Papers in Evolutionary Economic Geography

05.04

The spatial evolution of the British automobile industry

Ron A. Boschma & Rik Wenting

Utrecht University
Urban & Regional research centre Utrecht

The spatial evolution of the British automobile industry

Ron A. Boschma and Rik Wenting

Faculty of Geosciences
University of Utrecht
PO Box 80 115
3508 TC Utrecht
The Netherlands
r.boschma@geog.uu.nl

version
August 9, 2004

Abstract
This paper aims to describe and explain the spatial evolution of the automobile sector in Great Britain from an evolutionary perspective. This analysis is based on a unique database of all entries and exits in this sector during the period 1895-1968, collected by the authors. Cox regressions show that spinoff dynamics, localization economies and time of entry have had a significant effect on the survival rate of automobile firms during the period 1895-1968.

1. Introduction

Until recently, evolutionary economics paid little attention to geographical issues related to economic development and qualitative change. The main emphasis has been on explaining the behaviour of firms, the evolution of industries, and the performance of national economies with an emphasis on technological innovation and structural change. More recently, scholars have explored the possible linkages between the fields of evolutionary economics and economic geography.

Boschma and Frenken (2003) have dealt with the issue of how evolutionary economics may contribute to a new understanding of industry location. More in particular, they have defined the main features of an evolutionary approach that is able to explain the spatial evolution of a newly emerging industry. The basic starting point of an evolutionary economic geography is to understand firm behaviour in space as being guided by routines. The key question then becomes through which mechanisms (such as spinoffs and spillovers) these organisational routines diffuse and cluster spatially when a new industry emerges.

The paper aims to describe and explain the spatial evolution of the automobile sector in Great Britain from an evolutionary perspective. Following a long-term study of the (spatial pattern of the) automobile industry in the US by Klepper (2002), we estimate the importance of spinoff dynamics and agglomeration economies as vehicles of knowledge spillovers for the emerging spatial pattern of automobiles in Great Britain since the late nineteenth century. This project is based on own data collection of all entries, exits, mergers and acquisitions in this sector during the period 1895-1968. It concerns data on their location, the techno-economic background of entrepreneurs, their age, etc. We apply a hazard model to determine which factors (such as localization economies) explain the spatial formation of the automobile industry in Great Britain.

The paper is structured as follows. In the next section, we shortly outline two types of explanations of industry location provided by evolutionary economists like Arthur and Klepper, one on industry location through spinoff, and one on industry location in which spillovers and agglomeration economies play an important role. In Section 3, we explain which data sources have been used to describe the spatial evolution of the automobile sector in Great Britain during the period 1895-1968, and we present some preliminary results. In Section 4, we briefly explain the estimation techniques we have employed. Then, we present the empirical findings. Finally, in Section 5, a few conclusions are drawn.

2. Spatial formation of industries from an evolutionary perspective

Evolutionary economics puts emphasis on two processes that make fitter routines become more dominant in an industry. The first one concerns market competition between firms with different routines, resulting in asymmetrical profits. As a consequence, more efficient firms with fitter routines will expand their production capacity, at the expense of less efficient firms with unfit routines (Nelson and Winter, 1982). The second one concerns the emergence and diffusion of new and 'fitter' routines, due to processes of innovation and imitation. In this respect, increasing attention is paid to the importance of spinoffs as a mechanism that promotes the diffusion of fitter routines in an industry. Evolutionary economics is very keen on this spinoff mechanism, because it may provide evidence of the inheritance of routines from parent firms by spinoff firms. Under the assumption that the routines of spinoff firms are similar to the routines of the parent firm, spinoff processes can be considered a key vehicle for the economic evolution of routines in emerging industries. Both processes will result in differential growth rates of firms with different routines.

But how about geography? We have still little understanding of how this is affected by spatial factors and spatial proximity. How do new routines emerge and diffuse spatially when a new sector grows? Evolutionary economists like Arthur (1994) and Klepper (2002) have provided an explanation for the spatial evolution of new industries over time. They refer to two main mechanisms through which inter-organizational learning (i.e. the diffusion of 'fitter' routines from one firm to the other) may take place. The first is spinoff dynamics, as explained above, in which the transfer of knowledge occurs between a parent firm and its spinoffs. The other one is agglomeration economies, in which knowledge spills over from one firm to the other in a restricted spatial area. In the following sections, we discuss both mechanisms in a brief way. We build on their ideas to construct a theoretical and analytical framework to explain the spatial formation of the British automobile industry.

2.1 Spatial emergence of sectors through spinoffs

In a spinoff model, an industry comes into being as a sequence of firms giving birth to firms which generate new firms themselves, *et cetera* (Arthur, 1994). There is an emerging body of literature that give witness of the fact that this process has played an important role in the rapid growth and spatial concentration of industries like the ICT sector in Silicon Valley (Saxenian 1994), the U.S. automobile industry in Detroit (Klepper 2002a), and the wireless telecommunications cluster around Aalborg in Denmark (Dahl et al. 2003), just to mention a few. In all these cases, scholars have pointed to the creation of new firms through spinoff by incumbent firms as a major driving force of industrial growth and geographical concentration. Based on evolutionary thinking, two main reasons have been proposed in this respect.

Arthur (1994) developed a firm birth model in which the probability of a spinoff is equal to the number of incumbent firms in each region. This model assumes that spinoffs locate in the same region as the parent company, and that spinoffs do not move to other regions. By drawing at each time t randomly one firm that produces a spinoff, an evolving spatial distribution of firms in an industry is simulated. This process is also known as a Polya process, which produces a stable spatial distribution in the longer run. The long-run stability of the spatial distribution can be understood from the fact that the more firms are already present in the industry, the less an impact each new spinoff will have on the spatial distribution. Furthermore, the process is path-dependent: it is the stochastic sequence of draws early on that determines the spatial pattern of the industry. The resulting spatial distribution will be highly skewed, when some regions, by pure chance, will have a relative high number of spinoffs early on, and, subsequently, also produce more spinoffs thereafter. However, remark that routines do not play any role in this model.

Klepper (2002a) proposed a spinoff model within an evolutionary framework that accounts for the role of routines. In fact, the basic principle in his industry model is that spinoffs inherit the routines of parents firms. In contrast to Arthur's spinoff model, this truly concerns a process of inheritance in which the experience as embodied in routines and competences acquired in the same industry is inherited by spinoffs. As such, the spinoff process is regarded as a mechanism in which routines and competences are transferred or diffused from parent firms to new firms. Accordingly, Klepper claims that entrepreneurs with a techno-economic background in the same or related industries will perform better than start-ups that lack that kind of experience. In addition, Klepper claims that success breeds success: he expects the survival probability of spinoff firms to correlate positively with the survival probability of parent firms. Successful firms (with 'fitter' routines) will generate more successful spinoffs because they have a superior learning environment.

In sum, the spinoff process is a localised mechanism through which knowledge, competences and routines are transferred from a parent firm to its offsprings. Recall that this inter-firm learning process is expected to be localized geographically, because spinoffs tend to locate near parents almost as a rule. This literature points out that spinoff dynamics may be a sufficient explanation for a self-reinforcing process of spatial concentration of an industry. However, there are other mechanisms, such as agglomeration economies, that might stimulate inter-firm learning, and which may induce inter-firm learning to be confined to a geographical area. We turn to this topic now.

2.2 Spatial emergence of sectors through agglomeration

Besides spinoff dynamics, the spatial evolution of an industry may be affected by agglomeration economies. This notion covers all advantages that can be exploited by firms when located together in a restricted area. In economic geography, it is common to distinguish between urbanization and localization economies (Hoover, 1948). Urbanization economies are externalities available to local firms irrespective of the industry. Localization economies arise from a spatial clustering of economic activities in either the same sector or related industries. While accounting for agglomeration economies, geography plays a more prominent role in explaining the spatial evolution of industries.

Myrdal (1957) took a more dynamic view on agglomeration economies, or what he called a process of cumulative causation: the more firms locate in a region, the more diversified the local labour market, the more specialized the suppliers, the higher local demand, the better the infrastructure, the more local firms, *et cetera*. Thus, the more start-ups enter in a region, the higher the number of local firms, and the stronger the impact of agglomeration economies becomes. Following this line of thought, Arthur (1994) simulated agglomeration economies using a population of firms that enter the economy sequentially. Once one region has attracted slightly more entrants than other regions, a critical threshold is passed, and suddenly all new firms will opt for this one region as to profit from the higher agglomeration economies. As a consequence, agglomeration economies can cause an industry to concentrate in one region.

