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Firm technological responses to regulatory changes: A longitudinal study in the Le Mans Prototype racing

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ABSTRACT

Despite the critical role of regulations on competition and innovation, little is known about firm responses and related effects on performance under regulatory contingencies that are permissive or restrictive. By longitudinally investigating hybrid cars competing in the Le Mans Prototype racing (LMP1), we counter-intuitively suggest that permissive regulations increase technological uncertainty and thus decrease the firms' likelihood of shifting their technological trajectory, while restrictive regulations lead to the opposite outcome. Further, we suggest that permissive regulations favour firms that innovate their products by sequentially upgrading core and peripheral subsystems, while restrictive regulations (in the long term) favour firms upgrading them simultaneously. Implications for theory and practice are discussed.

1. Introduction

A traditional stream of research in management literature investigates how firms respond to environmental changes and competition by exploring different innovation opportunities (Andriopoulos and Lewis, 2009; Blind et al., 2017; Dosi, 1982; Gupta et al., 2006; March, 1991; O'Reilly and Tushman, 2007). Firms' responses are indeed critical in competitive settings, particularly when winning or losing is driven by technological innovation (Ansari and Krop, 2012; Jenkins, 2010; Marino et al., 2015; Rothaermel and Deeds, 2004).

One essential aspect for a firm's success in a competitive environment is striking the optimal degree of exploration to maximize performance (Posen and Levinthal, 2012). In technological arenas, a firm's exploration has been traditionally defined as the level of innovation—in products, technologies, solutions—that the firm advances beyond the knowledge baseline of its competitive setting (Benner and Tushman, 2002; Marino et al., 2015). Scholars have identified in many cases curvilinear returns from exploratory innovation, so that beyond an optimal point returns might plateau, or even turn negative (Gupta et al., 2006; Posen and Levinthal, 2012). Research highlights that this optimal point is a "moving target" that varies as environmental changes occur (Posen and Levinthal, 2012). Striking such a moving target by deploying the right amount (and type) of innovation to maximize performance is particularly difficult, particularly in dynamic contingencies (Bourgeois and Eisenhardt, 1988; Davis et al., 2009; Jansen et al., 2006). To overcome this challenge, it is thus necessary to fully understand the structure and nature of environmental shifts (McCarthy et al., 2010).

According to previous studies, environmental change can arise from a variety of different sources (Bourgeois and Eisenhardt, 1988; McCarthy et al., 2010) and may involve different dimensions, such as distinctive frequencies (Posen and Levinthal, 2012) or divergent magnitudes (Tushman and Anderson, 1986). Among other environmental changes, regulatory frameworks (Amable et al., 2016; Blind, 2012; Blind et al., 2017; Mahon and Murray, 1981; Porter and Van der Linde, 1995; Ramaswamy et al., 1994; Reger et al., 1992; Smith and Grimm, 1987; Teece, 1986) directly affect and concern several major industries such as automotive, transportations, farming, chemicals, banking, pharmaceutical and defence—among others—and have been extensively leveraged to preserve the environment (Jaffe and Palmer, 1997). Recent studies show that firms competing in regulated and technology-driven settings maximize their performance by engaging with moderate levels of exploration as regulatory changes turn radical (Marino et al., 2015). In these studies, however, regulatory changes are considered only by their change in magnitude, and not by the potential differences in the direction (i.e., the actual content) of the rule change (Mahon and Murray, 1981; Reger et al., 1992). In fact, from the regulators' perspective—which we adopt in our study—regulatory changes can have at least two main objectives, namely they could be more *restrictive* (i.e., by reducing and binding the agents' allowances and actions) or *permissive* (i.e., by increasing the agents' freedom, or in simple

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terms by 'deregulating' a specific domain of activity).

Research seems to agree that regulations—both whether permissive or restrictive—stimulate innovation at the firm level (Aggarwal, 2000; Blind et al., 2017; Hart and Ahuja, 1996), as organizations exploratory responses usually manage to find ways to work both 'within' or 'around' regulatory frameworks (Jenkins, 2014a; Porter and Van der Linde, 1995). It is however unclear whether restrictive regulatory enforcement in a specific domain (e.g., road cars gas emissions) might hold contrasting effects on competition compared to shift towards deregulation. For example, one could wonder whether such changes would favour firms that respond by deploying radical (e.g., electrical and hybrid vehicles) rather than incremental innovations (e.g., traditional combustion engine optimizations). In such contexts, the system complexity of the product architecture also plays an important role, (Banbury and Mitchell, 1995; Henderson and Clark, 1990; Simon, 1962; Zirpoli and Camuffo, 2009), but it is not clear whether firms might obtain an advantage in engaging with core (e.g., car engine) rather than peripheral subsystems (e.g., gearbox, hybrid systems) within the overall product architecture (Murmann and Frenken, 2006).

