

THE EVOLUTION OF GEOGRAPHIC STRUCTURE IN NEW INDUSTRIES*

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We review the evolution of the market and geographic structure of the automobile, television receiver, and tyre industries in order to gain insights into the primary forces governing the agglomeration of industries. Spinoffs, which are firms founded by employees of incumbent producers, played a prominent role in the agglomerations that emerged around Detroit, MI and Akron, OH in the automobile and tyre industries respectively. The television receiver industry became less agglomerated over time, and this is connected with the domination of the industry by diversifiers from the radio industry. The patterns in all three industries are shown to be compatible with a theory of organisational birth and heredity proposed in Klepper (2003).

JEL Classification: L65, R12, R30.

Keywords: Agglomeration, Spinoffs, Entry

* Helpful comments were provided by an anonymous referee. Support is gratefully acknowledged from the Economics Program of the National Science Foundation, Grant No. SES-0111429.

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I. Introduction

In recent years there has been a resurgence of interest among economists in questions related to geography. In part spurred by the clustering of economic activity in Silicon Valley, attention has focused on why certain industries agglomerate narrowly in one or a few regions. Ellison and Glaeser (1997) developed an index to measure geographic clustering in industries. It calibrates the extent to which clustering in an industry exceeds what would be expected merely on the basis of the chance location of a limited number of plants of unequal size. Their findings suggest that some degree of agglomeration is the norm, but the kind of extreme clustering present in Silicon Valley is the exception. While clustering in some industries can be explained by the uneven geographic distribution of a key input, instances of clustering such as Silicon Valley seem to reflect a deeper process at work. Exactly what that process is and why its effects vary across industries has been the object of much theorising in recent years. Testing of the new theories of geography, though, has lagged behind. The object of this paper is to review recent evidence and theorising on the evolution of a select group of new industries to probe the determinants of the geographic structure of industries.

Modern theories of geography feature the influence of agglomeration economies on the location of producers. Such economies can derive from the sharing of inputs whose production involves increasing returns, labour market pooling that facilitates a better match between the needs of firms and the skills of workers, and spillovers of knowledge that are mediated by distance (Marshall, 1920). Other mechanisms, such as firms locating closer to demanders to economise on transportation costs, can also induce agglomeration (Krugman, 1991). All of these benefits impart a self-reinforcing character to agglomerations. The more firms in an area then the greater the agglomeration benefits, and the greater such benefits then the more firms will be drawn to an area and the better firms in the area will perform. Congestion costs, in the form of higher land prices and compensating wage differentials, ultimately limit the extent of agglomerations. Until that limit is reached, though, all firms located in agglomerated areas benefit from the externalities resulting from their collective presence.

If agglomeration economies are influential, it might be expected that industries would agglomerate around regions where successful early entrants located. Such regions would initially produce more output, employ more labour, and be subject to more innovation, all of which would contribute to agglomeration economies that would attract subsequent entrants and enhance the performance of firms located there. There has been little empirical investigation of the evolution of the geographic structure of new industries, but Klepper (2003) argues that this is not the way either the automobile or television receiver industries

evolved. Both industries were initially characterised by a large number of producers and then experienced sharp shakeouts and evolved to be tight oligopolies. The automobile industry became famously agglomerated around Detroit, MI even though production in the Detroit area was initially negligible and early entry provided a decided competitive advantage (Klepper, 2001). Television producers were initially heavily concentrated in just three cities, New York, Chicago, and Los Angeles. Even though early entry was also advantageous in TVs (Klepper, 2002a), over time New York and Los Angeles lost all their producers and Chicago did not grow, causing the industry to become more dispersed over time.

Klepper (2003) advanced a hypothesis based on the ideas of organisational birth and heredity to explain the evolution of the geographic structure of both industries. Subsequently Buenstorf and Klepper (2005a, 2005b) explored the evolution of the geographic structure of the pneumatic tyre industry, which was also famously agglomerated around a single city, Akron, OH. Similar to autos and television receivers, initially many firms produced tyres and then the industry experienced a sharp shakeout and evolved to be a tight oligopoly. Unlike automobiles, the industry was concentrated around Akron from its outset, and over time the agglomeration there of the industry grew. Buenstorf and Klepper (2005a, 2005b) investigated the extent to which agglomeration economies influenced the location and performance of tyre firms. They concluded that it was not primarily agglomeration economies but similar forces to those operating in the automobile industry that caused the industry to become so heavily agglomerated.

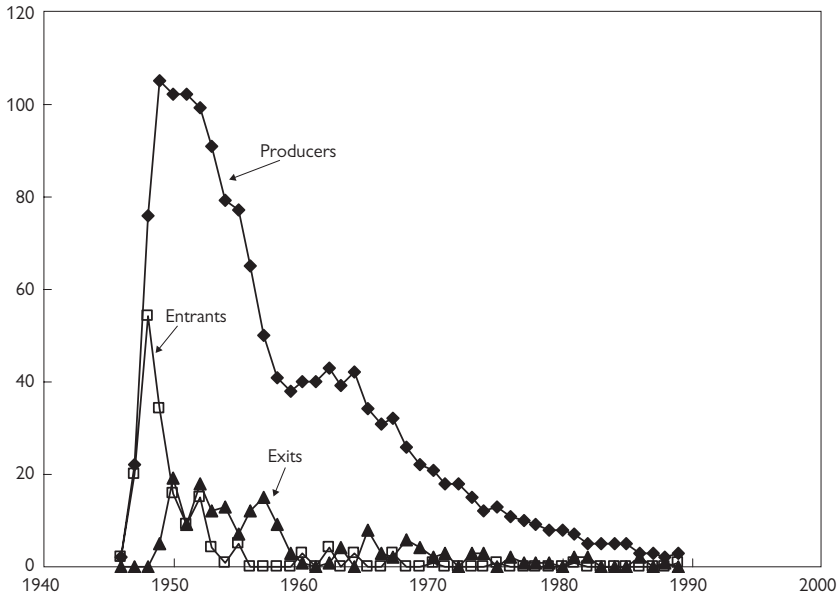
We review the evolution of the market and geographic structure of the automobile, television receiver, and tyre industries in order to gain insights into the primary forces governing the agglomeration of industries.¹ We begin with television receivers, which is the easiest to understand and provides a useful backdrop for the automobile and tyre industries. Next we consider the evolution of the automobile industry, followed by the evolution of the tyre industry. We conclude with observations about the importance of organizational heredity and birth in shaping industry agglomeration.

2. Television Receivers

The annual number of entrants, exits, and producers of television receivers in the United States over the period 1946-1989 based on listings in *Television Factbook* is presented in Figure 1. A total of 177 firms entered

1. The review of the evolution of the market structure of the three industries is primarily based on Klepper (2002a). The review of the evolution of the geographic structure of the three industries is primarily based on Klepper (2001, 2002b, 2003, 2005) for automobiles, Klepper (2003) for TVs, and Buenstorf and Klepper (2005a, 2005b) for tyres.

