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Rock ?n Roller Coaster: An Explorative Study on the Evolution of the European Steel Roller Coaster Industry

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Abstract

This article investigates the 50 years evolution of the European steel roller coaster industry, which can be classified as a complex products systems (CoPS) industry. This industry is characterized as a non-shake out industry where entry can be divided in three waves, i.e. early diversifiers, new technological entrants, and late diversifiers and spin-off dynamics. Diversified entry can be further separated in firms with market relatedness, i.e. firms that have been active in the amusement industry prior to entry, and technological relatedness, i.e. firms that have experience from different industries but their technological competences enable them to manufacturing (often technological more advanced) steel

roller coaster. Despite the fact that this industry is a non-shake out industry, we observe acquisition of the intangible and tangible assets of those firms that (are close to) exit by the firms that remain in the industry, which might be considered a sign of industry resilience.

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1 Introduction

Over the last decades, much empirical evidence has been collected on the evolution of industries. These studies have investigated a large diversity of industries, most notably, the automobile industry (Klepper, 2002; Boschma and Wenting, 2007; Cantner 2009). The majority of these studies follow the traditional three-stage model inspired by Abernathy and Utterback's (1975) product life cycle. Be that as it may, this model has several strong assumptions and, consequently, there may be just as many industries that deviate from this pattern (Nelson, 1994; Malerba and Orsenigo, 1996; Klepper, 1997). Those deviating industries may be well linked to the organizational characteristics of Hobday's (1998) complex product structure (CoPS) industries, but the precise determinants of these alternative evolutionary paths are only recently being investigated (Klepper and Thompson, 2007).

In investigating the evolution of industries there is a clear interest in the literature to identify entry and exit. The interest in entry has lead to a typology of entry modes, mainly in relation to pre-entry experience of the founders. The issue of exit has received not that detailed attention. Similarly, a number of studies have made a distinction between different types of exit modes, such as firm closure, merger and acquisition, firms leaving the industry, and firms that move abroad (Hannan et *al.*, 1998). However, it is surprising that hardly any on the long list of industry studies focus on the post exit knowledge diffusion, especially since knowledge is considered the main driving force of the life cycle pattern (Cantner et *al.*, 2009). In addition, this knowledge diffusion and the ability of the industry to absorb the knowledge of exiting firms can be regarded as an important indicator of the resilience of an industry.

This paper applies these perspectives in an explorative but detailed case study on the evolution of the European steel roller coaster industry. Although one may not directly think of it like that, we believe this industry to be an excellent example of what has been coined a CoPS industry (Hobday, 1998), which will be further elaborated in Section 2.2.1. There are three specific reasons why we have chosen this industry. First, the overall development of the roller coaster is characterized by several large structural technological changes (i.e. from wood to steel to tubular coasters). Yet, contrary to other large technological break-throughs, the earlier technological stages co-exist with the newest one (i.e. there is still a market for wooden roller coasters). Because of the extensive use of steel, and particularly the application of tubular structures, roller coasters require quite specific technical competences. This created room for new entrants, and as we will show, these new companies have not necessarily been active in the manufacturing or design of wooden roller coasters before. Second, while there is only a limited number of roller coaster buyers – think of amusement parks and showmen – these buyers offer their services to a large and very diverse user community. Consequently, the demand of products on this market is very heterogeneous and many products are custom-made. Existing industry studies typically focus on industries that have a much lower level of heterogeneity and often move towards a dominant design (both regarding technology but also aesthetically). This lust of diversity might lead to a diverse set of entrants and is also likely to have an impact on the exit of firms. Third, the archives and records in this industry allow us to obtain detailed information on what happens with the firms after they exit, which is relevant given the diversity in this

industry. So, in addition to reporting on the survival and death of firms we have the opportunity to report on the aftermath. And finally, perhaps our strongest (although probably somewhat biased) motivation to focus on this market is that the roller coaster industry is downright funky.

To investigate the evolution of European steel roller coaster industry we compiled a dataset that pools data from a wide variety of sources, but has its point of departure in, unique census-like database on roller coasters, the Roller Coaster Database (RCDB). Put together by roller coaster enthusiasts, this database not only includes detailed information on almost any roller coaster ever taken into use, but also provides a large amount of information on their designers and manufacturers.

The structure of this paper is as follows. In the next section, Section 2, we will present the theoretical framework on the evolution of industries and the role of different modes of entry. We will also include a discussion on the firm exit and the potential this exit unleashes for the further development of industries. In Section 3, we will introduce the case of the roller coaster industry where we present the method by which we identified the relevant firms. In Section 4, we present the empirical analysis on the European steel roller coaster industry, which includes: a general overview on the history of the roller coaster; the genealogical tree of the European roller coaster industry; the different modes of entry; the knowledge development, which is done by looking at the firm's patent portfolio; and the exit of these firms. Finally, in Section 5, we will discuss the findings of this study and provide directions for future research.

2 Theory

2.1 Industry Life Cycle

This study on the evolution of the European roller coaster industry can build upon the experience of many earlier attempts to characterize the evolution of industries. Previous research, stretching several decades, has investigated a broad and heterogeneous set of industries, including but not limited to tires (Buenstorf and Klepper, 2009), lasers (Klepper and Thompson, 20007; Buenstorf, 2007), telecommunications (Dahl et *al.*, 2011), wind turbines, fashion (Wenting, 2008), TV receivers (Klepper and Simons, 2000), wind turbines (Menzel and Kammer, 2011), turbo-prop engines (Bonaccorsi and Giuri, 2000), and automobiles (Klepper 2000, Boschma en Wenting, 2007, Canter 2009). Most of these studies feature an industry that evolves in line with the traditional life cycle model, based on the earlier work of Utterback and Abernathy (1975) – which has a remarkable resemblance with an earlier model by Hirsch (1965). These models consist of three stages. These stages are: (i) the initial growth stage, often initiated by a radical innovation, during which the number of firms in the industry increases; (ii) the period of shakeout where the total number of firms decreases due to the exit of producers but also due to fewer entries, partly attributed to the emergence of a dominant design; and finally, (iii) the stage of stability or maturity, during which the number of firms does not change substantially and the focus shifts from product innovation to process innovation. In these studies the driving force of the life cycle patter is shaped by various forms of knowledge, i.e. pre entry knowledge, knowledge obtained after entry and in particular the knowledge that is obtained during innovative activities (Cantner et *al.*, 2009).

Consequently, these studies are focused on the identification of distinctive events that occur during the life of an industry, most notably the dynamics of entry and exit.

2.1.1 Entry modes and pre-entry experience

One of these core events is the entry of firms into the industry. However, what constitutes firm entry is not that easily defined. To illustrate the different ways of entry Hannan et *al.* (1998) listed a set of entry modes in the automobile industry, i.e.: (i) *de novo* founding, (ii) *de alio* entry, (iii) merger, (iv) acquisition, (v) restart after bankruptcy, (vi) re-entry, or (vii) split of firms. Another typology of entry, particularly popular among scholars in life cycle theory, is that of Helfat and Lieberman (2002). It is summarized in Table 1.

Table 1: Typology of firm's entry

Entrant Type	Mode of Entry	Parent Company Ownership
Diversifying Entrant	Internal Growth	Full
	Acquisition	Full
Parent Company Activity	Joint Venture	Partial
	Parent Spin-off	Partial
	Franchise	Partial
De Novo Entrant	Entrepreneurial Spin-off	None
	Experienced Start-up	None
	Inexperienced Start-up	None

Source: based on Helfat and Lieberman (2002)

This typology also considers another important factor of entry, i.e. the pre-entry experience. Here, diversifying entrants and parent company activities enter into the industry with experience from other, potentially related, industries. *De novo* entrants might have experience from similar or related industries, respectively entrepreneurial spin-offs and experienced start-ups, while the founders of inexperienced start-ups come from other non-related fields. The importance of this pre-entry experience is based on the observations that entries from the same or related industries outperform in-experienced entry (Klepper, 2001). The underlying mechanisms that explain this difference in performance are the knowledge and the underlying routines, in line with the thinking of Nelson and Winter (1982). The capabilities of firms are important and those firms with experience in related and similar fields are better equipped than entries without this experience (Agarwal et *al.*, 2004). In addition, firms with better routines will outperform those with inferior routines. Good – but also the bad – routines can be transferred from forms into their spin-offs (Dahl and Reichstein, 2006).

