Heritage and Agglomeration: The Akron Tire Cluster Revisited

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Abstract

We use new data on the location and background of entrants into the U.S. tire industry to analyze the factors that caused the industry to be so regionally concentrated around Akron, Ohio, a small city with no particular advantages for tire production. We analyze the states where firms entered and for the Ohio entrants the counties where they originated and entered, and we conduct various analyses of how proximity to other tire firms and to demanders affected the longevity of tire producers. We also examine how the heritage of the Ohio entrants influenced their longevity. Our findings suggest that the Akron tire cluster grew primarily through a process of organizational reproduction and heredity rather than through agglomeration economies, as has been commonly posited by scholars of the industry.

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I. Introduction

Over its first 40 years, the U.S. tire industry became heavily concentrated around a small city, Akron, Ohio, that possessed no compelling advantages for tire production. Subsequently, the industry began steadily moving away from Akron, and fifty years later little was left from Akron's heyday as the capital of the U.S. tire industry. Such extreme cases of industrial clustering call out for explanation, especially given the resurgence of interest among economists in the study of geography.

For decades, scholars have tried to explain the rise and fall of the Akron tire cluster (cf. Barker [1939], Gaffey [1940], Allen [1949], Knopf [1949], Frank [1952], Sobel [1954], Overman [1957], Knox [1963], Bazaraa [1965], Jeszeck [1982], Krugman [1991], Sull [2001]). Relying on a wealth of historical materials, they have developed an account that resonates with modern theories of economic geography. The purpose of this paper is to exploit new, detailed evidence that we assembled on the evolution of the tire industry to analyze the forces that led the industry to become so concentrated around Akron. We end up telling a story that is markedly different from the conventional account of the Akron cluster, and which also helps put in context the subsequent exodus of the industry from Akron.

The conventional account begins with an historical accident (Gaffey [1940, p.150], Knopf [1949, p. 7], Krugman [1991, p. 62]). In 1871, Akron capitalists managed to attract B.F. Goodrich to move his small rubber firm there. Apparently, Goodrich's motivation for relocating from New York to Ohio was to escape the more intense competition in the East. When his business began to prosper, additional entrants were attracted to the Akron rubber industry. Proximity to the carriage industry in Ohio and Michigan induced the Akron rubber firms to enter early into the growing businesses of carriage and bicycle tire production.[1] As a consequence of these earlier developments, the Akron rubber industry was well positioned when the automobile industry – and with

[1] It has even been suggested that the tire business was the only segment of the rubber industry in which Akron firms were able to compete with Eastern companies (Sobel [1954, p. 12]).

it the automobile tire industry – took off in the early 20th century (Frank [1952, p. 16], Knox [1963, p. 149], French [1981, p. 21]).

The second ingredient in the conventional account is geography. Akron's location in the Midwestern manufacturing belt arguably provided local producers with a competitive advantage over Eastern firms stemming from their proximity to the emerging automobile industry, which was shifting west from New England and the Mid-Atlantic region toward Michigan and Ohio. And just as the automobile industry became increasingly concentrated in Detroit, so the story goes, its tire suppliers agglomerated in the (relatively) nearby Akron. It is moreover argued that Akron's location was similarly beneficial for serving the replacement demand for tires, which constituted roughly two-thirds of the market. By 1930 more than half of the country's automobile registration was within a 500-mile radius of Akron (Gaffey [1940, p. 153], Frank [1952, p. 17], Sobel [1954, p. 13]).

According to the conventional account, Akron's head start and its geographical advantages combined to generate a self-reinforcing process based on agglomeration economies that provided a competitive advantage to the existing Akron tire firms and attracted new entrants to the region. The large scale of the Akron rubber and tire industry created benefits from the pooling of skilled labor (Knopf [1949, p. 109-10], Sobel [1954, p. 14]). Specialized input and service suppliers emerged that catered to the rubber and tire industry (Knox [1963, p. 150]). Knowledge spillovers helped turn Akron into the center of product and process innovation in the industry, including the rapid introduction of mass-production methods (Gaffey [1940, p. 153-4], Sull [2001, p. 15]). According to Allen [1949, p. 167], the Akron tire firms "did not worry too much about patents and trade secrets," but they were "virtually pooling ideas which would expand the business." The supply and transfer of local know-how was further increased by the research activities at the University of Akron's laboratory for rubber chemistry (Sull [2001, p. 15]). As a result, the productivity of Akron tire firms greatly exceeded that of companies located elsewhere. The concentrating process was reversed only when the growth of regional markets allowed for profitable branch plants to be located outside Akron and when unionization and militant labor eliminated Akron's edge in productivity (Jeszeck [1982]).

We analyze the factors that influenced where tire entrants located and the influence of location on firm survival using a newly assembled set of data on the location and background of all the entrants into the industry, with particularly detailed information on the Ohio entrants. In the empirical analysis we find that several aspects of the evolution of the U.S. tire industry are hard to reconcile with the conventional account. First, the share of new entrants locating in the Akron region was much smaller than would be expected if Akron indeed provided unique advantages to tire firms based on agglomeration economies, and it declined sharply over time. Moreover, Akron did not attract many entrants from other regions, with most of the firms that entered in Akron having ties to local firms. Second, in spite of the increasing concentration of automobile production in Detroit, few tire firms located in the Detroit region. This lack of entry in the direct neighborhood of the automobile industry is all the more surprising – at least from the perspective of the conventional account – because U.S. Rubber, the only non-Akron firm among the "Big Four" of the tire industry, was located there. Third, qualitative evidence renders some of the arguments for agglomeration economies less than compelling. For example, during its spectacular growth, the Akron tire industry went to great lengths to secure suitable labor, suggesting that the benefits of labor pooling were limited.

Most importantly, the findings of our econometric analysis of firm performance are not compatible with the conventional account. We find no evidence that firms located close to Detroit had a competitive advantage. We also find no evidence of agglomeration economies in regions with a higher concentration of tire firms or in more urbanized regions. We do find that firms located in the Akron region performed better than others, but this did not extend to firms in contiguous counties within a 30 mile radius of Akron, including firms in Cleveland, which at the time was a thriving metropolis with an active automobile industry. While it could be that agglomeration economies did not extend very far, this would not explain why Akron's share of new entrants declined while nearby areas like Cleveland increased their share of new entrants over time. Alternatively, when we control for differences in the background of firms, only the Akron entrants that descended from the leading Akron firms performed distinctly well. This suggests that it was primarily the heritage of the Akron producers that accounted for their distinctive performance. Indeed, the later exodus of the industry from Akron as the leading firms branched out into other parts of the U.S. is an indication that there may even have been disadvantages of locating in Akron.

The durable lesson from our reconsideration of the Akron tire cluster is that historical accidents can lead to agglomerations merely through a process of heredity and reproduction of indigenous firms. Klepper [2004a] draws a similar conclusion from the study of the agglomeration of the U.S. automobile industry around Detroit, indicating that the tire industry was not an isolated case. Indeed, Klepper [2004b] provides a theoretical account of the evolution of the market and geographic structure of industries that helps put the experiences of the tire and auto industries into a broader context in which heredity and reproduction are the primary forces that shape the geographic structure of industries.

The paper is organized as follows. In section II, we describe the evolution of the U.S. tire industry and its changing geography. In section III, the locational choices of entrants into the tire industry are analyzed, both at the national level and within the state of Ohio. In section IV, the performance of firms is analyzed. In section V, the implications of our findings are discussed and concluding remarks are offered.

II. Overview of the Evolution of the U.S. Tire Industry

Our analysis is based on a list of all 607 U.S. producers of automobile tires over the period 1905-1980, which was compiled primarily from annual issues of *Thomas' Register of American Manufacturers* and adjusted for ownership changes (Klepper [2002]).[2] We also identified firms that diversified into the tire industry by adding tires to their product line (Klepper [2002]).[3] For the subset of 126 firms that entered the tire industry in Ohio through 1930, we used information from trade journals, county histories, city directories, incorporation records, and various other historical sources to trace their

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[2] Few firms were in the industry prior to 1905. For firms listed in 1905 in the initial volume of *Thomas' Regis*ter, issues of *Hendrick's Commercial Register of the United States* for 1901-1904 were used to backdate their entry date according to year they were first listed in *Hendrick's*. The dataset used in this study slightly differs from the listing in *Thomas' Register* because additional information from other sources allowed a better sorting out of ownership changes and name changes for a few of the firms.

[3] Firms were classified as diversifiers if they were listed as a rubber goods producer or in the general index (available from 1915 on) in *Thomas' Register* at least two years prior to being listed as a tire producer. For

pre-entry background and geographic origin.[4] In addition to the division of entrants into diversifiers and *de novo* firms, the *de novo* entrants in Ohio were divided into spinoffs, defined as firms founded by employees of incumbent tire firms, and (other) startups. The geographic origin of the Ohio entrants was identified for diversifiers as the county where they produced just prior to producing tires, for spinoffs as the county where their parent firm (i.e., the prior employer of the founder(s) of the spinoff) was located, and for startups as the county where their founder(s) resided prior to organizing the startup.

The annual number of entrants, exiting firms, and producers is presented in Figure 1. Entry generally increased through 1922 and then fell sharply. It became negligible by 1930, after which no significant firm entered the industry. The number of firms also peaked in 1922 at 278 and then went through a long shakeout despite robust output growth interrupted only by the Great Depression. By 1940 only 51 firms were left in the industry, which declined further to a trough of 24 in 1970. The industry evolved to be a tight oligopoly dominated by the "Big Four" firms of Goodyear, Goodrich, Firestone, and U.S. Rubber (Uniroyal), which by the 1930s accounted for over 70% of the market (French [1991, p. 47]).

We restrict our analysis to the 532 firms that entered through 1930.[5] Entrants located in 33 different states, but entry was concentrated in five Midwestern and Northeastern states: Ohio, Pennsylvania, Illinois, New Jersey, and New York. These states are featured in the map in Figure 2 along with notable cities in Ohio and elsewhere. The five states collectively accounted for 32% of the U.S. population in 1900 but 64% of the tire entrants, with Ohio accounting for 24% of the entrants, New York 15%, New Jersey 11%, Pennsylvania 8%, and Illinois 6%. The Ohio firms were distinctly successful, causing the industry to be much more concentrated there than the entry figures reflect. Census data compiled in Table 1 indicate that the percentage of production in Ohio steadily rose through 1935, when it peaked at 67.1%. Much of this

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early entrants, the information from *Thomas' Register* was supplemented by *Hendricks' Commercial Register*. Additional information was obtained from historical material and French [1991].

[4] See Buenstorf and Klepper [2004] for the sources and methods used to compile this information.

[5] In addition to the small number of entrants after 1930, the post-1930 listings in *Thomas' Register* contain a number of questionable producers of tires (such as Standard Oil, which may only have distributed tires manufactured by other firms). Accordingly, we considered only the firms that entered by 1930.

output was produced by Goodyear, Goodrich, and Firestone, all of which were located in Akron, but Ohio, in particular Northeastern Ohio around Akron, also dominated the next cadre of second-tier firms. No comprehensive firm market share data are available for the first 30 years of the industry, but we used various sources to compile a ranking in Table 2 of the leading firms in the industry in the early 1920s when the number of firms peaked. Six of the next 20 firms entered in Akron, with one soon moving to Northwestern Ohio and another one eventually relocating to Western Maryland. Another four firms entered in Northeastern Ohio, and two others entered in Ohio in Dayton and Columbus. All told, nine of the top 24 firms were located in Akron, and in total Ohio accounted for 15 or 63% of the largest firms in the industry. Plant capacity figures indicate that firms other than Goodrich, Goodyear and Firestone accounted for about 32% of the total Ohio plant capacity in 1921 (39% in 1933).[6]

Consistent with the conventional account, BF Goodrich played a key role in the emergence of the Akron cluster through its influence on all the early major Akron tire producers. Goodrich was a successful producer of bicycle tires before it produced the first pneumatic automobile tire in 1896, and it quickly became a major automobile tire producer (Blackford and Kerr [1996, p. 30-32]). It also manufactured the first carriage tire based on an important patent held by the Kelly-Springfield Company, which was located near Cincinnati in the Southwestern corner of Ohio. When Kelly-Springfield itself diversified into the production of automobile tires in 1899, it established a plant in Akron and soon became a major producer there (Jackson [1988, pp. 28-29]). Diamond Rubber, another successful early Akron tire producer, was an 1894 spinoff of Goodrich that was absorbed into Goodrich in 1912. Goodyear was founded in Akron in 1898 by Frank Seiberling, the son of a successful local businessman who had been one of Goodrich's initial financial backers and whose ventures included an earlier rubber business that Frank was familiar with (O'Reilly [1983, p. 8], French [1991, p. 10]). Last, Firestone was organized in Akron in 1900 by Harvey Firestone, a native of nearby Columbiana, Ohio. He came to Akron to work for a local carriage tire producer, Whitman and Barnes, after selling a successful carriage tire sales business he had started

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[6] The plant capacity figures are based on *India Rubber Review* [1921, p. 795] and Gettell [1940, p. 92] and

in Chicago (Lief [1951, p. 3-7]). Firestone's first tires were manufactured by Goodrich, which later supplied prepared rubber and fabric for Firestone's own tire manufacturing (Blackford and Kerr [1996, p. 34]).