1. Entry, Exit, and Number of Producers in the Television Industry, 1946-1989

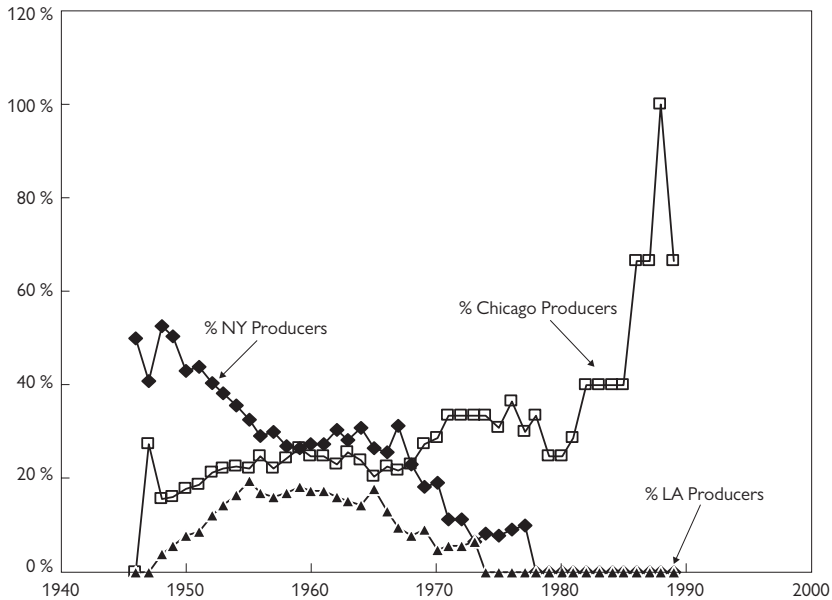


Source: See Klepper, 2003

the industry, most of them by 1951. Experimental television systems were introduced prior to World War II, but the War delayed the start of the industry until 1946. RCA and DuMont were the first firms to begin producing in 1946. Many firms followed soon after, reflecting the rapid growth in the sales of television receivers. Entry peaked in 1948 at 54 firms, and by 1955 entry was negligible. The number of firms rose from 1946 to 1949, reaching a peak of 105 in 1949, and then fell sharply. International competition, initially from Japan, began in the late 1960s when roughly 30 US based producers were left in the industry. At that point RCA and Zenith were the top two US producers of television receivers, accounting for 39% of US sales of black and white TVs and 48% of the sales of colour TVs, and the four-firm concentration ratios in black and white and color TVs were 61% and 65.5% respectively. International competition mounted over time and the number of US based firms fell steadily. By 1989 only three US producers were left in the industry, all of which were destined to exit within a short period.

Klepper (2003) analysed the location of the TV producers, which was heavily concentrated in three US cities, New York, Chicago, and Los Angeles. Although these three cities accounted for only 15% of the US population, 73% of television producers entered in the three cities, with 44% entering in New York, 15% in Chicago, and 14% in Los Angeles.

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



Source: See Klepper, 2003

Figure 2 presents the annual percentage of television producers based in each of these three cities from 1946 to 1989. New York initially contained over 50% of the television producers, but over time this percentage declined sharply. By 1970 New York's share had declined to 20%, and by the end of the 1970s no firm was based in New York. Firms were slower to enter in Los Angeles, but by the mid-1950s 20% of the producers were located there. Subsequently the share of producers in Los Angeles fell sharply, and by the mid-1970s no firm was based in Los Angeles either. Chicago accounted for around 25% of television producers in the initial years of the industry. It maintained its share through about 1980, after which its share increased sharply as the number of firms dwindled from eight to three. Thus, at the start of the industry television producers were heavily concentrated in three cities, but from the mid-1950s until 1980 the collective share of producers in the three cities declined from 70% to 25%.

The evolution of the location of the television producers was greatly influenced by the location of firms in the radio industry. Entry, exit, and the location of radio producers was reconstructed from annual listings of radio producers in the *Thomas' Register of American Manufacturers* (see Klepper and Simons, 2000; Klepper, 2003). At the start of the television industry, 266 US firms produced radios. They were heavily concentrated in New York, Chicago, and Los Angeles, which accounted for 33%, 15%, and 7%

respectively of all radio producers in 1945-1948. Of the 177 television entrants, 58 or approximately one-third diversified from the radio industry, and nearly all began producing television receivers where they produced radios. Thus, it is not surprising that among the 58 diversifiers, 55% of them located in New York, Chicago, and Los Angeles, which mirrors the fraction of radio producers in the three cities. Perhaps more surprising is that among the remaining 119 entrants, 82% also located in these same three cities, especially in New York and Los Angeles, which accounted for 53% and 18% respectively of these entrants (Klepper, 2003).

Klepper and Simons (2000) demonstrated that the radio producers that diversified into the television industry tended to be the largest and most experienced radio producers, and they tended to enter earlier than other entrants into the TV industry. They also found that the diversifiers from the radio industry had much lower hazards of exit at all ages than non-radio diversifiers, and among the radio diversifiers, the larger ones had much lower hazards at all ages. Indeed, 13 of the top 14 television producers over the history of the industry were diversifiers from the radio industry, and four of the top five television producers were among the top five radio producers as of 1940 (the other radio producer among the top five in 1940 was among the top ten TV producers).

The location of the leading radio producers was the dominant force shaping the location of TV producers in the long run and the evolution of the geographic structure of the industry. Only one of the top radio producers was located in New York, and it accounted for only 11% of the sales of the top radio producers as of 1940, and Los Angeles had no leading radio producer as of 1940. With the leading radio producers ultimately dominating the television industry, New York and Los Angeles were destined to experience a sharp decline in their share of television producers as the industry proceeded through its shakeout. Chicago had five of the top 16 radio producers that jointly accounted for 38% of the sales of the leading radio producers as of 1940. Correspondingly, Chicago had three of the top ten television producers and maintained its share of television producers over time. The other leading radio producers were scattered throughout the Northeast and Midwest. Many of these firms, including RCA, Philco, and GE, became leading television producers. They survived much longer than other firms, and as a result the base location of television producers became increasingly dispersed throughout the Northeast and Midwest as the industry evolved. In a statistical analysis of firm hazard rates, New York and Los Angeles firms had higher hazards of exit than firms located elsewhere, but once the background and time of entry of firms was controlled, there were no significant differences in the hazard rates of firms by region (Klepper, 2003).

International competition further contributed to a geographic dispersal of television production. While US firms maintained their base locations, they increasingly moved their operations into low-wage countries in order

to counter foreign competition (Levy, 1981, pp. 261-278). But this did not head off their demise. They were behind the technological frontier, especially regarding the use of semiconductor technology. They lost much of their market share to Japanese firms that had pioneered the use of semiconductor components in radios and that were consistently ahead of the US firms in the use of semiconductor components in television receivers (La France, 1985).