Remark once again that routines do not play an explicit role in the agglomeration models of Arthur. As explained earlier, an evolutionary approach to the spatial evolution of an industry should focus on the spatial distribution of routines within a sector and its evolution over time. An evolutionary approach based on agglomeration economics should therefore focus explicit attention on how agglomeration economies may enhance the emergence and diffusion of routines and competences as an industry grows. Evolutionary approaches on agglomeration economies therefore concentrate on the role of knowledge spillovers as a vehicle of local diffusion of routines and competences.

Studies have demonstrated that geographically localised knowledge spillovers may indeed exert a positive effect on knowledge output in terms of patents or innovations (Feldman, 1999). Simple co-location (Malmberg and Maskell, 2002), as well as networked relationships (Breschi and Lissoni, 2002), may act as vehicles of local knowledge production and diffusion. The former explanation suggests that being co-located, without explicit interaction, provides opportunities for agents to learn via monitoring, observing and imitating local rivals. The latter explanation suggests geography by itself does not play a role in knowledge spillovers, but social connectedness does. Social networks are considered mechanisms through which knowledge circulates and moves around rather easily, but also through which interactive learning and knowledge creation take place. Because social networks are often highly localised in a geographical sense, knowledge spillovers turn out to be localised geographically as well. As a result, knowledge will accumulate and become increasingly available within a region through co-location and local networks as an industry grows. Both mechanisms ensure that local firms sharing common values and similar competences in a particular field will have a better absorptive capacity and learning ability than actors outside the region.

Porter (1990) called attention for an additional factor: the importance of local competition. He argues that increasing spatial concentration of a specific industry induces firms to be innovative in order to survive. In other words, co-location of competitors implies strong local rivalry, which fosters the pursuit and rapid adoption of innovation. This is somewhat opposed to the view that increasing local competition forces firms (with less efficient routines) to exit the market (Klepper, 2002b). This is especially true during the later stages of the product lifecycle of an industry, when cost competition becomes fiercer, resulting in a shakeout process (Klepper, 1997). This shakeout process may disproportionally affect regions that host less successful firms, resulting in a change of the spatial distribution of the industry.

2.3 A dynamic, evolutionary perspective

Spinoff dynamics and agglomeration economies provide different evolutionary explanations for the spatial pattern of an industry. There is reason to expect that both the spinoff mechanism and agglomeration economies play a role simultaneously. When operating at the same time, both mechanisms would reinforce the spatial concentration process: the spinoff rate would become dependent on agglomeration economies, while agglomeration economies are further reinforced by a higher rate of spinoff creation within a region. Since spinoff dynamics and agglomeration economies provide different explanations for the same phenomenon of the spatial formation of an industry, the challenge for empirical research is to disentangle both processes as to assess their presence and importance.

It is plausible to expect that the spinoff mechanism (i.e. new firms founded by former employees of incumbent firms in the new industry) will be less dominant in the very early stages of the lifecycle of an industry, because there are simply few firms with a great deal of experience in this new field of activity. The same is true for localization economies. Localization economies (i.e. spatial externalities based on regional concentration of the new industry) are expected to become more important only in later phases of the development of an industry. Developing a new industry requires new types of knowledge, skills, inputs and institutions, which existing organizations and institutions cannot provide, since these are orientated towards previous technologies and routines (Boschma and Lambooy, 1999). In fact, firms typically have a low level of vertical disintegration at the start of a new industry (Klepper, 1997), and thus profit little from specialised suppliers. Moreover, firms initially profit little from thick labour markets as they need to train personnel in-house to acquire the new routines specific to the new industry. Only once concentration becomes denser, and local demand for input increases and becomes more standardised, firms will outsource activities to newly founded local suppliers, and local labour markets become more specialized.

Since the spinoff mechanism and localization economies (based on the new industry) are unlikely to provide an explanation for the spatial pattern of the new industry during its initial stage of development, other alternative mechanisms are likely to do so. Urbanization economies may be relevant at the early stages of an industry (Hoover and Vernon, 1962), because large urban areas may offer new entrants opportunities to acquire generic resources like employees, capital and other inputs. It is also (and even more) plausible to expect that localization economies based on the regional concentration of *related* industries will matter more at this stage: some regions may be more favourable from the very start, because they are well-endowed with related activities, offering a stock of potential entrepreneurs and skilled labour that can be readily exploited by entrants in a new industry. In other words, a new industry may have a higher probability to develop in regions where related activities are present in abundance. For instance, it is commonly known that the new automobile industry drew heavily on pre-existing industries such as coach and cycle making, while the new television industry built on (or even emerged out of) radio producers.

Similarly, experienced entrants are also expected to influence the spatial pattern of a new industry at its initial stage of development: new, successful firms in the new industry will be mainly founded by employees of pre-existing firms in related industries. In so far experienced entrepreneurs locate their new venture in the same region, the pre-existing spatial pattern is reproduced. Like the spinoff process, experienced entrepreneurship reflects a localised mechanism through which knowledge and routines are transferred from parents to new entrants. Entrants with prior experience in the same industry (spinoffs) rather than in related industries (experienced entrants) are, however, expected to have an even better learning environment and, thus, possess superior capabilities. As a result, the logic of spatial location through experienced entrepreneurship may be taken over by spinoff dynamics as the industry grows.

With respect to the role of local competition, we expect it will have no impact on the spatial pattern of a new industry during its initial stage of development. Since there are ample opportunities to enter the market (entry barriers are low), local competition will be rather weak. Over time, local market competition will become stronger, eventually resulting in a shakeout process. As noted earlier, it is uncertain what effect this will have. On the one hand, one expects a positive Porter-effect, because more local rivalry urges firms to innovate and upgrade their routines (while benefiting from local knowledge spillovers). On the other hand, one expects a negative effect when local competition becomes more intense, forcing firms to exit.

In sum, we expect that localization economies (based on related industries), experienced entrepreneurship and urbanization economies affect the location of a new industry during its initial stage of development. Localization economies (agglomeration economies based on the new industry) and spinoff dynamics are expected to be more important in later stages of industry location. Competition is also expected to be significant only in later stages, yet its precise impact is theoretically ambiguous. We test for these expectations in the remaining part of the article.

3. Evolution of the British automobile industry 1895-1968

Inspired by a long-term analysis of the US automobile industry conducted by Klepper, we present a spatial analysis of the British car industry for the period 1895-1968. Below, we discuss which sources provided the necessary data. Then, we describe the evolution of the market structure and the spatial pattern of the British car industry for this period. In Section 4, we provide an explanation for the spatial evolution of the British automobile industry.

3.1 Data sources

We have collected data on the years of production, the location and pre-entry techno-economic background of every manufacturer of automobiles from 1895 to 1968 to sketch the evolution of the market structure of the British car industry and its spatial concentration around Coventry. In '*The Complete Catalogue of British Cars, 1895-1974*', Culshaw and Horrobin (1974) compiled a list of every automobile manufacturer[1] in Great Britain from the start of the industry in 1895 through 1974[2]. This list includes information about the 461 makes made by those manufacturers who have put one or more models into series production. This list also includes the most important acquisitions leading to the major corporations. We have made use of '*The Complete Encyclopedia of Motorcars 1885-1968*' (Georgano, 1968), and '*The World Guide to Automobile Manufacturers*' (Baldwin et al, 1987) to obtain each firm's year of entry and exit, its location of production, and the background of its founder(s) [3]. The former source offers great detail on years of production, firm location and entrepreneurial background, the latter source primarily on the founder's background. Information on acquisitions was obtained from Culshaw and Horrobin (1974, p. 493), Georgano (1968) and Church (1995, p. 80-83). The list of automobile manufacturers from Culshaw and Horrobin (1974), which acted as the primary list of entrants due to a more or less shared definition of automobile manufacturer, has been adjusted according to the research period and obtained information on the entrants[4]. The data on firm market shares has been obtained from Saul (1962) for the automobile industry until 1914, and from Church (1995) and Wood (1988) for the period thereafter. Population and employment data by region by sector have been obtained from Lee (1979).