But the question which form of entry is the most common (or most successful) one is not so straightforward to answer. As highlighted by Boschma and Wenting (2007), in the early stage of industry development it is most likely that diversified entry will play a more important role than spin-off. This can be explained by the fact that there are not that many firms with experience in the industry. In the later stages, when the industry is more established, entrepreneurial spin-offs will occur more frequently. However, which form of entry that eventually will dominate the industry will differ from one industry to

another. Many examples, as presented in a review by Klepper (2009), show that entrepreneurial spin-offs are the dominant mode of entry for the formation of an industry but in some cases diversified entry is the driver of industry development, as for instance in the television receiver industry (Klepper and Simons, 2000).

The relatedness of the pre-entry experience is an important factor in shaping the further (spatial confined) development of the industry. After all, there is a reason why pre-entry experience in radio technology was crucial for entry into the television receiver industry and experience in coach or bicycle manufacturing for entry into the automobile industry (Boschma and Wenting, 2007). However, this relatedness can have many different dimensions, e.g. relatedness based on the underlying technologies but also relatedness based on the market properties. Since industries emerge in particular geographical regions, the type of relatedness might differ from one region to another depending on the region's industrial profile. Due to the localized character of entry, i.e. diversifiers and spin-off will generally remain in the area where they were before entry into the industry, combined with the regional specific pre-entry (related) knowledge there might emerge different industry branches emerging in different geographical areas. These branches do not necessarily have to compete between them, since they serve distinctive markets, despite the fact that these firms are active in the same industry.

2.1.2 Exit modes and post-exit knowledge flows

Firm exit is another core event in understanding the evolution of an industry. Thus, in addition to the pre-entry characteristics of firms, it is equally important to consider the characteristics of exit. Hannan et *al.* (1998) have listed a number of ways in which a firm can exit the population of firms, i.e.: (i) disbanding, (ii) exit to another industry, (iii) merger, (iv) acquisition by another firm, (v) take-over by creditors, (vi) nationalization, and (vii) ended by war – no reentry. Some of these exits, namely mergers and acquisitions, might lead to a new entry. However, studies that investigate exit dynamics (e.g. Cantner et *al.*, 2009) rarely move into a further discussion on the aftermath of the exit.

Since knowledge is an important driver of the life cycle pattern of an industry (Cantner et *al.*, 2009) it would be worthwhile to investigate what happens to the various tangible and intangible assets of firms that exit the industry. It is also not uncommon that other firms (active or not in the same industry) acquire the remaining assets, in particular where: (i) the exit of a firm is not due to technological incompetence but due to mismanagement; (ii) the market demands a heterogeneous offer of products[1], or (iii) where the exit of the firm has consequences for maintenance contracts and supply of spare parts.

As argued by Hoetker and Agarwal (2007), the exit of a firm might hurt but the consequences might not be fatal. There are different channels in which the assets of the firms may be preserved and diffused throughout the industry. These pattern are quite similar to the well-understood inter-firm knowledge flows that are associated with: (i) the mobility of employees (Song et *al.*, 2003), which also occur with the creation of spin-offs (Agarwal et *al.*, 2004); (ii) the transfer of intellectual property rights (Mowery et *al.*, 1996; Hoetker and Agarwal, 2007), and (iii) the transfer of machinery and

[1] Which is actually one of the characteristics of a non-shakeout industry (Klepper, 1997).

equipment (Argote and Ingram, 2000). In fact, the knowledge of exiting firms is embodied in all the artifacts of these firms (Cowan et *al.*, 2000).

Compared to traditional described patterns of inter-firm knowledge flows, the knowledge flows after exit are less hampered by any form of reluctance with the firm that possessed the artifacts; after all, patents, equipment, and other assets can be more easily acquired and (a large badge of) former employees may be seeking new employment opportunities. Nevertheless, despite this relative ease to access this knowledge, the inability to interact with the firm might cause some issues in the transfer of this knowledge.

Whether this knowledge subsequently can be absorbed by other firms in the industry depends is of course dependent on their absorptive capacity (Cohen and Levinthal, 1990). However, the degree to which the tangible and intangible assets of exiting firms are preserved can also act as an indicator on the resilience of the industry, where resilience is defined as: *"the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks"* (Walker et *al*., 2004, p. 5).

2.2 Alternate Life Cycle Patterns

While the 'regular' industry life cycle pattern seems to holds for many of the earlier-mentioned industries, there are some stringent assumptions (see below), which do have significant consequences on the generalizability of this pattern (Pavitt and Rothwell, 1976). Consequently, it is hardly surprising that a large set of industries can be identified that do not follow this life cycle pattern (Nelson, 1994; Malerba and Orsenigo, 1996; Klepper, 1997; Barras, 1990).

There are several elements on which this life cycle pattern differs. First, the identified pattern seems to apply to a larger extent for manufacturing industries where "dominant designs" emerge (Nelson, 1994). There are industries in which products converge to a standard due to rather homogeneous customer preferences and some of the larger industry studies, e.g. automobile, fits this convergence of consumer preferences. However, there are (many) industries where the preferences of consumers are and remain heterogeneous and dominant design or standards will never appear. Second, a (subsequent) radical technological change might occur in the industry, which interrupts the life cycle pattern (Tushman and Anderson, 1986)

Another element that characterizes the traditional life cycle patter is the shakeout process. The two elements mentioned in the previous factor might lead to a delay or even prevent shakeout from happening. Klepper (1997) suggest that shakeouts do *not* occur in the presence of the following industry characteristics (Bonaccorsi and Giuri, 2000): (i) separation between firms that design and manufacture products and specialist firms that develop process technologies and sell them on a competitive basis; (ii) innovating firms do not appropriate their benefits through the integration of manufacturing activities but license new products to other manufacturers; (iii) final demand is highly heterogeneous and fragmented, so that there is no emergence of leaders covering all segments, and no associated shakeout of small competitors. These characteristics are closely related to the ways in which CoPS are organized. These non-shakeout patterns have been observed in various industries, including the laser industry (Klepper and Thompson, 2007; Buenstorf, 2007), the turbo-prop engine industry

(Bonaccorsi and Giuri, 2000), and the telecommunications industry (see the interesting account of this sector around Aalborg in Dahl et *al.*, 2011). Overall, the determinants of these alternative evolutionary paths are only recently being investigated (Klepper and Thompson 2007).

2.2.1 Complex Product Systems

Many firms that have several of the above-mentioned characteristics are categorized as being active in the so-called CoPS industries. CoPS are high cost, engineering- intensive products, systems, networks and constructs (Hobday, 1998,). The products, systems and constructs often include high-technology product components and have the following characteristics (Hobday, 1998; Yeo and Ren, 2009): (i) they often consist out of customized components requiring multidisciplinary skills and knowledge inputs; (ii) they are often made in projects and small batches; (iii) production units vary from single firms to larger project-based consortia's; large scale projects are likely to be developed in stages; (iv) the products are often bought be single users; and (v) they require often long delivery times.

The literature review in this section shows that while there is already a well-developed insight into the phenomenon of firm entry, the understanding of firm exit and the importance of (post-exit) knowledge flows is much more limited. This study aims to fill this gap by conducting an explorative study on the roller coaster industry (a CoPS industry that is actually listed as such by Hobday's (1998)). We attempt to answer the following research questions:

- First, what are the patterns of entry and exit of firms in the European steel roller coaster industry and how can this development be characterized?
- Second, how does the pre-entry experience of firms affect the further product development in the industry?
- Third, if firms exit, what happens to their technological competences?