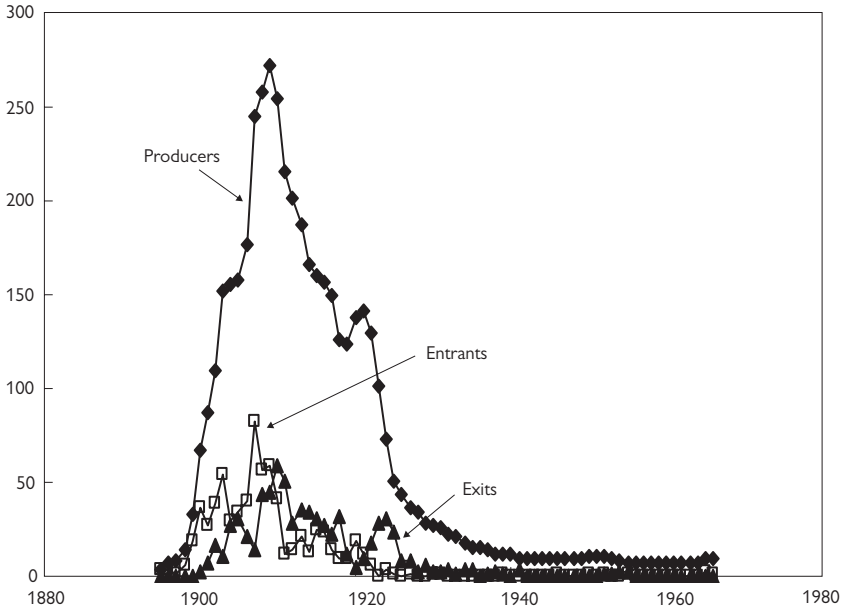
Television receivers illustrate a few themes that are pertinent to automobiles and tyres. First, firms in related industries are important seeds for firms in a new industry, and their location is an important determinant of where entrants into the new industry locate. Second, the pre-entry experience of firms has a profound effect on their ability to compete. In televisions, experience in radios was so significant that no new firm was successful in the industry over the long term. Consequently, over the long run the base location of the leading radio firms was the dominant influence on the location of television producers. Third, agglomeration economies were not a major factor shaping the base location of television producers. Two of the three regions where firms were concentrated declined over time, and regional differences in firm performance were largely due to differences in their pre-entry experience rather than any influence of the regions themselves. Last, as the number of US firms declined, the leading firms increasingly moved their production into lower-wage areas, further dispersing production.

3. Automobiles

The annual number of US entrants, exits, and producers of automobiles from the start of the industry in 1895 through 1966 based on a list compiled by Smith (1968) is presented in Figure 3. Only firms that produced a non-negligible number of automobiles are included, which encompassed 725 firms through 1966 (Klepper, 2002a). In contrast to televisions, entry was initially low, reflecting the limited demand for automobiles when they were introduced. Subsequently entry grew, peaking at 87 firms in 1907. Entry remained high for the next three years and then declined to an average of 15 firms per year for the next 12 years, after which it became negligible. The number of firms peaked at 272 in 1909, after which it fell steadily despite average annual output growth of over 20% during the next 15 years. By 1941 only nine firms were left in the industry. As of 1911, the top two firms in the industry, Ford and General Motors, accounted for 38% of the output of automobiles. They increased their joint market share to over 60% by the 1920s and with Chrysler, which emerged out of two early entrants in the 1920s, they jointly accounted for over 80% of the output of the industry by the 1930s.

The industry became famously agglomerated around Detroit, MI, but initially no firm produced a non-negligible number of automobiles in the

3. Entry, Exit, and Number of Producers in the Automobile Industry, 1895-1966



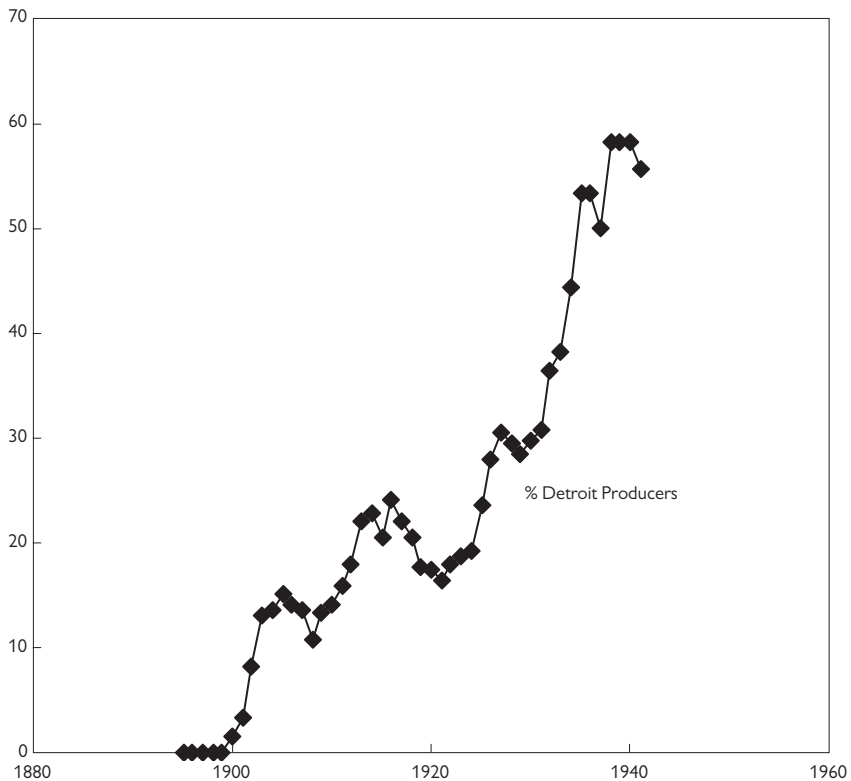
Source: See Klepper, 2003

Detroit area. Figure 4 reports the annual percentage of producers based in the Detroit area from the start of the industry through 1941, when only nine firms were left in the industry.² No producer was located in the Detroit area until 1901, when Olds Motor Works began production in Detroit and Lansing, MI. Olds was the first great firm in the industry. After Olds' entry the percentage of automobile producers in the Detroit area steadily rose into the 1910s, when it peaked at over 20%. It then fell back a little but rose again after 1920, exceeding 50% by 1941. The firms based in the Detroit area were extraordinarily successful. By the mid-1910s they produced 13 of the 15 leading makes of automobiles, and over 60% of automobiles were produced in Michigan, nearly all in the Detroit area. Although 69 producers entered the industry in 1895 to 1900 before any producer entered in the Detroit area, Detroit nonetheless became the capital of the US automobile industry by the mid-1910s, and it maintained its hegemony for many years thereafter (Klepper, 2001).