3.2 Evolution of market structure and spatial pattern in the British automobile industry

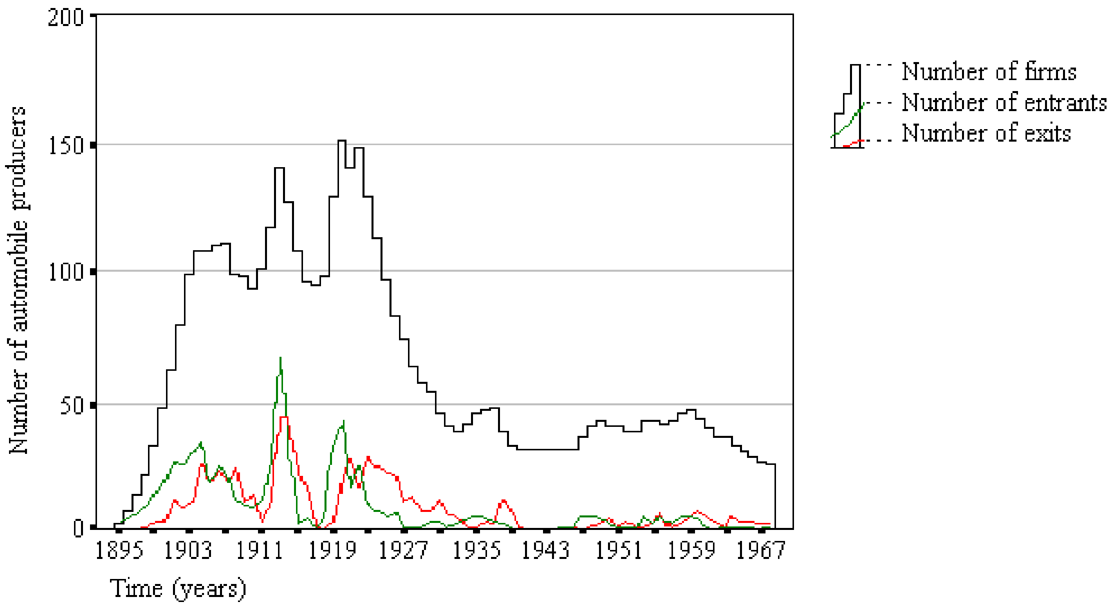
Figure 1 displays the evolution of the number of automobile firms (including the number of entrants and exits) in Great Britain in the period 1895-1968. The British density-pattern falls between the French and German: the industry started relatively late, but the number of new entrants peaked in 1913, and the number of firms remained very high until after the early 1920s (Hannan et al., 1995). By and large, three periods can be distinguished.

At the first stage of development of the sector, covering the period of about 1895-1921, the density rate goes up very steeply, with the exception of two major interruptions. The most striking growth occurred during the closing years of the nineteenth century and the first years of the twentieth century. For instance, Great Britain had 21 firms in 1898 and 99 in 1903. The 'slump' of around 1907 can be explained by the general liquidity crisis[5] in Britain at that time (Church, 1979). The density rate remains high in the period 1910-1922, with the major exception of the First World War, when the density declined more than 25%. After the war, in 1919, soaring car prices stimulated the adaptation of pre-war car-making firms and led to the entrance of a host of new producers (Maxcy, 1958)[6]. However, many of the new British entrants were not successful and few survived (Church, 1995).

After 1922, a real shakeout process took place, resulting in a steep decline in the number of automobile firms, which lasted until the mid-1930s. This was a critical period, during which the industrial structure changed from one of intense competition consisting of a large number of small firms with high mortality rates, to one dominated by three (British) companies: Morris Motors, Austin and Singer. These three giants together accounted for about 75 per cent of car production in Britain at that time (Maxcy, 1958). Two of these, Austin and Singer, were early entrants that located in Coventry. William R. Morris was one of the '1913 entry-boom' entrants, who located his firm within a hundred kilometers of Coventry in Cowley, Oxfordshire (Georgano, 1968).

During the period 1933-1968, the number of car manufacturers in Great Britain more or less stabilized. It remained exceptionally high (around 35 companies), compared with France, Germany and the US (Hannan et al., 1995; Klepper, 2002a). This outcome can be attributed to the high number of surviving small producers of high-priced, high-quality cars, filling market niches. The evolved market structure, however, with a few leading companies dominating the sector, is comparable to the outcome of the shakeout process in other countries, such as the US, where the automobile industry evolved into an oligopoly dominated by three companies (Ford, General Motors and Chrysler).

Figure 1. The Number of Automobile Manufacturers, Entrants and Exits in Great Britain, 1895-1968

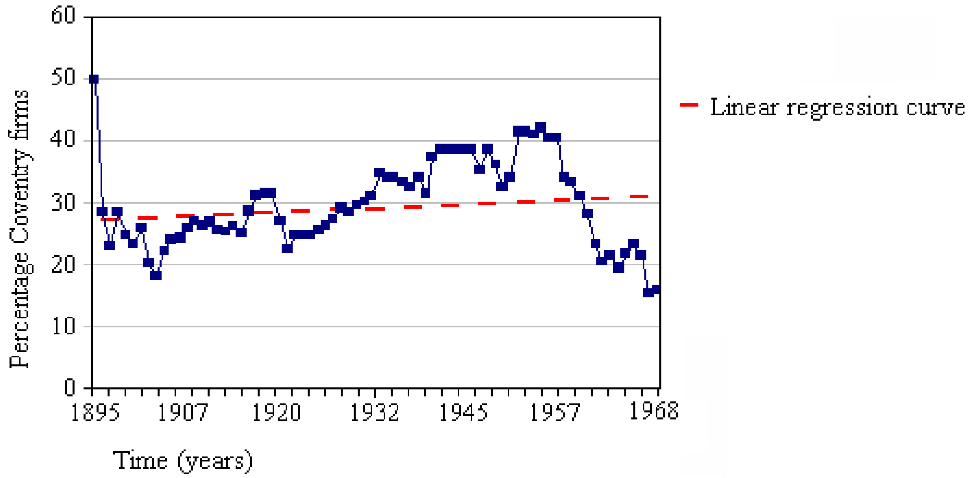


Source: own elaborations of Culshaw and Horrobin (1974) and Georgano (1968).

Just as Detroit and Paris emerged as the main centers of, respectively, the American and French motor industry, Coventry became Britain's first motor city. Yet, prior to the 1860s, Coventry had little or no engineering tradition. This sprang from the bicycle trade that arrived in Coventry in 1868, and after the bicycle-boom of 1893-1897, the city became the center for the British bicycle industry. Indeed, from its outset, the British motor industry differed from its continental contemporaries in that it sprang, to a notable extent, from the bicycle industry (Wood, 1988). In fact, our data show that experienced firms were the main early entrants in the Coventry region: 89% of the entrants that located in the Coventry area in the period 1895-1900 had prior experience in related industries. Whether or not this concentration of related industry in the Coventry-area was decisive in the concentration of the British car industry in this region will be tested later on.

Figure 2 depicts the share of the Coventry area in the total number of automobile firms in Great Britain in the period 1895-1968. The Coventry region has been defined as the area that is within a distance of 50 kilometres (by road) from the city of Coventry. In contrast to Detroit, the number of Coventry area firms was already high in the beginning of the industry[7]. Throughout the whole period, 30-40 % of all British car manufacturers were located in the Coventry area (in terms of production, this share was, of course, much higher). During periods of decline, firms outside the Coventry area are hit disproportionally. For example, from 1914 to 1918, the number of automobile manufacturers in Britain declined from 126 to 96, while the share of the Coventry area rose from approximately 25% to 32%. The same occurs during the major shakeout of 1922 to 1932. In those ten years, the number of automobile manufacturers in Britain plummeted from 147 to 40, and again the share of the Coventry area rose, from approximately 25% to 35%. The decline of Coventry's share in the total number of car firms after the late 1950s is striking. The market share of Coventry firms in Great Britain, however, remained above 50 percent up through 1968 (Church, 1995).

Figure 2. The share of the Coventry area in the total number of automobile firms in Great Britain in the period 1895-1968



Sources: own elaborations of Culshaw and Horrobin (1974) and Georgano (1968).

4. Spatial formation of the British automobile industry: spinoff dynamics and/or agglomeration economies?

As demonstrated above, automobile manufacturing in Great Britain, like the US experience, became heavily concentrated in a particular region. It is yet unclear to what extent this has been determined by a spinoff process (as was the case in the US, according to Klepper), and to what extent location (i.e. agglomeration economies) has played a role (which was not the case in the US, according to Klepper). First, we introduce the main explanatory variables in our estimation model, and we present some empirical outcomes. Then, we estimate Cox regressions, in order to determine which factors provide an explanation for the spatial evolution of the British car industry in the period 1895-1968.

