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ORIGINAL PAPER

Innovating for Good in Opportunistic Contexts: The Case for Firms' Environmental Divergence

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Abstract

Opportunistic behaviors are considered ethically and strategically troublesome since they disrupt otherwise mutually beneficial relationships. Previous literature has shown that firms attempt to protect their investments from opportunism by generating a large amount of patented marginal innovations in domains central to their industry. However, this approach may generate some ethical dilemmas by preventing firms and societies from more radical, collaborative, and much-needed environmental progress. We extend the environmental innovation literature using strategic and ethical lenses to analyze the potential of an alternative, divergent way to provide financial opportunities for a focal firm without aiming to prevent innovative opportunities for competitors. Our longitudinal analysis of 6768 environmental patents from 59 large companies worldwide in the electrical components and equipment industry shows that high levels of innovation intensity, environmental scope, bargaining power, and environmental expertise increase the incidence of patented environmental innovations related to domains in which industry competitors are less focused (i.e., technological divergence). We also show a positive relationship between this divergence and market-based firm performance. Our results suggest that pursuing innovative divergence to avoid opportunism may make ethical *and* market sense and we also identify the organizational factors that can support these efforts.

Keywords Organizations and natural environment · Environmental innovations · Opportunism · Divergence

Introduction

Environmental innovations, defined as the development of green products and processes that modify an existing designs to reduce any negative impact on the environment (e.g., Cheng 2020; Huang and Li 2017; Wijethilake et al. 2018), have attracted growing attention from both scholarly and practitioner communities. This increased attention is mirrored by empirical measures, including the number of environmental patents worldwide increasing nearly threefold in the last two decades (OECD 2019). While much of the management literature has focused on how such innovations are useful for firms in avoiding competitive threats and driving positive financial results (e.g., Berrone et al. 2013; Wen and Zhu 2019), some scholars have begun to highlight the relevance of balancing these competitive aims with the ethical aspirations of generating social wealth through such innovations (e.g., Enderle 2009; Mishra 2017). We shed new light on this balancing effort using strategic and ethical lenses to better understand firms' environmental patenting activities. Specifically, we develop hypotheses predicting when firms will develop environmental innovations outside of the central technological domains of their industry, and the performance implications of such efforts. Ultimately, our findings show how looking beyond the central technological domains of a firm's industry for environmental innovations may make these competitive and ethical interests more compatible.

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The extant literature on patenting has found that firms often react to competitors' threats by accumulating marginal patents (i.e., patents of little standalone value) in the central technological domains in their industry, thereby creating legal barriers to block other firms' developments (e.g., Steensma et al. 2015; Ziedonis 2004). Firms then reinforce these barriers with aggressive strategies of patent lawsuits (Somaya 2012) or using large stocks of patent-related innovations as leverage in formal exchanges with competitors (Comino et al. 2019; Hall and Ziedonis 2001). As effective as these tactics may be, however, they also present ethical dilemmas because although it may protect a firm's current position in their industry, it does so at the possible expense of pursuing environmental innovations in more far-flung technological domains. In this regard, a focus on defensive, marginal environmental innovation implies ethical concerns since "business ethics should not be limited to the creation of private wealth" (Enderle 2009, p. 291) and meaningful environmental progress often requires innovations outside of the central technological domains of an industry (UN 2016).

Building on Park's (2007) delimitation of strategic divergence, we capture a firm's innovative divergence by its generation of patents in technological domains in which competitors in the industry have few or no patents. Such innovative divergence poses several intriguing theoretical questions (including those we endeavor to address here), but it also has very real strategic and ethical ramifications in situations where "doing more of the same, but slightly better" is not a viable option. For example, the United Nations (UN) has called for major innovations to help avoid exceeding a 2 °C threshold for global temperature increase by end of the century and recognized that focusing only on incremental progress in current technologies will result in an increase of more than 4° (UN 2016). This call for major environmental innovations implies an ethical commitment to innovate not only for the good of the firm, but also in service of meeting "the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987, p. 8).

Much of this needed environmental progress will likely require advances outside of the current central technological domains of a given industry (e.g., there is no path to carbon–neutral mobility through further improving gasoline engines), yet the literature offers limited guidance on how firms can develop divergent environmental innovations while also protecting themselves from opportunistic competitors (Berrone et al. 2013). As a result of this need (both theoretical and practical) to understand divergence in the context of environmental innovation, we analyze how firms can facilitate this type of innovative activity and then we test the resulting effect of this divergence on firm performance. In doing so, we shed light on the basic, yet critical, question of whether the type of divergent, pioneering innovation needed to make significant environmental progress is at odds with the financial performance of the very firms tasked with developing such innovations?

By addressing this research question, we endeavor to make three interrelated contributions to previous research. First, we extend the ethics perspective on environmental innovations (e.g., Huang and Li 2017; Mishra 2017; Wijethilake et al. 2018) by investigating tensions between protecting from opportunistic competitors and pursing pioneering environmental innovations. Second, we extend the traditional corporate environmental literature on innovation (e.g., Cheng 2020; Huang and Li 2017) by analyzing how firms working in different technological domains than their peers in the industry may simultaneously improve their financial performance and make a positive difference in the environment. Third, our study responds to the calls for analyzing divergence (or lack thereof) in the specific context of environmental innovations (Berrone et al. 2013; Starik 2013).