Entry was far more dispersed geographically than in televisions. Michigan had more entrants than any other state, but it accounted for only

2. Firms established branches and moved within a 100 mile radius of Detroit. Accordingly, the market area around Detroit was defined to correspond to this 100-mile radius (Klepper, 2001).

4. Percentage of Automobile Producers in the Detroit Area, 1895-1941



Source: See Klepper, 2003

18.6% of the 725 entrants through 1966, followed by New York with 13.5% of the entrants and Ohio with 12.3% of the entrants. Thus, the top three states accounted collectively for 44.7% of the entrants whereas the top three cities in televisions accounted for 73% of the entrants. This largely reflects that the leading seeding industries for automobiles were considerably more dispersed geographically than the radio industry. Klepper (2001) identified firms that diversified into autos or were founded by an individual who headed a firm in another industry based on the listings in Smith (1968) and the brief histories of automobile firms in Kimes (1996). The industry from which the greatest number of these two types of entrants came was carriage & wagons. In a statistical analysis of the location of automobile entrants, Klepper (2003) found that states with more carriage & wagon production not only had more entrants originating from the carriage & wagon industry but also more of other types of entrants as well. Unlike radio producers, which were concentrated in three cities, the carriage & wagon industry was dispersed throughout the

Northeast and Midwest, with the top three states accounting for only 32% of all carriage & wagon producers. Moreover, among US states Michigan was ninth in terms of carriage & wagon producers and fourth in terms of value of carriage & wagon production. The second most important seeding industry for automobiles was bicycles, which was also dispersed throughout the Northeast and Midwest, and few bicycle firms were located in Michigan. Consequently, the geographic dispersion of entrants and the slow start of the industry around Detroit were predictable.

Similar to televisions, automobile entrants that diversified from other industries, particularly carriages & wagons, bicycles, and engines, had lower hazards of exit at all ages, as did new firms founded by individuals who headed firms in these industries (Klepper, 2001). But diversifiers were far less important in automobiles than televisions. Whereas 33% of the entrants into the television industry diversified from the radio industry, only 16.6% of entrants into the automobile industry were diversifiers from any industry (Klepper, 2003). In large part this reflects the novel technological challenges faced by automobile firms. Automobiles soon required precision manufacturing to produce interchangeable parts, manufacturing was done on an unprecedented scale, and technological progress was far more rapid than had occurred in carriages & wagons and other related industries. Consequently, experience in related industries was much less valuable in automobiles than in televisions.

This opened up opportunities for new firms, especially firms with one or more founders that previously worked for an incumbent automobile firm, which are called spinoffs. Klepper (2001) identified the spinoff entrants and the firms their founders previously worked for, dubbed their parents, based on the brief firm histories in Kimes (1996). Approximately 20% of entrants into automobiles were spinoffs, most of which were founded by top managers or heads of incumbent firms. At their peak in 1916, spinoffs accounted for 11 of the 15 leading makes of automobiles. Nearly all of these spinoffs descended from the leading automobile producers in the sense that their founders had worked for one of these firms (Klepper, 2001, 2005). Statistical analyses indicated that the annual likelihood of a firm having employees leave to start spinoffs was greater for better-performing firms, and on average better-performing firms had better-performing spinoffs (Klepper, 2001). One explanation for these patterns is that leading incumbent firms provided a superior venue for employees to learn about organisational best practices, especially top employees. Top firms were also magnets for talented individuals, which is another possible reason their spinoffs performed so well. Spinoffs formed for various reasons. Among the top firms, many of them arose from internal disputes about strategy and technology, reflecting control struggles that were common in the early years of the industry (Klepper, 2005).

In large part because of the influence of Olds Motor Works, spinoffs played a key role in the concentration of the industry around Detroit.

Olds Motor Works had been a successful producer of steam and gasoline engines before it entered the automobile industry. Its manufacturing and marketing experience enabled it to become the first firm to sell over 1,000 automobiles in a year, selling over 5,000 by 1904. Olds subcontracted all of its parts, which involved orders of unprecedented size, to various local firms, providing its subcontractees with invaluable experience. Two of these firms were instrumental in the formation and success of Cadillac and Ford Motor Co., both of which were located in Detroit. Another one of Olds' subcontractors initially financed Buick, which was located in Flint, MI near Detroit. Buick was the cornerstone of the later merger that formed General Motors. This same contractor also co-founded another successful firm, Maxwell-Briscoe, which later evolved into Chrysler.

Olds Motor Works, Cadillac, Ford Motor Co., and Buick/General Motors were among the most successful early automobile producers, and they collectively unleashed a spinoff juggernaut that propelled Detroit to become the automobile capital of the United States. They were the most prolific parents in the industry, reflecting the greater rate of spinoffs among the better firms. Olds had more descendants than any other firm in the industry, and in total 41 firms descended from Olds, Cadillac, Ford, and Buick/General Motors. These firms mainly located in the Detroit area, reflecting the general tendency for spinoffs to locate close to their parents (Klepper, 2001). Together Olds, Cadillac, Ford, and Buick accounted for 11 of the 13 spinoffs that produced leading makes of automobiles after 1903, with each firm spawning at least two of these spinoffs. Consequently, by the mid-1910s nearly all the leading makes of automobiles were made by firms based in the Detroit area. With the leading makes accounting for over 80% of the output of the industry, Detroit firms totally dominated the industry. Indeed, what distinguished Detroit was primarily its spinoffs. Spinoffs accounted for 48% of the entrants in Detroit versus only 15% of the entrants elsewhere. Moreover, spinoffs in Detroit greatly outperformed spinoffs elsewhere, whereas the rest of the entrants in Detroit performed comparably to their counterparts elsewhere. In a statistical analysis, the superior performance of firms in Detroit was confined to its spinoffs, and their superior performance in turn was largely attributable to their superior heritage rather than being located in Detroit (Klepper, 2001).

The leading firms remained based in Detroit, but over time they conducted more of their business outside of Detroit as they established branch assembly plants throughout the United States. It was much cheaper to ship parts rather than a finished car. Consequently, if a firm had sufficient output to accommodate multiple plants of minimum efficient size then it made sense to build branch assembly plants closer to the market. Ford, the largest producer in the 1910s, was the first to build branch assembly plants in the 1910s. It was followed by General Motors in the 1920s and later Chrysler and two of the other large automobile firms in

the 1930s (Rubenstein, 1992). While this caused auto production to become more dispersed over time, Michigan still accounted for over 40% of the output of automobiles as of 1931, and the leading firms remained based in the Detroit area.