3 Data Collection

The research questions that were introduced above require detailed information about the industry in question. Our study on the European steel roller coaster industry is based on detailed records about the backgrounds of firms that have entered the industry in the period from the early 1950s until 2011. This process was extensive since we needed to trace the relevant firms and collect information on the pre-founding conditions. First, we need to identify the firms that at any point in time have existed in the industry (at least those that manufacturer and/or designed steel roller coasters). For each of these firms we tried to identify the year in which the firm was founded and the year in which the firm manufactured and/or designed its first steel roller coaster (the year of founding might not be the same as entry into the industry). In addition, we also tried to identify whether the firm is still active and – if not – the year in which the firm defunct (see more below on our definitions). The second step was to identify the pre-entry activities of the firm and its founders so we can identify the type of entry according to the categorization presented in Table 1. Finally, we also investigate in more detail what happens to those firms that exit. However, we will start by describing the

history of the roller coaster and identifying the important technological advances that are made in the industry.

3.1 Identifying the European Steel Roller Coaster Firms

To further analyze the emergence and development it is important to identify the relevant firms in this specific industry. To do so, we use the online Roller Coaster Database (RCDB) as a point of departure. This database is a self-proclaimed census on roller coasters and provides a description on approximately 5,500 roller coasters produced worldwide in a period covering 1843 until 2012.[2] The information that can be obtained from this database are: (i) the status of the roller coaster, including the year in which the coaster opened, whether the coaster is still operational and – if not – in what year it closed down, (ii) the location where the coaster is operating, including the name of the amusement park that owns – or has owned – the coaster, (iii) the technical specifications of the roller coaster, in various typologies, and (iv) information on who designed and/or manufactured the coaster, and details on that party. For this study we are mainly interested in the firms that that are listed in the database and who are involved in the production/design of steel roller coasters, in the country where these firms are located, the in the type of roller coaster the firm produces, and the number of roller coasters these firms were involved in. In total we could identify 51 European firms from this database.

3.2 Selecting the final population of firms

A closer inspection on the activities of these firms revealed that there is a large degree of diversity; for that reason, we divided these firms in four categories (see Table 2). In the first category (A) we place the firms that have designed and/or manufactured at least one roller coaster ride. Within this category there is a large heterogeneity among the firms. Some firms manufacture extreme rides while others only produce and design family coaster and 'kiddie rides'. The firms placed in the second category (B) produce related amusement rides (but no roller coasters) in varying degrees of complexity, such as log flumes or splash rides, drop towers, and Ferris wheels. These firms operate on the same end-user market and rely on a similar customer-base as the roller coaster manufacturers in category (A). In the next category (C) we find firms that are not active in the amusement ride industry. Instead these firms produce and/or design products that can be closely related to the underlying roller coaster technology, e.g. transportation systems, pipelines, steel construction, and engineering consultancy. The last category (D) includes firms that provide services in relation to roller coaster manufacturing. These firms vary from specialized suppliers and firms that are responsible for the theming of the roller coaster ride. Other examples of firms in the last category are firms assisting in the assembly and disassembly of roller coasters, as well as traders of pre-owned roller coasters. In explaining the evolution of the roller coaster industry we mainly focus on firms listed in Category A.

Firms in Category B, C and D will be included depending on the type of relationship that these firms have with the firms in that are active in Category A. Firstly, firms in these categories will be included whenever they are considered to be (one of) the parent or spin-off firms of firms that fall in Category A. Secondly, such firms will be included when

[2] The online database can be found on www.rcdb.com.

key employees (e.g. engineers) have left these firms to strengthen the existing roller coaster activities or diversify into the manufacturing or design of roller coaster rides of Category A firms. Due to these requirement we end up with: 41 firms in Category A; 16 firms in Category B; nine firms in Category C; and four firms, all active in the sales of roller coasters, in Category D.

Table 2: Categories of Firms

Category A	**Category B**	**Category C**	**Category D**
Roller Coaster suppliers	*Suppliers of products in related markets*	*Firms in technology-related industries*	*Service providers*
Firms that are manufacture and/or design of roller coasters varying from simple to complex rides.	Firms that manufacture and/or design of simple and complex amusement rides excluding roller coaster.	Firms that manufacture and/or design of products that are based on similar technologies.	Firms that provide services related to the production of roller coaster.
Type of products/services			

• Steel, tubular, and wooden coasters
• Thrill rides, family rides, kiddie rides.
• Powered coasters
• Sit down, stand up, suspended, inverted, etc.
• Etc.
	• Log flumes
	• Drop tower
	• Ferris wheels
	• Octopus
	• Carousel
	• Bumper cars
	• Etc.
		• Transportation systems, e.g.:
		  • monorails
		  • gondolas
		  • ropeways
		• Steel components
		• Engineering consultancy
		• Etc.
			• Specialized suppliers
			• Assembly of roller coasters
			• Theming of roller coasters
			• Roller coaster trader
			• Etc.

Number of Companies in our Final Set			
N=41	*N=16*	*N=9*	*N=4*

Note: firms are not limited to be active in only one category

4 The Evolution of the European Steel Roller Coaster Industry

4.1 The History of the Roller Coaster in a Nutshell

This study focuses on the development of the European steel roller coaster industry from introduction of the first steel roller coaster in 1953 until 2011. However, the origin of the roller coaster dates back centuries earlier. According to historical records, e.g. Cartmell (1987) and Lanfer (1998), the concept of the roller coaster can be dated back to 15th century Russia,[3] while the first commercial rollercoaster was introduced – and patented – by LaMarcus Thompson, in 1884.[4] However, the reason why we start describing the entry of firms from 1953 is due to a significant change in the manufacturing process caused by the shift from wood to steel. When building a wooden roller coaster, a designer would typically contact one or several local construction companies to build coaster on site and in many cases the construction of the roller coaster was in hands of the amusement park itself. Consequently, the number of

[3] This is still reflected by the French word for traditional roller coasters: *montagnes russes.*
[4] One of LaMarcus Thompson's roller coasters is still operational in Tivoli Gardens, Copenhagen.

construction firms that could be regarded as dedicated roller coaster manufacturers was rather limited, making it problematic to identify roller coaster manufacturers. With the gradual introduction of steel parts into these mostly wooden roller coasters, the manufacturing process did not change. However, the introduction of roller coasters fully made out of steel, did change this process, and 'real', specialized roller coaster producers emerged. Now, steel components were constructed in larger manufacturing plants and transported over long distances. The need of large manufacturing plants was even more apparent with the introduction of the tubular roller coaster in the end of the 1950s. These tubular roller coasters, as the name suggests, are shaped by a large pipe-like structure on which one can easily identify a track.

4.2 The Genealogy of the European Roller Coaster Industry

Now that we have identified all the firms to be included in our analysis we will first present the overall evolution of firms in the European roller coaster industry in a genealogical tree. This genealogical tree present several important elements that explain the evolution of this particular industry. First it shows the year in which the firm has entered the roller coaster industry. As mentioned in Section 2, there are different ways in which firms enter a particular industry. Firms might diversify their activities and thus at a later point during their existence enter into roller coaster. The genealogical tree allows us to identify this diversification strategy by providing information on the year of founding and separately indicating the year in which the firm entered into producing roller coaster (in some cases it might be the year in which the first roller coaster was build). Second, firms might have entered the industry as a spin-off – either of the entrepreneurial or the parent type. This spin-off relationship is identified with a straight or a dashed thin line that connects the firm with the parent firm. Be aware that not all parents firm need to be active in the manufacturing of roller coasters. In this genealogical tree we also decided to include spin-off firms that are not active in roller coaster manufacturing. By including these firms it also illustrates that the competence in building roller coaster also leads to the development of other technological fields, e.g. transportation systems. Other organizational developments that took place in the industry are mergers and acquisitions and other larger reorganizations (e.g. the formation of, mainly Italian, consortiums). If such changes occurred this is indicated with a bold line. Finally, one important relationship that was observed when identifying the firms were the different types of knowledge flows that occurred between the firms. In the genealogical tree we focused on the knowledge transfers that were associated with the exit of firms. These knowledge transfers, which are indicated with a dotted line, were either the move of key employees, or the acquisition of intellectual property rights. In addition to the genealogical relations, there are many other relations that exist between the different firms in the industry (some will be mentioned throughout the paper).