The rest of this study unfolds as follows. First, we delimitate the theoretical background that motivates our analysis. We then develop hypotheses that explain the organizational features that promote divergence in a firms' portfolio of environmental innovations and the performance implication of such divergence. Following our development of these hypotheses, we describe our longitudinal dataset of 6768 environmental patents and the methods we use in its analysis. After reporting the results, we then discuss the findings and the study's implications for theory and practice.

Theoretical Background

Portfolio of a Firm's Innovations

A firm's patent portfolio is crucial for developing innovative products or processes; however, companies do not only consider their own patents since releasing an innovation usually requires formal agreements with other firms due to the highly complex nature of innovations (Hall and Ziedonis 2001). Although the literature offers multiple definitions of innovation, it often focuses on the technological outcome related to a firm's generation of value-added novelty for its products or processes (Crossan and Apaydin 2010). We are well past the time when a single company owned all the innovations embedded in its final product (Ziedonis 2004). However, some firms may behave opportunistically by appropriating part of the value generated by a focal firm or using all of this firm's efforts for its own benefit (Acquier et al. 2017; Chen et al. 2016; Joshi and Nerkar 2011). As such, "appropriability problems have always been an issue of central concern in the economics of innovation" (Pisano 1990, p. 154). The business ethics literature has also highlighted that appropriability issues could lead to the underdevelopment of an otherwise promising technology, which results in a "decline in social welfare" (Huang et al. 2013, p. 102) and a behavioral threat that companies tend to avoid (e.g., Acquier et al. 2017).

Multiple studies have shown that sharing and exchanging innovations may foster competitors' threat of value appropriation. Acquier et al.'s (2017) analysis of global value chains shows that individual firms are reticent to create innovations when these may result in a disproportionate distribution of profit and investment across other value chain members. The analyses of Joshi and Nerkar (2011) and Vakili (2016) on patent pools show that both pool members and outsiders may avoid investing in a given technology because of the expectation that their counterparts may behave opportunistically and appropriate improvements. Bosse and Alvarez's (2010) analysis of alliances between small and large firms and Ariño et al.'s (2008) study of alliances between small firms also show that sharing technology may foster opportunistic behavior. Likewise, Fosfuri's (2006) analysis shows that large multinational chemical firms are reticent to license out their know-how if it spurs competition.

Given this hazard of opportunistic behavior, empirical studies have analyzed the strategies employed by firms to address this difficulty in value appropriation, highlighting the frequent use of innovative convergence as an approach to limiting value dissipation (Steensma et al. 2015). For example, Grindley and Teece's (1997) case study of electronics and semiconductor companies and Ziedonis's (2004) study of US semiconductor firms both show that certain firms patent more aggressively in the central technical domains of their industry, seeking to avoid potential delays and losses caused by competitors. These "protecting" strategies are a double-edged sword, as they can also be used to appropriate competitors' value creation (i.e., they can be sued both defensibly and offensively). In this regard, Blind et al.'s (2009) study of German companies shows that firms patent to block other organizations and to negotiate with competitors on a more favorable basis. Similarly, Steensma et al.'s (2015) analysis of US patents from 2001 to 2006 shows that firms generate extensive patent portfolios with the purpose of blocking competitors' commercialization of technologies.

Firms also face a steep financial price as conflicts with competitors regarding innovative developments increase (Comino et al. 2019). For example, Ziedonis (2004) notes that US firms spend approximately one-third of their total basic R&D budget on patent lawsuits. Additionally, the time needed to resolve a patent case increased from less than 1 year in 2002 to almost 3 years in 2017 (Price Waterhouse Coopers 2018), and the annual litigation cost for large companies has grown at a double-digit rate, from \$1.7 billion in 2005 to \$3.3 billion in 2019 (Morrison Foerster 2019). Whatever the net financial result may be for defending the firm (or attacking competitors) using large packages of patented innovations, it seems clear that this strategy comes at the cost of the underdevelopment (or at least, the slower development) of the converging innovation.

While the innovation literature has paid substantial attention to the explorative vs. exploitative (March 1991) nature of a firm's innovations (e.g., He and Wong 2004; Jansen et al. 2006) and the local vs. global relation within the neighborhood of a firm's current expertise (e.g., Diestre and Rajagopalan 2011), it has paid less attention to innovative divergence. Innovative divergence involves entering less central technological domains in the industry and is substantially different from other related terms employed in studies of innovation. Park (2007) treats strategic convergence–divergence as the extent to which a focal firm draws closer to or further away from a competitor. We will analyze innovative divergence in the environmental arena.