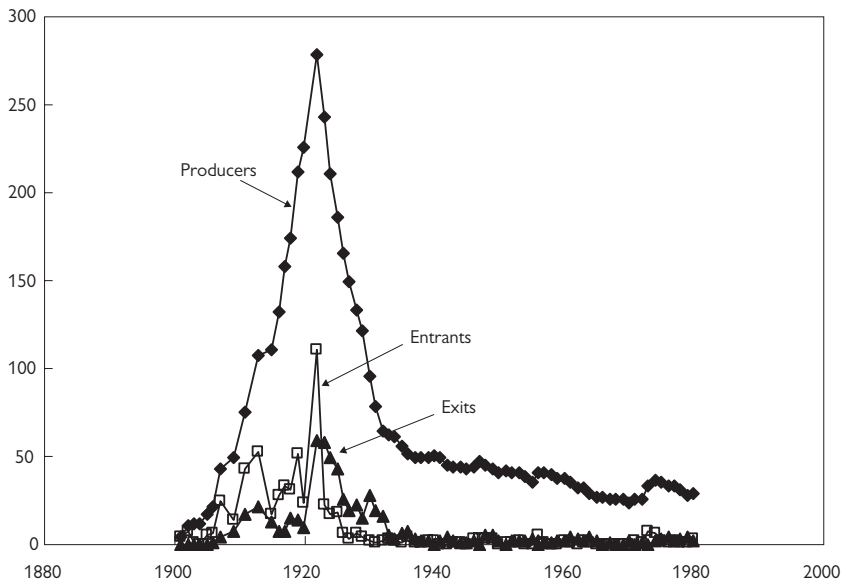
Some of the lessons that emerge from automobiles are similar to TVs. Like TVs, firms in related industries, such as Olds, were important seeds for the new industry. Also like TVs, there was enormous heterogeneity in entrants in terms of their pre-entry experience that persistently affected their performance. The key difference between autos and TVs was that spinoffs were competitive with, if not superior to, diversifiers. This reflected both the limited relevance of prior industries to autos and possibly the distinctive opportunities within firms, particularly the leading firms, for high-level employees to learn valuable tacit organisational knowledge that they could apply to their own firms.

With better firms having higher spinoff rates and better-performing spinoffs, the spinoff process effectively led to a buildup of firms and activity around the leading firms in the industry. This was especially potent in autos because of the location of four of the most successful early firms in one narrow region, fueling a great agglomeration of activity there. The four firms were connected through Olds, which was the catalyst for the agglomeration of the industry around Detroit. But the other three were important parents of spinoffs, and their creation near the industry leader added another random element to the agglomeration process that could help explain why agglomerations as extreme as autos are rare. Indeed, while Detroit was part of the manufacturing belt dating back to the 1860s, it was hardly the most likely place for the automobile industry to agglomerate. Its development was largely attributable to the influence of Olds Motor Works and the inherent randomness in the location of any one firm.

Agglomeration economies from locating near other producers do not appear to have been a major factor in causing the industry to agglomerate around Detroit. Indeed, the establishment of branch assembly plants throughout the US by the leading firms is indicative of the potential disadvantages of the leading firms clustering in one area. It is notable that it took the industry leaders to exploit the advantages of assembling cars outside of Detroit. This is indicative of the difficulty of imitating the leaders of the industry from afar, no doubt in part due to the tacit knowledge the leaders possessed. It is also suggestive of why the leading firms had more and better spinoffs— their high-level employees had access to valuable tacit knowledge about how to structure their own firms.

The evolution of the market structure of the automobile industry may have influenced the evolution of its geographic structure, though not directly. The TV industry also experienced a shakeout and evolved to be an oligopoly yet its geographic structure evolved oppositely to autos.

5. Entry, Exit, and Number of Producers in the Tire Industry, 1901-1980



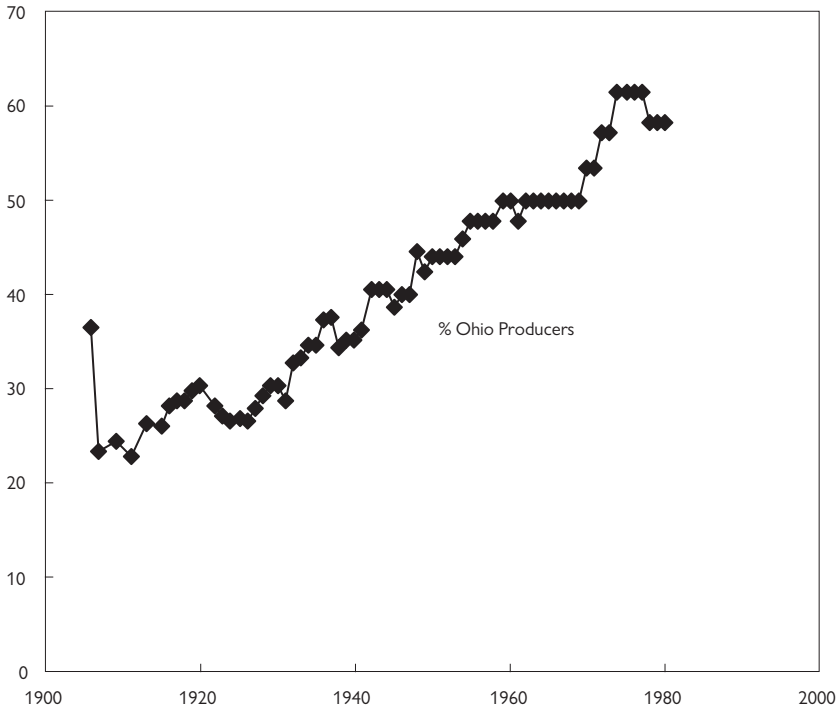
Source: See Buenstorf and Klepper, 2005b

Moreover, the hegemony of Detroit was established before the shakeout in the automobile industry began. It is possible, though, that the eventual drying up of entry that characterised the industry after 1925 eliminated a force that could have unseated the leaders and conceivably reduced the concentration of the industry around Detroit.

4. Tyres

The annual number of entrants, exits, and producers of tyres in the United States over the period 1905-1980 based on listings in the *Thomas' Register of American Manufacturers* is presented in Figure 5. With the initial demand for automobiles limited, the demand for tyres was initially modest and entry started out low. Subsequently it grew for many years, peaking in the early 1920s before falling off sharply and becoming negligible by 1930. A total of 533 firms entered the industry through 1930, after which no significant firm entered. The number of firms peaked in 1922 at 278 and then went through a long shakeout despite robust output growth interrupted only by the Great Depression. Only 51 firms were left in the industry in 1940, and by 1970 only 24 firms were still in the industry. The industry evolved to be a tight oligopoly dominated by Goodyear, Goodrich, Firestone, and US Rubber (Uniroyal). Together these four firms accounted for over 53% of the output of the industry in 1926, which they

6. Percentage of Tire Producers in Ohio, 1906-1980



Source: See Klepper and Buenstorf, 2005b

increased to over 70% by 1933 and then subsequently maintained (Klepper, 2002a).