In addition to show the genealogical relations, we also divided the firms in different geographical areas, i.e. Germany and The Netherlands, Switzerland, Italy and Other Europe. Outside these countries there are only a few manufacturers that can be found in the other European countries and even the most of these companies went bankrupt.

Figure 1: Genealogy of the European Roller Coaster Industry

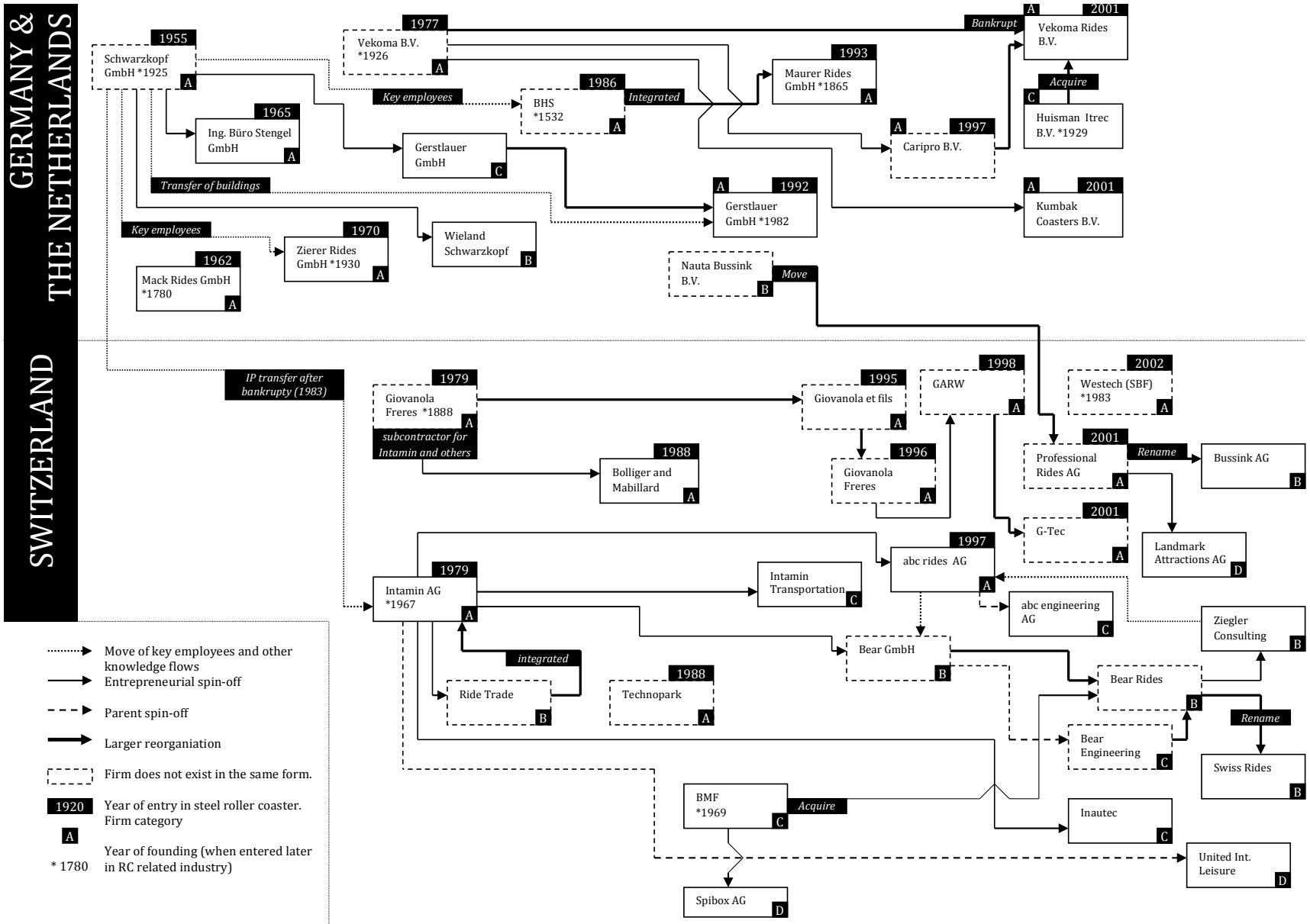
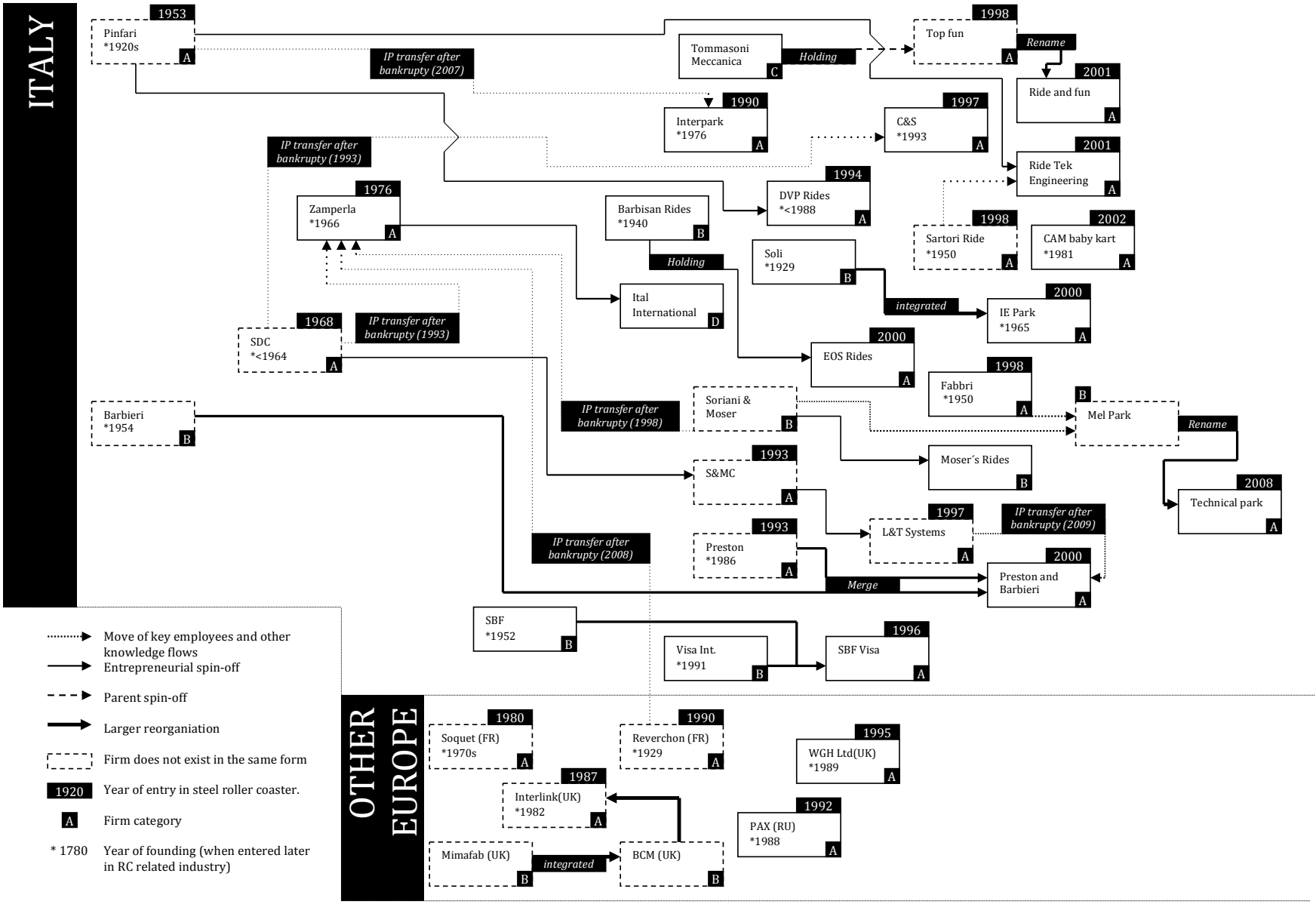