4.1 Descriptive statistics

There are several variables in Klepper's model that are expected to determine the performance of firms as well as to affect the spatial pattern of the automobile sector. Below, we take a more detailed look at three of these factors, that is, time of entry, the techno-economic background of the entrepreneur, and the location of firms.

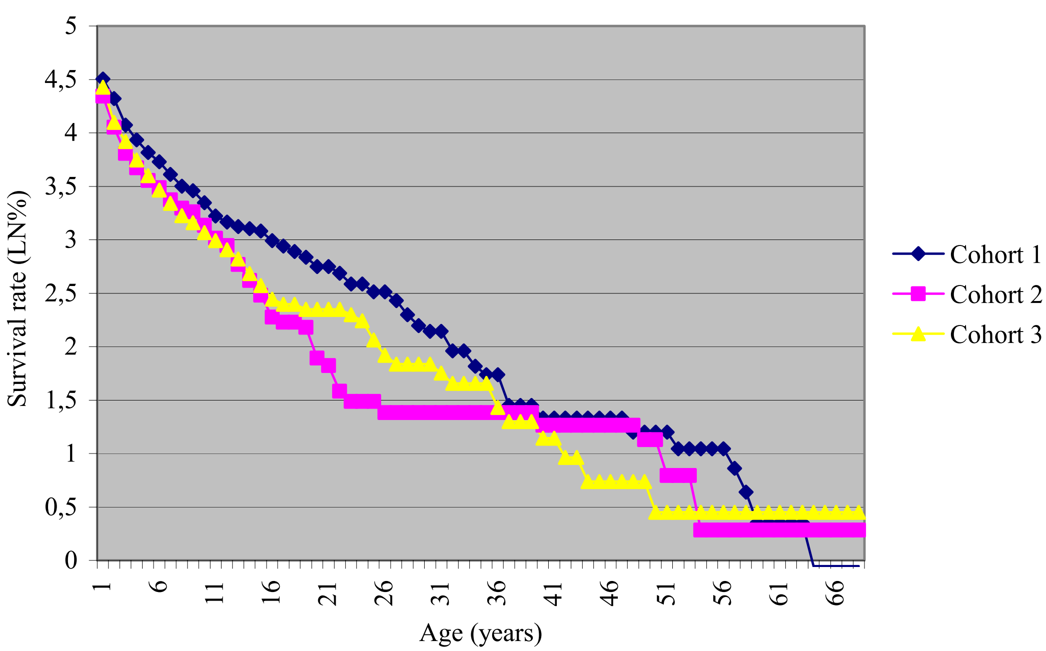
Time of entry

According to Klepper (2002a), earlier entrants will have higher survival rates. In Klepper's basic model, earlier entrants face a higher price-cost margin than later entrants. In the earlier stages of development of a sector, firms make higher profits, they can allocate more resources to R&D, and, therefore, they grow more. As a result, earlier entrants will have a lower hazard at every age. Following Klepper (2002a), all automobile manufacturers have been divided according to their time of entry. To probe the importance of time of entry, the firms are grouped into three entry cohorts of comparable size. Cohort 1 refers to the 1895-1906 entrants (211 firms), cohort 2 to the 1907-1919 entrants (226 firms), and cohort 3 to the 1920-1968 entrants (191 firms).

The survival rate of each car manufacturer has been determined as follows. Since we have data on the entry and exit years of each automobile firm that existed in Great Britain in the period 1895-1968, we can determine their age by counting the number of years between their first and last year of commercial production. In the case of acquisition by another automobile manufacturer, the purchased firm exits the industry and the acquiring firm continues. However, firms that were reorganized or acquired by non-automobile producers were treated as continuing producers. Approximately 5% of the firms exited through the acquisition by another automobile firm or through a merger. This number is comparable to that of the American automobile industry (Klepper, 2002a). If a foreign company enters the British automobile industry by acquiring an incumbent firm, such as General Motors' acquisition of Vauxhall in 1925, this is treated as an exit of the purchased firm, and an entry of the purchasing firm. If a foreign company, such as Ford in 1911, establishes a branch plant in Great Britain, it is treated as a new entrant into the British automobile industry. The foreign entrant is designated an entrepreneurial background equal to the experience of its original founder[8]. In the case of a firm having a British and a foreign founder, this was treated as a new entrant and, as with all entries concerning multiple founders, the designated entrepreneurial background is determent by the founder with the most techno-social related experience[9]. In the case of multiple parent-firms, the last parent is considered the mother company from which the spinoff sprang (and from which it is assumed to inherit its routines).

Figure 3 presents survival curves indicating the percentage of firms surviving to each age for each of the three cohorts of entrants. The vertical axis shows this percentage plotted on a logarithmic scale. As expected, cohort 1 shows a better performance (higher survival rates) at all ages than cohort 2 and 3. The Pearson correlation between the age of a firm and whether or not firms entered in the earliest period (cohort 1) is positive (0.088) and significant at the 0.05 level. This outcome is in line with the US experience (Klepper, 2002a) and the German experience (Cantner et al. 2004).

Figure 3. Survival rate by time of entry



Source: own elaborations of Culshaw and Horrobin (1974) and Georgano (1968).

Techno-economic background of entrepreneur

An important element in Klepper's model is that the probability of survival of spinoff firms depends on the characteristics of the parent company. As set out in Section 2, pre-entry backgrounds of entrants are considered essential because they refer to capabilities of parent organizations that are taken to the new firm. Klepper (2002a) made a distinction between types of firms based on their entrepreneurial background. The spinoff type of entrant is a new firm founded by (former) employees of incumbent automobile firms. The second type concerns pre-existing firms diversifying from related industries. The third type refers to new firms founded by employees of pre-existing firms in related industries. Finally, Klepper defined a group of inexperienced entrants. Any firm that has not been classified as spinoff or as experienced firm was assigned to this residual category.

We mainly followed these categories defined by Klepper. We categorized the types of entrants according to the technological relatedness of their pre-entry industry experience: spinoffs, experienced firms and inexperienced firms. We defined experienced firms as entrants who entered with prior experience in related industries. It is expected that firms with (technical and commercial) backgrounds most closely related to automobiles (e.g. coach, bicycle, or engine industries) to have superior capabilities. A firm was classified as a spinoff, if the founder had previous experience in the motor industry, either as founder or as employee of another motor company on Culshaw and Horrobin's list. Whenever a firm had multiple founders, the founder with the most related experience to the automobile industry was viewed as the founder determining the entrepreneurial background of the firm. Firms were classified into the category of experienced firms when the sources indicated at least one of their founders as having experience in a related industry[10], either as employee or as founder[11]. These firms usually diversified into automobile production. If an entrant was described as having experience in semi-related industries[12] (i.e. mechanical engineering), it was also classified as an experienced firm. The firms that were not classified as spinoffs or experienced firms were included in the residual category of inexperienced firms.

Table 1 displays the entrants in the British automobile industry by background and time of entry. Unfortunately, we could not determine the background of 248 entries (accounting for 39% of the total number of entrants), because our data sources failed to deliver any information on this particular issue. Therefore, this last group of entrants was excluded from most of the analyses below. We have further analyzed the group of entrants with unknown backgrounds, and we have made a comparison between this group and the group of firms with known backgrounds. We found that firms assigned to the group with unknown background had a shorter life span. This is understandable because for firms that have existed for only one or a few years, less information will be available.