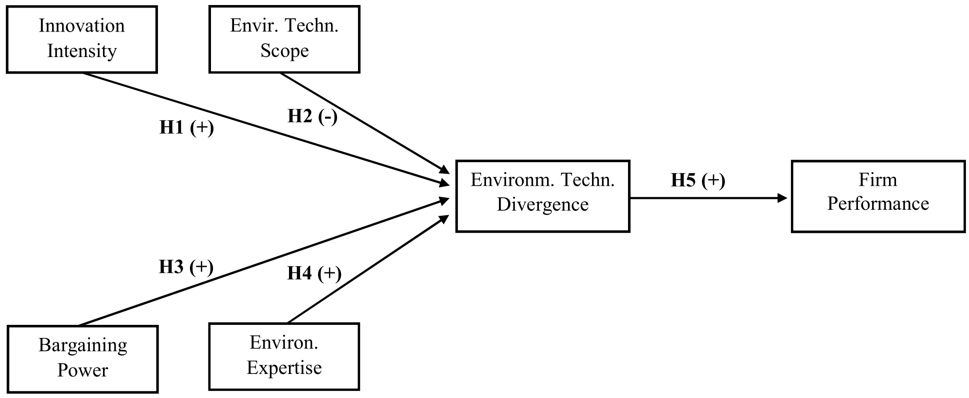
Environmental Innovations

In the case of environmental innovations, faster and more profound development needs to go beyond the sole focus of firms' interests, as such innovations are critical for achieving a global sustainable society (Wartzman and Tang 2019; United Nations 2020). The term 'environmental innovation' is strongly integrated with the general idea of innovation but with the additional requirement that environmental innovation generates a lower environmental impact than existing products and processes, even when a firm's intention to reduce its environmental impact might not necessarily be ecological in nature (Aragon-Correa and Leyva-de la Hiz 2016; Chang 2011; Vazquez-Brust et al. 2010).

In short, environmental innovations include the development of green products and processes to reduce negative impacts on the environment (e.g., Cheng 2020; Huang and Li 2017; Wijethilake et al. 2018). For example, in Woodhouse and Breyman's (2005) study of Green Chemistry they highlight both product innovations such as antifouling paint for ships that does not bioaccumulate in marine organisms and process innovations such as a new method of manufacturing the painkiller ibuprofen that lowered the amount of waste from 60% of the initial raw materials to 1%. Thus, if firms want to accomplish the goals embedded in the ethical dimension of their mission (as frequently publicized in their corporate reports) of facilitating movement toward a greener society, they should consider developing pioneering, as opposed to merely incremental, environmental innovations. This particular orientation brings about at least four relevant differences between general and environmental innovations in firms.

First, while environmental innovation may help a firm reduce or eliminate the burden of their production processes or their final products on the natural environment,

Fig. 1 Empirical model



related research and development is often costly and has uncertain financial returns (e.g., Leyva-de la Hiz 2019; Wijethilake et al. 2018). Environmental innovations require greater financial commitment than regular management practices and, compared with general innovations, usually accrue returns in the long-term (e.g., Aragón-Correa and Rubio-Lopez 2007; Eiadat et al. 2008; Hart and Dowell 2010). This additional financial risk creates conflict and ambiguity for organizations in their approaches to managing environmental innovation strategy (Wijethilake et al. 2018).

Second, environmental innovations have important externalities because they can lead to a cleaner and safer world, whereas general innovations do not necessarily have these positive externalities (Berrone et al. 2013; Montiel and Delgado-Ceballos, 2014). While general innovations tend to be focused on the internal efficiency or improved effectiveness of products and processes in a firm, environmental innovations must balance internal return on investment with positive external implications (Chang 2011; Vazquez-Brust et al. 2010).

Third, environmental innovations often carry positive implications for a firm's legitimacy (e.g., Berrone et al. 2017; Darnall et al. 2018; Chen 2008). Companies have greater incentives to generate environmental innovations when the legal and general institutional frameworks are stronger (Aragon-Correa et al. 2020).

Fourth, and finally, environmental innovations provide ample opportunities for improvements across a heterogeneous set of industries. Such innovation deals with environmental issues related to energy savings, water consumption, raw materials, pollution prevention, waste recycling, and eco-design, among others (Huang and Li 2017). Hence, environmental innovations are particularly demanding on effective communication, collaboration, and coordination among people from different backgrounds and functional areas (e.g., Cheng 2020; Huang and Li 2017).

Hypotheses

We analyze the circumstances under which innovative environmental divergence may allow firms to protect their investments and reduce the opportunistic behavior of competitors, all while developing the type of pioneering environmental innovations needed to fulfill their ethical obligations toward creating a more sustainable economy. Figure 1 shows a visual summary of our proposed relationships in this manuscript.

A firm's investment in such divergent environmental innovations may be an ethical way for it to generate more radical innovations for society and simultaneously avoid the risks of competitors' value appropriation. However, the opportunity to develop this approach may depend on the existence of particular features of a focal firm. Hence, we analyze a number of organizational attributes that may encourage a firm to try to avoid competitors' threats by directing its efforts toward divergent environmental innovations in its industry. More specifically, we analyze how the levels of a firm's innovation intensity, environmental technological scope, bargaining power, and environmental expertise influence their development of a divergent environmental innovation strategy.