The conventional account stresses how the westward movement of the automobile industry and the demand for automobile tires, coupled with agglomeration economies associated with the initial Akron cluster, fueled further entry and growth in tire production in and around Akron. Figure 3 presents the annual percentage of entrants and tire producers in Ohio and various regions over the period 1905-1930. The percentage of producers in Ohio grew to over 30% in 1920, fueled by a rising share of entrants in Ohio from 1905 to 1919. After 1920 it declined for a few years as the percentage of entrants in Ohio declined, but it increased again to over 30% by 1930, reflecting the success of the Ohio producers. Figure 3 also indicates that the rise in Ohio was part of a general movement of the industry toward the Midwest. Figure 4 presents data respectively from the Census and the U.S. Federal Highway Administration on the annual shares of automobile production volume and automobile registrations in various regions from 1900 to 1930. The data indicate that, consistent with the conventional account, the rise of Ohio and the Midwest coincided with the general westward shift of the demanders for original equipment and replacement tires.

A closer look at the entry and firm patterns raises some doubts about the conventional account. Only 11 tire firms entered in the state of Michigan, and only three, including U.S. Rubber and Ford,[7] were located in Detroit, where the automobile industry and thus the original equipment demand for tires was concentrated. Perhaps this can be reconciled with the conventional account if it was only necessary to locate reasonably close to Detroit, such as 200 miles away in Akron, to exploit the advantages of proximity to the automobile producers.

The conventional account also suggests that entrants were drawn to Akron by agglomeration economies, but Figure 5 indicates that the share of Ohio entrants and

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are adjusted for the estimated capacity figures of the West Coast branch plants of the big Akron firms.

[7] Ford was one of the few automobile firms that attempted, unsuccessfully, to integrate backward into tires.

active firms in Summit County, which contains Akron, declined sharply into the 1920s.[8] Figure 5 also indicates that the share of entrants and firms in the counties contiguous to Summit County increased markedly over time. Perhaps this dispersion of entry within the Akron region can be reconciled with the conventional account if congestion costs are taken into account, which appear to have created problems in Akron regarding the availability of land for new plants, transportation, and even water supply.[9] Moreover, contemporary sources indicate that substantial movements of people, capital, and even ideas occurred between locations and counties in Northeastern Ohio and beyond.[10] The cord tire, which was a key product innovation that eventually all firms adopted, is illustrative of the flow of ideas in Northeastern Ohio. By 1920 every producer in Summit County and the contiguous counties had introduced it, whereas the adoption rate of the cord tire elsewhere in Ohio and in the other states was only about 60%.[11] This suggests that it was unnecessary to locate in Akron proper to exploit any external agglomeration benefits emanating from the Akron cluster, which along with congestions costs could explain the movement of entrants and producers away from Summit County to the contiguous counties.

The geography of entry and firm location in the tire industry thus corresponds to the broad patterns postulated by the conventional account, yet some modifications and extensions appear necessary to fully accommodate the historical record. We now turn to a statistical analysis of the location of entrants to probe the conventional account further.

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[8] Furthermore, Table 3, which reports the county of origin and entry for the Ohio entrants, indicates that a smaller percentage of firms were drawn to Summit County from other origins than were drawn to the other Ohio counties.

[9] This led some firms that entered in Akron, including Kelly-Springfield and Giant, the precursor to long-term survivor Cooper, to move out of Akron (Gaffey [1940, p. 160], Love and Giffels [1999, pp. 204-205]).

[10] Qualified workers in Ohio such as plant superintendents and managers were highly mobile and frequently switched to employers located in other counties and even other states. Similarly, we found several cases of capitalists backing the establishment of tire firms outside their own county, and also specialized providers of tire machinery and services such as factory design seem to have catered to the entire region.

[11] These figures are based on data from Klepper and Simons [2000]. The differences in the adoption rates of firms within 50 miles of Akron and elsewhere were statistically significant even after controlling for differences in firm size and age (Klepper and Simons [2000]).

III. Analysis of the Location of Entrants

We begin with an analysis of the states where entrants located and then proceed to a county-level analysis of entry in the state of Ohio. For both analyses, we use the conditional logit methodology that, beginning with Carlton [1983], has emerged as the standard econometric model for studying locational choice. For all entrants, the probability of entrant *i* locating in region *j*, p_{ij}, is modeled as:

$$p_{ij} = \frac{\exp\{x_{ij}^{'}\beta\}}{\sum_{j}\exp\{x_{ij}^{'}\beta\}},$$

where x_{ij} is a vector of characteristics of region *j* pertaining to entrant *i* and β is a vector of coefficients.

Following the theoretical discussion in Buenstorf and Klepper [2004], we expect that the two main influences on p_{ij} are the supply of potential entrants in region *j* and the inherent profitability of locating in region *j*. We consider three sources of potential entrants: preexisting firms in related industries, employees of incumbent tire firms, and individuals with commercial experiences related to tire manufacturing. Both for social and economic reasons, it is assumed to be less costly for preexisting firms to enter a new industry close to their base location and for new firms founded by either tire employees or other individuals to enter close to where their founders reside. Consequently, the supply of related preexisting firms and potential founders of new firms in a region will influence the region's share of entrants. In addition, the inherent profitability of a region will influence the opportunity cost of entering there. Accordingly, in more profitable regions we expect a larger share of potential entrants to enter in their region of origin, and also a larger number of non-indigenous potential entrants to be willing to incur the additional costs to locate there, both of which will increase p_{ij} in these regions.

The conventional account stresses the role of regional demand and agglomeration economies in the location of entrants, both of which should influence the profitability of entering in a region. The regional demand for tires is composed of the demand from automobile producers and the demand by consumers for replacement tires. We used data from the *Census of Manufactures* on the share of automobile production volume by state, denoted as $Autoprod_j$, to measure the annual demand for tires by automobile producers in each state *j* (interpolation was used for non-Census years). Data from the *U.S. Federal*

Highway Administration on the annual share of automobile registrations by state, denoted as $Autoreg_j$, were used to measure the annual demand for replacement tires in each state j. Agglomeration economies related to the local concentration of tire producers were measured by $Tire_j$, which is the share of all U.S. tire firms in state j computed from the annual listings in *Thomas' Register*. In addition to the intra-industry agglomeration effects picked up by $Tire_j$, producers are also expected to benefit from the availability of business services, transportation, and the like that depend on the degree of urbanization. To measure the degree of urbanization in each state j, data from the *Decennial Census* on the share of the U.S. population by state, denoted as Pop_j, were employed (interpolation was used for non-Census years).[12] All variables are based on the year prior to each firm's entry and are normalized to percentages of the U.S. totals so they are comparable over time.

Various variables are used to represent the regional supply of potential entrants. Spinoffs arise from incumbent firms, hence the variable $Tire_j$ will also serve as a proxy for the regional supply of potential spinoff entrants. Similarly, Pop_j will also represent the general supply of individuals available to found startups as well as urbanization effects. The supply of firms in related industries is also expected to influence the supply of potential tire entrants. The main industries related to tires were the rubber, bicycle, and carriage & wagon industries.[13] The annual listings of rubber firms in *Thomas' Register* were used to measure the annual percentage of U.S. rubber producers in each state j, which is denoted as Rub_j. Data from the *Census of Manufactures* were used to measure the percentages of U.S. carriage & wagon and bicycle producers in each state j, which are denoted respectively as Bic_j, and CW_j, with each variable interpolated for non-

[12] We also used state population density in lieu of population, but this had no effect on the estimates.

[13] Diversifying rubber firms were a sizable group among the entrants into the tire industry, whereas the link to the bicycle and carriage & wagon industries was more indirect. The first rubber tires were used on bicycles as well as carriages and wagons. Even though the technology of automobile tires was substantially different from the earlier vintages used on bicycles and carriages and wagons, we hypothesize that automobile tire producers may have grown out of earlier tire businesses (for which we have no systematic information), and consequently we expect higher entry rates in regions with a strong tradition in the bicycle and carriage & wagon industries.

Census years.[14] Because of the obsolescence of the bicycle and carriage & wagon industries, no information on bicycle producers is available after 1904 and for carriage & wagon producers after 1914. As a consequence, after these dates there is no temporal variation in the respective variables, and we use the most recent information available to account for the locational choices of later entrants.

The coefficient estimates for the initial model, which includes the variables $Autoreg_j$, $Autoprod_j$, $Tire_j$, Pop_j, Rub_j, Bic_j, and CW_j, are reported in Model 1 of Table 4. The coefficient estimates for $Autoreg_j$, and $Autoprod_j$ are both positive and significant (at the .01 and .10 levels, respectively), indicating that tire firms were more likely to locate in states where demand from consumers and automobile firms was stronger. The coefficient estimate of $Tire_j$ is positive and significant at the .01 level, indicating a tendency for tire firms to cluster. This could be due to agglomeration economies and/or the supply of potential spinoff entrants. Similarly, the coefficient estimates for Rub_j and CW_j are both positive and significant at the .01 level, suggesting that the location of the rubber and carriage & wagon industries helped shape the geography of the tire industry. Finally, the coefficient estimates for Pop_j and Bic_j are both negative, with the bicycle coefficient estimate unexpectedly significant at the .01 level. It appears that firms were not attracted to more populous states based on urbanization effects or a greater supply of potential startup entrants, and the bicycle industry does not appear to have been an important source of tire firms.

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The estimates are consistent with the emphasis in the conventional account on the importance of demand conditions and agglomeration economies associated with the regional concentration of tire producers. To probe the determinants of entry further, two additional models were estimated, with the estimates reported in Table 4. First, separate coefficients were estimated for each variable for the diversifying and *de novo* entrants, where the former represent 14% of all the entrants (Model 2). The increase in the log-likelihood is significant at the .01 level, suggesting systematic differences in the factors influencing the locational choices of the two types of entrants. The coefficient estimate of

[14] We also experimented with the number of manufacturing firms and the volume of manufacturing production by state as determinants of the supply of potential entrants, but coefficient estimates of these variables generally were insignificant and including them had little effect of the other coefficient estimates.

Rub_j is more than twice as large for the diversifiers than the *de novo* entrants. This supports the assumption that the supply of rubber producers affected the entry of diversifying firms. In contrast, $Tire_j$ and $Autoreg_j$ have larger and more significant effects on the *de novo* entrants than on the diversifiers, which suggests that agglomeration and demand factors may have been more important for *de novo* entrants than diversifiers.

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Second, in Model 3 fixed effects for each state were added to the initial specification[15] to control for unobserved state characteristics that persistently affected entry. The coefficient estimates of the two demand variables $Autoreg_j$ and $Autoprod_j$ continue to be positive and significant (both at the .01 level), consistent with the westward shift in demand causing entry to shift westward. The coefficient estimate of $Tire_j$, however, shifts sign and is negative and significant at the .05 level, which is not consistent with agglomeration economies attracting entrants as posited in the conventional account. It is also not consistent with states with more tire producers spawning more spinoff entrants. The coefficient estimate of Bic_j also shifts sign and is now positive and significant at the .05 level, whereas that of Rub_j becomes negative and marginally significant (at the .10 level). The other coefficient estimates are insignificant.

