from the agglomeration economies. It is hard to rule out such a theory, and it is conceivable that agglomeration economies played a role in inducing so many of the spinoffs of the Detroit-area firms to locate there as well. Yet spinoffs in all areas tended to locate close to their parents. Moreover, the Figueiredo et al. (2002) findings for modern Portuguese startups and Buenstorf and Klepper's (2006) findings for historical entrants into the U.S. tire industry, another highly agglomerated industry, suggest that all firms tend to locate close to their geographic roots regardless of their background or geographic origin. Firms appear to possess valuable local knowledge based on their pre-entry experience that makes it profitable to locate close to their origins, which for spinoffs is where their parents are located.

[16] Spinoffs also may have enhanced the agglomeration of the industry around Detroit by indirectly benefiting the leading Detroit firms. Economies of scope were prominent in the automobile industry, making spinoffs attractive acquisition targets given their distinctive orientation relative to their parents. As reflected in Figure 4, many of the spinoffs of Olds, Cadillac, Ford, and Buick/GM were acquired by other automobile firms, and a few of the leading spinoffs played important roles in the success of General Motors, Ford, and Chrysler. General Motors was able to compete with Ford in the smaller car market by acquiring Chevrolet, which it used to displace Ford as the leader of the industry. Chrysler evolved out of two successful early spinoffs, Maxwell-Briscoe and E. R. Thomas-Detroit (later renamed Chalmers), and later acquired the Dodge Brothers to round out its offerings. Last, Ford acquired Lincoln, a GM/Cadillac spinoff, which it later used to produce a successful luxury car.

Such knowledge can also substitute for the benefits associated with agglomeration economies, thereby muting their influence on the location and performance of firms (Buenstorf and Klepper 2006).

Recent findings suggest that the movement of employees is an important conduit for knowledge spillovers (Almeida and Kogut 1999, Breschi and Lissoni 2003). This accords with Klepper and Thompson's (2006a) model, which features how the strategic choices of spinoffs are influenced by knowledge gained at their parent firm. The theory also predicts that the performance of parents will decline after the formation of spinoffs because of the departure of (unrecognized) superior employees. Olds Motor Works exemplifies this. It had seven spinoffs in a span of 8 years. In the process, it lost its leader, chief engineer, and marketing head, all of whom were or would become celebrated figures in the industry. Soon after, Olds declined precipitously and dropped out entirely from the ranks of the leaders, only to be rescued by the GM merger. Other leading firms, such as E. R. Thomas-Detroit, also declined after top personnel left to found spinoffs. These examples suggest that the decline of firms can originate from within, and resolving disagreements can be an important element of a firm's strategy.

Automobiles is but one industry, and so it is natural to ask whether the forces underlying the agglomeration of the automobile industry were operative in other industries as well. Buenstorf and Klepper (2005) tell a remarkably similar story about how spinoffs drove the agglomeration of the U.S. tire industry around Akron, Ohio, a city with no compelling advantages for tire production. Moore and Davis (2004) also feature the role played by spinoffs in the development of the semiconductor industry in Silicon Valley, which they see as the main driver of the agglomeration of economic activity there. Considerably more evidence will be required to sort out the influence of spinoffs on the geographic evolution of other industries, but the findings for automobiles are encouraging that efforts to assemble the requisite evidence might yield significant insights into the geographic distribution of economic activity and regional economic performance.

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