Firm's Innovation Intensity and Environmental Divergence

The intensity of a firm's technological innovations refers to the level of resources that it dedicates to improving its innovativeness (Ziedonis 2004). A firm's greater resource commitment to innovations also increases the risks of competitors' opportunistic behavior to gain value from the focal firm's innovative efforts (e.g., Somaya 2012; Steensma et al. 2015). Hence, the intensity of a firm's technological innovation not only provides more opportunities to create new products and processes but also increases the risks of a cost-raising cycle to protect the viability of previous investments against the threat of rivals' entry (Pan et al. 2019).

Several scholars have suggested that firms protect themselves from competitors' threat of value appropriation by exponentially increasing the number of patents they hold related to the common technology (Hall and Ziedonis 2001; Hegde et al. 2009). However, this focus on such central technologies compels an innovation-intensive company to seek technology sharing agreements with a large variety of competitors due to its visibility and interaction with multiple firms. For instance, although Microsoft is a leading company, holding many patents in the central technological domains of its industry, the firm still paid $1 billion in royalties for access to other firms' technologies while earning only $100 million for allowing access to its own technologies (Ricadela 2006). Hence, a firm's innovation intensity focused on its industry's central technological domains may reduce the risks of opportunism but not guarantee net value appropriation. In contrast to this pattern in innovation more generally, a high intensity of innovative commitment may play out differently in the environmental arena.

Environmental innovations are quite heterogeneous and include multiple foci and technologies of potential interest (e.g., Cheng 2020; Huang and Li 2017). Exploring these options requires intensive resource deployment because of the emergent nature of the environmental arena and the quick evolution of related technologies and regulations (e.g., Berrone and Gomez-Mejia 2009). The intensity of a firm's technological innovation provides good opportunities to use those resources in technological domains. For instance, Toyota's commitment to divergent innovation provided the firm with resources to file multiple environmental patents related to hybrid vehicle technologies at a time when that domain was almost unexplored in the automotive industry (which was focused on traditional gasoline-powered engines); it was an enormous investment to explore the viability of those innovations in the industry, but this divergence from the domains typical for the automotive industry has allowed the firm to become an international leader in sustainability while largely avoiding value appropriation of these innovations by competitors.

Although a firm's innovation intensity might (or might not) provide opportunities for diverging through general innovations, divergence in environmental innovation is particularly attractive for firms that devote a high level of resources to innovation. This is both due to the technological heterogeneity of the environmental arena, and the additional utility of avoiding competitors when investment time frames are long and value appropriation is uncertain. Consequently, organizations that devote more resources to innovation may reduce the threat of competitors' value appropriation by investing in environmental technologies outside of the central technological domains of their industry. Hence, we propose the following:

Hypothesis 1: The intensity of a firm's innovations is positively related to the extent of its divergence from established industry domains in its patented environmental innovations.

Firms' Environmental Scope and Environmental Divergence

In contrast to the intensity of innovation, the scope of a firm's innovations refers to the number of different technological domains in which they participate (Lerner 1994; Steensma et al. 2015). For instance, environmental innovations aimed at reducing packaging materials and their associated waste have a broad scope because they can be applied to a wide variety of technological domains. In contrast, environmental innovations on algae-derived biodiesel represent a narrow domain because they mainly apply to only the technological domain of energy generation (Preiss and Kowalski 2010). A number of scholars (e.g., de Figueiredo and Silverman 2007; Menon and Yao 2013) have highlighted the relationship between innovation scope and "repositioning costs", which represent the effort and difficulties faced by companies willing to change their strategy. Thus, a broader environmental technological scope can help companies reduce these repositioning costs. In contrast, companies that pursue environmental innovations with a more narrow scope are more exposed to competitors' threats such as value appropriation because these companies find it difficult and costly to reposition themselves toward new applications and opportunities.

Whereas environmental innovations usually imply more diversity than nonenvironmental ones (Cheng 2020; Huang and Li 2017), navigating toward environmental innovations provides strategic opportunities for either a broader or narrower scope (Shrivastava 1995). In this regard, Wen and Zhu (2019, p. 1341) state that *domain-specific* knowledge "could heighten exit barriers and render repositioning too costly." Accordingly, we expect that companies pursuing a narrow scope of environmental innovation will tend to focus on domains with less risk of competitors' threats, i.e., those that are divergent from the central domains of their industry.

Combing these observations, we propose that firms whose environmental innovations are narrower in scope will tend to participate in divergent technological domains in an effort to avoid potential opportunistic behavior, while firms whose environmental innovations are broader in scope may be better suited to focus on the central technologies domains in their industries. Thus, we propose the following:

Hypothesis 2: The breadth of scope of a firm's environmental innovations is negatively related to the extent of its divergence from established industry domains in its patented environmental innovations.

Firms' Bargaining Power and Environmental Divergence

Bargaining power can be defined as the "resources controlled by one party and demanded by the other [as well as] the ability to withhold resources that the other party wants" (Stevens et al. 2016, p. 946). Whereas it may be generally true that a firm's bargaining power reduces its competitors' ability to appropriate value, we propose that such high bargaining power will be even more advantageous in the context of divergent environmental innovation. Three mechanisms explain how a firm's bargaining power provides better opportunities in such divergent domains.

