

A longitudinal study of MNE innovation: The Goodyear Tire and Rubber Company

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ABSTRACT

The ability to innovate constantly amidst a turbulent and competitive environment is often the key force behind multinational enterprise (MNE) survival and dominance. In this article we provide insights into the innovation trajectory and knowledge pipeline of US-based MNEs by conducting an in-depth and longitudinal study of a global manufacturing company in the tire and rubber industry: the Goodyear Tire and Rubber Company. Our findings, based on USPTO patent data of Goodyear from 1975-2005 reveal three crucial trends: (1) continuous investment in innovation plays a major role in MNE survival and turnaround; (2) the evolution of the firm's innovation network from a headquarter-centric model towards more geographical dispersal and (3) the changing mix of innovation from traditional "hard" science-based research towards a greater emphasis on "softer" competencies in design and trademarks. This third trend in particular opens up important new avenues for research on MNE innovation practices.

INTRODUCTION

Multinational enterprises (MNEs)—organizational entities configured through globally scattered subsidiary units, often use innovation to create new markets as well as to mitigate threats stemming from their rivals in a highly complex and uncertain global marketplace (Cantwell and Mudambi, 2005, 2011). In fact, leveraging knowledge and competencies across space and time to spur innovation has been recognized as the next frontier in the international business (IB) literature (Mudambi and Swift, 2011). However, the pathway to innovation is not straightforward. MNEs face a particularly difficult challenge in this aspect. By definition, these companies operate in multiple countries. Thus, they experience threats emanating from competitive actions of rival MNEs as well as from local firms.

Traditionally, R&D has remained among the least internationalized and most centralized value chain activities of many MNEs (Huggins *et al.*, 2007; UNCTAD, 2005). However, more recently, an increasing number of firms have begun to recognize the potential of global dispersed knowledge clusters and have set up competence creating global innovation centers in such locations (Andersson *et al.*, 2002; Cantwell and Mudambi, 2005, 2011; Lehrer and Asakawa 2002). Similarly, while in the past the upstream end of the innovation value chain (i.e., research and design) was considered as the main source of value-added, over the last few years there has been increasing recognition of the central role played by downstream innovation, i.e. innovation arising from marketing knowledge and capabilities (Mudambi, 2008). Accordingly, closely studying the innovation trajectory at both ends of the value chain and R&D can inform IB theorists as well practitioners more about the organization of MNE activities over time and space (Mudambi and Swift, 2012).

While there is considerable research on the global dispersal of R&D activities of MNEs, very little of this research takes a longitudinal perspective. Further, there is little research simultaneously examining MNE innovative activities at both ends of the value chain. To fill this crucial void in the IB literature, in this paper we explore the innovation trajectory of a

major US-based MNE operating in a dynamic competitive environment, the Goodyear Tire and Rubber Company, to better understand three interrelated research questions: (1) How does the innovation trajectory of Goodyear enable the company to face the turbulent external environment? (2) How has the geography of Goodyear's innovative activity changed over time? (3) How have the upstream and downstream ends of the innovation value chain evolved over time at Goodyear? To answer these questions we rely on a longitudinal dataset of utility patents, design patents and trademarks drawn from the US Patent & Trademark Office (USPTO). Table 1 presents the aforementioned research questions, their respective conceptual underpinnings and highlights the major findings of this study.

[Table 1 about here]

The context of our study is compelling for several theoretical and practical reasons. First, traditional models of innovation and strategy posit that the R&D efforts tend to focus on (exploratory) product innovation during an industry's early years followed by (exploitative) process innovation during maturity (Abernathy and Utterback, 1978). However, as the technology threshold rises, there are reasons to believe that firms may continue to pursue exploratory innovation as they "make the leap" to newer generations of a product (Mudambi and Swift, 2014). Second, over the last several decades MNEs in advanced economies like the US have come under increasing pressure from imitators in emerging market economies. Little is known about whether and how advanced economy MNEs change their models of innovation in response to these threats. The research questions that we address in our paper address both these critical issues.

This analysis also allows us to illustrate the idea of *resilience* as a firm-specific characteristic in the face of a turbulent environment. The survival and turnaround of Goodyear is more striking when we delve deeper into the context. Around 1970, the five US biggest tire manufacturers held 80 percent of US market. By 1980, this dominance was under tremendous

pressure and by the early 1990, the extant tire oligopoly had completely disappeared. Uniroyal and Goodrich had pooled their tire operations in a joint venture subsequently sold to France's tire giant, Michelin. Firestone was acquired by the Japanese MNE Bridgestone and General Tire was acquired by Germany-based Continental. Among the big five, only Goodyear remained independent.

From a theoretical slant we heed to the call for papers examining the local context in global business (Meyer et al, 2011). Most research in the domain of MNE innovation has focused on location-specific intangible resources and knowledge attributes that attract firms to relocate their value chain activities to foreign locations (Graf and Mudambi, 2005). In addition, most extant research has mostly concentrated on examining relocation decisions with regard to low-value added peripheral activities as opposed to high-value added functions such as R&D. Thus, with some exceptions (Jensen and Pedersen, 2011; Rugman *et al.*, 2011), there is a distinct paucity of research on how firms approach high-value added activities, such as R&D, organize their global value chain, and create value while being rooted in the local cluster (Kumar *et al.* 2009; Mudambi and Swift, 2012; Mukherjee *et al.*, 2013). Our analysis is one of the first to attempt a joint analysis of MNE's R&D configuration and local cluster evolution in an in-depth longitudinal study.

Finally, from a methodological perspective, the longitudinal analysis of a single company provides us with a less causally ambiguous laboratory to understand the dynamics of the interaction between a company's external environments and its own strategic choices. In addition, we use a blend of conventional business history, industrial dynamics, complemented by rigorous patent and trademark data analysis, all within an overarching IB framework. This blended approach used in our study is in concert with the call for using historical analysis to better capture evolution of strategic choices made by firms in the context of a dynamic environment (Buckley, 2009; Casson, 1986, 1997; Jones and Khanna, 2006; Morck and Yeung,

2007; Wilkins, 1996). Indeed, by adopting this novel integrated analytical approach, we hope to stimulate further scientific conversation along this line of inquiry in the fields of IB and management (Birkinshaw *et al.*, 2007).

The paper begins with a brief discussion on how innovation relates to MNEs and a short overview of the evolution of MNE R&D strategy giving rise to the competence creating subsidiaries and global centers of excellence. The next section changes in the global talent pool that has given rise to a more dispersed R&D networks for MNEs. Next, following a discussion of the methodology adopted in this study, its findings are discussed in the context of the research abovementioned research questions. The paper concludes with theoretical and managerial implications, as well as further research directions.

MNES, INNOVATION AND THE EVOLUTION OF THE INNOVATION NETWORK

While “*entrepreneurship theory has become a confusing mix of different elements, plagued by misunderstanding and disagreements*” (Casson, 2014: 8), at root is the idea that it involves using judgment to grasp perceived opportunities characterized by Knightian uncertainty. “*Corporate entrepreneurship*” (Guth and Ginsberg, 1990: 591) underlies the production of innovative outputs by established firms, and these are the basis of strategic renewal. In other words, the exhibition of resilience in the face of changes in its external environment is a firm level capability stemming from corporate entrepreneurship. Such firms are able to maintain innovative outputs when opportunities arise, even during periods of weak financial performance (Mudambi and Swift, 2014). This capability is particularly important in multinational firms that face turbulence in a wide range of markets, but also have innovative opportunities arising from multiple contexts (Meyer *et al.*, 2011).

Three interrelated streams of IB literature analyze the processes whereby MNEs benefit from globally dispersed R&D activities. Hymer (1976) argues that the internationalization process

of the firm is determined by leveraging firm-specific advantages into a bigger market. Internalization theory argues that MNEs make decisions regarding international intra-firm activities on the basis of the associated transactions costs (Buckley and Casson, 1976, 1993). The eclectic paradigm contends that firms internalize ownership-specific and location-specific advantages in foreign locations (Dunning, 1977, 1993). Although, these perspectives view the MNEs from different vantage points, all three underscore the importance of hierarchy and control. This may be taken to imply that high value activities R&D should be kept close to MNE headquarters. Early IB literature, both theoretical and empirical developed the 'hub and spoke' model of MNE organization where knowledge and innovation flowed from a central headquarters to peripheral subsidiaries. Later work emphasized the significance of a multi-hub differentiated network model where each entity of an MNE creates new knowledge drawing from its own external environments (Bartlett and Ghoshal, 1990; Ghoshal and Nohria, 1997). The local roots of an MNE play a crucial role in the development of competencies and knowledge assets as well. Specifically, the strong local linkages help the MNE to establish "the home base of the MNE international competitiveness by drawing on the home country location-bound assets" (D'Agostino and Santangelo, 2012). Indeed, studies exploring this area of research have underscored the importance of MNE home location as a key source of tangible and intangible assets that can be successfully exploited in a global scale (D'Agostino and Santangelo, 2012; Rugman and Verbeke, 2004). Empirical evidence focusing on sub-national locations shows that there is a link between the technological capacities of the home region and the innovativeness of the MNEs that have their headquarters in the region (Cantwell and Iammarino, 2003; Santangelo, 2000).

Similarly, foreign subsidiary embeddedness in host locations enables the entire system to benefit from host country location-bound knowledge assets since the subsidiary assimilates and applies new external knowledge, and then transfers it within the MNE network (Andersson

et al., 2002; Mudambi *et al.*, 2014). Thus, the innovation centers or offshore subsidiaries influence the conversion of location-bound knowledge assets into ownership advantage for the whole MNE (D'Agostino and Santangelo, 2012; Rugman and Verbeke, 2001). The contribution of foreign R&D units in creating new technological competence at home through the leveraging of host-location specific knowledge assets is also well documented in the literature (Cantwell and Mudambi, 2005; Rugman and Verbeke, 2001).