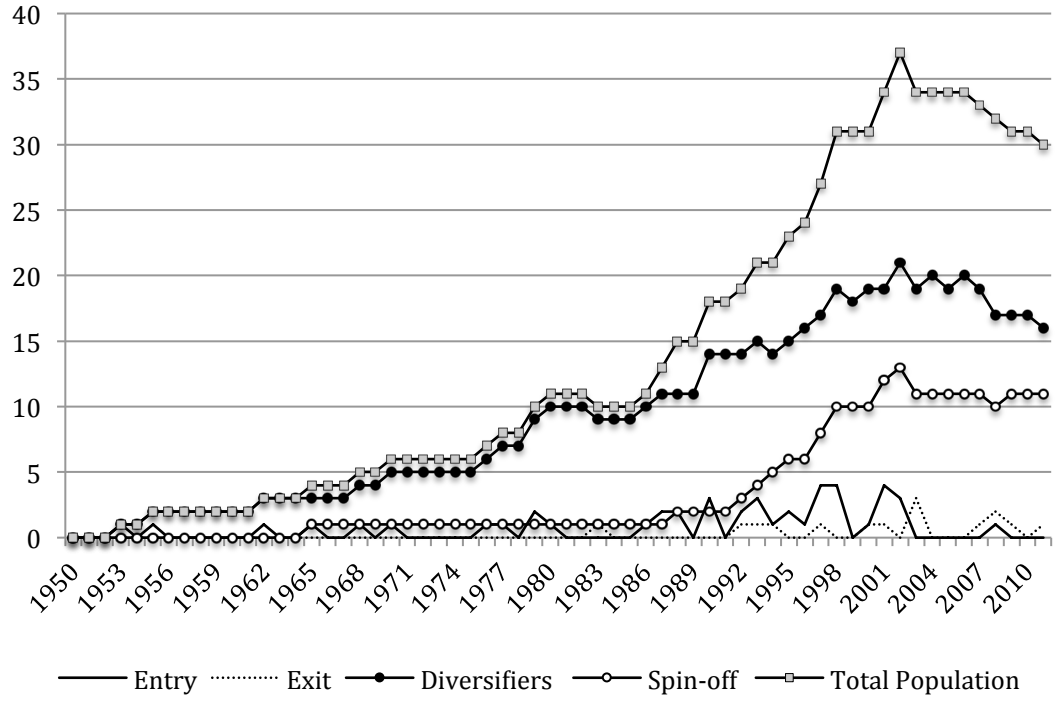
Figure 1: Genealogy of the European Roller Coaster Industry (continued)



4.3 Empirical results on firm entry

The start of this analysis will focus on the entry of firms. By providing a typology of entrance, based on Helfat and Lieberman (2002), we classify the firms into diversifiers and spin-offs, both entrepreneurial and parent spin-offs (we can only identify one *de novo* entrant and one joint venture). The overall entry and exit is presented in Figure 2. Based on this overall pattern of entry and exit combined with the genealogical tree and more detailed information on the pre entry history we can identify three phases of entry into the roller coaster industry. These three phases are: (i) Early Diversifiers (ii) New Technological Entry, and (iii) Late Diversifiers and Spin-off Dynamics. These three phases will be described in more detail in the following sections, which provide more information on the conditions and characteristics of entry. The following three subsections will present more detailed information on entry.

Figure 2: Exit and Entry of Firms into Steel Roller Coaster



4.3.1 50s and 60s: Early Diversifiers

The first firms enter the steel roller coaster industry the 1950s. The very first entrant into this industry is *Pinfari*, who built a steel roller coaster in Italy in 1953 (Lanfer, 1998). That the development of the steel roller coaster started in this country can be explained by two related factors: (i) in the previous period this country already hosted several firms that were active in the broader amusement ride industry, and these firms were already very familiar with the market; and (ii) these Italian regions are not rich in vegetation, which resulted in relatively high cost in acquiring wooden materials. Many of these firms are clustered in the North Italian regions of Emilia Romagna, Verona, and Lombardy. Despite the Italian focus on amusement rides, the number of Italian firms that would eventually enter the industry would be limited. Pinfari, who maintained bumper carts, entered the market in the 1950s and in the 1960s Italy's *SDC*, also active

in the manufacturing of amusement rides, produced their first steel roller coaster (interestingly *Pinfari*, *SDC*, but also *Schwarzkopf* from Germany build the same design roller coaster). It would not be until the 1970s that *Zamperla*, entered this industry, a company founded in the 1960s but where the founder's family history can be traced back to amusement industry all to way to the mid 1800s.

While the European development of steel roller coasters started in Italy, it is the German Anton Schwarzkopf Jr. who would make fame in the industry as being one of the European pioneers. Schwarzkopf produced his first roller coaster in the late 1950s in his father's business, a company that produced caravans and special trailers for showmen and circuses, a company which he would take over in the 1960s. Drawn by the development in roller coaster building in Italy, Schwarzkopf was sent for regular visits to Italy to investigate in more detail what happened there. This also explains why the earlier designs of *Schwarzkopf* resemble the *Pinfari* rides (Lanfer, 1998). During this period, Schwarzkopf collaborated with an engineering company in Munich working directly with Werner Stengel (Lanfer, 1998). Werner Stengel would establish his own engineering company, *Stengel Engineering*. This company would grow over the years and be involved in the construction of more than 450 roller coasters and designed some of in several record breaking roller coaster rides, including the first modern looping coaster (RCDB).

Later in the 1960s, two other German firms started to build steel roller coaster, namely *MACK Rides* and *Zierer*. It should be noted that these firms already had many years of experience in the amusement industry and were one of the few firms in Europe that manufactured wooden roller coasters before entering the steel roller coaster industry. *MACK* already introduced the first wooden roller coaster in 1921 and *Zierer* produced the first wooden roller coaster in collaboration with the showman Franz Xavier Heinrich in the 1930s, whose production lasted until the late 1950s (Lanfer, 1998). Similarly as *Schwarzkopf*, *MACK* had its roots in building coaches and trailers for showmen and circus people. *Zierer* build other amusement rides and had thus a similar pre-entry history as the early Italian branch of steel roller coaster manufacturers.

4.3.2 70s and early 80s: New Technological Entry

Another phase of entry can be identified in the 1970s and early 1980s. This phase of entry is not explicitly shown in Figure 1 and Figure 2 and the overall volume of entry was rather limited. Nevertheless, the pre-entry experiences of these firms are distinctly different from the earlier diversifiers. Entrant firms in this phase include *Vekoma* from he Netherlands, and *Intamin* and *Giovanola* from Switzerland. Other firms that entered the industry during this time, such as *Zamperla* from Italy and *Soquet* from France, more resembled the entry pattern of the earlier diversifiers. Furthermore, The German company *Gerstlauer*, which is a spin-off of *Schwarzkopf*, started manufacturing roller coaster technologies in 1982 but it would not be until the 1990s before the firm produced complete roller coasters itself.

The pre-entry technological profile of the three above-mentioned companies can be linked to a development within the steel roller coaster that occurred in the late 1950s in the United States when *Arrow Dynamics* produced the first tubular roller coaster. In order to build this roller coaster type, the manufacturer needed to have competences in

working with pipes. *Vekoma* was one of the companies that had such a competence prior to their roller coaster adventure. This company was founded in 1926 and moved from building agricultural machinery to mining equipment to providing material for the petro-chemical industry, which included working with large tubes. As a result of the energy crisis, *Vekoma* was compelled to focus on different areas and for that reason moved into the manufacturing of roller coasters. Their technological competence in working with tubes enables them to manufacture tubular roller coasters, although they already build a Ferris wheel in the late 1960s. *Vekoma* manufactured their first roller coaster in the late 1970s.