First, a focal firm's investments in divergent environmental technologies may not spur competitors' responses because these technologies are not considered as valuable as convergent technologies focused on the central technological domains of the industry (Gambardella and Giarratana 2013). For instance, when Tesla announced its first environmental patents related to electric car technology, it did not generate the same level of aggressive reaction from direct competitors that might have been generated by an announcement of environmental innovations in the domain of gasoline-powered engines. Additionally, it provided a good opportunity to use its reputation and bargaining power with firms in the battery industry. By making progress in domains outside the most central technological domains of the automotive industry, Tesla was able to safeguard its own innovations against competitors and take advantage of its bargaining power in less sensitive domain.

Second, striking deals with many competitors—often a requirement when developing environmental innovations in convergent domains in a given industry—may reduce the benefits of bargaining power because the total negotiation costs are very high, hence eroding the value created by the focal firm. For instance, Grindley and Teece (1997) note that the process of reaching a bilateral cross-licensing agreement may take a year because each firm has to evaluate the quality of the other's patents. Furthermore, this process could be much longer when a focal firm has to negotiate a multilateral deal with many stakeholders, as is common in complex environmental innovations. Although high bargaining power can allow a firm to appropriate more value from a competitor than vice-a-versa (i.e., positive net value appropriation), the fact that the focal firm has to negotiate with a large number of competitors increases the risks of lawsuits, delays in commercialization, or opportunity costs (e.g., Somaya 2012; Steensma et al. 2015).

Third, firms with more bargaining power may better preserve their future influence in the industry if they can avoid unintended knowledge spillovers, and enjoy more opportunities than competitors to enter emergent domains. With many firms in the industry developing new products around very similar technologies, know-how spillovers may reduce value appropriation due to the high number of parties involved in such technologies (Somaya 2012; Spencer 2003).

Even though possessing high bargaining power may reduce threats of opportunism by competitors, a focal firm still needs to exchange value with its competitors if they are innovating in the same technological domains (Joshi and Nerkar 2011; Vakili 2016). The high number of different actors in environmental innovations makes convergence particularly tricky for firms with high bargaining power. Therefore, companies with high bargaining power may seek to stake out territory in divergent technological domains when pursuing environmental innovation. Consequently, we propose the following:

Hypothesis 3: A firm's bargaining power is positively related to the extent of its divergence from established industry domains in its patented environmental innovations.

Firms' Environmental Expertise and Divergence

Companies' expertise brings about distinctive, specific, professional knowledge that can lead a firm into certain domains of activity (Ahuja and Lampert 2001; Peters et al. 2019). Expert organizations may benefit from faster learning and a higher absorptive capacity in multiple technological domains (Cohen and Levinthal 1990). We propose that environmental innovation expertise will be more valuable when companies technologically diverge from their competitors.

Because environmental expertise necessarily involves cross-disciplinary knowledge, it provides opportunities for developing innovations in multiple domains as an alternative to focusing on a narrow and popular domain. In general, environmental expertise may "act as a major source of change" across multiple departments, businesses, and products (Petruzzelli et al. 2011, p. 295). For instance, Corning's expertise in manufacturing durable, lighter, and energy-efficient glass has not only placed it as a world leader in the electronics industry with its "Gorilla Glass" products, but this know-how has allowed it to develop other solutions for a variety of industries, such as solar energy, pharmaceuticals, and aerospace.

From a capabilities perspective, the advanced environmental perspective is positively linked to the emergence of general organizational capabilities that a firm may use in multiple fields (Aragon-Correa and Leyva-de la Hiz 2016). This "virtuous cycle" of environmental innovative expertise and general competences (Ahuja and Lampert

2001; Martinez-del-Rio et al. 2015) enables organizations to develop a greater knowledge base, which may confer a relative advantage over other firms when dealing with multiple domains. Since expertise in the environmental arena helps develop capabilities that can be applied to a variety of domains (Martinez-del-Rio et al. 2015; Montiel et al. 2020), companies can take advantage of this expertise to pursue opportunities in more divergent domains. In contrast, environmental expertise may be less valuable when it is applied in a convergent manner, as competitors already have a well-established knowledge base in the central technological domains of a given industry.

Finally, in regard to environmental innovations, companies need to carefully select their partners (e.g., suppliers) to guarantee that the product they are offering complies with high social and ethical standards throughout the whole value chain (Acquier et al. 2017). In this sense, environmental expertise reduces not only the effort and investment related to the qualification of suppliers in general (Song and Di Benedetto 2008), but also the risk of choosing a supplier with poor ethical practices when entering a divergent technological domain.

Thus, we propose that greater environmental expertise encourages a firm's managers to generate value by pursuing innovative divergence. This is due to such expertise being comparatively less relevant when a firm's innovations are converging because a firm could opportunistically use competitors' expertise. Consequently, we propose the following:

Hypothesis 4: A firm's environmental expertise is positively related to the extent of its divergence from established industry domains in its patented environmental innovations.