Building a Foreign Innovation Network with Strong Local Roots

Collectively, the abovementioned studies propose that the MNEs and their networks of subsidiaries and R&D centers evolve over time and space. Modern MNEs possess competence creating subsidiaries - entities, which has been selected by headquarters for creation of distinct new knowledge in specific fields (Cantwell and Mudambi, 2005; Forsgren *et al.*, 2000). Such innovation centers are part of larger MNE networks that aim to source global human capital and establish linkages with partner companies and specialized suppliers with superior capabilities (Adenfelt and Lagerstrom, 2008). They engage in extensive high-value added research, scan technological developments in foreign markets, and may enrich the technological capabilities of the focal firm by providing access to foreign talent bases (Lehrer and Asakawa, 2002; Reger 2004).

Researchers agree that this trend will continue as firms worldwide continue to disperse their global value chains over multiple locations (Cantwell and Mudambi, 2000; Contractor and Mudambi, 2008; Kumar *et al.*, 2009) and the human talent required to perform these complex tasks will need to be sourced globally (Kedia and Mukherjee, 2009). Such instances are abundant in manufacturing as well as in service industries. For instance, Goldman Sachs set up a back-office service center in Bangalore in 2004 with 250 people to primarily provide technology and analytical research support to its global operations (Lampel and Bhalla, 2008). Today, the center is the firm's third-largest office, employing more than 1,200 people,

including software designers, and increasingly highly skilled analysts who produce modeling and other data that appear in Goldman research reports. Similarly, Shell operates five offshore captive R&D centers located in Malaysia, UK, Poland, Philippines, and Guatemala. These examples are archetypal – today virtually all major MNEs have significant foreign R&D centers. The core competences of these centers may be grounded in more specialized capabilities that are combined with unique local resources at different locations. Thus, globalization of these centers “*may locate sales close to markets, production facilities where costs are lowest, logistics units in a transportation hub or R&D units in a technology cluster*” (Meyer, 2006).

The choice of location in relocating or expanding R&D units is not a straightforward one. Each location presents a different combination of strengths and weaknesses and MNEs often respond by spreading their R&D units over a broader and balanced portfolio of regions and countries (Vestring *et al.*, 2005). The national institutional systems (e.g., educational systems, industry systems) shape distinct trajectories of differential knowledge development (Bartholomew, 1997; Hansen and Lovas, 2004). Considering this variety, MNEs are inclined to enlarge the scope of geographical diversity so as to expand their technological dimensions and to increase the likelihood of new combinations that can generate innovation.

In sum, for MNEs, the globalization of R&D and innovation that translates into the emergence of centers of excellence or research hubs around the world is a strategic response to the globalization of markets, increased competition, technological advancements and emergence of human capital pool in different pockets around the world. To further explore how such factors drive MNE’s global connectivity, internationalization of R&D, and innovation outputs, we conducted a longitudinal study of Goodyear’s innovation activities over and time and space.

RESEARCH METHODOLOGY

In-depth single company case studies help to develop theories and are particularly suitable for understanding phenomena that are dynamic in nature (Eisenhardt, 1989). In addition, a longitudinal case study can often better capture firm dynamics over time (Pettigrew, 1990). In fact, it has been argued that such in-depth case studies enable researchers “*to get close to the theoretical constructs and causal forces of interest*” (Joseph and Ocasio, 2012: 637; Siggelkow, 2007). To this end, in this study we adopt a blended approach which integrates historical analysis of a single firm in the context of its changing industry context. Moreover, we fortify such historical analysis with a detailed longitudinal quantitative analysis of patents and trademarks filed by the focal firm. In doing so, from the methodological vantage point, we embrace the intellectual movement that calls for bringing ‘history back into IB’ literature (Buckley, 2009; Casson, 1986, 1997; Jones and Khanna, 2006; Morck and Yeung, 2007; Wilkins, 1996). Scholars have successfully employed this method in the extant MNE literature (for example, Sun, 2009).

Patents and trademarks as proxies for innovation

In order to explore Goodyear’s innovative activity, we employed two types of data, namely patents and trademarks. Patents represent an established proxy for innovation, as widely asserted by prior research in this field (Griliches, 1990). We included in our analysis both utility and design patents, which in our research framework represent two different aspects of upstream innovation. The USPTO clarifies that “[...] *“utility patent” protects the way an article is used and works, while a “design patent” protects the way an article looks. The ornamental appearance for an article includes its shape/configuration or surface ornamentation applied to the article, or both*” (<http://www.uspto.gov/>).

Searching for sources of innovation is a problem-solving activity (Nelson and Winter, 1982); that is, firms solve problems by combining knowledge elements and thus create new products. Because a patent describes a technical problem and its solution, patent data offers a detailed

and consistent chronology of how firms solve problems and the manner in which they search for those solutions. A granted patent creates a legal title that indicates the name of the inventors or inventing firm, the relevant technology types (Griliches, 1990), as well as the technological antecedents of the focal knowledge.

Like patents, trademarks are intellectual property rights. They confer on the owner the exclusive right to utilize a mark to identify goods or services, or to monetize its value by means of licensing. The USPTO describes a trademark as “*a word, phrase, symbol or design, or a combination thereof that identifies and distinguishes the source of the goods of one party from those of others*” (<http://www.uspto.gov/>). Due to the increasingly crucial role of innovation for economic growth and the consequent need to improve our assessments of innovation performance, researchers have proposed the use of trademarks as an additional indicator of firms’ innovative activity (Mendonca *et al.*, 2004). In fact, since they are costly to register and maintain¹, trademarks are likely to reflect meaningful events in a company’s life (Giarratana and Torrisi, 2010). Although these events are only partially associated with the introduction of new offerings on the marketplace², trademarks are critical aspects of marketing innovations, as they help companies to accomplish the objective of differentiating their products and services from those offered by other firms (Mendonca *et al.*, 2004). In sum, trademarks reflect the outcome of a firm’s marketing efforts and competencies (Fosfuri and Giarratana, 2009). Therefore, by analyzing the dynamics of a firm’s trademarking activity, we can gain considerable understanding of its innovative capabilities in marketing. Accordingly, we use trademarks as an indicator of firms’ downstream innovation output.

Data Sources

¹ Applicants must in fact pay filing and renewal fees, as well as providing proofs that the mark is being actually used in commerce.

² In fact, trademarks can be obtained regardless of the existence of an underlying innovation.

The USPTO provides access to both patents and trademarks data. The timeframe for the research is 1975 to 2005. Trademark data is accessible through the USPTO online TESS database, which allows for Boolean search using a set of criteria. In addition, in 2013 the USPTO released a comprehensive dataset (i.e., the Trademark Case Files Dataset) covering 7.4 million trademarks filed or registered between January 1870 and January 2014. Since it contains detailed information on trademarks - such as trademarks characteristics, ownership, classification³, renewal and other significant events - we employed this dataset to collect the universe of trademarks filed by Goodyear between 1975 and 2005. For each year in our observation window, we reconstructed the company's trademark portfolio by accounting for new registrations, changes in marks' ownership, as well as for trademarks that had been cancelled, abandoned or expired.

USPTO patent data includes the classification of the invention, the location of inventors, and the ownership of the intellectual property (IP) created in the invention. The challenges involved in the collection of patent data are well documented. Some of the difficulties have been lessened by the accessibility of public databases, such as that of the National Bureau of Economic Research (NBER) (Hall *et al.*, 2001). We relied on the Harvard Patent Network Dataverse (DVN), which is a product of the Harvard Business School and the Harvard Institute of Quantitative Social Science (Lai *et al.*, 2013). The DVN work draws on both raw data from the USPTO and processed data from the NBER set to create a disambiguated set of patent-inventor observations from 1975 through to 2010 (Lai *et al.*, 2013). The full database contains information on over 9.1 million patent inventors, with a singular data file containing more than 1.3 gigabytes of information (Lai *et al.*, 2013).

³ When filing a trademark, applicants are required to indicate the goods and services on which they are willing to use the mark. This indication is the basis for classification of trademarks into specific good and service categories. The USPTO utilizes two types of classifications, namely the International Classification of Goods and Services under the NICE agreement, in use since 1973 and serving as the primary classification set, and the U.S. classification, that was employed prior to 1973 and is still maintained as a secondary system (Graham, Hancock, Marco and Myers, 2013).

Accessing DVN dataset represents the valuable first step. From this data we extracted Goodyear patents filled between 1975 and 2005. DVN data has a substantial number of missing design patents for the period 1975 – 1998. Hence, we complemented the DVN dataset by extracting this information directly from USPTO to have the universe of Goodyear design patents.

Inventor innovation network and local context. Knowing the name of the inventors, their locations and the number of their patents, provides us a rich and personal view of the drivers of innovation. Within the patent data set, we can identify the inventors who lived in Akron (and more generally in Ohio) and also, elsewhere in the US, and in foreign countries. This helps us to highlight the geographical distribution of Goodyear’s inventors and map their relationship with the two main innovation centers of the firm. In particular, we classify Goodyear patents as Akron- or Luxembourg-based, if at least one listed inventor was located near the Akron or Luxembourg innovation center, respectively. This data can be used to provide a good indication of the levels of local and global collaboration on research, and point out the major differences and commonalities of the innovative activities carried out in Goodyear’s R&D centers.

OVERVIEW OF THE GOODYEAR TIRE & RUBBER COMPANY

Headquartered in Akron, Ohio, USA, Goodyear was founded by Frank and Charles Sieberling in 1898. Currently it is the third largest manufacturer of tires in the world after Bridgestone and Michelin and the biggest in North and Latin America, with around 72,000 employees worldwide. Today, it serves most regions in the world with 52 plants in 22 different countries. Apart from tires, Goodyear also produces rubber-based industrial products.

The company grew rapidly in the early years and by 1916 became industry leader and had one-third share of the domestic market by 1960 (French, 1987; Sull *et al.*, 1997). Innovative activities of the company were spurred by a series of external events. During World War I,

Goodyear supplied airships and balloons to the military and the company supplied the first tires on the moon, on the Apollo 14 mission. Currently, Goodyear has three innovation centers. The R&D center in Akron, Ohio was started in 1978 and serves the North American and Latin American markets. The innovation center in Colmar-Berg, Luxembourg and the development center in Hanau, Germany, serve the European, African and Asia-Pacific regions. Table 2 delineates the major innovation activities of these three innovation and development centers. Goodyear inherited the Hanau center as part of their acquisition of Dunlop tire in 1997. The innovation activities of the Hanau center are closely integrated with the Colmar-Berg center in Luxembourg and thus, have been included as part of the Luxembourg-based innovations for analytical purposes.