Similar to automobiles, the tyre industry became heavily concentrated around a single city, Akron, OH, located in the northeastern part of Ohio near Cleveland. Figure 6 reports the annual percentage of 1930 and earlier entrants that were located in Ohio from 1906 to 1980. For the first 25 years or so Ohio generally accounted for between 20% and 30% of all producers, but after 1930 the percentage of firms in Ohio rose steadily and by 1959 it exceeded 50%. Firms in Ohio, especially around Akron, were distinctly successful, and by 1935 over 65% of the output of tyres was produced in Ohio (Buenstorf and Klepper, 2005b). Much of this output was produced by Goodyear, Goodrich, and Firestone, all of which were based in Akron. But firms in northeastern Ohio also dominated the next cadre of firms. As of 1920, six of the next 20 largest firms were located in Akron, and four others were located nearby in northeastern Ohio (Buenstorf and Klepper, 2005b).

Like automobiles, Ohio had more tyre entrants than any other state, but it accounted for only 24% of all the entrants through 1930, followed by

New York with 15%, New Jersey with 14%, Pennsylvania with 8%, and Illinois with 7%. Klepper (2002a) and Buenstorf and Klepper (2005b) identified the entrants into tyres that diversified from another industry, which in most cases was the rubber industry. Similar to TVs and autos, in a statistical analysis Buenstorf and Klepper (2005a) found that states with more rubber producers had more tyre entrants that were diversifiers and also more of other types of entrants, and within Ohio counties with more rubber producers had more diversifying entrants (Buenstorf and Klepper, 2005a). Similar to Michigan and autos, Ohio was not the leading state in terms of rubber producers, but was fifth in 1890 with 3.5% of US rubber producers. While diversifiers had lower hazards of exit on average than other types of entrants, diversifiers accounted for only 15.6% of all entrants, similar to automobiles. In part, this reflects that automobile tyres represented a considerable break from prior rubber products. Bicycle tyres did not readily scale to automobiles, tyre manufacturing was much more complex than other rubber products, and tyres were subject to much more technological change than other rubber products. Thus, like automobiles opportunities existed for regions that were not well stocked with firms in related industries.

Within Ohio, the most important rubber producer at the start of the tyre industry was BF Goodrich, which was located in Akron, where the (limited number of) rubber producers in Ohio were concentrated. Goodrich was a leading bicycle tyre producer and successful producer of other rubber products, and like Olds Motor Works it was an important catalyst for the industry in Akron. It produced the first pneumatic automobile tyre in 1896 and immediately became one of the leading producers of tyres. Goodrich was influential in four other early tyre firms locating and prospering in Akron— Diamond Rubber, which merged with Goodrich in 1912, Kelly-Springfield, Firestone, and Goodyear. Diamond was a 1894 rubber spinoff from Goodrich. Goodrich produced Kelly-Springfield's initial carriage tyre based on a patented design before Kelly-Springfield initiated the production of automobile tyres in Akron in 1899. Goodrich also initially produced tyres for Firestone after its entry in Akron in 1900 and then supplied Firestone with prepared rubber and fabric when it began producing its own tyres in 1903. Last, Goodyear was founded in 1898 by the son of one of the original financiers of Goodrich that subsequently also operated a rubber firm (Buenstorf and Klepper, 2005b).

With five leading firms located in Akron early on, the stage was set for spinoffs to play a key role in the further development of the industry around Akron. Buenstorf and Klepper (2005a) traced the origin of the 126 firms that entered in the state of Ohio through 1930. Like Detroit, spinoffs accounted for a disproportionate share of the entrants that originated from the Akron area— 58% of the 36 entrants that originated in Summit County (the home of Akron) were spinoffs versus 35% of the other entrants originating elsewhere in Ohio. Most of them were formed

by high level employees, similar to the automobile industry. Furthermore, the bulk of the spinoffs that originated in Ohio either entered in the same or a contiguous county to where their employer was located (Buenstorf and Klepper, 2005a). A statistical analysis of the rate at which employees left Ohio firms to form spinoffs revealed that the highest spinoff rate among Ohio producers occurred in the leading Akron firms, followed by the next tier of leading producers in Ohio (Buenstorf and Klepper, 2005a). In an analysis of firm performance (Buenstorf and Klepper, 2005b), firms located in the Akron area had lower hazards than firms located in the rest of Ohio and outside of Ohio. Similar to Detroit, the distinctive performance of the firms in the Akron area was confined to the spinoffs located there. Furthermore, among all spinoffs in Ohio, those that descended from the leading firms or the second tier of leading producers had lower hazard rates, suggesting that the superior performance of the Akron spinoffs was largely attributable to their heritage.

Buenstorf and Klepper (2005a) traced where entrants in Ohio originated, which for diversifiers was where they previously produced, for spinoffs where their parents were located, and for startups where their founders previously worked. Not only did spinoffs tend to locate in or close to their county of origin, but so did diversifiers and other startups. In a statistical analysis of the county where entrants located given their county of origin, Buenstorf and Klepper (2005a) found that the number of tyre producers and the population of an entrant's county of origin did not positively influence its likelihood of entering there. However, these same characteristics influenced whether an entrant located in a distant county. Figueiredo *et al.* (2002) found similar patterns for modern Portuguese entrepreneurial startups. One interpretation of these findings is that entrants have valuable knowledge about their home region, such as where to find labour, input suppliers, transportation, and even sources of knowledge spillovers, but they lack this knowledge about other regions. Consequently, even if their home region is not well stocked with firms in their industry and other industries and local markets for labour, inputs, etc. are thin, they still know where to secure their needs. Without this knowledge about other regions, they would be better off locating in regions with more firms in their industry and in other industries because such regions would have better developed local markets to supply their needs.

While the entrants in Ohio tended to locate near their geographic roots, when they established branch plants they tended to locate these away from their base location, similar to autos. In the 1920s the leading tyre producers established branch manufacturing plants throughout the United States to save on transportation and labor costs (Jeszeck, 1982). This intensified after 1935 due to increasing militancy on the part of the union representing tyre workers (Jeszeck, 1982), causing the share of tyre production in Ohio to decline. Similar to the automobile industry, it was the leading firms that were in the vanguard of exploiting the advantages of more remote areas. Their willingness to set up plants outside of Ohio is

suggestive of the limited advantages of locating in Akron. Consistent with this, Akron was not a major draw for either startups or spinoffs that originated elsewhere, and a number of spinoffs that originated in Akron did not locate there (Buenstorf and Klepper, 2005a).