Environmental Divergence and Firm Performance

Patenting in an industry's central technological domains (i.e., convergence) has been suggested as a useful approach to maintain financial performance and block opportunistic competitors' innovations (e.g., Ziedonis 2004). However, we propose that firms may find greater financial opportunities in pursuing divergent innovation in the environmental arena. We also suggest that this competitive potential can be augmented with the potential to generate more innovative value for society. Specifically, when firms diverge, they may not only reduce the disadvantages associated with crowded technological domains (e.g., litigation costs, delays in product development, and opportunity costs) but also create market leadership (Spencer 2003), extract temporary monopoly rents (Acquier et al. 2017; Somaya 2012), and provide more socioenvironmental value for innovative developments instead of blocking others' approaches (Mishra 2017).

Being the industry pioneer in a given environmental technology allows an organization to enjoy a reinforced corporate image that provides a temporary monopoly, capturing all of the market share while increasing its learning, thus making it difficult for new incumbents to compete. Legitimation from environmental innovations (e.g., Berrone et al. 2013, 2017) makes it easier for a firm to obtain funding for future projects while also becoming a reference point for environmentally conscious customers.

Therefore, environmental innovators may secure a large market share and offset the entry of new competitors through the creation of consumer loyalty that may entail consumer switching costs (Darnall et al. 2018; Elijido-Ten and Clarkson 2017). Customer switching costs and learning related to divergent environmental innovations are also a way to maintain the first-mover advantages of technological divergence by limiting imitability (Hegde et al. 2009; Somaya 2012). In the environmental arena, firms' divergent innovations may both generate socioenvironmental progress and enhance their financial performance. For instance, ABB diverged from the manufacturing of electrical lighting toward the transmission of electricity, specifically looking for connecting green electricity sources. This early move placed ABB as one of the world leaders of electric grid technologies and provided the firm with the unique opportunity to develop the first high-voltage grid in the Beijing area that includes the integration of remote wind, solar, and hydro energy (ABB 2018). Even if, in the long run, competitors develop relevant environmental patents in a firm's technological domain, the investments initially made by the firm can help maintain leadership in terms of reputation and market share (Spencer 2003), reduce production costs, and increase the speed of creating new related products, mainly due to early learning (Cohen and Levinthal 1990). This investment in divergent innovation also may place the firm in a privileged position for bargaining further cross-license agreements.

A company that is an early entrant into certain technological domains may issue patents to build a central "fence" against current and potential competitors (e.g., Blind et al. 2009; Lin 2011). Since the environmental arena provides more opportunities for creative and multidisciplinary innovations than most of the other arenas (Cheng 2020; Huang and Li 2017), a firm entering early into one of these environmental domains may obtain the competitive benefits of a monopoly while generating value for society. Competitors may try to invent around such a fence, but the pioneering firm still keeps a privileged situation when it holds key patents (Ziedonis 2004). Consequently, our hypothesis regarding the relationship between environmental divergence and financial performance states the following:

Hypothesis 5: A firm's divergence from established industry domains in its patented environmental innovations is positively related to its financial performance.

Method

Sampling and Data Collection

Previous empirical research has encouraged the use of patents because of the rich data available, their comparability, and their suitability for longitudinal analysis (Mishra 2017; Petruzzelli et al. 2011; Somaya 2012; Steensma et al. 2015). In this study, we use patent data from the European Patent Office (EPO) database, including all international firms that have filed in up to 40 European countries. The EPO is one of the largest patent offices in the world (along with its US and Japanese counterparts); we chose this database because the EPO was one of the first patent offices to use a specific classification code for innovations with environmental content, and so it provides more precise data for our aims in this research than would other similar databases (EPO 2010). We used this classification by EPO examiners as the basis for our selection of environmental patents, rather than subjective, abstract-based analysis by the authors (e.g., Lee et al. 2011). We used only the "family representative" document of each application (i.e., a given application is counted just once, despite being filed in several national offices), and we used the EPO's European Classification System (ECLA) codes to sort these environmental patents by technological domain.

The Electrical Components and Equipment (E&E) industry, code 6190 in COMPUSTAT, was our focus and fit our objectives because of its highly innovative nature (i.e., one of the most productive in terms of patents) and its significant direct and indirect impact on the natural environment. Although most leading innovative companies in this industry [traditionally known as original equipment manufacturers (OEMs)] are located in mature markets such as Japan, the United States, and Europe, the high innovativeness of the industry, along with a decrease in entry barriers through technological spillovers, has made newcomers to challenge this status quo (ILO 2017).

Regarding the environmental impact of this industry, it has faced relevant shifts toward greener production in recent years. For instance, relevant laws in the European context have been the directive on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment and the Waste of Electrical and Electronic Equipment. This legislation includes an increase in recycling and/or reuse of electronic waste, requiring heavy metals such as lead, mercury and, cadmium to be replaced with safer alternatives and requiring EU Member States to collect at least "65% of the average weight of electrical and electronic equipment placed on the market over the two previous years" (European Commission 2012).