[Table 2 about here]

Our period of study (1975-2005) witnessed major turbulence in the global tire industry. Therefore, at this point it is important to understand the major dynamics of the tire industry and the local and the global context in which Goodyear has operated.

The dynamics of the US Tire Industry and the Akron Region Cluster

The tire industry in the US was centered in Akron, Ohio, to such an extent that Akron used to be called the ‘rubber capital of the world’. All the major tire manufacturing companies had a presence in this cluster. Four of the five biggest tire companies in the world, namely – Goodyear, Goodrich, General Tire and Firestone had their headquarters in Akron. Collectively, plants in the Akron cluster produced 65% of the tires manufactured in US (Sull, 2001).

These companies were responsible for the major tire industry–related innovations in the early part of twentieth century. Between 1900 and 1937, these companies generated slew of innovations in raw materials and tire design, which considerably increased the overall tire performance (Sull, 2001). For instance, the average tire manufactured in 1900 lasted approximately 500 miles, while the typical tire produced in the mid-1930s lasted more than

20,000 miles (Sull *et al.*, 1997). The early innovations were not limited to the tire performance. The average price of the tire declined by over 80% between 1913 and 1933 (U.S. Bureau of Labor Statistics, 1934, cited in Sull, 2001). Such radical improvement in the product and process resulted from a steady stream of incremental innovations in design that cumulatively increased tire performance and production.

Changes in tire design offered the potential for improved performance, but realizing this potential required a host of innovations in complementary technologies (Rosenberg, 1979), especially the raw materials needed to construct a tire, i.e., chemical additives, steel wire, and textiles. Thus, the Akron region became a hub of the related industries as well. The region was further fueled by the flourishing steel industry in Pittsburgh and the automotive industry in the Detroit, Michigan. Consequently, Akron remained an important and highly concentrated industry cluster and the tire companies maintained strong local roots.

The local roots of these companies went beyond the location of their headquarters. The top executives of Goodyear, Firestone, B.F. Goodrich, and General Tire had deep local connections. Sull (2001; L2/L3) describes this connection succinctly:

“An Akron native led Goodyear as either president or chairman of the board continuously between 1940 and 1983. In 1972, between one-third and two-thirds of the executives at Goodyear, Firestone, and General Tire were Akron natives; between one-third and one-half had risen through the ranks of the domestic tire industry; and a significant percentage had followed in their fathers’ footsteps as executives in the same company. Industry insiders referred to these homegrown executives as “gum-dipped,” in reference to the production process developed by Firestone in the 1920s in which fabric strips were dipped in rubber and thereafter took on a uniform shape. Most of these executives lived within a five-block radius of one another, socialized at the Portage Country Club, and relied on the Akron Beacon Journal for their news”.

Goodyear’s competitors and technological turbulence in the tire industry

The Akron industrial cluster and the Akron-based tire MNEs retained their dominance till the 1960s. However, they faced an unprecedented competitive shock in the mid-1960s known as the “radial revolution” (Sull *et al.*, 1997) from the French tire company, Michelin. The radial tires had significantly improved features. Sull (2001, L5) reports that radial tires “*reinforced the tire’s plies with steel wire, increased the tire’s useful life from 20,000 to 40,000 miles,*

reduced a driver's gasoline consumption by 5-10%, improved handling, and dramatically reduced the likelihood of a catastrophic tire failure, known as a 'blowout'". These pioneering features helped Michelin to capture a significant portion of the European market and the Akron-based companies also lost significant market share in a continent they had dominated since the end of the First World War.

The major rivals of Goodyear, Firestone, Uniroyal, General Tire and BFGoodrich responded differently when faced with the 'radial innovation'. Sull *et al.* (1997) describes these differential responses in greater details. As the new radial technology offered substantial benefits over the prevailing 'bias ply' technology, major automakers in the Detroit area embraced the change and adopted radial tires. Sull and his colleagues noted that while the improved radial technology was profoundly beneficial for the car owners, the change proved disastrous for the tire manufacturers. Making radial tires required huge capital expenditure because existing manufacturing infrastructure did not support the switch and building Greenfield plants meant added costs. Notwithstanding these difficulties, Firestone, Uniroyal and General Tire continued to invest in building new plants that could produce radial tires. The then Goodyear CEO and Chairman Charles Pilliod was a huge advocate of radial tires and the company invested 'every penny' on converting the existing plants to support the new technology (Sull *et al.*, 1997). Unfortunately, despite these huge investments these companies continued to report very weak earnings (Sull, 1999; Sull *et al.*, 1997). This led to closing plants in the Akron area as well as in other parts of US. From the early 1980s to mid 80s all five automakers faced acquisition threats. Goodyear avoided this threat by "*putting its oil and aerospace businesses on the block, and borrowing heavily to buy back over half its stock*" (Sull *et al.*, 1997: 494). BFGoodrich, after forming a joint venture with Uniroyal sold its tire business to the latter and left the tire industry. Uniroyal was later acquired by Michelin. Firestone did not survive either as the Japanese giant Bridgestone acquired it and gained the network of 1,500

automobile service centers in US (NY Times, 1988). During the same period General tire sold its tire business to Continental.

Thus, with the exception of Goodyear, none of the Akron-based tire companies survived the shocks they suffered in the radial revolution. During the 1970s they all experienced catastrophic declines. The Akron region also witnessed major decline; the waning of steel, auto and tire production in the 1970s in this region has been attributed to internal factors such as local mismanagement and high union labor costs (Braunerhjelm *et al.*, 2000), and external factors such as globalization and overseas competition.

The transition from bias-ply technology to radial design for passenger tires and the changing fortunes of one of America's best known industrial centers provide a rich historical example of environmental and technological changes that had a profound impact on incumbent firms in a mature industry. Our analysis of Goodyear's patents is situated in the backdrop of these changes in the industry. Below, we dig deeper into the innovation responses of Goodyear from 1975-2005 and aim to delineate how global innovation connections and local context spurred a revival (Bathelt *et al.*, 2004). In particular, unlike its other Akron-based competitors, Goodyear maintained its innovative output even in periods of weak financial performance, displaying the resilience that enabled it to remain the sole survivor in the formerly dominant industry cluster.

MAJOR FINDINGS

RQ 1: How does the innovation trajectory of Goodyear enable the company to face the turbulent external environment?

Innovation can be a major determinant of firm's ability to adjust to changes in the external environment. By constantly innovating, firms set up the basis for their strategic renewal and improve their chances of long-term survival. In order to investigate how Goodyear's innovation

trajectory has sustained the company in times of severe competitive and technological changes, we analyze the evolution of Goodyear's innovation as represented by patents, and relate it to its financial performance and to major shocks in the external environment. Figure 1 depicts the cumulative number of utility and design patents during the analyzed period, combined with the dynamics of new patent applications⁴ and expired patents between 1975 and 2005. The cumulative number of patents steadily increases throughout these years, demonstrating the firm's consistent commitment to technological progress. The trend of new patent applications is also mainly positive, although it shows a slight decline in the later part of the 1970s and in the early 1980s. It could be argued that the slow down of Goodyear's innovative production in this period is at least partially related to the complexity of catching-up with the radial breakthrough. Throughout the 1980s the number of patent applications remained relatively constant, in line with the findings of previous studies that have pointed out the decline of the US-based tire industry over this period (Sull, 2001). However, starting in 1995 the innovative performance of Goodyear takes off with the aim to renew the firm's patent portfolio, which by the time had started to shrink due to the increasing number of patents getting close to expiration. Figure 1 shows that from 1996 onwards the number of new patent applications is substantially higher than the number of expired patents indicating the growth of Goodyear's innovative portfolio. Hence, while its competitors were collapsing in the face of technological changes and take-over threats, the company engaged in the build-up of a solid base of technological capabilities that enabled the company not only to react to the major changes spurred by the radial innovation, but also to push the technological threshold in its industry.

[Please insert Figure 1 about here]

⁴ New patent applications refer to those patents that were applied for and successfully granted in our observation period.

The comparison between the dynamics of new patent applications and the company's financial performance offers additional insights on the firm-level conditions under which Goodyear's innovation trajectory has developed, and influenced its competitive advantage. Table 3 demonstrates that while the innovative output shows an increasing trend, the company's R&D/Sales ratio remains quite stable over time, indicating an increase in R&D productivity. Moreover, the positive pace of the number of new patent applications occurs in spite of the discontinuity of Goodyear's financial performance. In particular, while the company's return on equity decreases over the years 1998-2003, the number of new patent applications shows an overall positive trend, reaching the peak of 288 new patents applied for in 2001. Interestingly, the excellent innovative performance reported by the company in the early 2000s is followed by a substantial improvement in the company's financial performance (Table 3).

[Please insert Table 3 about here]

To put Goodyear's performance in perspective, Figure 2 shows the patents productions of Goodyear, Bridgestone and Michelin (the three major players in the international tire industry) over the period 1975-2010.⁵ The diagram reveals that Goodyear has been ahead of the curve right from the very beginning until the late 1980s, and again after the late 1990s until the end of the period. Hence, with the exception of the decade following the radial revolution, Goodyear has been the leading innovator in the global industry.

[Please insert Fig 2 about here]

Overall, these findings stress the importance of a consistent commitment to innovation and the role that such approach may play in MNE knowledge creation, performance and even survival.

Over time, Goodyear has been able to develop a global leadership in patent production. This

⁵ Michelin acquired, Goodrich, one of the Akron tire 'majors' in 1988, after which that firm's patent output rapidly declined to zero. Goodrich's patent output had been relatively weak, suggesting a relatively low level of innovative output. This underlines the importance of innovation in MNE survival and also suggests that Goodrich was acquired for its downstream distribution and brand assets, i.e., to become a competence-exploiting subsidiary (Cantwell and Mudambi, 2005).

status seems to have afforded the company the ability to successfully face even the most dangerous external threats that have occurred in the global tire industry over a 30-year period. While in the 1970s, mainly Akron-based companies populated the world tire industry, along the years only Goodyear has survived as an independent organization, thus demonstrating resilience in the face of its turbulent external environment. Just like any other company in the industry, Goodyear was slow in reacting to the radial technological breakthrough. However, contrary to most competitors, its strong focus on innovation allowed the firm to survive, and eventually to push the technological trajectory of the industry to the cutting edge.