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The inclusion of the fixed effects means that the estimated effect of each variable is based only on changes in the variable over time. Some of the variables, such as Rub_j and CW_j, do not change much over time, making it difficult to estimate reliably their effects from the fixed effects model.[16] For others, the state may be too high a level of aggregation to capture changes in what the variable is intended to measure. The failure to find evidence of agglomeration economies, for example, may reflect that the share of tire producers in a state is not a good measure of changes over time in agglomeration economies. It was also conjectured that the state's share of tire producers could influence the location of spinoff entrants through the supply of potential entrepreneurs. However, we suspect that outside Ohio most of the *de novo* entrants were startups and not

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[15] We also estimated this model with the diversifiers and *de novo* entrants allowed to have separate coefficients, but this did not change the primary findings and we report the simpler estimates.

[16] As is well known, if a variable is measured with error, then measurement error will typically account for a greater fraction of its variation when expressed as a change rather than a level, which typically biases the coefficient estimate of the variable toward zero.

spinoffs,[17] and since only the location of spinoff entrants would be expected to vary with changes in a state's share of tire producers, this effect may not be picked up very well in the fixed effects specification.

An alternative way to test for the influence of agglomeration economies on the location of entrants is through the county data on the origin and location of the Ohio entrants, which are analyzed in Buenstorf and Klepper [2004]. There are 88 counties in Ohio, and the county seems more appropriate than the state as a unit of analysis to measure agglomeration economies. Furthermore, as Figure 5 makes clear, there was a substantial shift over time in the locus of Ohio producers at the county level. Hence the county share of tire producers might provide a better measure of changes over time in the incidence of agglomeration economies than the state share of tire producers. Another advantage of the Ohio county data is that they not only distinguish between diversifiers and *de novo* entrants, but also distinguish among the *de novo* entrants between spinoffs and startups. This provides a more precise way to tease apart the importance of agglomeration economies from influences operating through the supply of potential entrants. The relevance of the distinction is indicated by Table 3, which shows how different the composition of entrants in Summit County was from entrants elsewhere in Ohio. In Summit County diversifiers and spinoffs accounted for a much greater fraction of entrants than elsewhere in Ohio, and over time its share of the various types of entrants varied considerably.

We use the county data to analyze the county of origin of entrants, which Buenstorf and Klepper [2004] analyze in greater detail. We then briefly report their findings on the locations of entrants given their origins and on the rate at which firms spawned spinoffs. The only proxy we can compute for the demand for tires at the county level is the percentage of Ohio automobile firms in the county, denoted as $Autoest_j$, which we measured based on data from Klepper [2002]. Given that few tire firms entered in Michigan, though, it seems doubtful that being close to automobile firms *within* Ohio provided much of a competitive advantage, so that demand factors are not likely to play

[17] As discussed further below, the spinoffs in Ohio descended primarily from the leading Akron firms and the next tier of leading firms in Ohio. Apart from Michigan, which had U.S. Rubber, no other state had any

much of a role anyway in the locational choices of Ohio entrants. We also were not able to get measures of the number of bicycle and carriage & wagon firms at the county level, but given the inconsistent role these variables played in the national analysis, we doubt this omission is serious. Our analysis thus focuses on the role of four variables on the origin of entrants: $Autoest_j$ and the fraction of tire firms, rubber firms, and population in each county, which we continue to denote respectively as $Tire_j$, Rub_j, and Pop_j.[18]

As in the national analysis, we initially estimate a model in which the four explanatory variables are constrained to have the same effect for each type of entrant. The coefficient estimates of this model, reported as Model 4 in Table 5, are positive and significant at the .01 level for Pop_j, Rub_j, and $Tire_j$ whereas the coefficient estimate of $Autoest_j$ is negative and insignificant. As expected, the location of the automobile producers within Ohio did not influence where entrants originated. In contrast, entrants were more likely to originate in counties that were more populous and had a greater number of rubber and tire firms.

We anticipate that Rub_j primarily affected the origination of diversifiers through its influence on the supply of potential diversifying entrants. If $Tire_j$ and Pop_j similarly operated through their influence on the supply of potential entrants then they would be expected to affect primarily the spinoffs and startups respectively. To test these conjectures, we next estimated a model in which each variable was allowed to have a separate coefficient for each of the three types of entrants (Model 5 in Table 5). The change in the log-likelihood is significant at the .01 level, implying that the coefficients varied across the three types of entrants. The coefficient estimates of $Autoest_j$ are all insignificant, confirming that local automobile demand did not affect any of the types of entrants. The coefficient estimates of the other three variables are consistent with each operating primarily through its influence on the supply of potential entrants. The coefficient estimate of Pop_j is positive and significant (at the .01 level) only for the startups, the coefficient estimate of Rub_j is positive and significant (at the .05 level) only

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firms comparable to the leading Akron firms and few comparable to the next tier of Ohio firms. Consequently, it seems likely that *de novo* entrants in all but Ohio were largely startups.

[18] County shares of manufacturers and manufacturing volume were also constructed using data for 1899, which was the only year for which such data were available. These variables had no effect on the location of entrants and were not included in the reported analyses.

for the diversifiers, and the coefficient estimate of $Tire_j$ is positive and significant (at the .01 level) for both spinoffs and startups, with the former coefficient nearly twice that of the latter.

As in the national entry analysis, we estimated one more model in which county fixed effects were added (Model 6 in Table 5). To maintain the precision of the estimates, we dropped all effects that were insignificant in the prior specification. The expected primary effects of the supply of entrepreneurship—the effects of Rub_j on diversifiers, $Tire_j$ on spinoffs, and Pop_j on startups—remain positive and significant for all three variables, now all at the .01 level. The effect of $Tire_j$ on the startups is also positive and significant, now at the .10 level, but is only one-third as large as the effect of $Tire_j$ on the spinoffs.[19] Thus, these estimates provide further support for the influence of each variable operating primarily through the supply of entrepreneurs.

To probe further the influence of $Tire_j$ on the entry of spinoffs, Buenstorf and Klepper [2004] estimated an ordered logit model of the factors influencing the annual rate at which the Ohio firms spawned spinoffs. Table 6 lists the Ohio spinoffs according to their parent firm. Consistent with Table 6, Buenstorf and Klepper [2004] found that the leading Akron firms had the highest rate of spinoffs, followed by the second tier of leading Ohio companies, with both patterns statistically significant. The larger number of spinoffs spawned by the leading firms may simply reflect that they had a greater number of employees to start spinoffs. Alternatively, the leading firms may also have provided their employees with a superior environment to learn about organizational best practices that they could apply to their own firms. As will emerge from the performance analysis below, the spinoffs from the leading firms performed better than the other spinoffs, suggesting that the higher spinoff rates of the leading firms were not merely caused by their greater size.

[19] To put these estimates in perspective, if the share of tire producers, rubber producers, and population in each county was 1.1% then the probability of any kind of entrant originating in each county would be .011. If one county's share of tire firms increased from 1.1% to 50%, with the other counties each suffering a decline in their share to 0.57%, the estimates imply that the probability of a spinoff entrant originating in the county would rise to .30, whereas the probability of a startup entrant originating in the county would only rise to .03.

Eliminato: 4

Eliminato: 4

In summary, it appears that the main influence on where firms originated in Ohio was the supply of potential entrants. The only unequivocal indicator of an influence of agglomeration economies was on the origin of the startups, and this effect was relatively modest. The findings of Buenstorf and Klepper [2004] regarding where the Ohio firms entered reinforce these inferences. The most important determinant of the county of entry was the county of origin, reflecting that a majority of firms entered in the same county as where they originated (see Table 3). There was no evidence that the decision to enter in the county of origin was influenced by county characteristics. In contrast, among the firms that did not locate in their county of origin, startups and diversifiers (which were pooled) had a modest tendency to move to counties with a greater share of tire producers whereas spinoffs did not. This result is again suggestive of a modest effect of agglomeration economies on the startups.

To put all of these findings into perspective for the Akron cluster, recall that of all firms entering in Ohio, Summit County accounted for a much greater share of diversifiers and spinoffs than startups. This can be explained statistically based on the Ohio entry analysis by the fact that Summit County had a high percentage of the Ohio rubber producers and also tire firms from the outset of the industry, whereas it was not a populous county. Summit County also did not attract many entrants that originated elsewhere. Table 3 indicates that more indigenous spinoffs moved away than diversifiers and startups moved into Summit County, making it a net exporter of firms. Overall, the bulk of the firms in Summit County were indigenous entrants related to local rubber and tire producers.

Thus, the evidence so far provides limited support for the conventional account of the Akron tire cluster. The westward shift of the automobile industry and consumers of automobiles appears to have contributed to the westward shift of the tire industry, favoring Ohio and other Midwestern states. Akron possessed BF Goodrich, which seems to have been instrumental in the initial success of the tire industry in Akron. But Goodrich and the other early successful Akron firms apparently were more important as sources of new indigenous firms than as attractors of firms from other places, with numerous spinoffs descended from them. The lack of firms moving to Akron does not rule out, however, that the Akron cluster generated substantial external agglomeration economies. Perhaps the high rate of indigenous entry, possibly coupled with congestion costs, crowded out entrants that originated elsewhere. If so, the high rate of creation of firms in the Akron area may have sustained the Akron cluster even without attracting entrants from outside. This possibility suggests a modified version of the conventional account in which agglomeration economies operated primarily through the performance of firms rather than through attracting entrants. We now turn to the survival experiences of the firms to judge whether this modified version of the conventional account is supported by the historical evidence.

IV. Location and the Performance of Firms in the U.S. Tire Industry

The years of survival of all the tire entrants provide us with a measure of their competitive performance. The leading firms in the industry tended to survive the longest, suggesting survival was a good measure of performance in tires. Accordingly, we probe how location affected firm performance by testing how location conditioned the hazard of firm exit for the tire firms that entered through 1930.[20]

Following Klepper [2002], we estimate a Gompertz model for the hazard of firm exit at age τ, $h(\tau)$:

$$h(\tau) = \exp[\beta_0 + \beta' z] \cdot \exp[(\gamma_0 + \gamma' x)\tau],$$

where z is a vector of covariates that shift the hazard proportionally at all ages, x is a vector of covariates that condition how age affects the hazard, β_0 and γ_0 are scalar coefficients, and β and γ are vectors of coefficients. The Gompertz specification allows variables such as the time of entry and pre-entry experience to affect the hazard differently at different ages, which accords with Klepper's [2002] theory and findings for tires. Firms that exited because they were acquired by another tire firm are treated as censored exits.[21]

We begin by exploring how the hazard is related to agglomeration economies. Our main measure of agglomeration economies, denoted as $Othtire_j$, is the fraction of

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[20] We also experimented with including all the firms in our analyses, but this had little effect on our results.
[21] The first year of observation is 1905, and firms that entered earlier are assigned an age in 1905 based on their backdated entry year (see note 2), which addresses left truncation of the data.

active tire firms located in the same county *j* as the focal firm.[22] It is based on the listing of tire firms from *Thomas' Register*. We also experimented with the share of the U.S. population in county *j* and the population density of county *j* as measures of urbanization economies, but neither of these variables lowered the hazard and thus they were not included in the analysis. $Othtire_j$ was included in the vector of variables z, which constrained it to shift the hazard proportionally at all ages. The coefficient estimate of $Othtire_j$, which is reported as Model 7 in Table 7, is negative and significant at the .05 level, implying that firms located in counties with a greater share of tire firms had lower hazards. This is consistent with the (modified version of the) conventional account and suggests that firms in counties with a greater share of tire producers may have benefited from agglomeration economies.