The two Swiss firms are strongly connected in their entry into roller coaster manufacturing. The founders of *Intamin* were involved in several technological infrastructure projects in the United States during the 1960s (e.g. manufacturing of ropeway, high tension overhead cable, ski lift, and other metal structures). While in the US, Six Flags, an US amusement park corporation, contacted *Intamin* in 1969 to manufacture several prospect platforms. During this contact the founders of *Intamin* understood the market potential of the roller coaster industry in Switzerland. However, they also realized that they did not have the right competences for building roller coasters. While searching for the necessary competences, *Intamin* started to represent *Schwarzkopf* and *Stengel* outside of Germany in the mid 1970s. This relation was organized in such a way that *Intamin* generated ideas and *Schwarzkopf* and *Stengel* turned these ideas into reality. This collaboration provided *Intamin* with the necessary skills to operate in the roller coaster industry. In the meantime, *Giovanola Frères*, a company that started as a metal forging shop in 1888, was identified as a company with the necessary competences to build roller coasters due to their experience in building steel equipment like, e.g., electrical power stations, pipelines, highway bridges, and ropeways. Consequently, *Giovanola* started to produce roller coasters for *Intamin* and the two companies became leading international players on the global roller coaster industry and made Switzerland one of the most successful nations in producing thrill rides (both roller coasters and other type of rides).

4.3.3 Late 80s - now: Late Diversifiers and Spin-off Dynamics

As can be observed in Figure 2, the entry into the industry accelerated in the late 1980s, a development that had many different faces. First, there are the late diversifiers like *Maurer Söhne* in Germany; *Ronald Bussink*, who started in the Netherlands and moved to Switzerland; *Technopark* in Switzerland; *Interpark*, *Soli-IE park, Cam Baby Kart, Sartori, Preston and Barbieri, SBF-VISA and Fabbri, all from* Italy; and *Reverchon* from France. In addition to the late diversifiers, we also observe several entrepreneurial spin-offs in theis period. These firms are *Caripro* and *Kumbak*, which are entrepreneurial spin-offs of *Vekoma*; *Gerstlauer*, which is an entrepreneurial spin-off of *Schwarzkopf*; *GARW* and *Bolliger & Mabillard (B&M),* respectively a parent and entrepreneurial spin-offs of *Giovanola*; *abc rides*, which is an entrepreneurial spin-off of *Intamin*; *Ride Tek*, which is an entrepreneurial spin-off of *Pinfari*; *S&MC* which is an entrepreneurial spin-off of *SDC*; *L&T systems*, which was – in turn – an entrepreneurial spin-off of *S&MC.* Furthermore, there is one parent spin-offs of firms that appear to have no history in building roller coaster, i.e. *Top Fun,* which started to exploit the technological competences of the

parent firms by entering the roller coaster industry. Finally there is *EOS Rides* that is a spin-off of another amusement ride manufacturer, i.e. *Barbieri rides*.

In diversifiers, we identify two types. On the one hand we identify the 'Italian' and 'early German' type of diversifiers. Such firms moved into the industry after having been active in amusement ride industry. All the Italian entries during this period, as well as the company of Ronald Bussink, a leading designer of Ferris wheels, and also *Interlink* and *WGH* from the UK can be placed in this category. On the other hand there are firms that entered the industry due to the acquisition of roller coaster manufacturing competences. The two most important firms in this category are *Maurer Söhne* and *Gerstlauer*. Before *Maurer Söhne* entered the industry in the early 1990s, this company was active in manufacturing bridges and other steel constructions. The entry into roller coaster manufacturing occurred when *Maurer Söhne* acquired *BHS* (Bayerische Hütten Stahl). *BHS* collaborated with *Schwarzkopf* and when Schwarzkopf went bankrupt BHS continued the production of *Schwarzkopf* roller coasters. *Gerstlauer*, which started as a spin-off from *Schwarzkopf*, only started producing roller coaster in 1992 after they acquired the production facilities of Schwarzkopf. One entry, i.e. *Technopark*, was a joint venture between engineers and other international roller coaster firms, i.e. *SDC, Stengel, Coop and associates*, and *ETH* in Zürich.

In our entire data set, there are only one *inexperienced start-ups*, i.e. *Pax* in Russia. Furthermore, in addition to the entry of roller coaster firms, we observe many other firms that have spun out of roller coaster manufactures. This illustrates that the competences possessed by roller coaster manufactures can also be used in other industries, i.e. the manufacturing of transport systems (e.g., *Intamin Transport)*, the amusement rides (e.g. *Bear Rides* and *Ride Park*), other services (e.g. *Ital international*).

4.4 Empirical results on knowledge development

As argued in Section 1, modern roller coasters require rather sophisticated knowledge on the side of the designers and manufacturers. Given the desired speeds of a thrill ride, the installations are under extreme stress. Safety requirements and coping with a very diverse and 'non-professional' users pose additional challenges, in contrast to for example the mining industry, where some of the firms were previously active in. As a way of illustration, we found several roller coaster companies to apply 'Eddy current' brakes; a rather unique brake design for extreme situations that are based on the principle of electromagnetic induction. Apart from roller coasters, these advanced type of brakes are mostly found in the most recent generation of high-speed railways such as the German ICE-3 train, and the Japanese 700 Series Shinkansen trains. Another illustration is the use of advanced materials; we found some roller companies that developed materials for use in bridge bearings that contain ultra high molecular weight polyethylene.

In this section, we complement the earlier analysis by focusing on the knowledge development strategies of roller coaster firms. More specifically, we are looking at knowledge as it appears as patents or patent applications. While we acknowledge that not all knowledge that is developed is necessarily patented (c/f Cohen et al, 2000), patents are still the most tangible expression of knowledge in this specific industry. In the reminder of this section, we will fist provide some comments on how a patent data

set was compiled, and then discuss some of our observations and findings, aiming at understanding differences between diversifying firms on the one hand and spin-offs at the other.

4.4.1 Distinctive differences in patent portfolios

Based on the availability of data, we base our patent analysis on a sample of 37 firms (see Appendix A on an overview of these firms). Here we make a distinction between two types of spin-offs (parent or entrepreneurial) and the two types of diversifiers (market-based and technology-based). As mentioned above, there is one *De Novo* Entrant and one Joint Venture. Given the small size of these categories, we have not further considered these firms. We wish to remind the reader that the European roller coaster industry is a relatively small one, and even though the overall number of observations in the analysis below is a mere 37 firms, this is full population of firms as derived from the previous section, so we do not have to deal with uncertainties related to sample selection.

Considering the patent portfolio features of different types, we observe remarkable differences (Table 3). While diversifiers are, on average, similar in size as spin-offs (measured in the number of coasters they delivered to the market), their knowledge portfolio is considerable larger. They apply almost three times as many patents, and their patents also receive considerably more incoming citations, suggesting a higher technological value of these inventions.[5]

Table 3: Differences in patent portfolio between types of firms

Type of firm	*N*	*No. of RC*	*No. of relocated coasters*	*Patent families*	*Family size*	*Cumulative forward citations*	*Cumulative unique forward citations*	*Ibid, excluding self citations*
Diversifier	25	59.40	13.44	5.92	3.35	12.20	11.00	9.96
Spin-off	12	53.42	12.50	2.25	4.26	8.83	7.08	6.75

Note: analysis includes both granted patents and patent applications

Interestingly, a further split-up reveals that these differences are simply the consequence of diversifiers versus spin-offs. As shown in Table 4, it is the specific category of diversifiers that entered into the market on the basis of their technological skills are the category that have a patent portfolio that outperforms all the other types of firms by at least a factor of six. We note again that we only consider roller-coaster / amusement specific patents, so these scores are not the result of patent portfolios coming from the technological fields these diversifiers were previously active in. This higher performance can be observed both in the number of patent families, and the citation performance. The overall size of the patent families (in practice: the number of countries for which a patent on a given innovation is applied for) is higher for the entrepreneurial spin-offs. Perhaps this group of firms finds patents more important in order to attract venture capital.

[5] Note that, for his indicative analysis, we have not corrected forward citations for age.

Table 4: Differences in patent portfolio between types of firms

Type of firm	*N*	*No. of RC*	*No. of relocated coasters*	*Patent families*	*Family size*	*Cumulative forward citations*	*Cumulative unique forward citations*	*Ibid, excluding self citations*
Diversifier (Market)	20	51.70	11.85	2.95	3.39	5.60	5.05	4.75
Diversifier (Technology)	5	90.20	19.80	17.80	3.33	38.60	34.80	30.80
Spin-off (Entrepreneurial)	9	69.22	16.56	2.78	4.52	11.78	9.44	9.00
Spin-off (Parent)	3	6.00	0.33	0.67	1.00	0.00	0.00	0.00

Note: analysis includes both granted patents and patent applications

Comparing the two types of diversifiers, we note that most of the market-based diversifiers come from the Amusement Rides market, producing simpler and smaller rides. Presumably, these markets required considerably lower technological capabilities, and from there on, these companies moved into the 'lower end' of roller coasters, whereas the technology-based diversifiers, which their superior technological capabilities, aimed at the 'high end' where they could exploit their specific technological advantages.