RQ 2: How has the geography of Goodyear’s innovative activity changed over time?

Although R&D centers tend to be more centralized in the HQ’s home country compared to other functions, MNEs increasingly set up their innovation network to exploit knowledge-based resources that are geographically dispersed. Recent research shows that this may happen in combination with the maintenance of strong linkages with the home location (Kumar *et al.* 2009; Mudambi and Swift, 2012; Mukherjee *et al.*, 2013). In order to investigate how Goodyear has managed this phenomenon over time, we map the geographic location of its inventors between 1975 and 2005. In fact, inventors’ location has been widely employed by IB scholars to analyze the geography of MNEs’ innovative activity (Lahiri, 2010). Figure 3 shows a concentration of US-based inventors in Akron and nearby cities, demonstrating a strong cluster effect and the importance of the corporate R&D center.

[Please insert Figure 3 about here]

The company has clearly played a prominent role in the innovativeness of the Akron area. Figure 4 shows Goodyear’s share of innovation as a percentage of the total innovative output

of the Akron region⁶ from 1975 to 2005. In spite of the decreasing trend that characterizes Goodyear's share of innovation in the late 70s, starting from 1997 the company steadily accounts for more than 25% of the total patent production of the Akron area.

[Please insert Figure 4 about here]

Although the Akron corporate R&D center has consistently played a critical role in the company's innovation trajectory, Goodyear knowledge creation is not locally bounded. Accordingly, Figure 5 shows a consistent increase in the percentage of Goodyear patents that are internationally connected. While at the end of 1979 only 8% patents were internationally connected, in 2004 almost half (48%) of the patents had at least one international collaborator.

[Please insert Figure 5 about here]

Analyzing the inventors' location, it appears that the main foreign inventor location is Luxembourg (Figure 6).

[Please insert Figure 6 about here]

The majority of the other European inventors, i.e. Belgian, German and French, are mainly located on the border with Luxembourg, so we can reasonably link them to the Luxembourg innovation center (Figure 7). This innovative activity may presumably be assumed to be exploratory, product innovations. In addition, we were able to link most other dispersed inventor locations to Goodyear production plants (e.g., Danville VA, Fayetteville NC, Birmingham, UK, etc.). These innovations are likely to be exploitative, process innovations.

[Please insert Figure 7 about here]

⁶ We measure the innovative output of Akron region extracting USPTO patents whose inventors were located in the Core Based Statistical Area (CBSA) of Akron. This involved building a new database by matching locations in the DVN patent database with Akron CBSA boundaries, as defined by the U.S. Office of Management and Budget (OMB). We used zip codes to identify inventors located in the CBSA of interest to our study. The result is a dataset of USPTO patents with at least one inventor located in the Akron CBSA.

Extant literature shows that knowledge created in foreign subsidiaries and R&D centers is a key source of competitive advantage and often helps MNEs to better understand the local markets (Pearce and Papanastassiou, 1999). In this regard, it is useful to highlight that the company's innovation and development center in Luxembourg has been consistently innovative. Presumably, this played a crucial role in supporting Goodyear's competitive position in the European market.

The comparison of patent production between the Akron and Luxembourg-based innovation centers reveals some interesting distinctions. Figure 8 shows that Goodyear's dependence on HQ-based innovation is diminishing and the innovation emanating from Luxembourg center is steadily growing. A closer look tells us that also the innovative collaborations between the corporate R&D center and the Luxembourg center (with at least one inventor located in Ohio and one in the Luxembourg area) slightly increase over time. This finding is in line with the stream of IB literature that underscores the importance of competence creating subsidiaries (Canwell and Mudambi, 2005) and effect of such entities on MNE's total innovation output. Overall, our data shows that the configuration of the geographic sources of Goodyear's innovation has evolved over time, spanning from a home-centered archetypal to a more internationally-oriented model. This suggests that – along with a persistent innovation capability – the firm has progressively developed the ability to recognize the opportunities for knowledge creation arising from geographically dispersed locations, and to set-up a proper organization for the exploitation of such opportunities.

[Please insert Figure 8 about here]

In order to verify whether the geographic distribution of Goodyear's innovative activity also mimics its technological specialization, we have also investigated the technological categories of the main R&D locations. Figure 9 shows that solely Akron-based patents have a uniform distribution between the mechanical and chemical categories. The rapid growth in the

mechanical sector can be attributed to the growth of ‘transportation’ industries in the Akron region. However, when it comes to collaboration between the Akron and Luxembourg centers, the mechanical category of patents still dominates. Interestingly, design patents become prominent in the Luxembourg-based patents, providing further support for a competence creating subsidiary perspective on this subsidiary.

[Please insert Figure 9 about here]

In spite of the gradual international dispersal of R&D activities, it is important to emphasize the local partnerships of Goodyear and their role in enhancing the talent-base of the company. Akron, proudly known as the “Rubber Capital of the World” for nearly the entire 20th century, no longer produces tires, but is part of a budding Midwest revival (Weissmann, 2012). It has become a leading global innovator in liquid crystals, polymer science and transportation. As tire manufacturing was phased out, the focus turned to polymers (Carlsson, 2002). The University of Akron established the first College of Polymer Science and Polymer Engineering, and hosts the Goodyear Polymer Center and the National Polymer Innovation Center. Industry-university collaboration in Akron has been directed towards developing a global reputation in polymer science. More than 400 polymer-related firms are now located in Akron. Akron has also built on its role as a transportation hub and the home of the Goodyear Blimp. Firms including Goodyear, Roadway, and Lockheed-Martin are creating innovation in several areas of transportation, including motor vehicle production, freight movement, and lighter than air technology (City-Data.com, 2013). At the same time Akron has attracted other global tire makers. The Chinese giant, Triangle group has established a new research company A3T LLC, by partnering with The University of Akron (UA) and the University of Akron Research Foundation (UARF) on rubber research, technology development and licensing.

RQ 3: How do the upstream and downstream ends of the innovation value chain evolve over time at Goodyear?

A firm's innovative activities concentrate at the two ends of the value chain: upstream innovation includes basic and applied research and design, that are responsible for new concepts development, while downstream innovation encompasses marketing and brand management capabilities (Mudambi, 2008). In order to investigate the evolution of upstream and downstream innovation at Goodyear, we employ both patent and trademark data. More specifically, while trademarks are used to capture downstream innovation, i.e. the output of companies' marketing knowledge, utility patents and design patents are used to explore – respectively – the research dimension and the design dimension of upstream innovation.

Figure 1 shows the increasing number of Goodyear patents, especially from the early '90s, distinguishing between utility and design innovation. Starting from the '90s the cumulative number of design patents becomes relevant in Goodyear's patent production, boosting Goodyear innovative performance. Figure 10 demonstrates the major technological categories⁷ of the Goodyear patents. The figure illustrates that patents related to chemical compounds and mechanical processes dominate the innovation scenario. In fact, traditionally Goodyear had been mainly focused on basic and applied R&D, and the high number of utility patents in mechanical and chemical classes supports its technical specialization. Nevertheless, from the early 1990s traditional basic R&D has been increasingly complemented by design innovation. In fact, as we can see in Figure 10, from 1992 the number of design patents takes off and becomes a relevant component of Goodyear's patent portfolio. Of Goodyear's design patents, 97% are classified in the USPTO category D12 (Transportation), which includes design patents

⁷ We reclassified the original USPTO primary patent classes using the taxonomy of Hall et al. (2001). The original taxonomy includes the following six technology categories: chemical, computers & communications, drugs & medical, electrical & electronic, mechanical and others. Mechanical includes, among other subcategories, "motors, engines & parts" and "transportation". Chemical includes, among other subcategories, "Coating" and "Resins". We complemented the existing classification with an additional category including design patents.

claiming ornamental designs for tires (USPTO, 2005). Specifically, the majority of Goodyear's design patents are related to tread design and pattern, which are not only ornamental features of tires but also key technical characteristics determining the performance and life of the product. As a consequence, it appears that Goodyear's design patents are closely linked with its utility patents and represent a transition to a different type of upstream innovation.

[Please insert Figure 10 about here]

However, research and design competences do not represent the only driving forces of competitive advantage in the global tire industry. Brands and marketing capabilities have always played a central role in this context. As highlighted by Figure 11, Goodyear filed for a total of more than 950 trademarks between 1975 and 2005, with a peak of more than 90 trademarks applications filed in 2000.

[Please insert Figure 11 here]

By analyzing the primary classification (i.e., the IC class) of trademarks⁸, it appears that most of Goodyear trademark registrations are associated with the "vehicles" class (012), followed by the "rubber goods" class (017) (Figure 12), meaning that Goodyear protects its marketing intellectual property mainly in these two product categories. This reflects the distribution of both utility and design patents by technological class.

[Please insert Figure 12 here]

Since trademarks can be abandoned, cancelled or can expire over time, we also look at the evolution of Goodyear's trademark portfolio by considering only the company's live trademarks. As Figure 13 highlights, the stock of Goodyear's live trademarks tends to decline over time.

⁸ It should be noticed that more than one primary class can be associated with a single trademark registration.

[Please insert Figure 13 here]

Hence, although Goodyear is still actively using trademarks to protect its marketing knowledge, as witnessed by the increase in the cumulative number of new trademarks registered (Figure 11), it seems that the firm's trademark portfolio is undergoing a process of reconfiguration. Some trademarks have been abandoned or simply not renewed before expiration, and a smaller amount of new trademarks have entered the scene. This may suggest that the company is either trying to consolidate the property rights arising from trademarks, or shifting to a slightly different IP protection strategy. Because obtaining IP protection is costly and companies have a limited amount of resources to allocate to the safeguard of their intangible assets, it is arguable that they constantly strive to adjust the composition of their IPRs to changing environmental conditions.