To probe the breadth of the potential agglomeration economies, we added to the vector of variables *z* a dummy variable, denoted as *Akron*, equal to 1 for firms located in Summit County (Model 8 in Table 7). The coefficient estimate of *Akron* is negative and significant, and implies that firms in Summit County had a 62% lower annual hazard at all ages. In contrast, the coefficient estimate of $Othtire_j$ is now trivial and insignificant, suggesting that any potential agglomeration benefits were restricted to firms located in Summit County. To probe this further, another dummy variable, denoted as *NEOhio*, which equals 1 for the counties contiguous to Summit, was added to the vector of variables *z* to test if firms in these counties also benefited from any agglomeration economies associated with the Akron tire cluster, as conjectured earlier (Model 9 in Table 7). The coefficient estimate of *NEOhio* is positive but insignificant, whereas the coefficient estimate of *Akron* remains negative and significant. Apparently the lower hazard of firms in Summit County was not shared by firms in the contiguous counties. This is puzzling if indeed agglomeration economies emanating from the Akron cluster were significant.

Another puzzle regarding the location of entrants was the paucity of firms that entered in Detroit, where the automobile industry was concentrated. We reconciled this with the conventional account by conjecturing that firms could be located as far from

[22] We also experimented with measuring this as the number of other firms in the county, but this had a

Detroit as Akron and still gain the main benefits of proximity to the automobile producers. To test whether proximity to Detroit provided firms with a competitive advantage, we estimated a model containing two variables in the vector *z*, the dummy *Akron* and a second dummy, denoted as *Detroit*, which equals 1 for all firms located in Michigan or in counties in Ohio and Indiana at least as close to Detroit as Akron (Model 10 in Table 7). The coefficient estimate of this variable is trivial and insignificant while the coefficient estimate of *Akron* is only slightly reduced. Perhaps regional entry was sufficient to eliminate any excess returns from locating near the great concentration of automobile producers in Detroit. Whatever the reason, proximity to Detroit and the concentration of automobile producers there does not appear to have contributed to the superior performance of the Akron firms.

Given these puzzling results, we next test a somewhat radical variant of the conventional account. In the early years of the tire industry, it may have been especially beneficial to locate close to other tire firms because specialized markets for labor and technology pertaining to tires were not yet well developed. Consequently, the benefits of locating in the Akron cluster may have been experienced primarily by the early Akron entrants, particularly the early successful firms associated with BF Goodrich. To test this, we constructed a new Akron dummy, denoted as *Akronini*, equal to 1 for all the firms located in Akron except Goodrich and the four early entrants associated with it (hereafter referred to as the non-initial entrants), and used this alone in place of *Akron* (Model 11 in Table 7). The coefficient estimate of *Akronini* is smaller absolutely than the coefficient estimate of *Akron*, as is to be expected, but it is still negative, sizeable, and significant at the .01 level. Apparently later as well as the initial entrants into the Akron cluster performed distinctively well.

Another possible explanation for the superior performance of the Akron firms, which has nothing to do with the conventional account, is that the Akron firms were disproportionately early entrants and diversifiers, both of which Klepper [2002] predicted and found contributed to longer survival in the tire industry. To control for time of entry, we follow Klepper [2002] in dividing the entrants into four cohorts spanning the years

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weaker and insignificant effect on the hazard than $Othtire_j$.

1905-1909, 1910-1915, 1916-1920, and 1921-1930, where the cohorts are defined to balance the number of long-term survivors. Let *S1*, *S2*, and *S3* denote dummy variables equal to 1 respectively for each of the first three cohorts (the fourth cohort is the omitted control group). We include these dummies in both the vector of variables *z* and *x* to allow them to have different effects on the hazard at young and older ages, as predicted in Klepper [2002]. We also include a dummy variable in *z*, denoted as *Highex*, for the firm-year observations in the period 1922-1932, which was a period of markedly higher exit rates for all tire firms (cf. Klepper [2002]). To control for diversifiers, we construct a dummy variable, denoted as *Divers*, equal to 1 for preexisting entrants. We include it in both *z* and *x* to allow differences in the hazards of diversifiers and *de novo* firms to decline with age, as predicted in Klepper [2002].[23]

The coefficient estimates of this model (Model 12 in Table 8) conform with the estimates in Klepper [2002]. They indicate that earlier entrants did have lower hazard rates, particularly at older ages, as reflected by the negative and significant coefficient estimates for *S1*, *S2*, and *S3* in the vector of variables *x*.[24] The positive and significant coefficient estimate of *Highex* reflects the higher hazard rate of all firms in the period 1922-1932. The negative and significant coefficient estimate of *Divers* in the *z* vector of covariates indicates that diversifiers had lower hazards at young ages. The coefficient estimate of *Divers* in the *x* vector is positive and significant, implying that the difference between the hazards of diversifiers and other entrants declines with age, as predicted. The controls for time of entry and diversifiers do not have much impact on the coefficient estimate of *Akronini*, though, which continues to be negative and significant at the .01 level. Thus, it appears that the lower hazard of the non-initial entrants did not stem from their early entry or prior background as producers of related products.

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[23] Klepper [2002] further interacted *Divers* with each of the entry cohorts based on his model. We experimented similarly, but this had little effect on the estimates.

[24] The coefficient estimates of *S1*, *S2*, and *S3* in the *z* vector indicate the effects of early entry on the hazard at age 0 whereas the coefficient estimates of *S1*, *S2*, and *S3* in the *x* vector indicate how the time of entry conditions the effect of age on the hazard. The estimates imply that at young ages, the hazard of the earliest cohort of entrants was significantly higher than all the later entry cohorts whereas the hazard of the next two entry cohorts was not significantly different from the last. In contrast, the negative coefficient estimates for *S1*, *S2*, and *S3* in the *x* vector (two of which are significant at the .01 and .05 levels) imply that at older ages, the hazards of each of the first three entry cohorts were lower than the fourth, with the first

We consider an alternative explanation for the superior performance of the Akron firms based on their distinctive heritage rather than on their location. We noted earlier that the leading Akron firms spawned the most spinoffs, which contributed to the disproportionate entry of spinoffs in Summit County. It turns out that among the non-initial entrants, all 13 of the spinoffs that entered in Summit County were descended from the Akron leaders in that their founders at one point worked for the Akron leaders. In contrast, this was true for only nine of the 30 spinoffs that entered outside Summit County. In the automobile industry, the spinoffs that descended from the leading automobile producers were superior performers (Klepper [2004a]). If the same were true in tires, this could account for the superior performance of the Akron entrants. To test this, we added to the vector *z* a dummy variable, denoted as *Akroninisp*, which interacts *Akronini* with a dummy variable equal to 1 for spinoffs (Model 13 in Table 8). The coefficient estimate of *Akroninisp* is negative and significant at the .01 level, implying that Akron spinoffs were superior performers. More importantly, the coefficient estimate of *Akronini* is now close to zero and insignificant, suggesting that it was only the spinoffs that performed distinctively well in Akron.

If the distinctive performance of the Akron spinoffs was due to their heritage, we expect heritage to condition the performance all the spinoffs in Ohio. We can distinguish four groups of spinoffs: those directly descended from the leading firms, those indirectly descended from the leaders (i.e., spinoffs of other firms whose founders had previously worked for one of the leading firms), those descended from the second tier of (Ohio) firms itemized in Table 2, and the remaining (Ohio) spinoffs. We expect direct spinoffs from the leading firms to outperform indirect ones, and we expect both the indirect spinoffs of the leading firms and the spinoffs from the second tier of leading firms to outperform the other spinoffs.[25] To test this conjecture, we replace *Akroninisp* with four variables, denoted as *Topspin*, *Indtopspin*, *Tier2spin*, and *Notopspin*, to account for the heritage of spinoffs (Model 14 in Table 8). *Topspin* equals 1 for Ohio spinoffs whose

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entry cohort having a particularly lower hazard than all the others at older ages. In part, this reflects the notable longevity of the big four firms, all of which were in the first entry cohort.

[25] We were unsure a priori how to order the performance of the indirect spinoffs of the leading firms and the spinoffs of the second tier of leading firms. The two groups are not mutually exclusive, with some of the indirect spinoffs also being direct spinoffs of second-tier firms.

founders worked for Goodrich, Goodyear, Firestone or Diamond Rubber before starting their own firms, *Indtopspin* equals 1 for indirect spinoffs of these firms, *Tier2spin* equals 1 for spinoffs from second-tier firms, and *Notopspin* equals 1 for the remaining Ohio spinoffs. We experimented with allowing all four spinoff variables to affect the hazard through both z and x, but only the proportional effects on the hazard at all ages operating through z were nontrivial and these are the only estimates we present (the others were similar).

The coefficient estimates of Model 14 indicate substantial differences in the performance of the four groups of spinoffs that accord with our expectations. The coefficient estimate of *Topspins* is negative and significant at the .05 level and implies that spinoffs of the top firms had a 56% lower annual hazard than startups in Ohio and *de novo* entrants elsewhere. The coefficient estimate of *Tier2spin* is also negative, and although it is not significant it indicates a 40% lower annual hazard for spinoffs from the second tier of firms. Similarly, the coefficient estimate of *Indtopspin* is negative and although insignificant it implies a 31% lower hazard for the indirect spinoffs. In contrast, the coefficient estimate of *Notopspin* is trivially positive, implying that Ohio spinoffs did not have lower hazards unless they descended from the top firms. The coefficient estimate of *Akronini* is approximately 55% less than before the addition of controls for the spinoffs and is no longer significant. These findings are consistent with the superior performance of the Akron spinoffs being attributable to their superior heritage.

The fact that the coefficient estimate of *Akronini* is still negative and nontrivial reflects that most of the direct and indirect spinoffs of the leading firms that were located outside Akron (hereafter referred to as non-Akron top spinoffs) performed poorly. This pulled down the coefficient estimates of *Topspins* and *Indtopspin*, leaving some of the Akron effect unexplained. Table 6 reports the longevity of the individual spinoffs, and it vividly conveys the difference in the performance of the Akron and non-Akron top spinoffs. There were 13 spinoffs among the Akron firms that were not among the initial entrants, and all of them descended either directly or indirectly from the four leading firms. Six out of the 13 spinoffs survived 20 or more years, with two surviving over 60 years to the end of the sample period in 1980. In contrast, among the nine non-Akron top spinoffs, one survived 61 years to the end of the sample period whereas all the others survived less than ten years. Except for the lone long-term survivor, this record was similar to the other 21 non-Akron spinoffs, whose longest-lived member survived 12 years.

The poor performance of the non-Akron top spinoffs suggests the possibility of agglomeration economies that were accessible only to spinoffs descended from the leading firms that themselves were located in Akron, which would be yet a further variant of the conventional account. Agglomeration economies are typically associated with technological spillovers, access to suppliers, and the market for specialized labor. Conceivably the Akron spinoffs might have had superior access to technological developments in the leading firms, who dominated tire innovation (Warner [1966]). They may also have had superior knowledge about specialized Akron suppliers that serviced the leading firms but were also willing to supply other firms as well. Last, the Akron firms may have superior knowledge about and access to the top managerial talent at the leading firms, enabling them to hire top managers better matched to their needs than the non-Akron top spinoffs.

We suspect that all three of these factors played little if any role in the superior performance of the Akron spinoffs. Regarding access to the technological developments in the leaders, the experience of the cord tire discussed earlier and its cousin the balloon tire is telling. The cord was pioneered by Goodrich and Goodyear, and as of 1917 only eight firms produced the cord. But three years later when about two-thirds of tire firms produced the cord, all the firms in Akron and the contiguous counties, regardless of their background, produced the cord. The balloon tire, which was the next great tire innovation, was introduced by Firestone in 1923. Seven of the 21 earliest adopters of the balloon tire were located in Ohio, including Firestone, Goodyear, Goodrich and four other Akron firms, only two of which were spinoffs.[26] It also seems doubtful that access to specialized Akron suppliers provided the Akron spinoffs much of a competitive advantage. Akron was not a prominent center for tire machinery, accounting for less than 10% of the firms listed in *Thomas' Register* as producers of calenders, vulcanizers, and

[26] These figures are based on the data compiled in Klepper and Simons [2000].

tire machinery between 1905 and 1930.[27] Last, the leading Akron spinoffs did hire a number of managers from the leading firms, but so did some of the non-Akron top spinoffs,[28] and we suspect the causality was reversed, with less well qualified firms at founding less prone and/or able to hire managers from the top firms.