The lessons from the tyre industry closely parallel those from autos. Firms from the rubber industry, the most closely related industry, were important seeds for tyre entrants, but spinoffs were also significant competitors. There was great heterogeneity among entrants in terms of their pre-entry experience that persistently affected their performance. One firm was a key catalyst for activity around Akron, both through its effects on other early Akron producers and through the spinoffs that it and the other successful Akron producers disproportionately spawned. As a consequence, the industry became extremely agglomerated around an unlikely region, reflecting both the randomness in the location of any one firm and the unlikely combination of early firms in one narrow region that was critical to the extreme agglomeration of the industry there. Agglomeration economies did not appear to play a major role in the agglomeration of the industry around Akron, and branching by the leaders eventually reduced the agglomeration of the industry there. The evolution of the market structure of the industry, particularly the eventual drying up of entry after 1930, may have contributed to the geographic concentration of the industry, but this concentration was established well before the industry underwent a shakeout.

5. Observations

Various themes emerge from the study of the three industries regarding the evolution of the geographic structure of new industries.

5.1. The location of firms in related industries influences where entrants locate

In all three industries, the location of firms in related industries influenced the location of entrants into the new industry. This was most apparent in televisions, where both diversifiers and other entrants concentrated in the three cities where the radio firms were clustered. In both autos and tyres, regions with more firms in related industries also had more diversifiers and other entrants. But firms in related industries were more dispersed in autos and tyres than TVs, so entrants were more dispersed in these two industries than TVs. The radio industry may also have had more influence on the location of TV producers than any related industry had on autos and tyres because of the greater overlap between radios and TVs than any product had with either autos or tyres. This was reflected in the much higher fraction of entrants that were diversifiers (from the radio industry) in TVs than autos and tyres.

The influence of related industries on entry into TVs, autos, and tyres suggests two points. First, firms need competence to compete in a new

industry, and one source of that competence is experience in related industries. Indeed, the fact that diversifiers in all three industries had lower hazards of exit on average than other entrants suggests that experience in a related industry was an important source of competence in all three industries. Second, diversifying entrants do not venture far geographically from their roots, which also appears to have been the case for spinoffs and other startups. Buenstorf and Klepper's (2005a) findings concerning the location of Ohio tyre entrants suggest that entrants locate close to their roots to exploit valuable local knowledge they possess based on their pre-entry experience. Consequently, an important determinant of regional entry into a new industry is the stock of local firms that could provide the competence needed to succeed in the new industry.

5.2. Incumbents can also be important sources of competence

Just as firms in related industries appear to be an important source of competence for a new industry, in autos and tyres incumbent firms also appear to have been an important source of such competence, especially the leading incumbents. The leading firms had higher rates of spinoffs, and on average their spinoffs were better performers than spinoffs from lesser firms. Moreover, their spinoffs were certainly competitive with if not superior performers to diversifiers from related industries, suggesting that the leading incumbent firms were also an important source of competence for entrants. The superior performance of spinoffs from the leading firms could reflect that these organisations had more to pass down to offspring. Alternatively, it could reflect that better firms attracted better managerial talent and more talented individuals founded superior firms.

Judging from the dominance of the industry by diversifiers from the radio industry, spinoffs were not competitive in TVs. Two factors may have been at work. Radios and TVs overlapped considerably in terms of technology and marketing whereas autos and tyres represented a greater break from past products. Consequently, diversifiers from radios may have had a greater advantage in TVs than any kind of diversifier had in autos and tyres, limiting the opportunities for new firms in TVs relative to autos and tyres. Second, demand initially grew much faster in TVs than autos and tyres, which may have limited opportunities for later entrants of all kinds, including spinoffs. Klepper (2002a) developed a model of shakeouts in which earlier entrants have a head start in building up a market for their products, which enables them to apply their R&D over a larger output, providing them with a competitive advantage. Spinoffs naturally enter later because they require a gestation period, in the form of employees gaining experience in incumbent firms. Consequently, they will be at a greater disadvantage in markets in which demand initially grows rapidly, as occurred in TVs relative to autos and tyres. Consistent with this, entry became negligible within 10 years of the start of the TV industry whereas it continued much longer in autos and tyres.

5.3. The spinoff process can induce agglomerations around successful firms

In both autos and tyres, better firms had higher spinoff rates. Spinoffs (and other entrants) did not venture far from their geographic roots, so entry was greater around successful firms. The spinoffs of successful firms also performed better than other spinoffs and were competitive with, if not superior to, diversifiers from related industries in autos and tyres. Consequently, over time activity built up around successful early producers, especially in Detroit and Akron, where successful early auto and tyre producers were concentrated.

Entry in Detroit and Akron was disproportionately composed of spinoffs and it was spinoffs in both regions that performed distinctly well, suggesting that the spinoff process alone can give rise to agglomerations. On the other hand, it is conceivable that the agglomerations in both Detroit and Akron were driven by agglomeration economies, which could give rise to the same patterns of entry being concentrated in agglomerated areas and firms in agglomerated areas performing better than firms elsewhere. But if agglomeration economies were the primary cause of the agglomerations in autos and tyres, then entrants of all kinds should have been attracted to Detroit and Akron. Moreover, entrants of all types should have performed better in Detroit and Akron than their counterparts elsewhere. Yet in both areas entry was disproportionately composed of spinoffs and only spinoffs performed better than their counterparts elsewhere. Furthermore, nearly all the spinoffs in Detroit and Akron had parents located there and so were not drawn from other regions. Judging from Buenstorf and Klepper's (2005a) findings for tyres, spinoffs (and other types of entrants) that originated from agglomerated regions were also no more likely to locate in their home region than spinoffs that originated elsewhere. Thus, agglomeration economies do not appear to have played a major role in fostering the agglomerations in either autos or tyres.

The TV industry is also instructive about the power of spinoffs versus agglomeration economies to generate agglomerations. Agglomeration economies would have been expected to operate as strongly in TVs as autos and tyres. Yet despite the extraordinary concentration of entrants in three narrow areas, the TV industry became less agglomerated over time. What appears to have been missing was a spinoff process that generated firms that were competitive with the leading diversifiers. This further suggests that the key to the agglomerations of the auto and tyre industries was the spinoff process and not agglomeration economies.

5.4. The spinoff process can magnify an early cluster of leading firms into an extraordinary agglomeration

Within the first ten years of the auto and tyre industries, most of the leading producers in autos and tyres were present in Detroit and Akron.

The setting was ripe for the spinoff process to magnify the initial cluster of leading firms in each region, and this is precisely what occurred. Consequently, over time the percentage of firms and activity around Detroit and Akron increased and both regions evolved to account for over 60% of activity in their industries. While establishment level data are not available to compute the Ellison-Glaeser (1997) index of geographic concentration, conservative estimates would put both industries in the tail of manufacturing industries in terms of geographic concentration.

Having so many early leaders in one narrow region is surely an uncommon event, which would explain Ellison and Glaeser's (1997) finding that agglomerations as extreme as autos and tyres are rare. On the other hand, even if the early leaders of an industry were not as clustered as in autos and tyres, the spinoff process would still be expected to cause activity to build around successful early firms. Activity would still agglomerate, but it would be dispersed across more regions than in autos and tyres. This could explain Ellison and Glaeser's (1997) finding that activity in most manufacturing industries agglomerates to some degree, but generally much less so than in autos or tyres.