DISCUSSION

Research and managerial implications

This research contributes to the burgeoning literature on 'local contexts in global business' (Meyer *et al.*, 2011) by tracing the evolution of the innovation process of a major US-based manufacturing company. More importantly, the settings of this study also allow us to enrich our understanding of a major US 'industry cluster'. This is especially crucial when we consider the intellectual movement that promotes such industrial clusters as keys to the overall competitiveness of the US economy.

The main findings of this study are in concert with the scholarly perspective that argues that continuous investment in innovation often help firms survive and capture value in the long run. We contribute to the extant literature in several meaningful ways. In this paper, we explore a relatively underdeveloped, implicit but important question pertaining to MNE innovation - how

does an MNE's innovation trajectory evolve over time and space? Answering this question is important as it is directly related to firm performance and indirectly sheds light on the viability of 'innovation efforts' as a strategic imperative.

We also recognize that such innovation trajectories of MNEs cannot be analyzed in isolation and must be understood within a broader set of environmental variables that are intertwined with the strategic choices made by the focal MNE. We argue that such trajectories grow in parallel with the factors such as globalization, technological advancements, increased competition in the domestic and global market, and changes in the local context. Thus, our findings are consistent with the perspective that argues the process of high-value added activity relocation should be examined in the context of a larger co-evolutionary perspective encompassing both the industry and the firm's location profile (Bathelt *et al.*, 2004; Mukherjee *et al.*, 2013).

The decision of where to internationalize knowledge-intensive activities is another important strategic issue that has been addressed here. The extant literature argues that it is contingent upon an array of factors of location attractiveness (Contractor and Mudambi, 2008; Graf and Mudambi, 2005; Meyer *et al.*, 2011). We found preliminary evidence that as the nature of the activity becomes more knowledge intensive, location factors such as the availability of a highly skilled and motivated talent pool, a highly functional technology infrastructure, and availability of a local knowledge cluster gains increased significance. We noticed that Goodyear gradually internationalized its R&D activities from a primarily headquarters-centric operations based in Akron to a globally dispersed one encompassing a competence-creating R&D subsidiary in Luxembourg.

Our analysis of the different dimensions of innovation suggests that in traditional industries, where competition has been conventionally based on basic and applied R&D, new strategic levers such as design and marketing competences are becoming increasingly relevant. Because

at this stage the nature of technical innovation is mainly incremental, companies need to find alternative ways of competing and differentiating their offerings on the marketplace. Design and marketing knowledge may provide the proper complementary resources to develop and sustain long-term competitive advantage through differentiation. Companies may use design to communicate the quality of their offering through the product physical appearance (Beebe, 2010). On the other hand, marketing competences and trademarks protection enhance such distinctiveness by signaling specific product attributes and performance, and by generating association and awareness in the mind of customers (Krasnikov *et al.*, 2009). Moreover, the rise of design patents and trademarks highlights the shift of design and marketing knowledge from a more tacit to a more codified nature. While in the past such competences were less exposed to imitation and much more appropriable, the increasingly global distribution of innovative activities and the upsurge of new competitors (e.g., rivals from emerging markets) have induced incumbents to improve the extent of protection on these assets. Design, in particular, is able to create a link between innovation and user perception. All the different aspects of a design patent are connected to same nexus of delivering a better user experience. In the case of Goodyear, design innovation is not only related to the tire look, but may also act as a channel to convey a better driving experience. Hence, design may enhance drivers' experience both in terms of external appearance and in terms of performance. For example, the Goodyear design patent no. D457130, protecting a new ornamental design for a tire sidewall patten, improves the esthetic of the tire, the external pattern and the lettering providing a visible signal of the innovativeness of the product. On the other hand, the Goodyear design patent no. D482319, introducing a new design for the tire trade, enhances the performance of the vehicle (e.g. under particular weather conditions), delivering a better experience to the driver. Overall, these insights suggest that the nature of innovation strategy is evolving toward an increasing reliance on design. In particular, it could be argued that a change is occurring in the way

innovation is managed and leveraged, at least in major multinational firms. This opens an entirely new avenue for theory development. More specifically, our study raises interesting questions for technology management theory: (1) Does the increasing role of design signal a move by advanced country MNEs to more sophisticated forms of innovation? If so, how might such a transition be understood and modeled?

Important implications for managers also emerge from this study. First, we emphasize that successful R&D offshoring often entails making appropriate location choices. Top companies considering R&D offshoring should make their location choices based on potential talent base, presence of an appropriate ecosystem consisting partner firms, and market growth opportunity in the foreign market. Secondly, managers should also treat the global R&D labs as potential innovation and strategic growth hubs. These R&D labs can serve as conduits of organizational learning and can transfer location-specific knowledge to other centers.

Limitations and Future Research Directions

This study also paves avenues for further research in this area. Given the limited generalizability of a single company study design, further research may benefit from large-scale longitudinal studies involving similar industrial area companies in order to identify additional factors that may influence a company's innovation trajectory, and extrapolate findings in a population of firms. Future studies may also concentrate on the further development of constructs and measures in order to capture the sub-processes associated with the contribution of innovation to the resilience of a company. This requires an in-depth understanding of different models of innovation, which may be achieved through qualitative and quantitative enquiries. For instance future research may concentrate on the unbundling of innovation activities from the headquarters and investigate the impact of increased modularity and flexibility (strategic and operational) on firm value creation and performance. Additionally, while our study has the advantage of using a variegated set of data to investigate

innovation, among which trademarks - that constitute a relatively underexplored indicator in this field - it is worth noting that basic trademarks counts can be exposed to biases arising from data consolidation issues (Mendonca *et al.*, 2004). Future studies should refine this measure, for instance by aggregating trademarks data at the level of the brand. Finally, an issue that deserves further attention refers to the consumer value creation through innovation practices. The potential of innovation to deliver benefits to the focal firm and the local economy is being increasingly explored by the researchers. However, the focus on customer value creation seems to be rather limited. Further studies may investigate links between company innovation and the amount of value captured by its consumers.

Table 1

Summary of Research Design and Findings

Research Question	Conceptual Underpinnings	Major findings
<ul style="list-style-type: none">• RQ 1	Innovation as the key to the firm's resilience	<ul style="list-style-type: none">• Continuous investment in innovation• Increased modularity
<ul style="list-style-type: none">• RQ2	<ul style="list-style-type: none">• Geographic distribution of innovation• Linkages between MNE headquarters and foreign subsidiaries	<ul style="list-style-type: none">• Leverage on foreign innovative capabilities• Competence-creating subsidiary• Positive spillover on the local economy
<ul style="list-style-type: none">• RQ3	Upstream and downstream innovation	<ul style="list-style-type: none">• Increasing role of design• Complementary function of design and marketing knowledge for differentiation

Table 2**Goodyear Innovation Center Network**

Innovation Center Locations (COEs)	Demographics	Description of R&D centers and their main Value Added Activities
<i>Akron Innovation Center, Ohio, USA</i>	Established = 1983 Employees= 775	The Goodyear Innovation Center at Akron (GIC*A) is the main R&D Center of the company. It coordinates with the other centers and oversees the R&D efforts in the North and South American markets. GIC*A is involved in core tire technology innovation and serves as new product engine for Goodyear.
<i>Colmar-Berg, Luxembourg</i>	Established=1972 Employees=900	The Goodyear Innovation Center Luxembourg (GIC*L) conducts R&D activities related to building and testing of new tires for passenger cars, light and medium trucks and farm vehicles for the European, African and Asian markets. A team of 900 engineers, scientists and technicians composed of 29 different nationalities work on new raw materials, tread designs and on rubber quality. One of the innovation objectives of this center is to obtain Original Equipment approval on their tires from vehicle manufacturers.

Source: www.goodyear.com and personal communication.

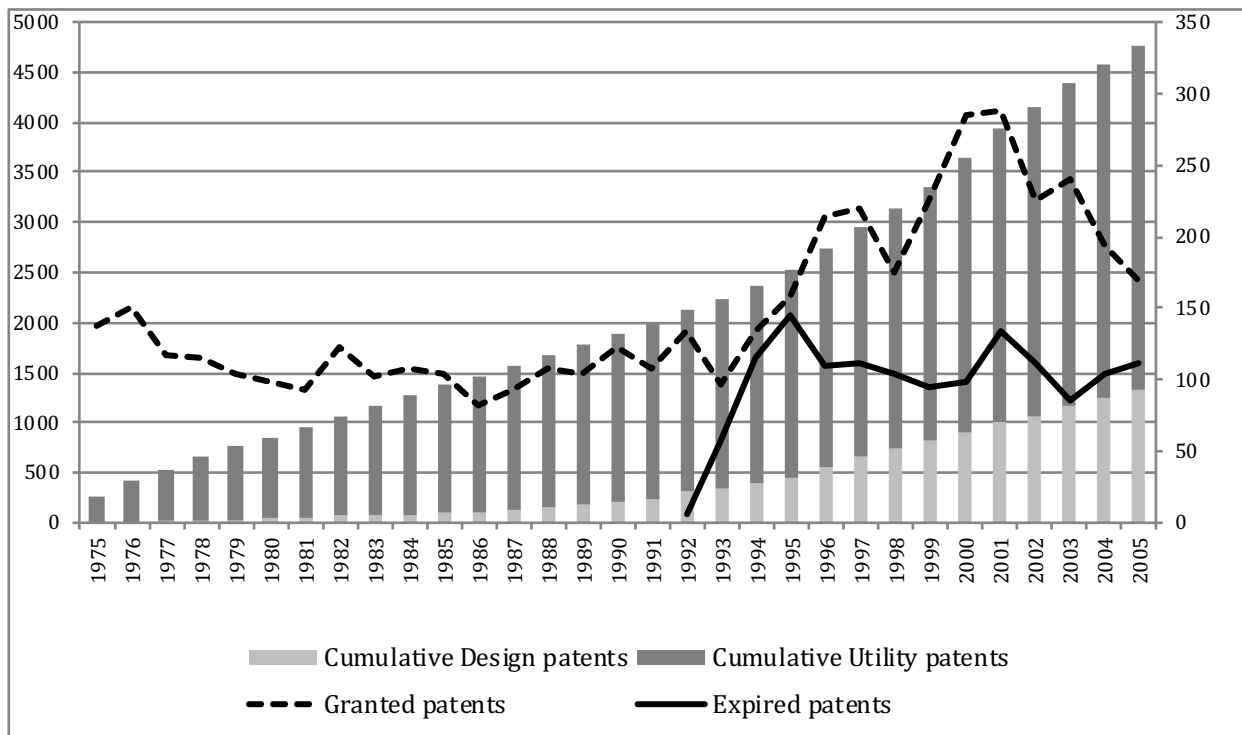
Table 3**Goodyear financial and innovation performance (1980-2005)**