Indeed, the Akron spinoffs generally seemed much more like blue chip startups than the non-Akron top spinoffs. The Akron spinoffs tended to be founded by well-known individuals in the industry[29] whereas the founders of the non-Akron spinoffs generally were more obscure.[30] Several of the non-Akron spinoffs were started for reasons that add to our perception of them as lesser firms from the outset.[31] While our knowledge of why firms do not locate where they originated is limited, we suspect that the spinoffs descended from the leading firms that located outside of Akron were an unrepresentative group that resembled the spinoffs of lesser firms and startup entrants more than the distinctive spinoffs that entered in Akron. Finally, the very fact that so many of the spinoffs descended from the leading firms entered outside Akron may itself indicate that agglomeration economies were not a key driver of locational choice. After all, if it were advantageous for these firms to locate in Akron, why would nine of the 22

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[27] Note that Ohio did have 55 tire machinery suppliers, reflecting that they were dispersed throughout Ohio, but major suppliers such as the Birmingham Iron Foundry, developer of the Banbury Mixer, and Thropp were located outside of Ohio in the traditional centers of the rubber industry, New England and New Jersey.

[28] For example, Seiberling Tire and Rubber of Barberton (Summit County) hired away a number of top-level employees from its parent firm, Goodyear. Among the first employees of General Tire of Akron was Charley Jahant, who had been Firestone's tire production superintendent. Similarly, the sales manager of Denman & Myers of Cleveland, C.L. Mason, had previously been a district sales manager for Firestone.

[29] Five of the most successful Akron spinoffs are illustrative. Seiberling Tire and Rubber was founded by Goodyear founder Frank Seiberling after he had lost control of Goodyear. Swinehart Clincher Tire was founded by James Swinehart, who had developed Firestone's original solid tire design. Falls Rubber was organized by William Sherbondy, the founder of Diamond Rubber. Mohawk Rubber was founded by Samuel Miller, who after leaving Goodyear had been the local manager of Kelly-Springfield. Finally, the founders of Marathon Tire and Rubber, Walter Ridge and Walter Jenks, had been manager and chief engineer, respectively, of Firestone's pneumatic tire department.

[30] The founders of Standard Tire and Rubber and Denman & Myers in Cleveland are illustrative. Mark Gillen, who founded Standard, had been a timekeeper with Goodrich, and Walter Denman, who co-founded Denman & Myers, had been a draftsman at Diamond. Our sources were not informative about the positions previously held at the leading Akron firms by a number of the other founders, suggesting they similarly had not held prominent positions.

[31] Three cases are illustrative. Oldfield Tire and Rubber in Cleveland, co-founded by renowned car racer Barney Oldfield, specialized in racing tires. McWade Tire and Rubber in Garrettsville was started on the basis of an inner tube design developed by its founder. Standard Tire of Willoughby was formed to take over the vacant plant of a bankrupt tire firm.

locate outside of Summit County, particularly the six whose founders were already in Akron?[32] We suspect there were no such advantages, and it was the idiosyncratic circumstances surrounding their founding that drew these firms away from Akron.[33]

V. Discussion

The tire industry went through a distinctive evolution regarding its market structure and geography. Over roughly the first 30 years of the industry into the early 1920s, the number of firms increased steadily. Despite continued growth in the market, entry dried up afterwards and the number of producers went through a long and pronounced decline. Early entrants were more likely to survive the shakeout, and four of the earliest entrants, Goodrich, Goodyear, Firestone, and U.S. Rubber, ultimately dominated the industry with a joint market share of over 70%. With Goodrich, Goodyear, and Firestone all located in Akron, the industry was concentrated there from the outset. Subsequently, firms that entered in and around Akron were distinctly successful and the share of production in Ohio steadily rose, reaching a peak of 67.1% in 1935 (Table 1). Although the fraction of firms based in Ohio continued to increase thereafter,[34] the share of production in Ohio steadily declined as the leading Ohio-based firms increasingly established branch plants throughout the United States (Jeszeck [1982]). By 1939, the share of production in Ohio had declined to 46.1% (Table 1). It remained steady at 30-35% of the national output from the post-WWII period into the 1960s. Subsequently, the advent of the radial tire dealt another blow to the U.S. tire industry and its traditional center, and by 1992 Ohio's share of U.S. tire shipments had declined to a mere 3.8% (Census of Manufactures [1992, p. 30A-9]).

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[32] Four of the nine non-Akron spinoffs descended from the Akron leaders were direct descendants of the Akron leaders and thus their founders were already in Akron. This was also true of two of the other five spinoffs, whose founders were working for Akron firms prior to founding their firms. Indeed, founders of two of the other three spinoffs were working for firms outside of Ohio and so they too could have easily located in Akron as in their nearby locations.

[33] The founders or cofounders of three of the spinoffs were located outside of Akron before their spinoffs were founded, three of the spinoffs exploited vacant plants that were located outside of Akron, and one of the spinoffs located outside of Akron to avoid a scandal involving one of its founders. The impetus for the other two spinoffs locating outside of Akron is unknown.

[34] Our data from *Thomas' Register* indicate the base location of each tire producer. Among the firms that entered by 1930, the share of survivors based in Ohio increased from 30% in 1930 to over 61% by 1977.

Our analysis focused on the rise of the Akron cluster and the role played by the mechanisms featured in the conventional account of the cluster. According to the conventional account the early leaders of the tire industry clustered in Akron due to historical accident. Akron was well positioned to service the demand for tires, which was moving westward with the westward shift in the automobile industry and demanders of cars. External agglomeration economies created by the initial nucleus of firms in Akron encouraged further entry in Akron and enhanced the performance of the Akron producers, contributing to a self-reinforcing process. Although not featured, congestion costs may have ultimately limited the growth of the Akron cluster. The conventional account does not address the evolution of the market structure of the industry, but scale economies could explain why the industry evolved to be an oligopoly. Together, these mechanisms provide all the ingredients of modern theories of agglomeration.

We used the conventional account to organize our analysis of newly assembled data on tire producers, and it helped explain certain aspects of the evolution of the tire industry. There is no doubt that an initial nucleus of successful producers arose in Akron, fueled by the earlier success of BF Goodrich. The results of the national entry analysis confirm that the location of demanders influenced where firms entered, and Akron was favored by the shifting demand for original equipment and replacement tires from the Northeast to the Midwest. However, we did not find that proximity to Detroit, the center of the automobile industry, influenced the performance of firms. Conceivably this could have been the result of an equilibrating process in which entry drove out excess regional returns. Few firms entered in or near Detroit, though, which is surprising given the influence of the automobile industry on the location of entrants and the ideal position of Detroit to service both the original equipment and the replacement markets.

The evidence regarding the influence of agglomeration economies on entry and firm performance was more equivocal vis-à-vis the conventional account. The national entry analysis indicated that entrants congregated where rubber firms and incumbent tire firms were located. The influence of the rubber firms was greater for diversifying entrants, suggesting it operated by influencing the supply of potential entrants. The presence of the tire firms could have similarly operated through the supply of potential spinoff entrants, which is consistent with the finding that tire firms had a greater influence on the entry of *de novo* firms than diversifiers. Alternatively, entrants could have been attracted to states with more tire firms because of agglomeration economies, as posited by the conventional account. Yet another possibility suggested by the fixed effects estimates is that unobserved state characteristics could have caused entrants to cluster in certain states, although no candidates for the unobserved characteristics are readily apparent.

More discriminating evidence on the role of agglomeration economies is provided by the locations of entrants within the state of Ohio. Akron and Summit County attracted few entrants from other locations, and over time entry into the tire industry spread from Summit County to the contiguous counties. This pattern can be squared with the conventional account if increasing congestion limited entry opportunities in Akron and agglomeration benefits extended to firms in the contiguous counties. Qualitative evidence supports both of these conjectures. However, our statistical analysis indicated that firms in the contiguous counties performed worse than the firms in Summit County and no better than firms elsewhere, which would seem to run counter to the notion of agglomeration economies extending beyond the limits of Summit County. Again it is conceivable that the lesser performance of firms in the contiguous counties was due to an equilibrating process in which entry drove out excess local returns. However, this would require some kind of barrier to entry in the Akron area, perhaps related to congestion there, to explain the superior performance of the firms in Summit County.

Another possibility that is consistent with the general thrust of the conventional account is that entry in Akron and nearby counties may have been inherently limited by the local supply of potential entrants. Nonetheless, indigenous entry in Akron related to the large number of local rubber and incumbent tire producers may have been sufficient to fuel continued entry in Akron regardless of the attractive power agglomeration economies had on new entrants. If agglomeration economies narrowly extended only as far as the limits of Summit County, they could have fostered the growth of the Akron cluster without enhancing the performance of firms in the contiguous counties. Even though the survival analysis did not suggest a general performance effect of agglomeration, it is possible that clustering conferred benefits only if it exceeded a threshold that only Akron attained. However, after controlling for time of entry and whether firms were diversifiers, the evidence indicated that the superior performance of the Akron firms was confined to the spinoffs that entered in Akron. If agglomeration economies were important in Akron, it is unclear why they would not have benefited all types of firms. Again, perhaps an equilibrating process was at work in which entry drove out excess returns to diversifiers and startups, although it is unclear why a similar process would not have driven down the returns to spinoffs.

Thus, while the conventional account accords with many aspects of the evolution of the tire industry, accommodations are necessary to explain the entirety of the historical record. In contrast, our finding that the performance of tire firms located in Akron strongly depended on their background suggests an alternative explanation of the Akron tire cluster that emphasizes the importance of organizational inheritance and reproduction. The leading tire firms disproportionately spawned spinoffs, and the performance of spinoffs was related to the performance of their parents. Coupled with the fact that spinoffs tended to locate close to their parents, this led to a buildup of superior firms around the leading firms in the industry. With the early leaders of the industry concentrated in Akron, even without any agglomeration economies the industry was destined to become agglomerated around Akron. This process can be readily appended to Klepper's [2002] model of shakeouts (cf. Klepper [2004b]), thus enabling the alternative theory to address the evolution of the market structure of the tire industry as well as the rise of the Akron cluster.

The alternative explanation for the rise of the Akron cluster helps put a number of our findings in perspective. Starting from the early set of Akron firms associated with Goodrich, spinoffs disproportionately originated and entered in Summit County. The spinoffs in Akron were superior performers because they descended from the leading firms in the industry, and their performance alone can account for the superior performance of the Akron producers. Some of the spinoffs that originated in Akron located elsewhere, but these firms did not perform as well as those that stayed in Summit County. We suggested above that their lesser performance reflects a different impetus for their formation, which is consistent with observable differences in both the founders' backgrounds and the firms' hiring of top-level employees from leading incumbent firms. Alternatively, their lesser performance could be due to agglomeration economies accessible only to descendents of the leading firms that located in Akron. However, the historical record suggests that the likely sources of agglomeration economies were of limited importance in explaining the superior performance of the Akron spinoffs.

Over time, the Akron cluster spread out over Northeastern Ohio into the contiguous counties to Summit. Among these counties was the populous Cuyahoga County containing Cleveland, which was the source of numerous startups that entered there or nearby. As the population of tire firms spread to the contiguous counties, spinoffs naturally occurred at a broader range of sites, contributing to a further rise in entrants and producers in the contiguous counties. Consequently, the share of Ohio producers declined in Akron and rose in the contiguous counties, but the entrants in the contiguous counties were mostly startups and spinoffs from lesser firms and hence did not perform any better than firms in the rest of the country.

The failure of Michigan and Detroit to develop a presence in the tire industry can also be explained by the alternative theory. Michigan had few rubber firms to begin with that could have diversified into tires.[35] Apart from having one of the plants of U.S. Rubber, it did not have any leading producers to spawn spinoffs. And even U.S. Rubber was an unlikely source of spinoffs. The Detroit plant was originally located in Chicago and moved to Detroit only in 1906. Moreover, U.S. Rubber was not particularly successful in the early years of the tire industry, reflecting its failure to integrate the various plants it acquired to enter the tire industry (Babcock [1966]). So despite the inherent advantages of locating in Detroit, without diversifiers or suitable parents the tire industry never got started in Michigan.