Table 1. Entrants by background and time of entry

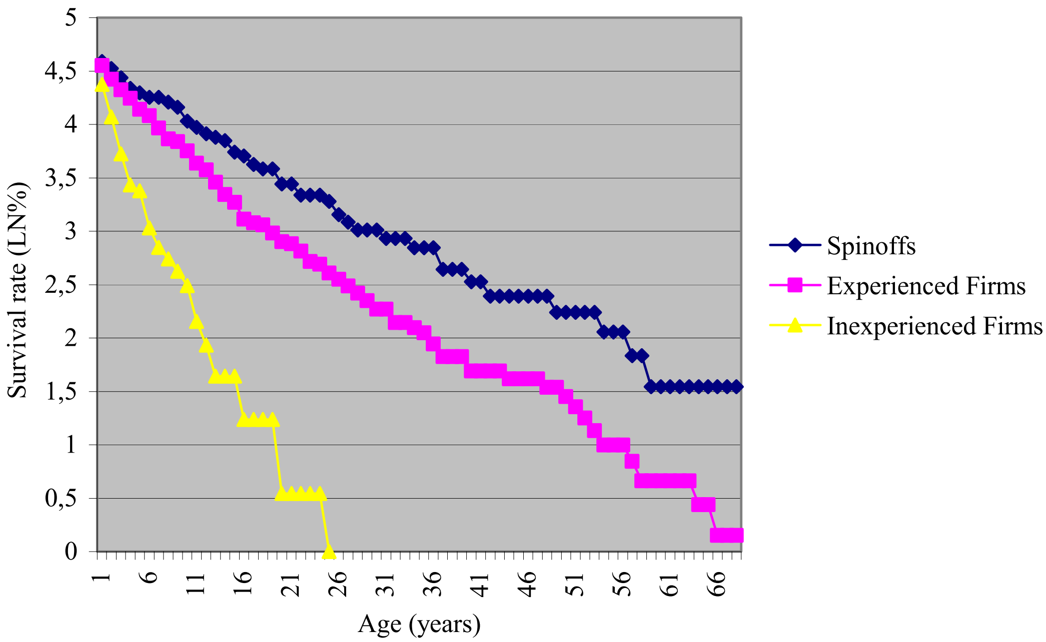
Cohort	Total	Spinoffs	Experienced	Inexperienced	Unknown
1895-1906	211	20	100	13	78
1907-1919	226	24	80	23	99
1920-1968	191	20	78	22	71
Total	628	64	259	57	248

Source: own elaborations of Culshaw and Horrobin (1974) and Georgano (1968).

When we consider the number of spinoffs generated by each parent, we notice similar experiences in the US case and the British case. In the US, a total of 145 spinoffs (20% of the total) was counted during the whole period. A few parents generated quite a considerable number of spinoffs in the US: two companies (Olds and Buick/GM) were responsible for 7 spinoffs each, and three firms (Cadillac, Ford and Maxwell-Briscoe) produced 4 spinoffs. In the British case, we have observed a number of 64 spinoffs, which is about 17% of the entrants with a known background. The two firms that generated the most spinoffs are Daimler (10 spinoffs, of which 6 directly[13]) and Wolseley (6 spinoffs, of which 4 directly). Both are located in the Coventry area. Arrol-Johnston in Glasgow generated 4 spinoffs, and nine other companies (of which four are located in the Coventry area) 2 spinoffs each.

As noted above, we expect that survival rates will differ across firms with different backgrounds: the more experienced the entrant is, the higher its survival rate at every age. We explained before that spinoffs are considered to be the most experienced firms in automobile production, followed by experienced firms, while the inexperienced firms are expected to have the lowest survival rates at every age. Figure 4 demonstrates that spinoffs and experienced firms show indeed, as expected, a higher survival rate than inexperienced firms at every age.

Figure 4. Survival curves by entrepreneurial background.



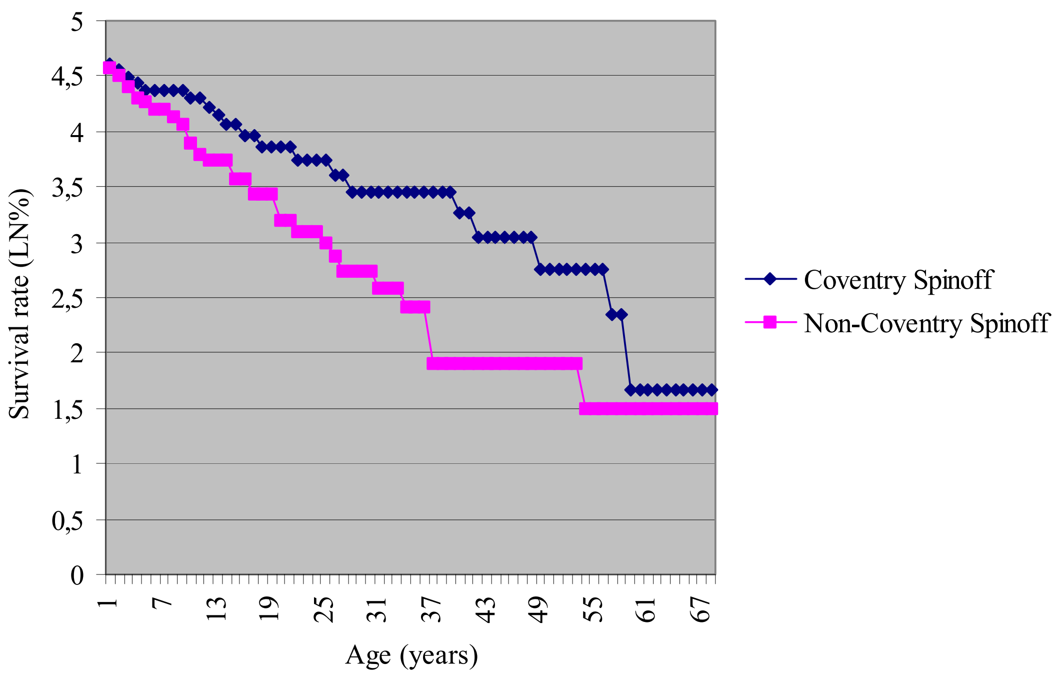
Source: own elaborations of Culshaw and Horrobin (1974) and Georgano (1968).

As stated in Section 2, the survival rates of spinoffs at every age may also be determined by the performance of their parents: spinoffs from better-performing parents are expected to show a higher performance rate. The data confirm that more successful parents generate more successful spinoffs than less successful parents: the Pearson correlation between the age of a parent firm and its spinoff(s) is positive (0.359) and significant at the 0.01 level.

Following Klepper, we expect that spinoffs of Coventry area parents will locate in the Coventry area and spinoffs located in the Coventry area will have parents located in the Coventry area. The data show that 19 spinoffs out of a total of 64 have located in the Coventry area. As predicted, 17 of these 19 spinoffs originated from Coventry area parents, 2 spinoffs located in the Coventry area had their parents elsewhere, while Coventry area parents generated another 7 spinoffs outside the Coventry area. Moreover, we predict there will be a disproportionate number of spinoffs in the Coventry area. This can also be confirmed. Whereas 22% of the total amount of entrants located in the Coventry area, this is true for 29% of the spinoffs. Inexperienced firms are underrepresented in the Coventry area (12%), while the share of experienced firms in the Coventry area is the same as for all entrants in the Coventry area, that is 22%. Figure 5 demonstrates that spinoffs located in the Coventry area have a higher survival rate that spinoffs located elsewhere,: the difference between the survival rates of spinoffs located either in or outside the Coventry area appeared to be significant. The Pearson correlation between location in Coventry and the age of a spinoff is positive (0.217) and significant at the 0.05 level.

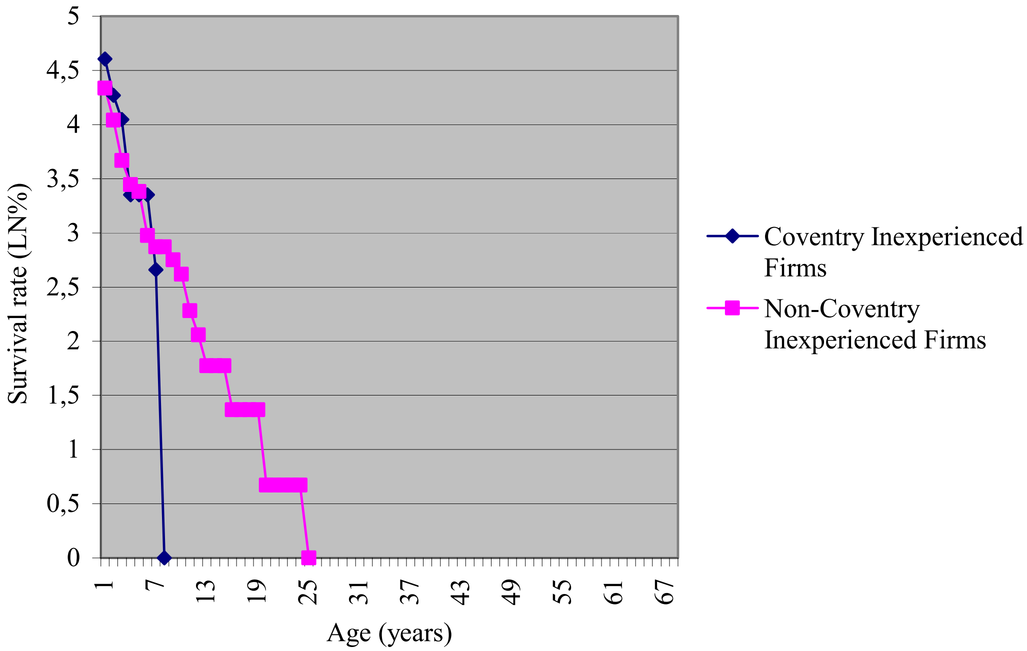
In his US study, Klepper observed that inexperienced automobile firms performed worse in Detroit than in other locations. According to Klepper, this is an important outcome, because it suggests that no knowledge from the successful firms in the Detroit area has spilled over to the local inexperienced firms: agglomeration economies (as vehicles of knowledge spillovers) have played no role whatsoever in the emerging spatial pattern of automobiles in the US since the late nineteenth century. In the British case, we witness the same picture. Figure 6 shows that inexperienced firms in the Coventry area have lower survival rates than inexperienced firms located elsewhere. The Pearson correlation coefficient between the age of the firm and whether or not an inexperienced firm was located in the Coventry area was, however, not significant.