Year	Return on Equity	Return on Total Assets	R&D / Sales	No. of patents*
1980	0.103	0.082	0.021	98
1981	0.111	0.084	0.023	92
1982	0.110	0.084	0.027	123
1983	0.112	0.078	0.026	102
1984	0.133	0.092	0.027	107
1985	0.123	0.087	0.031	105
1986	0.038	0.041	0.032	82
1987	0.319	0.128	0.027	93
1988	0.181	0.081	0.028	107
1989	0.099	0.056	0.028	104
1990	-0.018	N/A	0.029	123
1991	0.040	0.037	0.030	108
1992	-0.283	-0.046	0.028	134
1993	0.183	0.073	0.027	97
1994	0.222	0.091	0.028	134
1995	0.201	0.095	0.028	158
1996	0.031	0.051	0.029	214
1997	0.167	0.095	0.029	219
1998	0.191	0.106	0.033	174
1999	0.065	0.112	0.035	225
2000	0.011	0.087	0.029	284
2001	-0.064	0.069	0.027	288
2002	-0.629	N/A	0.027	226
2003	-2.516	0.030	0.023	241
2004	3.846	0.074	0.021	194
2005	3.128	0.080	0.019	170

Source: Compustat for financial data; USPTO and DVN database for patent data.

* Number of patents by application year.

Figure 1
Evolution of Goodyear patent portfolio (1975-2005*)



* Cumulative design and utility patents and granted patents by application year. Expired patents by expiration year.

Figure 2
Goodyear vs. Bridgestone and Michelin

(Patents as % of the total number of the three companies, by application year, 1975-2010)

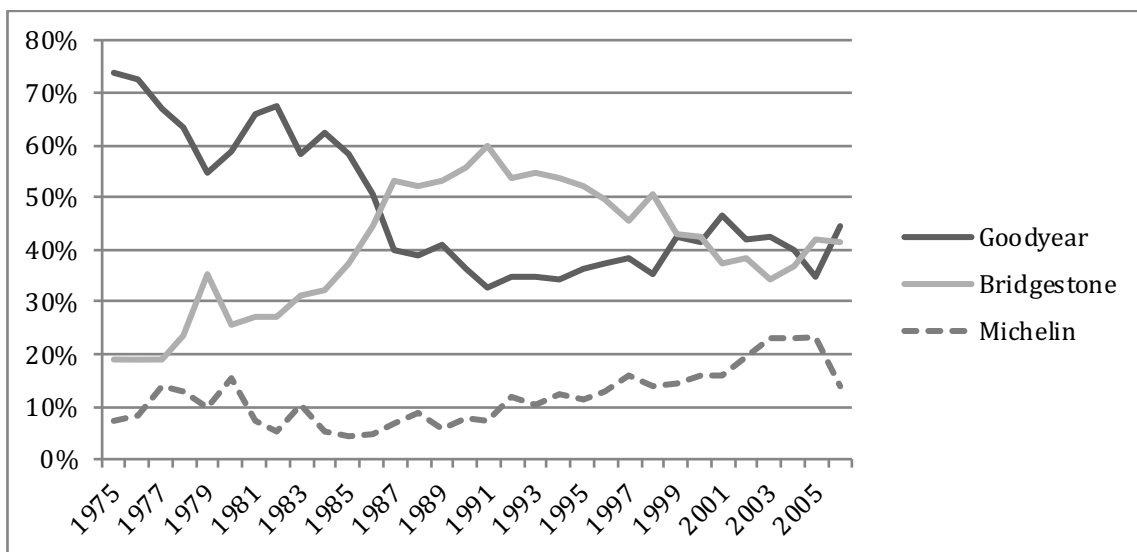


Figure 3
Location of US-based inventors (application year, 1975-2005)

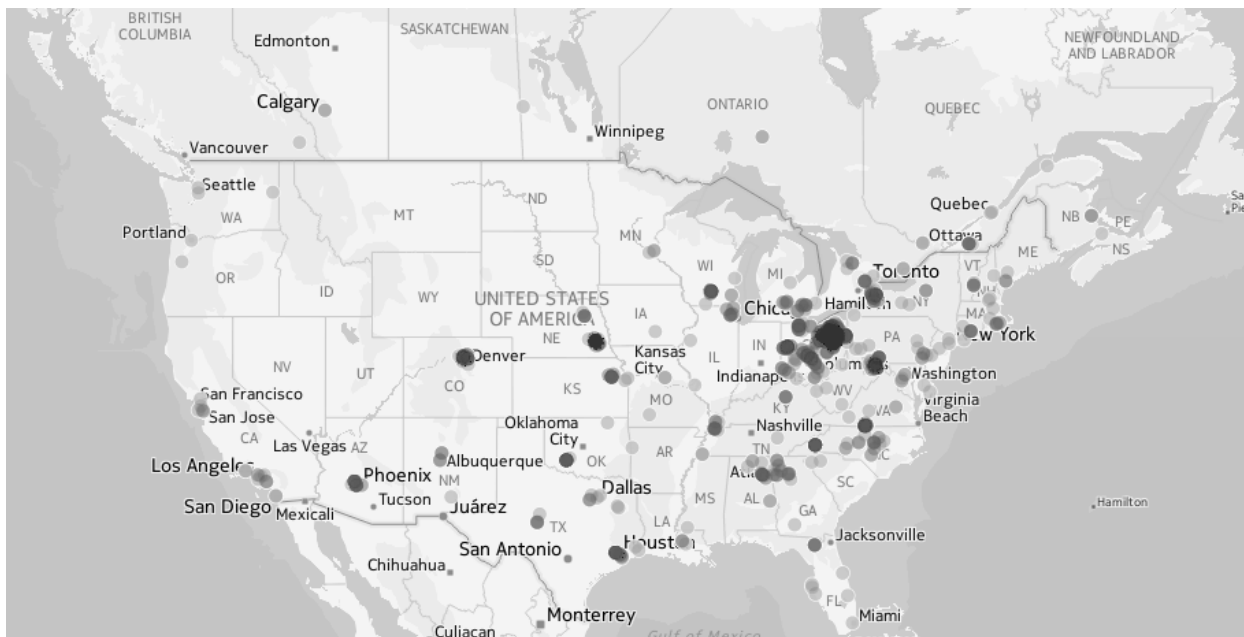


Figure 4
Goodyear's share of innovation as percentage of the innovative output of Akron region (by application date, 1975-2005)

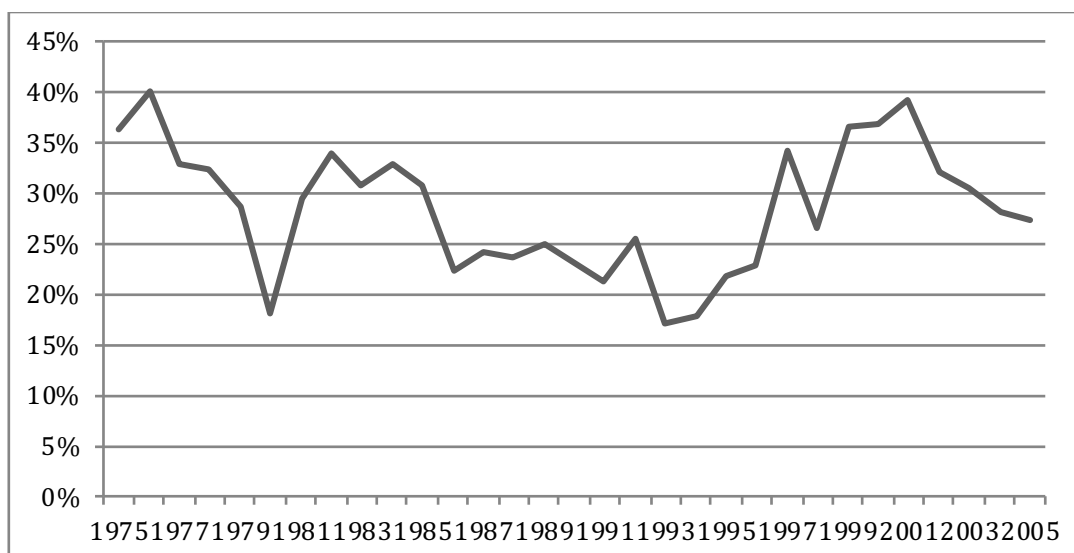


Figure 5
Percentage of Goodyear's internationally connected patents
(as % of the total number of Goodyear's patents, by application year, 1975-2005)