Finally, the ultimate decline of the Akron cluster is also readily explained by the alternative theory. A key to the cluster was that entrants set up their initial location, which generally was where they remained based, near their roots. With so many firms having roots in the Akron area, firms clustered near Akron, which was hardly ideal for servicing distant markets. Branching did not require firms to move their base location, and so it was inevitable that the leading firms would eventually set up branch plants to reduce their transportation costs given the small minimum efficient size of tire plants

(Reynolds [1938]). Not surprisingly, the first branch plants were established in the distant California market (Knopf [1949]). The subsequent escalation of labor costs in Akron due to the formation of the United Rubber Workers Union in the 1930s could readily explain the exodus of the industry's production activities from Akron (Sobel [1954]). Despite this exodus, the leading firms remained based in Akron for many years. Apparently this is characteristic of agglomerations in manufacturing industries, which are sustained by the longevity of plants in agglomerated regions but are ultimately undermined by the establishment and expansion of branch plants elsewhere (Dumais et al. [2002]).

One limitation of the alternative theory is that it has no role for demand and as a result cannot explain the attraction of entrants to regions with a greater volume of auto production and registrations.[36] To be sure, in the long run the location of entrants did not have much impact on where tire firms were based, as eventually the leading Akron firms plus U.S. Rubber took over most of the industry. But in the short run, regional demand apparently created opportunities for entry, possibly because of costs to the leaders of expanding into more distant markets. The leaders did eventually expand into some of these markets through their branches, though, so in the long run demand did influence the location of production even if it did not influence the base location of the producers.

The alternative theory posited a hereditary process whose theoretical basis needs to be explored in more detail. No theory was offered for why spinoffs occur in the first place, nor was a theory articulated about the mechanisms that link the performance of parents and their spinoffs. Various efforts have been made to address these questions in the context of other industries (see Klepper and Sleeper [2000], Klepper [2003]), but these are tentative beginnings. The evolution of the geographic and market structures of the tire industry bears an uncanny resemblance to the automobile industry (Klepper [2004a]), suggesting tires is not an isolated case, but that too needs to be investigated further. The policy implications of the alternative theory are quite different from the conventional account and modern theories of geography, but it is not worth dwelling on

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[35] According to the 1899 *Census of Manufactures*, Michigan accounted for only .09% of U.S. rubber and elastic goods production as of 1899.

these differences until the alternative theory is developed further and tested on additional industries. The analysis of the evolution of the tire industry hopefully will encourage comparable analyses of other industries, including promising ones like the semiconductor industry (cf. Moore and Davis [2004]), in order to subject the new theories of geography to more exacting tests.

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[36] Wang [2004] also persuasively argues that demand plays an important role in the timing and severity of shakeouts.

Table 1:Value shares of rubber and tire production in selected U.S. states (percent)

		California	Massa-chusetts	New Jersey	New York	Ohio	Penn-sylvania
1899	rubber and elastic goods	.1	26.4	16.1	10.1	14.0	2.2
1904	rubber and elastic goods	.4	22.4	7.7	13.1	25.3	3.5
1909	rubber goods	.3	12.3	15.2	6.8	42.0	3.7
1914	rubber goods	.4	10.3	11.4	4.6	49.0	5.5
1919	tires, tubes, rubber gds	.5	9.5	8.5	3.4	55.8	3.6
1921	tires and inner tubes	1.8	--	6.1	1.2	58.8	5.7
1923	tires and inner tubes	2.4	7.0	4.8	1.2	60.8	3.0
1925	tires and inner tubes	--	--	4.5	--	60.1	2.8
1929	tires and inner tubes	7.3	--	1.5	--	65.3	1.8
1933	tires and inner tubes	7.0	--	--	--	63.0	--
1935	tires and inner tubes	7.7	--	--	--	67.1	--
1937	tires and inner tubes	11.3	--	--	--	53.4	3.4
1939	tires and inner tubes	8.8	--	--	--	46.1	4.8
1947	tires and inner tubes	9.8	--	--	--	33.3	8.6
1954	tires and inner tubes	--	--	--	--	29.5	8.2
1958	tires and inner tubes	--	--	--	--	35.8	7.1
1963	tires and inner tubes	--	--	--	--	33.6	7.3

Sources: U.S. Census of Manufactures, various volumes. Note: Missing entries are not reported by the Bureau of the Census because of confidentiality considerations. Category definition wre subject to change so that figures are not strictly comparable over time. Figures for rubber goods exclude rubber footware, belting and hose.

Table 2: Top 24 U.S. tire firms around 1922

Top 5	Goodyear	Akron (OH)
	Goodrich	Akron (OH)
	U.S. Rubber	Hartford (CT) / Detroit (MI)
	Firestone	Akron (OH)
	Fisk	Chicopee (MA)
Second Tier	Ajax	Trenton (NJ) / New York (NY)
	Miller	Akron (OH)
	Kelly-Springfield	Akron (OH) / Cumberland (MD)
	Republic	Youngstown (OH)
	McGraw	East Palestine (OH)
	Mason	Kent (OH)
	Pennsylvania	Erie / Jeannette (PA)
	Mansfield	Mansfield (OH)
	General	Akron (OH)
	Dayton	Dayton (OH)
	Seiberling	Akron (OH)
Other major firms	Hood	Boston (MA)
	Gillette	Eau Claire (WI)
	Cooper	Akron (OH) / Findlay (OH)
	Mohawk	Akron (OH)
	Gates	Denver (CO)
	Pharis	Columbus (OH) / Newark (OH)
	Michelin	Milltown (NJ)
	Dunlop	Buffalo (NY)

Source: Own compilation based on French [1991, p. 45] and on figures on firms' production capacities between 1920 and 1923 reported by *India Rubber Review* [1921, p. 795], Leigh [1936, p. 17], and Moody's [1924]. "Top 5 firms" are those listed with a 1920 production capacity exceeding 10.000 tires/day in Leigh [1936]. The second tier includes the four "medium-sized" firms specified by French [1991], Seiberling, and six additional firms with a 1921 production capacity between 1,000 and 10,000 tires/day. "Other major firms" includes four firms characterized by French as "small, but still significant," plus four additional firms whose 1921/1923 production capacities are as least as large as those of the firms mentioned by French (Hood, Gillette, Cooper and Mohawk).

Table 3: Locations Of Origin And Locations Of Entry of Ohio Tire Producers

To From	Summit County	Other Ohio counties	Sum
Summit County			
Total	**26**	**10**	**36**
Startups	*6*	*2*	*8*
Diversifying firms	*7*	*0*	*7*
Spinoffs	*13*	*8*	*21*
Other Ohio Counties			
Total	**3**	**43 / 21***	**67**
Startups	*1*	*28 / 10*	*39*
Diversifying firms	*1*	*7 / 1*	*9*
Spinoffs	*1*	*8 / 10*	*19*
Other U.S. States			
Total	**2**	**7**	**9**
Startups	*1*	*3*	*1*
Diversifying firms	*1*	*0*	*4*
Spinoffs	*0*	*4*	*4*
Unknown origin			
Total	**3**	**2**	**5**
Startups	*3*	*2*	*5*
Diversifying firms	*0*	*0*	*0*
Spinoffs	*0*	*0*	*0*
Sum			
Total	34	**83**	**117**
Startups	*11*	*45*	*17*
Diversifying firms	*9*	*8*	*56*
Spinoffs	*14*	*30*	*44*

* First figure indicates the number of firms locating in the county where they originated, second figure is for firms that originated in Ohio and located in another Ohio county (excluding Summit County).

Table 4: Location of Entry of Tire Firms, U.S. 1905-1930

Variable	Model 1	Model 2	Model 3 (with state fixed effects)
$Autoreg_j$ (all entrants)	.180*** (.026)		.185*** (.048)
$Autoreg_j$ (diversifiers)		.130** (.063)	
$Autoreg_j$ (*de novo* firms)		.202*** (.029)	
$Autoprod_j$ (all entrants)	.009* (.005)		.072*** (.021)
$Autoprod_j$ (diversifiers)		.023* (.012)	
$Autoprod_j$ (*de novo* firms)		.007 (.005)	
$Tire_j$ (all entrants)	.033** (.007)		-.026** (.013)
$Tire_j$ (diversifiers)		.025 (.020)	
$Tire_j$ (*de novo* firms)		.035*** (.008)	
Pop_j (all entrants)	-.120 (.077)		-.329 (.347)
Pop_j (diversifiers)		-.629*** (.230)	
Pop_j (*de novo* firms)		-.066 (.081)	
Rub_j (all entrants)	.068*** (.013)		-.048* (.027)
Rub_j (diversifiers)		.133*** (.029)	
Rub_j (*de novo* firms)		.051*** (.014)	
Bic_j (all entrants)	-.062*** (.016)		.243** (.096)
Bic_j (diversifiers)		-.070* (.040)	
Bic_j (*de novo* firms)		-.055*** (.017)	
$C\&W_j$ (all entrants)	.179*** (.038)		.048 (.153)
$C\&W_j$ (diversifiers)		.501*** (.118)	
$C\&W_j$ (*de novo* firms)		.141*** (.040)	
No. of observations	17556	17556	17556
Log-likelihood	-1471.547	-1456.826	-1385.730
Pseudo R^2	.209	.217	.255

Standard errors in parentheses. *** $p \leq .01$; ** $p \leq .05$; * $p \leq .10$

Table 5: Location of Origin of Tire Firms, Ohio 1905-1930

Variable	Model 4	Model 5	Model 6 (with county fixed effects)
$Tire_j$ (all entrants)	.043*** (.007)		
$Tire_j$ (diversifiers)		-.006 (.032)	
$Tire_j$ (startups)		.053*** (.012)	.023* (.013)
$Tire_j$ (spinoffs)		.099*** (.025)	.073*** (.020)
Pop_j (all entrants)	.227*** (.064)		
Pop_j (diversifiers)		.195 (.168)	
Pop_j (startups)		.285*** (.089)	.219*** (.060)
Pop_j (spinoffs)		115 (.153)	
Rub_j (all entrants)	.044*** (.013)		
Rub_j (diversifiers)		.132** (.058)	.081*** (.025)
Rub_j (startups)		-.002 (.023)	
Rub_j (spinoffs)		.015 (.029)	
$Autoest_j$ (all entrants)	-.025 (.019)		
$Autoest_j$ (diversifiers)		-.126 (.086)	
$Autoest_j$ (startups)		-.006 (.028)	
$Autoest_j$ (spinoffs)		-.011 (.048)	
No. of observations	9064	9064	9064
Log-likelihood	-312.601	-293.778	-230.340
Pseudo R^2	.322	.363	.501