4.5 Empirical results on firm exit

When investigating the dynamics of industries, we not only need to focus on entry but also on the exit of firms.[6] When looking at the exit pattern of this industry, it can be stated that this industry is a so-called non-shake out industry. This, however, does not mean that exit does not occur. Over the years, several large players were force to leave the industry, and for most cases, the reasons for their bankruptcies are known. *Schwarzkopf* went – relatively unexpectedly – bankrupt in the early 1983, restarted, and went bankrupt again a few years after. This bankruptcy was caused by a series of unexpected events, including the cancellation of a large order. The demise of *Giovanola* occurred in the mid 1990s. The close connection with *Intamin* was an important reason for their demise. First, this connection limited the creativity of their employees, which caused two of their leading engineers to start up a new company, i.e. B&M. Second, *Giovanola* did not have a patent strategy (see Section 5) and entrepreneurial spin-out *B&M* was able to reproduce the roller coaster rides that were developed within *Giovanola*. Finally, *Intamin* had strong control over the operations and investments of *Giovanola*, which caused complications for *Giovanola* and they were never able to create

[6] The fist issue is, of course what constitutes an exit from the industry. Many firms have a portfolio of products within amusement rides. In the case that a firm has not produced a roller coaster in the last 5 years, I investigate whether the firm offers roller coasters in their product catalogue. If not, I consider the firm to have exited the industry and take the year in which the roller coaster is produced as the year of exit (this is only the case for 2 companies in the total population of firms).

a return on investments. *Vekoma* went bust in 2001, presumably due to overinvestments in R&D. The failure due to investment strategies may be explained by the ambition of the industry to build innovative roller coasters. This development was both seen as an economic and a technological challenge for these manufacturers during the 1990s. To cope with this, firms had to invest heavily in R&D, production facilities, and labour. However, not all firms had the financial resources and competences to manage this pressure from the market. This was the reason why several European firms, but also a number of U.S. manufacturers were forced to close down.

Despite of the exit of several relatively large players in the industry, such bankruptcies did not always lead to the loss of technological competences. As we can observe from the genealogical tree, the competences and products of the firms mentioned (but also other exits) remained in the industry. This occurred in several different ways. There are firms that continue to manufacture and maintain the roller coasters of the exited firm, others acquired IPR's and roller coaster designs, others again were able to take over production plants, and finally, some firms recruited former employees of defunct roller coaster firms. After their debt restructuration, *Huisman Itrec,* a company that is active in the offshoring industry, acquired *Vekoma*.[7] *Schwarzkopf* exited the market but its patents, designs and building were taken over by other firms in the industry (including *Gerstlauer* and *Maurer Söhne*). *Giovanola's* competences are still embedded in *Intamin* and in *Boliger & Mabillard,* and engineers that worked for *Pinfari* started the company *Ride Tek*. As can be seen in as Figure 1 shows, many other firms that exited the industry were able to sell their patents and other provide other knowledge flows to other firms in the industry. Some of these knowledge transfers lead to the entry of these firms into roller coaster manufacturing (e.g. *Maurer Söhne*), while in other cases the roller coaster division of existing firms was strengthened. The Italian company *Zamperla* was able to obtain much of the patents from exiting firms.

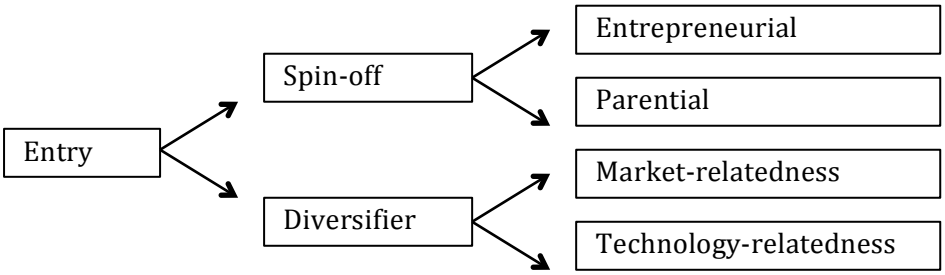
5 Discussion of the Findings

This case of the European steel roller coaster industry has provided some interesting findings. First, we can observe three distinctive entry waves. The first two waves are characterized by the entry of firms that can be classified as diversifiers, while the third wave sees an increase in the number of spin-offs, both of the entrepreneurial spin-off type as well as of the parent spin-off type. Although this study does find that in this industry there is a role for spinoffs, as suggested by Klepper (2009), it mostly confirms that diversified entry is up to know the dominant form of entry (Klepper and Simons, 2000). This initial entry complies with Boschma and Wenting's (2007) finding that the start of an industry is characterized by diversified entry by firms that were active in related industries. What this study contributes is the insight that this relatedness has two distinct dimensions: relatedness in the relevant market, and relatedness in the underlying technologies and skills. The first category we observe as entry from firms that are, or have been, active in the amusement ride industry. These firms have relations to the market of potential customers of roller coasters, i.e. amusement parks or

[7] This acquisition led to the introduction of new technologies into roller coaster manufacturing that was previously used in offshoring industries.

showmen. The second category we observe as diversifiers have the technological skills to build roller coasters, yet they never had any affinity with this particular industry. In fact, their relatedness might not be identified immediately, but for the market of advanced thrill rides, we observe entrants that are experienced in constructing large metal structures and piping. Obviously, their entry was not al all such a natural transition as that of the entrant firms that had pre-entry experience in the amusement rides. An overall scheme of these modes of entry in the roller coaster industry is presented in Figure 3.

Figure 3: Modes of Entry in the Roller Coaster Industry



The distinction between the types of entry is also relevant considering the knowledge development of the firm and identifying the underlying technological profile of the firms. As expected, the technology related diversifiers and their spin-off create more complex rides. This is both reflected in the patent analysis but also when closer investigating the type of roller coasters these entrants produce. The market related entrants appear to manufacture simpler types of roller coasters, which is also reflected fewer patent applications.

Furthermore, diversified pre-entry experience of the firms in the industry has strong regional determinants. Firms in Italy, aside a few exceptions, came from amusement ride manufacturers (many of which previously produced bumper carts). In contrast, the Swiss, Dutch and German firms were more familiar with producing larger industry structures – particular those firms that entered in the second and third wave. This divide also sketches the importance of the firms in these areas where the first three countries are known to produce the larger and more sophisticated rides while the Italians are dominant in producing smaller and simpler roller coaster rides (Sernaglia, 2008).[8] These differences are in line with the knowledge development and patenting behavior we observed, where technology-related entrants have larger and more valuable portfolios than market-related entrants. Interestingly, the introduction of more advanced products does not lead to the replacement of the earlier, simpler type of products. In fact, even wooden roller coasters are still produced and in demand. This can be explained by the heterogeneity of demand and the need of amusement parks and showmen to offer a wide variety of rides to serve a very heterogeneous set of users. This

[8] For that reason, industry experts make an analogy with the automobile industry stating that the Swiss, Dutch and German produce the 'Mercedes' among the roller coaster while the Italians produce the 'Fiats'.

is a market characteristic that is only seldom addressed in the various empirical studies industries that exist.

In this paper we also investigated modes of exit. In our data set, exit is a rare occurrence and the industry can be classified as a non-shakeout industry. This might be explained by: (i) the relative small size of the industry, with no more than 42 firms altogether in the period 1950-2011; (ii) the heterogeneous demand, which prevents the convergence towards a dominant design; (iii) the fact that most coasters are produced in the form of a project, which prevents a large entry into the industry and the occurrence of a shakeout. In addition, when a firm exits, this does typically not lead to the loss of skills and competences for the industry. Firms in the industry are able to absorb the skills of the firms that leave the industry, which provides an indication on the resilience of the industry.