Figure 5. The survival curves of spinoffs located in and outside the Coventry area



Sources: own elaborations of Culshaw and Horrobin (1974) and Georgano (1968).

Figure 6. The survival curves of inexperienced firms located in and outside the Coventry-area



Sources: own elaborations of Culshaw and Horrobin (1974) and Georgano (1968).

4.2 Cox regressions

We make use of a hazard model to determine which factors can explain the spatial evolution of the British automobile industry. More in particular, we estimate Cox regressions to assess the effects of location (i.e. agglomeration economies), time of entry, and spinoff dynamics (i.e. the techno-economic background of firms) on the survival rates of automobile firms.

Hazard modelling

As noted before, the dependent variable in our model is the survival rate, as a proxy for performance of firms. We could determine the years of entry and exit of almost each automobile firm that existed in Great Britain in the period 1895-1968. However, 25 car manufacturers still existed in the year 1968. That is why we have run Cox regressions (Audretsch & Mahmood, 1994). A Cox regression makes use of the contribution of censored cases. The firms that exited the industry after 1968 have been considered censored exits in our models.

The Cox proportional hazard regression model is popular, in part because it requires fewer assumptions than some other survival models (Lee, 1992). In this case, the use of a time-dependent Cox regression model is not necessary, since we assume that observations are independent, and the hazard ratio should be constant across time (i.e. the proportional hazard assumption[14] is not violated). Cox regression uses the hazard function to estimate the relative risk of failure. The hazard function, $h(t)$, is a rate. A high hazard function indicates a high rate of mortality. The model is used to determine the influence of predictor variables (covariates) on a dependent variable (e.g. survival), simply expressed in terms of the hazard function.

$$h(t) = [h_0(t)]e^{(B\,X)}$$

Here X is a covariate, B is a regression coefficient, e is the base of the natural logarithm, and $h_0(t)$ is the baseline hazard function when X is set to 0 (the expected risk without the variable). As with multiple linear regression, the model for Cox regression can be expanded to include more than one covariate:

$$h(t) = [h_0(t)]e^{(B_1 X_1 + B_2 X_2 + \ldots + B_n X_n)}$$

where X_1 … X_n are the covariates. For multiple level variables, *Exp*(*B*) estimates the percentage change in risk with each unit change in the covariate.

Estimation results

We have estimated five regression models via maximum likelihood, adding more factors in each new model. The estimates of the models are presented in Table 2.

As explained in section 2, agglomeration economies can play a key role in the spatial formation of an industry. In model 1, we test whether location has had any effect on the hazard rates of the automobile firms. Our data set provides information on the location of each entrant. All entrants have been assigned to one of 51 British regions, based on a regional classification of Great Britain developed by Lee (1979). In case firms had moved from one location to the other, we assigned firms to the location where they produced for most of their years. This latter correction has been conducted for more than twenty firms in our data set.

Three variables have been constructed in such a way to gauge the effects of localization and urbanization economies. With respect to localization economies (based on related industries), variable RVEHE measures for each entrant the number of people employed in related industries (i.e. vehicle production, including car making, coach making, cycle making, etc., see for more detail footnote 10) in its home region at the year the firm entered the automobile sector. As explained before, this variable is a proxy for the presence of local knowledge spillovers, while it may also influence the supply of entrepreneurs and required labour (Buenstorf and Klepper, 2004). As a proxy for urbanization economies, we have constructed the variable RPOPU, which measures for each entrant the population in its home region at the year it enters the sector. With respect to local competition, variable RCOMP measures for each entrant the number of automobile firms in its region at the year it enters the sector. As explained before, different interpretations of its impact on the survival of firms are possible. On the one hand, we anticipate that a high number of automobile firms in the immediate surroundings of a new entrant may be beneficial, because it induces firms to innovate and upgrade their routines, while local knowledge and skills required in automobiles are most likely available. On the other hand, more automobile firms in a region may imply more intense competition, increasing the hazard of a new entrant.

As shown in Table 2, RCOMP has a positive and significant effect on the hazard rate. This implies that the more automobile firms there are in the region of the entrant at its year of entrance, the more competition, and the lower its survival rate. As expected, the relation between regional employment in related industries (RVEHE) and the hazard rate is negative and significant: localization economies (based on related industries) indeed matters. In other words, automobile firms located in regions that are well endowed with knowledge and skills somewhat related to the emerging automobile industry at their year of entrance perform better. By contrast, urbanization economies are not important: the variable RPOPU has no significant relationship to the hazard of automobile firms, and its coefficient has even a wrong (positive) sign. When we take a more detailed look at the data, we observe that densely populated areas with no concentration in vehicle production (such as London) generated many entrants, but very few of the successful firms were located in these regions. In sum, location of firms matters: firms located in regions with related activities (rather than densely populated regions per se) show lower hazards.

The second model allows an impact of the time of entry on the performance level of automobile firms in Great Britain. As explained in section 4.1, we have made two 1-0 dummy variables, one for cohort 1 (ENTR1), and one for cohort 2 (ENTR2), with cohort 3 the omitted reference group. As model 2 shows, the coefficient estimates of the dummy variable for cohort 1 is negative and significant: early entrants show indeed a lower hazard rate, as expected. However, this is not the case for firms of cohort 2. Moreover, the impact of location is in model 2 again manifest and of the same nature.

In model 3, we add controls for the background of entrants by defining two 1-0 dummies equal to 1 for spinoffs (SPINF) and experienced firms (EXPEF). In other words, we test whether the pre-entry background of the entrants affects the survival rate of automobile firms. Section 4.1 provides more details on the definitions of both variables. Table 2 gives the answers. As expected, the dummies of spinoffs and experienced firms have a very strong, negative and significant impact on the hazard rate of automobile firms. More in particular, the relative effect of spinoffs is higher than the one of experienced firms, implying an even higher survival rate for spinoffs than experienced firms. This is in accordance to the evolutionary argument that firms inherit routines from their parents: the more close these routines are related to automobiles, the better the new entrants will perform. The impact of time of entry and firm location on firm survival remains the same in model 3, as compared to model 2.

As stated in section 2, Klepper's model (2002a) claims that better-performing parent firms have superior learning environments, and, therefore, generate more successful spinoffs. Because it is assumed that routines determine for a large part firm performance, it is important to control for the performance of parent firms. The variable YRPAR measures the number of years the parent firm produced cars[15]. In model 4, this variable is added. As expected, the

Table 2. Coefficient measures of the Cox regressions (standard errors).

	Model 1	Model 2	Model 3	Model 4	Model 5
RVEHE	-0.207*** (0.071)	-0.262*** (0.076)	-0.227*** (0.078)	-0.205*** (0.078)	-0.563* (0.281)
RPOPU	0.078 (0.068)	0.104 (0.069)	0.097 (0.069)	0.096 (0.069)	0.334 (0.260)
RCOMP	0.023*** (0.007)	0.025*** (0.008)	0.024*** (0.008)	0.023*** (0.008)	0.012 (0.028)
ENTR1		-0.312** (0.143)	-0.253* (0.144)	-0.235* (0.145)	
ENTR2		-0.097 (0.148)	-0.058 (0.147)	-0.051 (0.148)	
EXPEF			-0.860*** (0.154)	-0.870*** (0.154)	-1.302*** (0.377)
SPINF			-1.297*** (0.197)	-0.238 (0.480)	-11.656 (251.032)
YRPAR				-0.397** (0.164)	0.133 (85.178)
Chi-square *-2 Log Likelihood*	12.055*** 3622.553	17.881*** 3617.102	69.945*** 3575.545	73.470*** 3570.261	31.559*** 326.225
	N=380	N=380	N=380	N=380	N=133

*** significant at the 0.01 level
** significant at the 0.05 level
* significant at the 0.10 level

coefficient is negative and significant: better performing parent firms indeed generate better performing spinoffs. This outcome suggests that successful routines are transferred from parents to spinoffs. What is even more interesting is that the added control for parent performance cancels the significance of the effect of the variable SPINF on firm survival. This implies that prior experience in the automobile industry is of no importance *per sé*. What is important for the performance of the spinoff, however, is that the entrepreneur has had prior experience in a successful parent automobile firm. This result is comparable to what Klepper found in the US automobile industry. The effects of the other variables remain largely the same as in model 3. In sum, it is the location of firms (regional employment in related industries), the pre-entry background of firms (both spinoffs and experienced firms) and their time of entry (early entrants) that determine the hazard rate of British automobile firms.