Standard errors in parentheses. *** $p \leq .01$; **$p \leq .05$; *$p \leq .10$

Table 6: Ohio Tire Firms and their Spinoffs

Parent Firm	Active years of parent firm	Spinoff firm (Location)	Same county as parent	Active years of spinoff
Goodrich (Akron)	1901-80	Akron Pneumatic (Akron)	Yes	1909-12
		New Tread (Columbiana)	No	1917-22
		Eclat (Cuyahoga Falls)	Yes	1923-28
		Williams Tire (Akron)	Yes	1924-37
Goodyear (Akron)	1902-80	Seiberling (Barberton)	Yes	1922-64 (acq.)
		Excel (Wadsworth) (1)	No (adjacent)	1922-23
		Falor (Akron)	Yes	1922-23
Firestone (Akron)	1906-80	Swinehart (Akron)	Yes	1906-30
		Marathon (Cuyahoga Falls)	Yes	1913-24 (acq.)
		General (Akron)	Yes	1916-80
		Oldfield (Cleveland)	No (adjacent)	1917-23 (acq.)
		Standard Tire Co (Willoughby)	No	1922-30
Whitman & Barnes (Akron)	1905	Firestone (Akron)	Yes	1906-80
		Puncture Proof (Cleveland)	No (adjacent)	1907-12
Diamond (Akron)	1905-10 (acq.)	Falls Rubber (Cuyahoga Falls)	Yes	1911-30 (acq.)
Kelly-Springfield (Akron)	1902-34 (acq.)	Mohawk Rubber (Akron) (2)	Yes	1913-80
McGraw (East Palestine)	1911-22	East Palestine (East Palestine)	Yes	1913-21
Marathon (Cuyah. Falls)	1913-24 (acq.)	Amazon (Akron) (1,3)	Yes	1917-62
Bucyrus (Bucyrus)	1916-35	Orrville (Orrville)	No	1918-21
		Rufenacht (Bucyrus)	Yes	1922-26
Biltwell (Barberton)	1919-22	Akron Maderite (Newton Falls)	No	1919-21
Mansfield (Mansfield)	1913-80	Columbia (Mansfield)	Yes	1919-30
Orrville (Orrville)	1918-21	Glamorgan (Orrville)	Yes	1919-21
Mason (Kent)	1916-30	Erie (Cleveland)	No (adjacent)	1919-29 (acq.)
		Ideal (Cleveland)	No (adjacent)	1919-23
		Knox (Mt. Vernon)	No	1920-21
		Cascade (Ravenna) (2)	Yes	1922
Miller (Akron)	1915-29 (acq.)	Denman&Myers (Cleveland) (1,4)	No (adjacent)	1920-80
Amazon (Akron)	1917-62	McWade (Garrettsville) (3)	No (adjacent)	1922-24
		Northern (Akron) (3)	Yes	1925-30
Gordon (Canton)	1915-29	McKone (Millersburg)	No (adjacent)	1922-28
		Salem (Salem)	No (adjacent)	1922-29
Owen (Cleveland)	1919-22	Tuscora (New Philadelphia)	No	1922-26
Dayton (Dayton)	1911-60 (acq.)	Master (Dayton)	Yes	1922 (acq.)
Forster (Millersburg)	1919-21	Thomas (Millersburg)	Yes	1922-25
Ideal (Cleveland)	1919-23	Jordan (Cleveland)	Yes	1923
National (East Palestine)	1917-29	Ashtabula (Ashtabula)	No	1923
Excel (Wadsworth)	1922-23	Trump (Akron) (1,2)	No (adjacent)	1923-34
Columbia (Mansfield)	1919-30	Maderight (Cleveland)	No	1924
		Admiral (Coshocton)	No	1927-29

(1) firm is indirect Goodrich spinoff,
(2) firm is indirect Goodyear spinoff,
(3) firm is indirect Firestone spinoff,
(4) firm is indirect Diamond spinoff.
(acq.) firm exited by being acquired by another tire firm.

Note: Only Ohio spinoffs bred by Ohio parents are listed.

Table 7: Survival of tire firms, U.S. 1905-80

Variable	Model 7	Model 8	Model 9	Model 10	Model 11
Constant	-1.759*** (.063)	-1.802*** (.064)	-1.814*** (.065)	-1.783*** (.059)	-1.795*** (.058)
Othtire$_j$	-025** (.010)	.006 (.011)	.007 (.011)		
Akron		-.962*** (.244)	-.958*** (.244)	-.844*** (.256)	
NEOhio			.202 (.199)		
Detroit				-.053 (.166)	
Akronini					-.620*** (.206)
τ	-.046*** (.005)	-.042*** (.005)	-.042*** (.005)	-.043*** (.005)	-.046** (.005)
No. of ob-servations	4786	4786	4786	4786	4786
Log-likelihood	-802.519	-793.891	-793.402	-793.988	-800.609

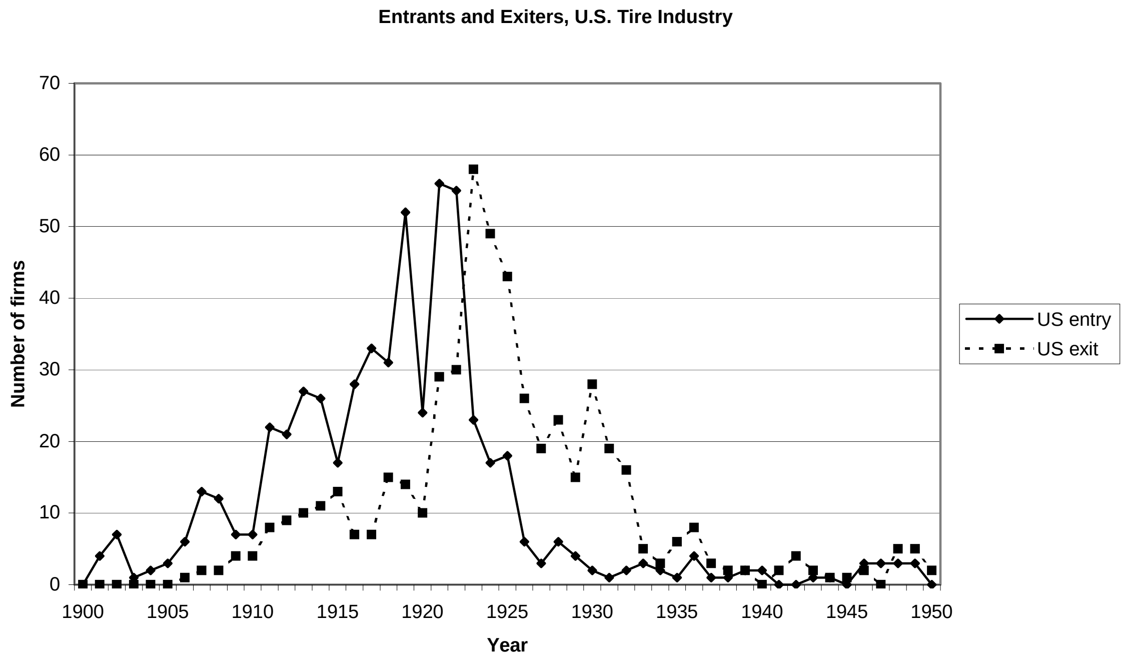
Standard errors in parentheses; ***p≤.01; **p≤.05; *p≤.10

Table 8: Survival of tire firms, U.S. 1905-80

Variable	Model 12	Model 13	Model 14
Constant	-.2.651*** (.164)	-2.629*** (.164)	-2.628*** (.165)
Akronini	-.638*** (.207)	-.092 (.251)	-.286 (.248)
Divers	-.563*** (.202)	-.601*** (.204)	-.595*** (.203)
Akroninispin		-1.187*** (.434)	
Topspin			-.830** (.404)
Tier2spin			-.515 (.482)
Indtopspin			-.370 (.451)
Notopspin			.049 (.262)
S1	1.078*** (.258)	1.047*** (.258)	1.050*** (.258)
S2	.154 (.211)	.119 (.212)	.130 (.212)
S3	-.118 (.145)	-.147 (.146)	-.121 (.147)
Highex	1.255*** (.132)	1.245*** (.132)	1.250*** (.132)
τ	-.001 (.011)	-.001 (.011)	-.001 (.011)
S1 * τ	-.112*** (.023)	-.110*** (.023)	-.107*** (.023)
S2 * τ	-.038** (.019)	-.037* (.019)	-.033* (.019)
S3 * τ	-.033** (.015)	-.033** (.015)	-.032** (.015)
Divers * τ	.037** (.016)	.035** (.016)	.035** (.016)
No. of observations	4786	4786	4786
Log-likelihood	-720.212	-716.149	-716.392

Standard errors in parentheses; ***p≤.01; **p≤.05; *p≤.10

Figure 1: Entry, exit and the number of producers in the U.S. tire industry, 1900-1950
(Source: own compilation based on *Thomas' Register of American Manufacturers*)



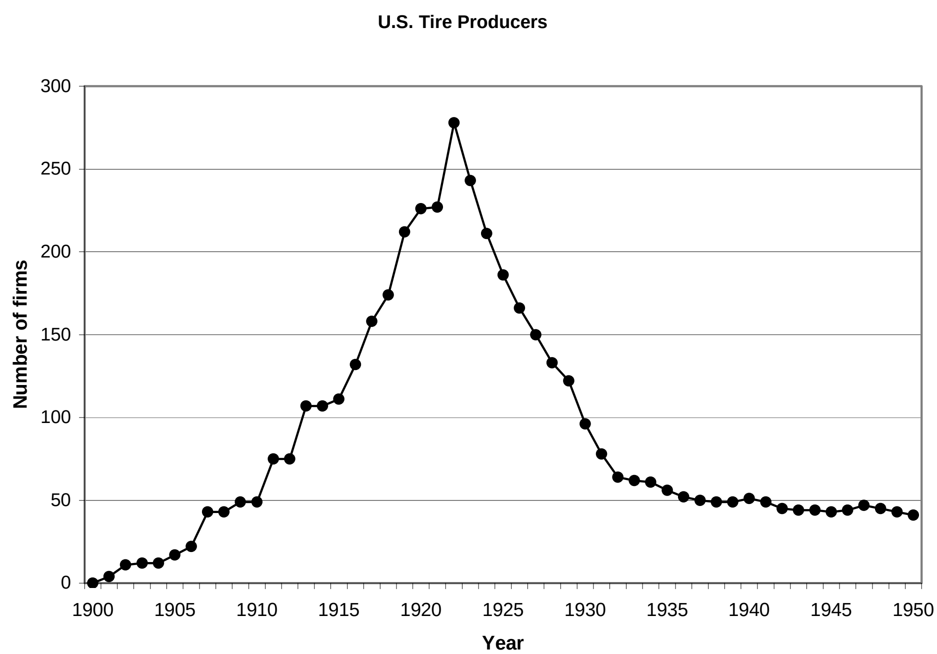
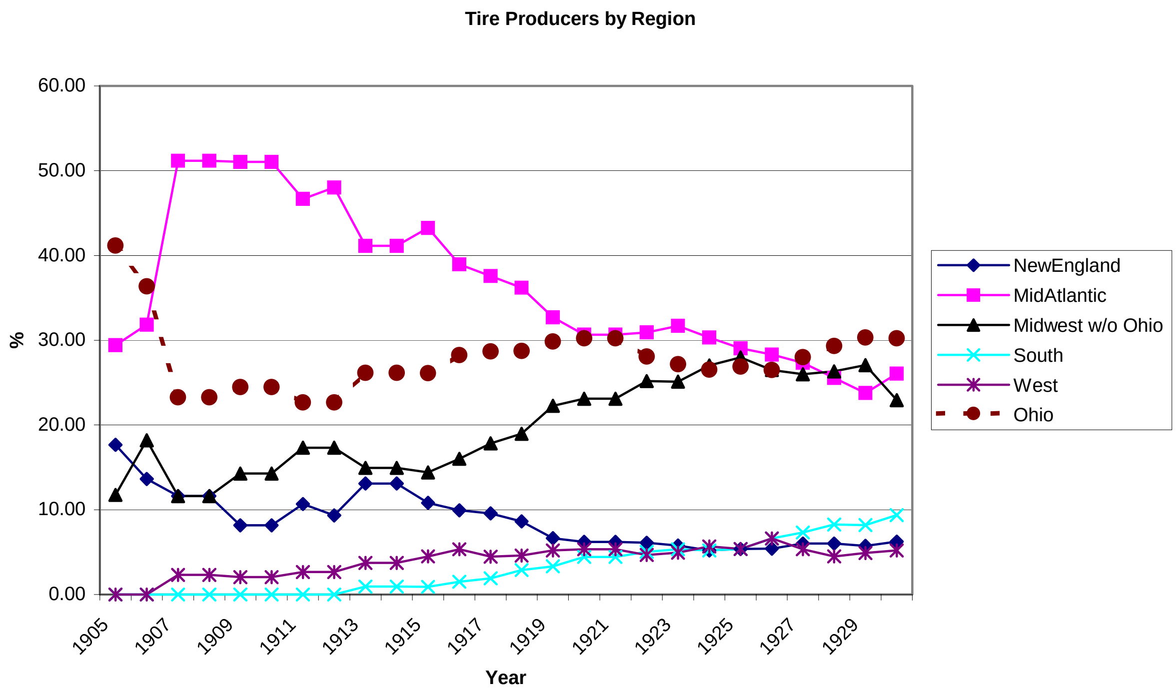


Figure 2: The Geography of Entry into the U.S. Tire Industry
(map generated using U.S. Bureau of the Census software)

Figure 3: Regional shares of producers and entrants, U.S. tire industry 1905-1930
(Source: own compilation based on *Thomas' Register of American Manufacturers*)