We claim that firms' compliance with increasing or decreasing limitations might differently affect organizational responses as well as the optimal type of innovation that maximizes performance. However, research still lacks an understanding of such phenomenon, particularly in a longitudinal perspective (Blind, 2012, p. 391). In this study, we thus investigate the following research question: *What are the firms' superior responses in terms of technological innovation when regulatory changes are characterized by different directions (i.e., restrictive vs. permissive)?*

If previous literature mentions the importance of studying the magnitude of environmental change —i.e., 'how large' the shock is—(Abernathy and Clark, 1985; Dosi, 1982; Tushman and Anderson, 1986) as well as the frequency—i.e., 'how often' new shifts happen—(Nadkarni and Narayanan, 2007; Posen and Levinthal, 2012), the direction of change—i.e., 'what kind' of variation—is rarely studied. More importantly, prior studies have already warned scholars about the importance of refraining from "lumping together" multiple dimensions of change (McCarthy et al., 2010, p. 610), but rather paying careful attention to the individual dynamics that each of them entails. In these regards, our investigation aims to provide a valuable contribution in understanding the fine-grained mechanisms involving regulations and firm exploratory innovation, as regulatory change is one of the key dimensions of environmental change both for theory (Bourgeois and Eisenhardt, 1988; Mercier, 2014a; McCarthy et al., 2010; Ramaswamy et al., 1994) and practice (Jenkins, 2014a; Stewart, 1993) across multiple disciplines and industries. Further, providing a response to our research question is not trivial, as—beyond the specific firm's innovation responses—several factors might influence the final outcome for organizations. Above other aspects, scholars warn to consider that the value of prior experience and knowledge (see among others Balconi, 2002; Cohen and Levinthal, 1990; Grant, 1996; King and Tucci, 2002; Zahra and George, 2002) as well as to its position within a particular technological trajectory (Dosi, 1982; Jenkins and Floyd, 2001), whose pace might be accelerated in hypercompetitive settings (D'Aveni, 1994; Hoisl et al., 2017; Volberda, 1996).

In this paper we classify firm's exploration strategies in terms of radical vs. incremental innovations that might be related to changes in a specific technological product (Henderson and Clark, 1990). To reach a more nuanced understanding we also identify whether the change affects a subsystem that is *core* or *peripheral* to the overall product architecture (Murmann and Frenken, 2006, p. 940). Such innovations will be analysed in a setting where regulatory releases vary in terms of magnitude (i.e., *radical* vs. *incremental*), but also direction (i.e., *permissive vs. restrictive*), while frequency of regulation release is kept constant (i.e., once a year), and predictability is equal for all rivals (i.e., all firms learn about the new rule change around two years before their enforcement). In doing so, we want to specifically isolate the role played by the direction of change, due to its relevance for firms operating in settings where regulations may influence the nature of competitive dynamics (Blind et al., 2017; Ramaswamy et al., 1994; Stewart, 2010). Finally, given the hypercompetitive nature of our setting (D'Aveni, 1994; Hoisl et al., 2017), we take into account the role of firms' prior technological knowledge, and thus control for the influence prior experience (King and Tucci, 2002), which we specifically classify as *general knowledge* or *specialised knowledge* (Balconi, 2002; Grant, 1996; Hamel, 1991)—depending on its proximity to the actual field of application. Embracing a longitudinal view in regulatory settings (as recommended by Blind, 2012) also allows us to carefully reflect on the value of prior technological assets (Dierickx and Cool, 1989) within specific technological trajectories (Dosi, 1982; Jenkins and Floyd, 2001).

By following rigorous protocols of qualitative analysis, we develop a comparative, multiple case study (Eisenhardt, 1989a; Yin, 2008) on the technological innovation strategies adopted by car constructors participating the Le Mans Prototype 1 (LMP1) racing series—which is part of the FIA World Endurance Championship (WEC) —in response to regulatory changes throughout the period 2012-15. Since 1923 and the first race of the iconic '24 Hours of Le Mans', endurance racing has become one of the leading and most technologically advanced motorsport events, and we identify and discuss several reasons that make LMP1 an ideal setting to respond to our research question. Among others, in year 2012 the FIA-ACO governing body introduced hybrid power units[1] for the first time in WEC history. A careful investigation of car blueprints, technical commentaries and official regulation bulletins, together with in-depth interviews with experts, revealed that in the following four years all four possible combination of *incremental vs. radical* and *restrictive vs. permissive* changes were introduced—a unique occurrence, which makes this setting almost an ideal natural experiment for our study, and gives us the opportunity to pioneer the very first management study based on data from the iconic Le Mans Prototype racing. We track a precise and nuanced account of the firms' competing technologies and race result; we identify not only the specific configurations associated with superior performance vis-à-vis different regulatory conditions, but also explanations of the conditions and mechanisms underpinning such outcomes.

After reviewing the theory that informed our study, we will present our empirical setting, our research methods, and findings. Finally, we will identify and discuss a set of propositions representing the contributions for present and future research, and depict two overarching models. Limitations of the study and implications for theory and practice will be also addressed in the concluding section.

2. Theoretical background

2.1. Technological innovation as firm response to environmental change

Organizational adaptation to changing environments and the firm's responses—for example via exploration and exploitation (March, 1991)—are traditional topics in studies investigating the role of innovation (Benner and Tushman, 2002, 2003; He and Wong, 2004; Jansen et al., 2006). According to Benner and Tushman (2002, p. 679) "exploitative innovations involve improvements in existing components and build on the existing technological trajectory, whereas exploratory innovation involves a shift to a different technological trajectory."[2] In

[1] Hybrid systems allow an energy saving by powering a car with two different sources of energy: fuel and electricity. In the FIA-WEC, the electricity can be produced via the recovery of the kinetic energy created by braking or the heat produced by exhaust gases. See our "Appendix" for an illustration of the Hybrid System used by Porsche in 2014.

[2] By joining studies envisioning exploration and exploitation as orthogonal, independent forces (Gupta et al., 2006: 697) this paper follows recent studies (Marino et al., 2015) in assessing the net value of exploration on performance by specifically investigating an empirical setting where exploitation plays a negligible role on performance.

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