Finally, we have tested whether localization economies (based on related industries), experienced entrepreneurship and urbanization economies have indeed affected the location of the British car industry during its initial stage of development. For this reason, we have included in our model only entrants that had been assigned to cohort 1, that is, automobile firms that entered the market during the period 1895-1906. Firms that survived after 1906 have been treated as right censored cases. With the exception of the time of entry variables, we have run the same hazard model as model 4. Model 5 presents the results.

As expected, localization economies and experienced entrepreneurship have an even stronger effect on the hazard rate during the first phase of development, as the higher coefficients of RVEHE and EXPEF in model 5 compared to model 4 indicate. Thus, prior experience in related industries matters even more at this stage, embodied in both the background of the entrants (experience in related industries) and their location (regional concentration of related industries). This is in line with the evolutionary argument: new firms will perform better when they inherit relevant routines from parent organizations and learn from local sources of knowledge and skills. It is interesting to observe that the spinoff variables SPINF and YRPAR are no longer significant in model 5. As expected, spinoff dynamics only becomes important during later stages of development. Moreover, the variable RCOMP is no longer significant in model 5. This outcome is as expected. It suggests that, in contrast to later phases, local competition has no impact on the hazard rate during the first phase of development of the automobile industry, because (local) competition is still weak. Finally, we expected urbanization economies to affect the hazard rates of firms at the very start of an industry. Model 5, however, shows that the variable RPOPU remains insignificant.

5. Conclusions

In the paper, the evolution and resulting spatial concentration of the British automobile industry have been addressed. It appeared that from the very beginning Coventry was, and is, Britain's Motor City. The first British automobile company, Daimler Motor Company, set up location in the Coventry area, and many others followed. After the main shakeout from 1922 to 1932, the Coventry area housed a high concentration of firms, as well as two of the three leading firms in the British car industry. Two different evolutionary approaches to industry concentration were used to analyze the spatial evolution of the British automobile sector.

Our analysis has demonstrated that agglomeration economies, spinoff dynamics (entrepreneurial background) and time of entry played an important role in the spatial formation of the British automobile industry. First of all, we were able to show that the spatial distribution of related industries has had a significant and negative impact on the hazard rate of firms. This mattered even more so during the first phase of development: some British regions were more favourable from the very start, because they were well endowed with related activities (e.g. bicycle and coach making), offering a local supply of potential entrepreneurs, knowledge externalities and skilled labour that could be readily exploited by entrants in the new industry. In particular, the pre-existence of a concentration of bicycle making in Coventry seems to have laid the foundations of a car industry in this region. In other words, location influenced the spatial formation of automobiles in Great Britain to a considerable degree.

The second mechanism that played an important role in the spatial formation of the British automobile industry appears to be spinoff dynamics. A few exceptionally successful early entrants in the Coventry area generated a disproportionally amount of local spinoffs, which, in turn, created spinoffs themselves. Coventry spinoffs also performed better than spinoffs located elsewhere. In other words, the large amount of spinoffs in the Coventry area and their exceptional success contributed to the spatial concentration of the industry in this region.

The influence of the pre-entry techno-economic background of the entrant appeared to be essential for firm survival. Whether or not the entrant possessed related experience to automobile manufacturing appeared to be a determining factor for a firm's performance, even more so in the initial phase of development of automobiles. Experienced entrants (with prior experience in related industries) and spinoffs (with prior experience in automobiles) had a significant positive relation to firm performance, as compared with inexperienced firms. Spinoffs performed even better than experienced entrants, because the routines of their parents are more closely related to automobiles. To be more precise, prior experience in a successful parent automobile firm had a positive impact on the performance of spinoffs, indicating a true evolutionary process of inheritance of successful routines between firms.

Evolutionary economic geography is a relatively young discipline. Its models on industrial evolution are only beginning to be tested empirically. This paper has contributed to this task. It not only proofs the importance of spinoff dynamics in the evolution of an industry. It has also demonstrated the effect of localization economies on the emergence of an industry and the performance of its firms: space matters indeed.

Bibliography

Adeney, M. (1989), *The Motor Makers: The Turbulent History of Britain's Car Industry*. Collins: London.

Arthur, W.B. (1994), *Increasing Returns and Path Dependence in the Economy*. The University of Michigan Press: Ann Arbor.

Audretsch, D.B. and T. Mahmood (1994), 'The rate of hazard confronting new firms and plants in U.S. manufacturing', *Review of Industrial Organization*, **9**, 41-56.

Baldwin, N., G.N. Georgano, M. Sedgwick and B. Laban (1987), *The World Guide to Automobile Manufacturers*. MacDonald: London.

Baldwin, N. (1994), *A-Z of Cars of the 1920s*. Bay View Books: Bideford.

Boschma, R.A. and K. Frenken (2003), 'Evolutionary economics and industry location', *International Review for Regional Research*, **23**, 183-200.

Boschma, R.A. and J.G. Lambooy (1999), 'Evolutionary economics and economic geography', *Journal of Evolutionary Economics*, **9**, 411-429.

Buenstorf, G. and S. Klepper (2004), 'The origin and location of entrants in the evolution of the U.S. tire industry', working paper, 33p.

Breschi S. and F. Lissoni (2002), 'Mobility and social networks: localised knowledge spillovers revisited', paper presented at the workshop 'Clusters in high-technology: Aerospace, biotechnology and software compared', UQAM, Montreal, 1 November 2002

Cantner, U., K. Dressler and J.J. Kruger (2004), 'Firm survival in the German automobile industry'. *Jenaer Schriften zur Wirtschaftswissenschaft*, **8/2004**, 1-14.

Church, R. (1979), *Herbert Austin: The British Motor Industry to 1941*. Europa Publications: London.

Church, R. (1995), *The Rise and Decline of the British Motor Industry*. Cambridge University Press: Cambridge.

Culshaw, D. and P. Horrobin (1974), *The Complete Catalogue of British Cars*. Macmillan: London.

Dahl, M.S., C. R. Pedersen and B. Dalum (2003), 'Entry by spinoff in a high-tech cluster', *DRUID working paper*, 3-11.

Doyle, G.R. (1959), *The World's Automobiles 1880-1958. A Record of 78 Years of Car Building*. Temple: London.

Feldman, M. (1999), 'The new economics of innovation, spillovers and agglomeration : a review of empirical studies', *Economics of Innovation and New Technology*, **8**, 5-25.

Georgano, G.N. (1968), *The Complete Encyclopaedia of Motorcars 1885-1968*. George Rainbird: London.

Georgano, N., N. Baldwin, A.D. Clausager and J. Wood (1995), *Britain's Motor Industry: The First Hundred Years*. Haynes Group: Sparkford.

Hannan, M.T., G.R. Carroll, E.A. Dutton and J.C. Torres (1995), 'Organizational evolution in a multinational context: entries of automobile manufacturers in Belgium, Britain, France, Germany and Italy', *American Sociological Review*, **60**, 4, 509-528.

Harrison, A.E. (1981), 'Joint stock flotation in the cycle, motor cycle and related industries, 1882-1914', *Business History*, **23**, 165-190.

Hoover, E.M. (1948), *The Location of Economic Activity*, McGraw-Hill: New York

Hoover, E.M. and R. Vernon (1962), *Anatomy of a Metropolis. The Changing Distribution of People and Jobs within the New York Metropolitan Region*, Anchor Books: New York.

King, P. (1989), *The Motor Men: Pioneers of the British Car Industry*. Quiller Press Ltd: London.

Klein, J.P. and M.L. Moeschberg (1997), *Survival Analysis: Techniques for Censored and Truncated Data*. Springer-Verlag: New York.