In both autos and tyres, the early leaders did not all locate in Detroit and Akron by chance. Rather, one firm in each region— Olds Motor Works in autos and BF Goodrich in tyres— played a key role in other successful producers being located nearby. Both firms were fertile sources of spinoffs, but their influence was broader. Olds provided valuable experience to its local subcontractors, some of whom later entered or financed the ventures of others, while Goodrich supplied inputs and sometimes initially manufactured tyres for local tyre firms. In both industries, input markets were not yet well developed, and so expertise accumulated in one firm redounded to the benefit of others nearby. This is a form of spillover, but it is of somewhat different variety than the externalities featured in modern theories of agglomeration economies. It is restricted to a small number of connected firms in a region and is consistent with the findings of Breschi and Lissoni (2002) concerning how technological knowledge is transmitted across firms.

The importance of a single firm helps explain how the agglomerations in autos and tyres got established in an unexpected place. Neither Detroit nor Akron was particularly distinguished in terms of activity in related industries or anything else that would have fueled an agglomeration there. On the other hand, both regions were located in the so-called manufacturing belt and certainly had a healthy amount of activity in related industries. As chance would have it, both ended up with a diversifier from a related industry that became the first outstanding performer in its industry. This was the seed for the agglomerations that emerged in both regions. With a single firm having so much influence on the agglomeration process, chance can play a big role in whether and where an agglomeration gets established. Again, the TV industry is instructive about the circumstances in which

chance can have such a big influence on the location of an industry. Without a strong spinoff process in TVs, no firm had the kind of influence on the location of the TV industry as either Olds or Goodrich. Consequently, firms ended up congregating where firms in the radio industry were concentrated, limiting the possibility of activity clustering in an unexpected area.

5.5. Agglomerations and shakeouts are not directly related

Clearly, the forces underlying shakeouts do not lead to agglomerations, as the TV industry illustrates. Moreover, by the time the shakeouts began in autos and tyres, Detroit and Akron were already well established as the centres of activity in their respective industries. Thus, the shakeouts in autos and tyres do not seem to have played a critical role in the agglomeration of either industry. But characteristic of shakeouts is the drying up of entry, as occurred in all three industries after their shakeouts began. This removed a force that potentially could have undermined the agglomerations that formed in autos and tyres. Therefore, indirectly the agglomerations in autos and tyres might have been promoted by the shakeouts both industries experienced.

Ultimately, though, the forces underlying the shakeouts in both autos and tyres appear to have caused both industries to become less agglomerated. Both industries were characterised by scale economies at the plant level, which no doubt led firms initially to enter with a single plant. Judging from the actions of the leading firms, though, the economies were not so overwhelming as to preclude the establishment of branch plants by the largest firms in the industry. Thus, as both industries consolidated and the leaders took over an increasing share of the industry's output, the leading firms established branch plants, which they generally located away from their base locations to save on transportation and labour costs. With the leading firms generally based in Detroit and Akron, this eventually caused the agglomerations in autos and tyres to decline over time. The same forces also led the TV industry to become more dispersed over time as firms moved some of their operations off shore to take advantage of lower labour costs.

Dumais *et al.* (2002) found that in manufacturing industries branch plants generally are de-agglomerating in the sense that their location and use causes employment to move away from agglomerated areas over time. They found that the main force sustaining agglomerations was the greater longevity of plants in agglomerated areas. Again, the findings for autos, tyres, and TVs are instructive about the forces possibly at work. Judging from Buenstorf and Klepper's (2005a) findings for tyres, firms did not choose their initial locations to minimise the costs of production but to exploit local knowledge they had accumulated through their pre-entry experience. Thus, when branch plants were established, it was natural to

locate them away from where the firms were based, which was generally in agglomerated areas. Furthermore, agglomerations themselves can raise the cost of production such as by land prices being bid up, necessitating the payment of compensating wage differentials. In tyres, the agglomeration of activity in Akron also no doubt facilitated the union organisation of workers, and militancy on the part of the union contributed to firms setting up branch plants elsewhere. The greater longevity of plants in agglomerated areas could result from a spinoff process comparable to the one that operated in autos and tyres. Firms in agglomerated areas would be better performers and thus their plants would be longer lived.

5.6. Three industries do not make a general theory

Generalizing based on three industries is certainly dangerous, but there is enough evidence from other industries to suggest that the forces at work in auto, tyres, and TVs are operative in other industries as well. Sorenson and Audia (2000) found that in the footwear industry, entry was more likely in agglomerated areas even though firms had higher hazards of exit in these areas. They interpreted this as a reflection of the natural tendency of entry to concentrate near incumbents even in the absence of agglomeration economies, consistent with the spinoff process in autos and tyres. Gordon Moore of Intel fame, along with his coauthor, implicated spinoffs in the semiconductor industry as the primary basis for the agglomeration of activity in Silicon Valley (Moore and Davis, 2004). The analog to Olds and Goodrich was Fairchild, whose offspring were so numerous that they were dubbed Fairchildren. Moore and Davis (2004) have a particularly interesting discussion of why working in an incumbent semiconductor firm provided distinctive organisational knowledge that enabled high level managers to form their own successful spinoffs.

A few studies analyse the spinoff process in specific industries without linking it explicitly to geography, and their findings are also consistent with those for autos and tyres. In both the disk drive (Franco and Filson, 2000, Agarwal *et al.*, 2004) and laser industry (Klepper and Sleeper, 2005), spinoffs performed distinctively well. In both industries more successful firms had higher spinoff rates, which also appears to have been the case among semiconductor firms located in Silicon Valley (Brittain and Freeman, 1986). In disk drives, the spinoffs of more successful firms were also better performers, which appears to have been associated with a (involuntary) transfer of technology and marketing expertise from parents to their spinoffs.

5.7. Questions about the evolution of industry geographic structure

The interpretation of the evolution of the geographic structure of the auto, tyres, and TV industries raises many questions. Firms are assumed to differ from the outset in terms of their competence based on their

pre-entry experience. But what exactly does the pre-entry experience of firms provide them and how does this influence their performance not just initially, but for many years after entry? Spinoffs played a key role in the agglomeration of both autos and tyres. Why do spinoffs occur, why are they more prevalent among the leading firms, and what drives the correlation between the performance of spinoffs and their parents? Under what conditions do successful early entrants galvanise other firms to form and prosper nearby? More generally, what are the mechanisms that influence the transmission of knowledge across firms in the same industry and between suppliers and producers, and how is this mediated by geographic distance?

These are just some of the questions raised by the evolution of the three industries. Hopefully further examination of the way the geographic structure of new industries evolves will shed light on these questions and on the fundamental drivers of agglomerations and the geographic structure of industries.

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