We searched the EPO database to identify E&E firms that had COMPUSTAT data available and that had been issued two or more patented environmental innovations during 2005–2009. This time period provides a useful window on the E&E industry since it spans a relatively stable period between major economic shocks (the bursting of the ".com bubble" in 2000 and the real estate speculation fueled recession of 2008–2010) and major technological transitions (after the widespread diffusion of computers, but before the broad adoption of smartphones). It is important to keep in mind that our analysis is based on fully granted patents, a process that may take several years from when the firm discovers an invention and first applies for an associated patent (i.e., patents fully granted in 2009 would likely represent discoveries made in 2006 or earlier). In this regard, a number of studies based on patent data take this conservative approach since it may lead to more reliable results. A remarkable example of this could be Steensma et al. (2015) analysis of USPTO patents, which is based on granted patents from 2001 to 2006. A minimum of two patents provided higher consistency in the identification of a divergent approach. Given that COMPUSTAT did not provide information for some companies, the final sample provided an unbalanced panel data on 6768 environmental patents from 59 companies, generating 197 observations.

Measures

Environmental Technological Divergence

Following previous patent-based studies (e.g., Clarkson and Toh 2010; Lerner 1994), we used the patent class (ECLA classification code) to delimit environmental technological domains. We measured the environmental technological divergence of a firm's environmental patents from the E&E industry as follows:

$$\text{Divergence} = \sum_{i=1}^{n} \left| \frac{\text{NFP}_i}{\text{TotalNFP}} - \frac{\text{NIP}_i}{\text{TotalNIP}} \right| \times \frac{\text{NIP}_i}{\text{TotalNIP}},$$

where NFP_i is the number of the firm's environmental patents related to domain i, and NIP_i is the number of the industry's environmental patents related to domain i.

If a firm's environmental patents are in the same technological domains and in the same proportion as the industry average, then the divergence value is 0, and the firm totally converges. Higher values of the index mean higher divergence from the industry. The analysis of the environmental technological divergence of each firm is challenging because the EPO database does not provide a system to automate the process of dealing with the ECLA codes of each individual patent.

Firm Performance

To assess market-based firm performance, we employed Tobin's Q, defined as the ratio of market value to the replacement cost of assets and calculated from COMPUSTAT. We chose Q over other measures of financial performance because it better reflects the market's judgment about a firm's future, which is particularly important when dealing with questions of innovation (Bharadwaj et al. 1999). We calculated Tobin's Q using data from COMPUSTAT (Chung and Pruitt 1994).[1] We used a $t+1$ value (i.e., 1-year ahead) to capture the effects of previous innovative developments on performance because of the nonimmediate effects of innovation on performance and the high rate of the obsolescence of innovations in the sampled industry.

Firm Innovation Intensity

Following previous research (e.g., Delios and Henisz 2000), we used the ratio of R&D expenditures to sales to reflect innovation intensity. A higher value indicates higher innovation intensity in the firm.

Firm Environmental Scope

We measured scope as the logarithm of the number of different technological domains in the analyzed environmental patents (e.g., Lerner 1994). A higher value indicates an average higher scope of the environmental patented innovations in the firm. We also checked that the absolute value of the different technological domains in the firm's environmental patents offered similar results in our analysis.

Firm Bargaining Power

Previous work has often used size as a proxy for a firm's bargaining power (e.g., Ariño et al. 2008; Shervani et al. 2007). We used the natural log of net sales to measure firm size. The log was used to achieve a simple linear structure, constant variance, and normal distribution. Because the sampled firms are located worldwide, we attempted to avoid bias due to changing currency rates by normalizing sales into 2005 US dollars.

Firm Environmental Expertise

We measured environmental expertise as the number of environmental patents a firm held divided by its total number of patents (range = 0–1; higher values mean greater environmental expertise), a measure that has been employed in previous studies (e.g., Popp 2003) as a propensity to patent in a given domain. Since most new knowledge generated is patented by firms to avoid competitors' value appropriation (Hall and Ziedonis 2001), we consider that a higher propensity to patent in environmental technologies is related to the development of knowledge or expertise in that area.

Additionally, we used the following control variables in our analysis.

Firm Age

Age, measured based on the firm's foundation year according to the Bloomberg and JP Morgan databases, was included to capture the effects of experience and learning on divergence (Hegde et al. 2009).

Firm Total Assets

In line with previous works that employ Tobin's Q as the dependent variable (Hall et al. 2005; Lian and Wang 2019), we included the level of assets as the control variable, measured in 2005 US billions of dollars.

Firm Sales Growth

We have included the value of sales growth rate as the proxies for growth in our model, following previous works based on Tobin's Q (e.g., Lian and Wang 2019).

Country Pollution Level

This variable is calculated in metric tons per capita of CO_2 emissions in the country in which a firm has its headquarters, as reported in the World Bank database. This variable controls for institutional factors influencing a firm's environmental approach (e.g., King and Lenox 2000).

Country Energy Production

This variable is measured as the energy production in *kt* of oil equivalents, according to the World Bank database. Organizations headquartered in countries with higher levels might tend to maximize their short-term production (Pakes and Griliches 1984), investing in well-known, convergent technologies.

GDP

Annual GDP growth (as a percentage, from the World Bank) is considered a proxy for munificence; firms in countries with higher growth rates may take risks that imply investing

[1] Since this variable may be subject to outliers, we corrected it through the winsorizing approach (Dixon 1980). We thank an anonymous reviewer for pointing out this issue.

in divergent technologies (Aragón-Correa and Sharma 2003).