Klepper, S. (1997), 'Industry life-cycles', *Industrial and Corporate Change*, **6**, 1, 145-182.

Klepper, S. (2001), 'Employee startups in high-tech industries', *Industrial and Corporate Change*, **10**, 3, 639-674.

Klepper, S. (2002a), 'The evolution of the U.S. automobile industry and Detroit as its capital', paper presented at 9th Congress of the International Joseph A. Schumpeter Society, Gainesville, Florida, March 2002.

Klepper, S. (2002b), The capabilities of new firms and the evolution of the US automobile industry, *Industrial and Corporate Change*, **11,** 4, 645-666.

Lee, C.H. (1979), *British Regional Employment Statistics 1841-1971*. Cambridge University Press: Cambridge.

Lee, E.T. (1992), *Statistical Methods for Survival Data Analysis*. John Wiley & Sons: New York.

Lewchuck, W.A. (1985), 'The return to capital in the British vehicle industry', *Business History*, **27**, 3-25.

Lord Montagu and D. Burgess-Wise (1995), *A Daimler Century: The Full History of Britain's Oldest Car Maker*. Haynes Group: Sparkford.

Malmberg, A. and P. Maskell (2002), 'The elusive concept of localization economies: towards a knowledge-based theory of spatial clustering', *Environment and Planning A*, **34**, 3, 429-449.

Maxcy, G. (1958), 'The motor industry', in P.L. Cook and R. Cohen (eds.), *Effects of Mergers*, Allen and Unwin: London

Michie, R.C. (1981), 'Options, concessions, syndicates and the provision of venture capital, 1880-1913'. *Business History*, **23**, 147-64.

Nelson, R.R. and S.G. Winter (1982), *An Evolutionary Theory of Economic Change*. Harvard University Press: Cambridge Mass.

Nicholson, T.R. (1983), *The Birth of the British Car Industry*, Vols I, II, III, Macmillan: London.

Porter, M. (1990), *The Competitive Advantage of Nations*. Free Press: New York.

Richardson, K. (1977), *The British Motor Industry 1896-1939*. Macmillan: London.

Saul, S.B. (1962), 'The Motor Industry in Britain to 1914', *Business History*, **5**, 1, 22-44.

Saxenian, A. (1994), *Regional Advantage*. Cambridge MA: Harvard University Press: Cambridge Mass.

Whisler, T. (1999), *The British Motor Industry, 1945-94, A Case Study in Industrial Decline*. Oxford University Press: Oxford.

Wood, J. (1988), *Wheels of Misfortune, The Rise and Fall of the British Motor Industry*. Sidgewick and Jackson: London.

---

[1] The term 'automobile manufacturer' is defined as a producer being principally devoted to four-wheeled petrol-engined passenger cars. We have deliberately excluded producers of racing cars, commercial vehicles, one-off specials, kit cars, three-wheelers, steam cars and electric cars, as well as those makes which cannot reasonably be termed production models (i.e. prototypes).

[2] Various lists of automobile manufacturers have been compiled. Because Culshaw and Horrobin (1974) have used a largely similar definition of an automobile manufacturer, their list was the obvious starting point.

[3] We also consulted 'A-Z of Cars of the 1920's' (Baldwin, 1994), 'The World's Automobiles 1880-1958' (Doyle, 1959), 'The Motor Industry in Britain' (Saul, 1962), 'Britain's Motor Industry' (Georgano et al., 1995), The British Motor Industry, 1945-94: A Case Study in Industrial Decline (Whisler, 1999),'The Complete Catalogue of British Cars' (Culshaw and Horrobin, 1974), The Motor Makers: The Turbulent History of Britain's Car Industry (Adeney, 1989), King (1989) and Richardson (1977).

[4] Obviously, the entrants between 1969 and 1974 of Culshaw and Horrobin's (1974) list were not included in the analysis, the researched period being 1895 to 1968. Also, the list includes companies, such as Burke Eng. Co. Ltd. from Clonmel (Ireland) and Shamrock Motors Ltd from Tralee (Ireland), that were not producing in Great Britain (defined as England, Scotland, Wales and Northern Ireland) and were thus not included in the analysis.

Listed entrants controversial to the stated definition of automobile manufacturer were excluded from the analysis (i.e. since the definition explicitly excluded racing car manufacturers, Jeffrey Racing Cars from Shilton is not included in the analyses). Also, whenever the *Complete Encyclopedia* by Georgano (1968) expresses strong and reasonable doubt on an entrant's qualification as an automobile manufacturer, it 'outrules' the list of Culshaw and Horrobin (1974), and the entrant is not included in the analysis. For instance, Georgano (1968) states concerning Automobile Transport Co. from London, there is "… no satisfactory proof that a single vehicle left the factory, if indeed there ever was a factory" (p. 427). Overall, the adjustments made to the list of automobile manufacturers compiled by Culshaw and Horrobin (1974) were few in numbers, but necessary for a clear analysis of the British automobile industry for the period 1895 to 1968.

[5] Afterwards, business confidence returned (Michie, 1981; Lewchuck, 1985), and a recovery set in. This recovery was strengthened by a reduction in risk for investors caused by the stabilization in car design (Nicholson, 1983; Harrison, 1981).

[6] Entry in 1919 was further stimulated, because the immediate post-war conditions of a decline in private motoring during the war and a import-reducing tariff created a pent-up demand (Church, 1979).

[7] It took some years before the first automobile firms located in the Detroit area. In the first six years of the industry, there were 69 entrants in the US without one locating in Detroit. After 1900, the number of firms in the Detroit area rose, reaching a peak of 41 in 1913. The percentage of firms in the Detroit area rose to 15% by 1905 to 24% by 1916, and to over 50% by 1935 (Klepper, 2002a). The number of Detroit-area firms subsequently declined along with the decline in the total number of automobile producers as a result of the shakeout process. The rising percentage in the period 1916-1935 was not caused by entry through spinoff, but by the asymmetrical effects of the shakeout, which hit regions outside the Detroit area more severely.

[8] This is why Ford is designated as a spinoff (Henry Ford worked at Cadillac), and the General Motors's Vauxhall plant (from 1925) as an experienced firm (General Motors was founded by a former bicycle manufacturer) (Klepper, 2002a).

[9] Implementing these standards resulted in the joint productions being categorized as spinoffs of the foreign founder's (previous) automobile manufacturing firm. They include Clement-Talbot, Adams-Hewitt and Sizaire-Berwick (Georgano, 1968).

[10] Using the list of occupations in the populations census of 1911, experience in related industries to automobile manufacturing in Great Britain has been identified as experience in commercial production of coaches, bicycles, automobiles services, motor car components (motor car body makers, etc.), and the following other professions: motor car attendant, motor garage-proprietors and -workers, motor car driver & motor cab driver, and motor, van etc. drivers.

[11] This standard was generally straightforward to implement. The principal exception concerned Hillman. The company produced bicycles for a number of years before diversifying to automobile manufacturing. Hillman started making cars in 1907, after it was joined by Mr. Coatalen, formerly of Humber. Hillman-Coatalen Motor

Co. Ltd. was formed and Hillman entered the British automobile industry. According to Baldwin et al. (1987), L.H. Coatalen "… practically ran the Hillman Works as well as the drawing office" (p. 221). Due to his role in the founding of Hillman-Coatalen and the impact on Hillman's production of cars, the experience of Mr. Coatalen is used as the entrepreneurial background of this automobile firm.

[12] Using the list of occupations in the populations census of 1911, experience in semi-related industries to automobile manufacturing in Great Britain has been identified as mechanical engineering, meaning experience in the following professions: boilermaker, others in engineering & machine making, others in textile machinery fittings, metal machinist, erector, fitter & turner-labourer, erector, fitter & turner, ironfounder, millwright, pattern maker, others in construction of vehicles, machinists & machine workers, merchant service, seaman-engineering department, and agricultural machine-proprietors & attendants.

[13] We counted 6 direct spinoffs of Daimler, and 4 spinoffs of these Daimler spinoffs.

[14] In the Cox proportional hazard model it is assumed that the proportionality of hazards from one case to another should not vary over time. The latter assumption is known as the proportional hazards assumption (Klein and Moeschberg, 1997).

[15] This indicator of the performance of parent firms is the only available one over such a long period. One of the problems with this indicator is that it should have measured (but does not measure) the performance of the parent only for the period when the founder of the spinoff was still working for the parent (or at least till the time of entry of the spinoff).