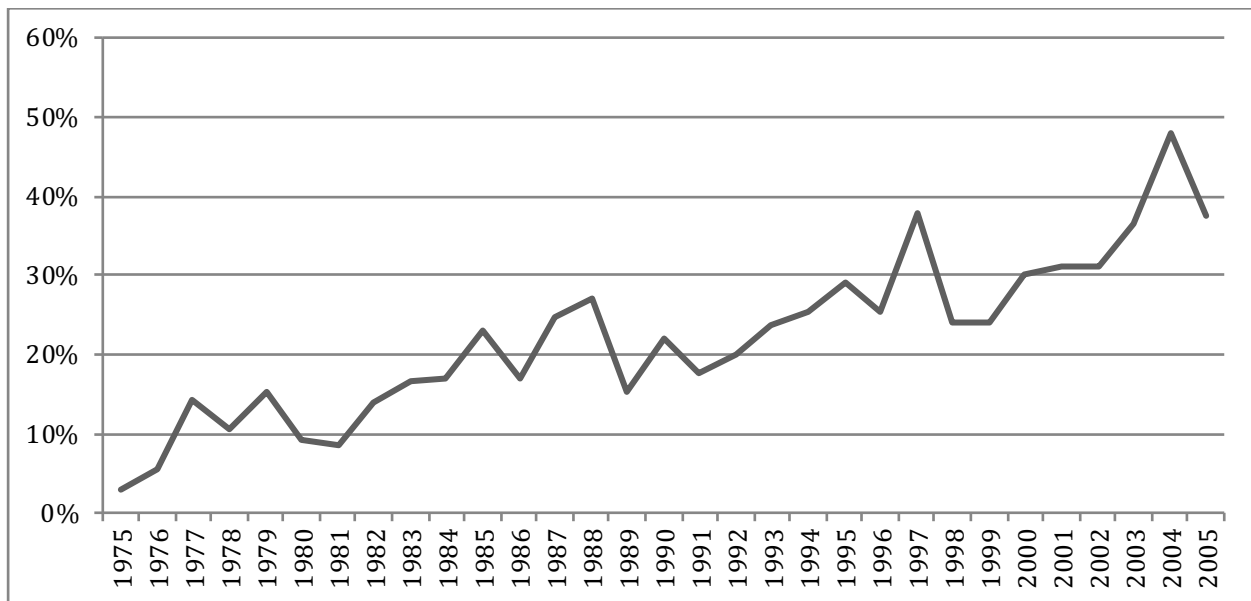


Figure 6

Top locations of Goodyear inventors (by application year, 1975-2005)

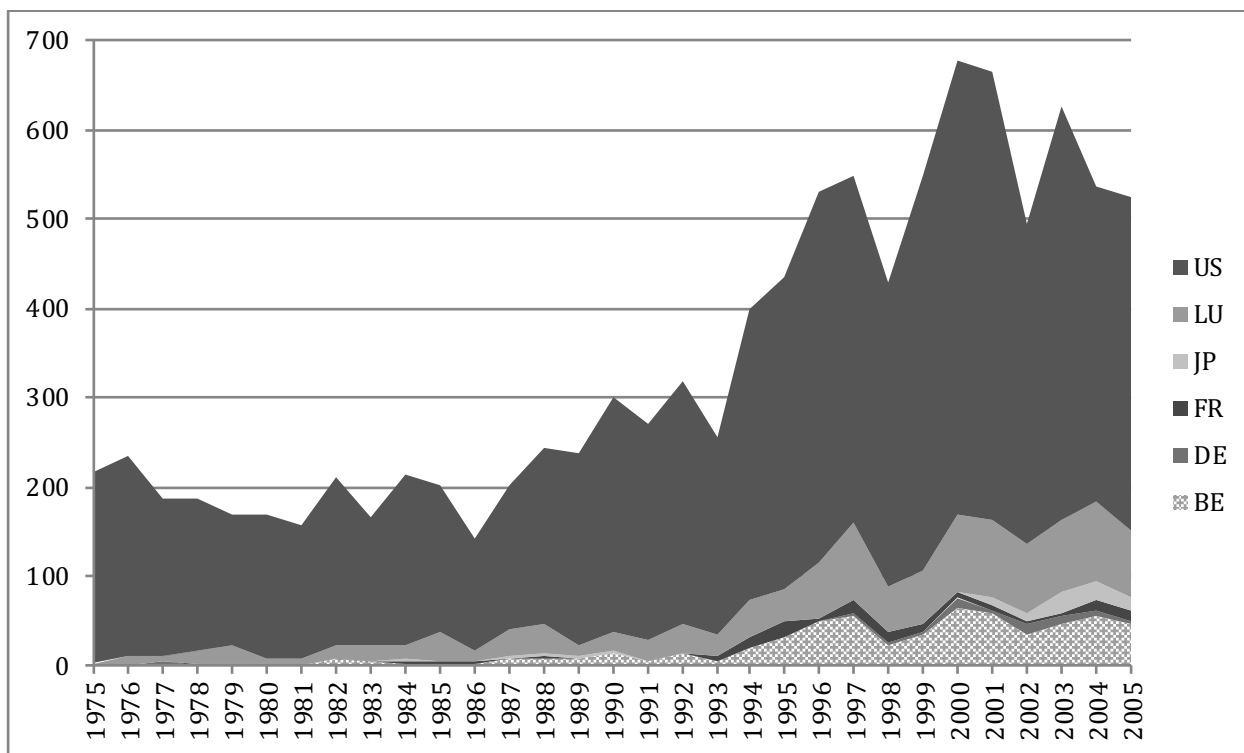


Figure 7

Location of Luxembourg-based inventors (application year, 1975-2005)



Figure 8
Goodyear patent production – Akron vs. Luxembourg innovation center (by application year, 1975-2005)

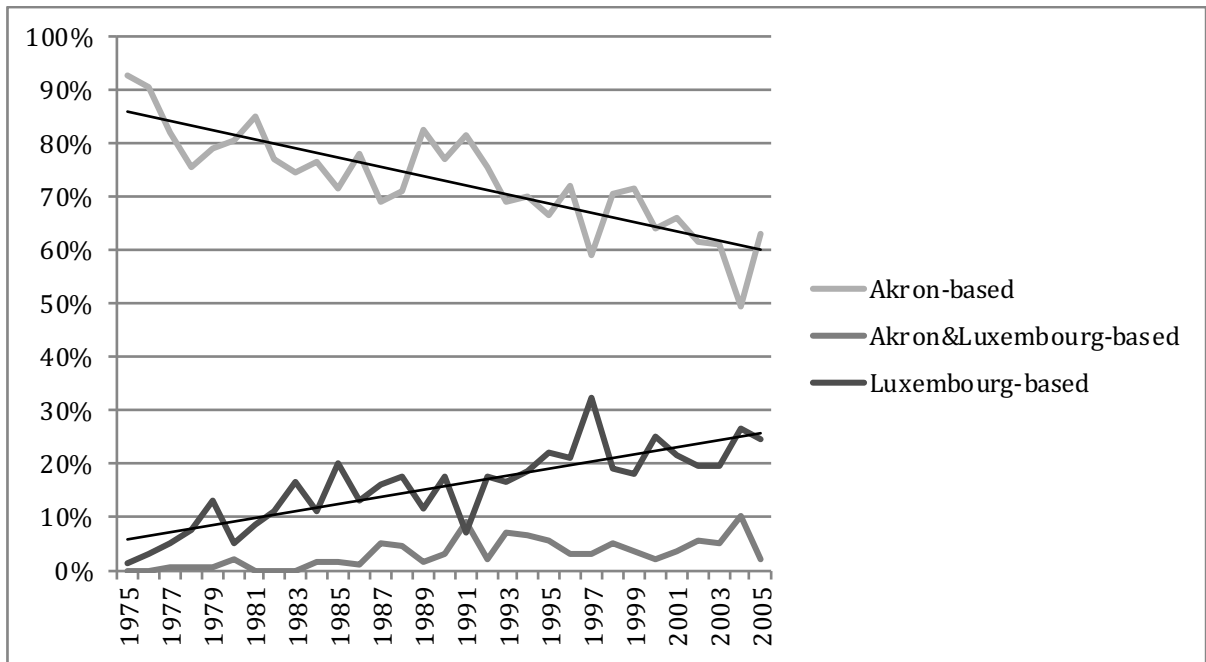


Figure 9
Main technological classes of Goodyear innovative activities – Akron vs. Luxembourg innovation centers (application year, 1975-2005)

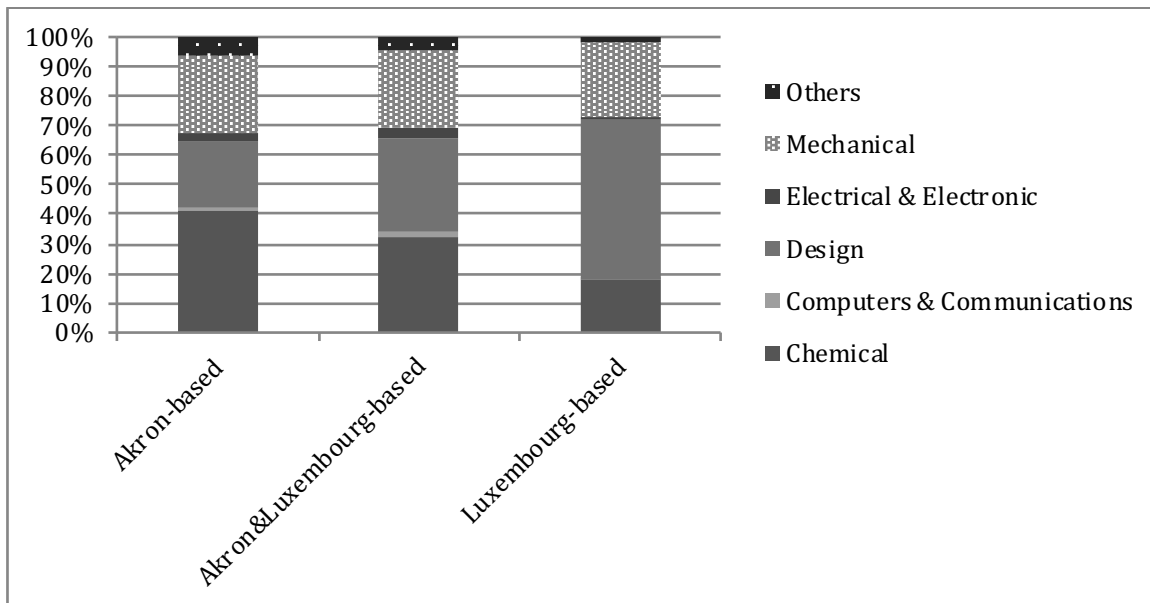


Figure 10

Main technological Classes of Goodyear Patents (by application year, 1975-2005)