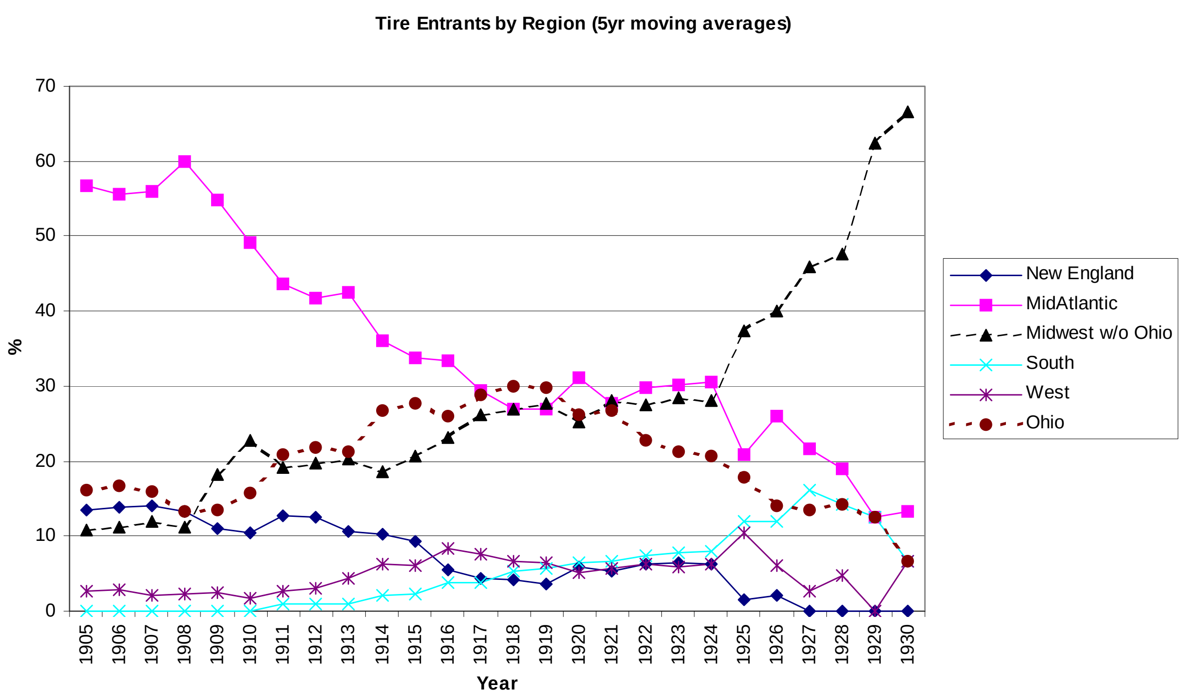
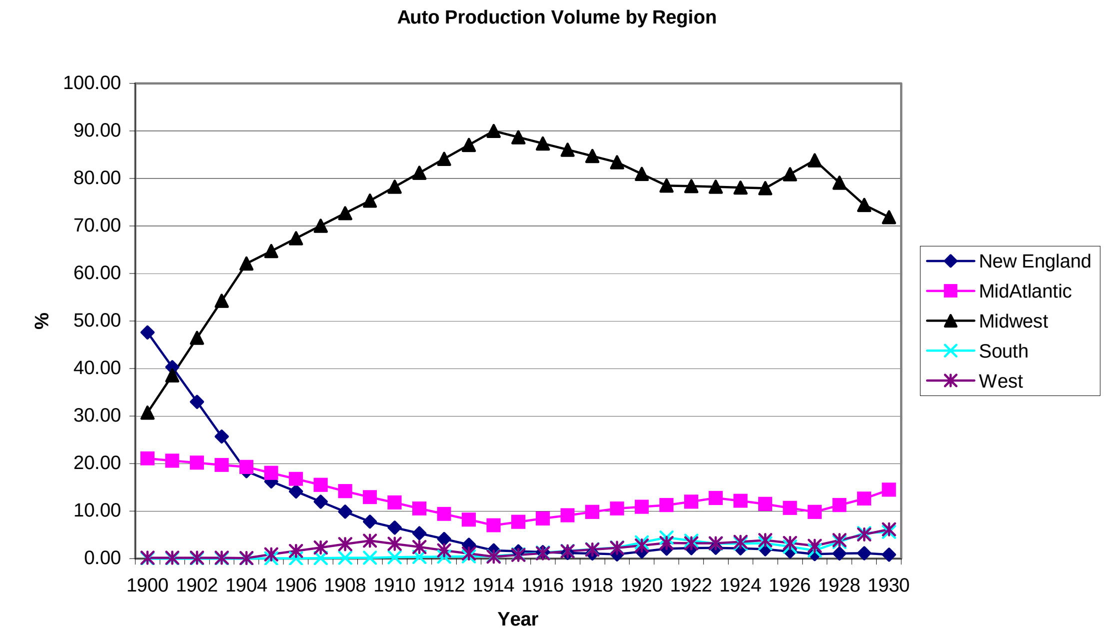


Figure 4: Regional shares of auto production and auto registrations, U.S. 1900-1930
(Sources: U.S. Census of Manufactures, U.S. Federal Highway Administration)



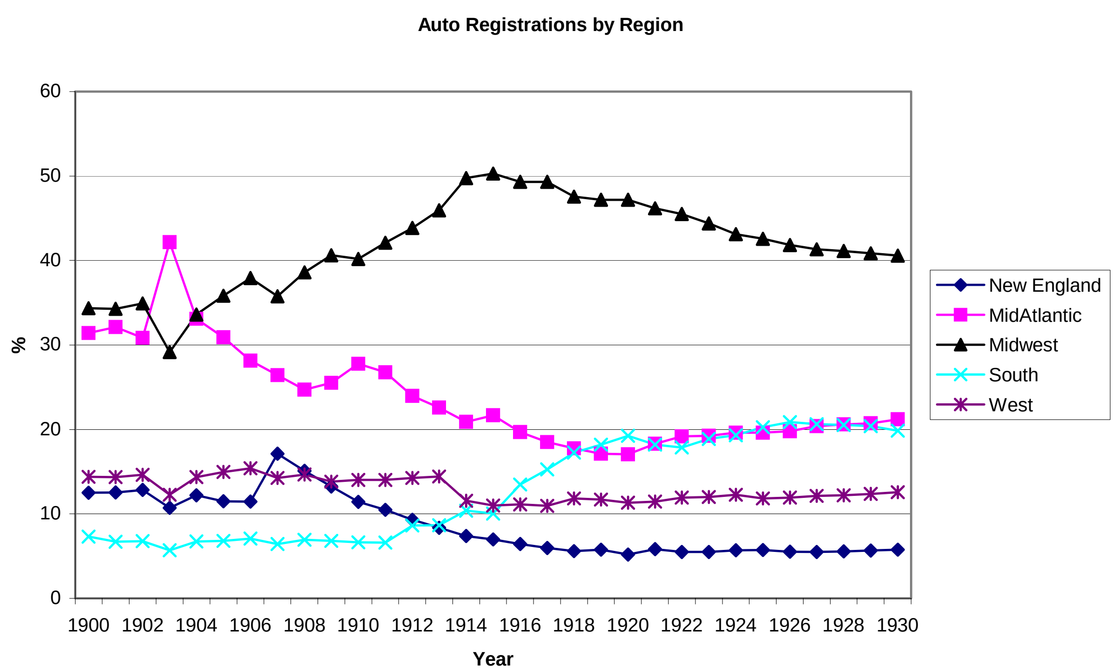
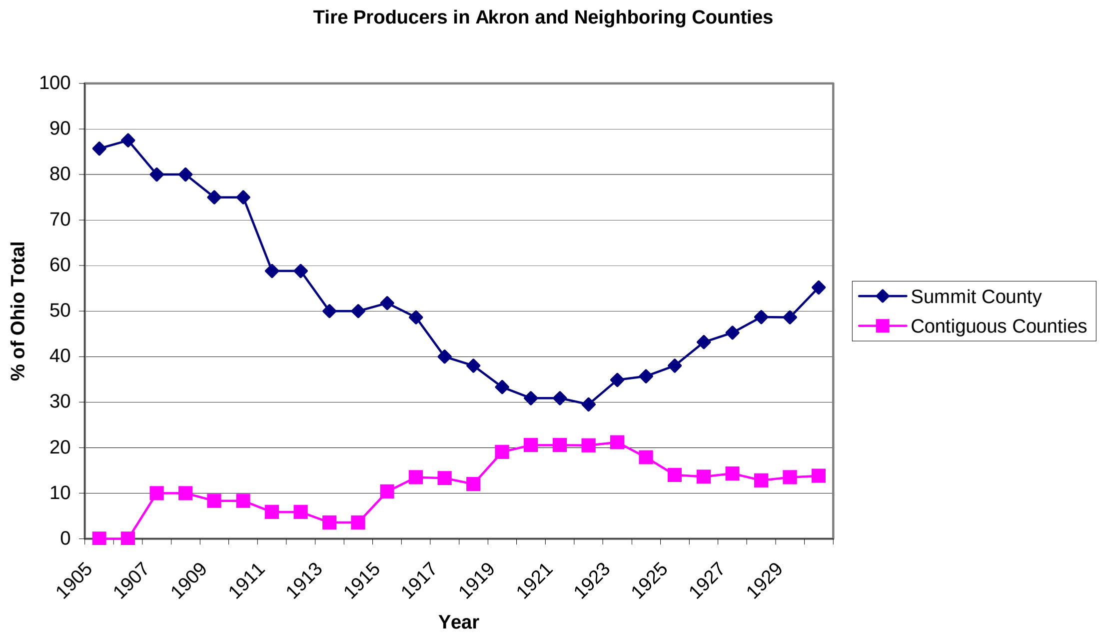
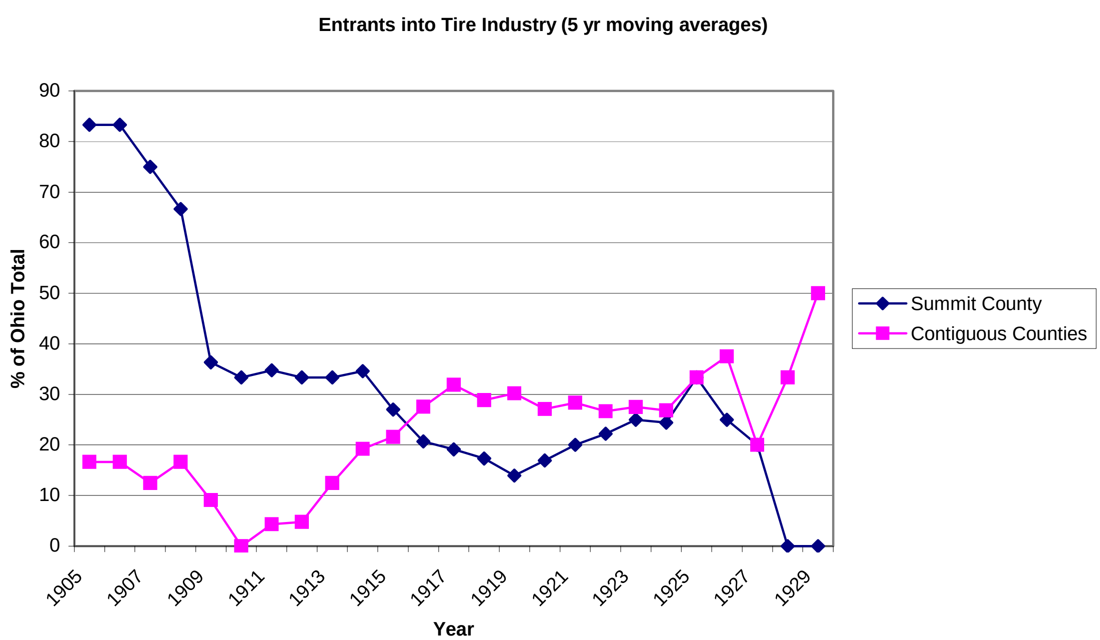


Figure 5: Regional shares of tire producers and entrants, Ohio 1905-1930
(Source: own compilation based on *Thomas' Register of American Manufacturers*)





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