There is one more interesting observation when studying this industry, although this one cannot be observed in the genealogical tree or the figure of entry and exit in the industry. This is the observation on the high level of collaboration between firms and the dense professional networks that exist in this industry. It appears to be that the majority of firms are closely connected, in particular on large custom-made products. Here, firms get together to make use of each other's skills and competences but also to spread the uncertainty that is involved in building these complex structures. These complex relations between manufacturers and designers might again explain why the exit of the firms is limited and why, when exit occurs, the remaining firms absorb the skill and competences of exiting firms.

Overall, this study confirms that elements of earlier theoretical findings also apply on this rather peculiar industry, i.e. the role of diversified entry and (entrepreneurial) spin-offs in the (regional) evolution of an industry, and the non-shakeout pattern of industries. Nevertheless, it provides some new perspectives that might be pursued in a follow up study on this industry or in the (follow up) analyses of other industries. First of all, a more in depth understanding on the role of exit and the aftermath of this exit (e.g. by mobility or patent investigation). The motives for exit can be the result of inferior technological competences, but are not necessarily so. When this is not the case, it would be interesting to investigate in more detail what happens to the competences and whether they are maintained or lost forever. This would definitely apply to high tech and knowledge intensive industries, in a similar fashion as Hoetker and Agarwal (2007), but also within the field of (knowledge intensive) entrepreneurship, i.e. what happens to the entrepreneur or entrepreneurial team when the start-up is forced to exit? In close relation to this, the issue of resilience, the degree but also the motives for absorbing the competences, could be investigated in more detail when analyzing the development of industries (Holm and Østergaard, 2011). This issue has received increased attention and is also interesting from the viewpoint of policy makers, in particular in times of crisis.

There are several limitations that need to be addressed. First, due to the explorative nature of this study, we only focus on the European roller coaster industry. In the future, we will include North American and Asian firms to provide a global picture of the

industry,[9] which also is more appreciative towards the global market on which these firms operate.[10] Second, we mainly rely on secondary sources of data to establish the history of the firms in our sample, which are mainly obtained from historic records of the firms and from industry enthusiasts. This causes some ambiguity regarding founding date, firm relations and firm activities. However, with carefully cross checking the data we believe that much of this ambiguity is avoided.

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[9] The RCDB identifies respectively 41 and 19 firms active in these continents.

[10] Most firms sell their roller coaster all over the world. Furthermore, cross continental collaboration on roller coaster manufacturing is common for the larger players in the market.

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Appendix A: Roller Coaster Firms included for Patent Analysis

Company	*Country*	*Firm Start*	*First RC*	*Firm Exit*	*Type of entrant*	*Previous Industry*	*No. of RC*
Stengel	DE	1965	1965		Spin-off (Ent)		439
Vekoma	NL	1926	1977	2001	Diversifier (Tech)	Petro-Chemical, Mining	263
Zamperla	I	1966	1976		Diversifier (Market)	Amusement rides	253
Pinfari	I	1925	1953	2007	Diversifier (Market)	Amusement rides	162
Zierer	DE	1930	1970		Diversifier (Market)	Amusement rides	144
Schwarzkopf	DE	1925	1955	1985	Diversifier (Market)	Coaches	138
Intamin	CH	1976	1979		Diversifier (Tech)	Gondola's high rise	111
Mack Rides	DE	1780	1962		Diversifier (Market)	Coaches	99
B&M	CH	1988	1988		Spin-off (Ent)		85
Maurer Söhne	DE	1865	1993		Diversifier (Tech)	Steel manufacturing	50
Gerstlauer	DE	1982	1992		Spin-off (Ent)		46
SBF VISA	I	1952	1996		Diversifier (Market)	Amusement rides	45
SDC	I	1965	1968	1993	Diversifier (Market)	Amusement rides	45
L&T Systems	I	1997	1997	2009	Spin-off (Ent)		35
Reverchon	FR	1929	1990	2008	Diversifier (Market)	Amusement rides	32
Soquet	FR	1975	1980	2008	Diversifier (Market)	Amusement rides	30
Giovanola / GARW	CH	1888	1979	2003	Diversifier (Tech)	Steel manufacturing	24
PAX	RU	1988	1992		De novo entrant		23
Interpark	I	1976	1990		Diversifier (Market)	Amusement rides	21
Fabbri	I	1950	1998		Diversifier (Market)	Amusement rides	19
Iepark	I	1965	2000		Diversifier (Market)	Amusement rides	15
Caripro	NL	1997	1997	2003	Spin-off (Ent)		9
Preston	I	1986	1993		Diversifier (Market)	Amusement rides	9
Sartori Rides	I	1950	1998	2011	Diversifier (Market)	Amusement rides	8
Top Fun	I	1998	1998		Spin-off (Parent)		8
EOS Rides	I	1995	1995		Spin-off (Parent)		7
WGH ltd	UK	1989	1995		Diversifier (Market)	Amusement rides	6
Cam Baby Car	I	1981	2002		Diversifier (Market)	Amusement rides	4
S&MC	I	1993	1993	1997	Spin-off (Ent)		4
abc-rides	CH	1997	1997		Spin-off (Ent)		3
BHS	DE	1532	1986	1994	Diversifier (Tech)	Steel manufacturing	3
Technical Park	I	2003	2008		Spin-off (Parent)		3
C&S	I	1993	1997	2000	Diversifier (Market)	Amusement Rides	1
Interlink	UK	1982	1987		Diversifier (Market)	Amusement rides	1
Kumbak	NL	2001	2001		Spin-off (Ent.)		1
Ride Tek Eng.	I	2001	2001		Spin-off (Ent)		1
Technopark	CH	1988	1988	1992	Joint Venture		1
Westech	CH	1983	2002		Diversifier (Market)	Amusement Rides	1
Professional Rides	CH	1985	2001		Diversifier (Market)	Amusement rides,	1

Appendix B: Building a patent data set

For finding the patents and patent applications of the companies in our sample, we performed a patent family search in the Derwent DII database.[11] We tried to recover all different assignee names these companies have been using over time to file their patents in different legislations, and correct for typo's (which are not unusual in patent databases). Using Derwent, we are able to identify patent families (i.e. patents in different legislations – and sometimes the same legislation - that basically cover the same invention), thus preventing over count for companies that file patents in multiple countries. We only selected those patents that relate to roller coasters in particular or to amusement rides more in general – it is virtually impossible to distinguish clearly between these categories. More specifically, we selected patents if these two application areas were explicitly mentioned in the patent. As a second check, especially for small companies of companies with hard to find names in databases (e.g. acronyms) we also checked whether the name of the founder, managing director or key engineers appeared as inventor in the patent database.

For each company, we typically started by looking for patents that had the term 'roller coaster', 'amusement ride' or similar terms in the patent title or topic, and we checked whether the patents were assigned to the following IPC subclasses or groups:

- A63G ("Merry-go-rounds; swings; rocking-horses; chutes; switchbacks; similar devices for public amusement") – many of our patents are in the particular class A63G7/00 ("Up-and-down-hill tracks; switchbacks")
- B61R21("Arrangements or fittings on vehicles for protecting or preventing injuries to occupants or pedestrians in case of accidents or other traffic risks")
- B61R22 ("Safety belts or body harnesses in vehicles")
- B60J which, in our context, particularly contains specific groups on doors etc. used in vehicles
- A47C07, which, in our context, particularly contains specific groups on seats with specific support for the head and for the back.

We also note that more often than not, patent are assigned multiple IPC codes, so a patent can be assigned both a 'roller coasting' class and a patent class specific to, say, braking systems. In cases of doubt, the obtained the full text of the patent and studied it.

On the basis of the approach outlined above, we built a patent dataset for the 39 European suppliers of roller coasters as identified in the previous section. We found a total of 611 patents (in 175 patent families), owned by 19 of the 39 firms under consideration.

[11] When appropriate, we use alternative databases for crosschecking. For instance when no records were found at all, and the search facilities of Derwent could be the reason (Derwent does not allow wildcards in the beginning of assignee names, for instance).