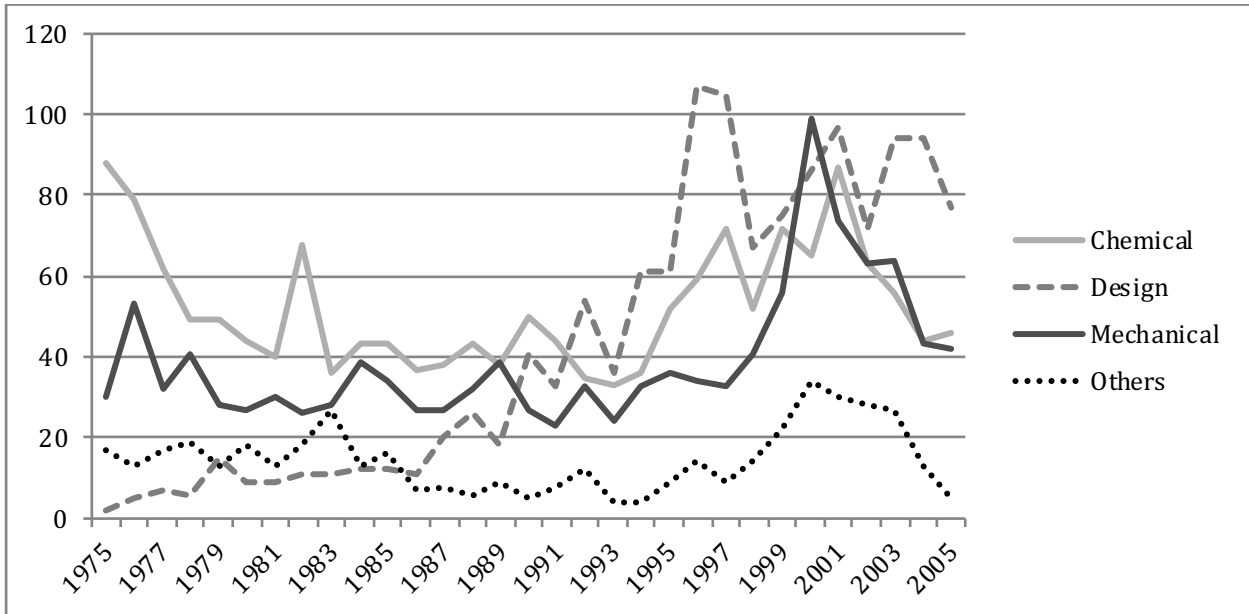


Figure 11

Cumulative number of Goodyear trademark filings (1975-2005)

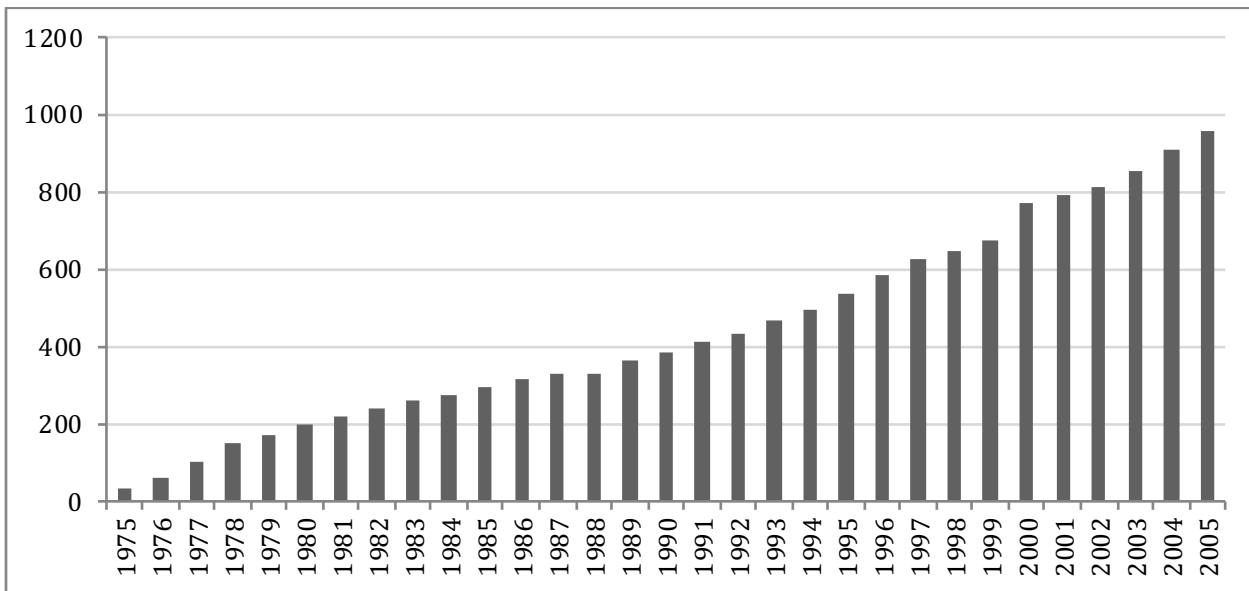


Figure 12

Distribution of Goodyear's trademarks by primary IC class (1975-2005)

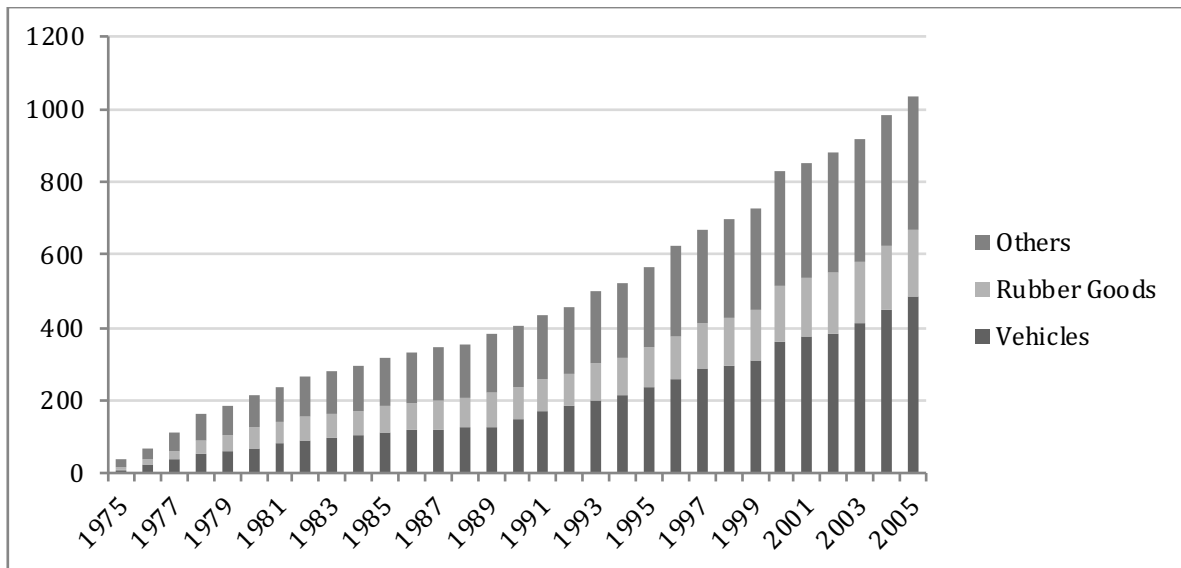
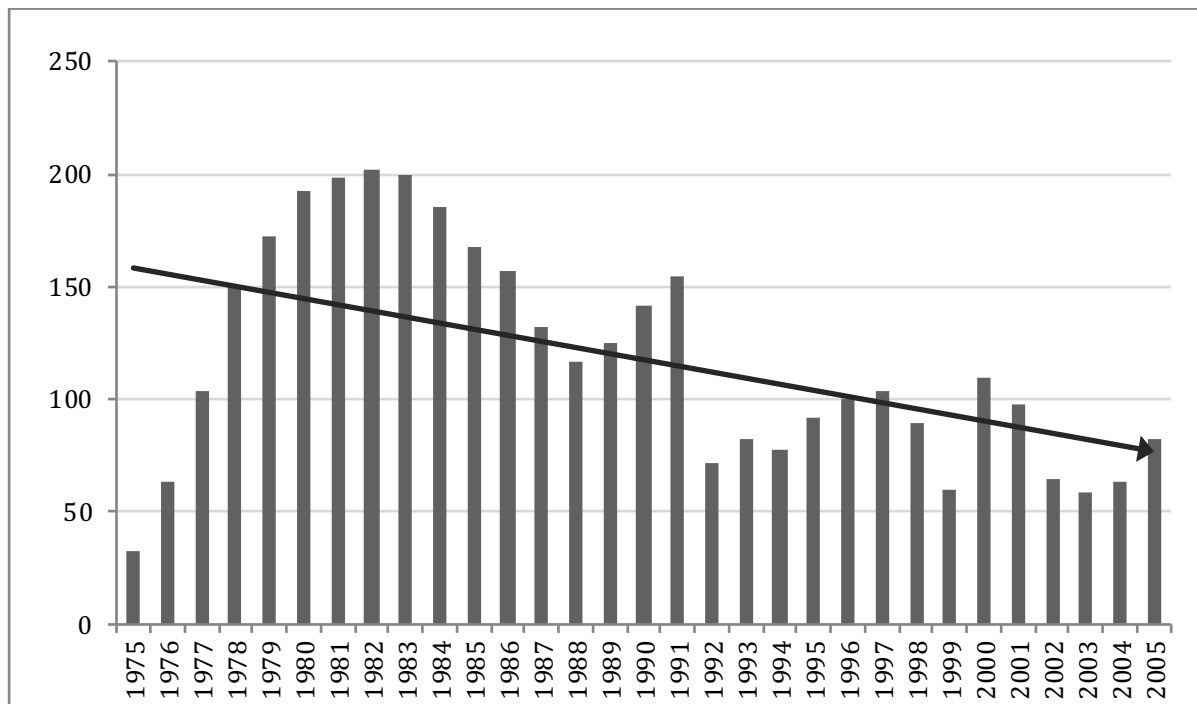


Figure 13
Stock of Goodyear's live trademarks (1975-2005)



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