Country Inflation Rate

This variable, also from the World Bank database, reflects price volatility and variability and their potential to generate uncertainty, influencing a firm's environmental approach. The environmental literature has noted the influence of uncertainty on corporate environmental innovations (e.g., Aragón-Correa and Sharma 2003; Berchicci and King 2007).

Results

We tested our hypotheses using conventional panel data methods (fixed and random effects regression) with STATA. Since we had two dependent variables, we ran two separate regressions. For the first four hypotheses, we used the technological divergence measure as a dependent variable, whereas for our fifth hypothesis, we used firm performance. For both regressions, we used the Hausman test (Hausman 1978), which endorsed the use of fixed effects in both cases. Fixed effects models are preferred over random effects models because the former provides a more reliable estimate of parameters, as they eliminate the unobservable variables in conventional OLS regression estimates (Ernst 2001). In addition, we used robust standard errors (clustered at the company level) to avoid serial correlation and heteroskedasticity, and we controlled for the variability in the intercept over time using year-specific dummies.

Table 1 includes the descriptive statistics of our variables. The correlations between the variables do not suggest any potential for serious multicollinearity in the regression analysis.

Table 2 presents the results of the first regression, in which the variables reflecting hypothesized effects were entered individually. Model 1, the base model, includes only the control variables when technological divergence is the dependent variable. Models 2 through 4 include the hypothesized effect variables, intensity of technological innovations, environmental scope, and bargaining power, entered sequentially. Model 5 includes firm environmental expertise and completes the specification. The R^2 statistics indicate that every additional variable improved model fit.

We use the full model to discuss the results of the hypothesis tests. Hypothesis 1 predicts a positive relationship between innovation intensity and environmental technological divergence. The coefficient on innovation intensity ($\beta = 11.48$, $p < 0.01$) was positive and significant, supporting Hypothesis 1. Regarding the economic significance, our analysis shows that a one-percent increase in the innovation intensity is associated with a 0.052 increase in

Table 1 Descriptive statistics and correlations

	Mean	S.D	Median	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12
1. Environm. Techn. Divergence	0.13	0.10	0.09	0.009	0.42	–											
2. Firm Performance	1.04	0.58	0.89	0.070	2.82	0.18**	–										
3. Age	65.14	39.49	65	1	158	−0.15**	−0.05	–									
4. Total Assets	0.14	0.23	0.03	0.002	1.05	−0.08	−0.25***	0.26***	–								
5. Sales Growth	0.58	3.26	0.09	−16.5	15.6	−0.07	0.10	−0.08	0.13	–							
6. Country Poll. Level	9.64	3.49	9.63	4.44	19.71	−0.24***	0.14*	0.38***	−0.08	−0.11	–						
7. Country Energy prod	0.38	0.65	0.10	0.00	2.09	−0.04	0.25***	−0.03	−0.08	0.19**	0.39***	–					
8. GDP	1.19	4.19	1.69	−5.66	14.2	0.08	0.13*	−0.24***	−0.04	0.43***	−0.18**	0.51***	–				
9. Country's Inflation	0.43	2.13	−0.50	−1.27	7.80	0.23***	0.23***	−0.08	−0.05	0.21***	0.03	0.65***	0.53***	–			
10. Innovation Intensity	0.05	0.03	0.04	0.00	0.23	−0.11	0.25***	0.13*	0.10	−0.12	0.34***	0.11	−0.18**	0.01	–		
11. Envir. Techn. Scope	1.69	0.75	1.61	0.69	3.47	−0.11	−0.16**	0.24***	0.52***	0.09	−0.05	−0.16**	−0.12	−0.08	−0.14*	–	
12. Bargaining Power	14.96	2.00	15.00	9.68	18.56	−0.09	−0.21***	0.27***	0.74***	0.20***	−0.12	−0.09	−0.03	−0.06	−0.13	0.44***	–
13. Environ. Expertise	0.17	0.23	0.05	0.00	0.86	0.18**	0.024	−0.12	−0.27***	−0.05	−0.09	−0.19**	−0.11	0.03	−0.12	−0.13*	−0.25***

*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

Table 2 Result of the regression analysis (dependent variable: technological divergence)

	Model 1	Model 2	Model 3	Model 4	Model 5
Age	0.04 (0.15)	0.07 (0.15)	0.03 (0.14)	0.03 (0.12)	0.03 (0.11)
Total Assets	− 1.33 (1.67)	− 1.25 (1.73)	− 0.53 (1.51)	− 0.05 (1.53)	− 0.36 (1.40)
Sales Growth	− 0.00 (0.02)	− 0.00 (0.02)	− 0.01 (0.01)	− 0.02 (0.01)	− 0.02 (0.01)
Country Poll. Level	0.11 (0.16)	0.12 (0.16)	0.19 (0.18)	0.12 (0.19)	0.17 (0.17)
Country Energy prod	− 0.98 (1.24)	− 1.39 (1.36)	− 1.51 (1.39)	− 2.19 (1.41)	− 2.45 (1.33)*
GDP	0.01 (0.09)	0.04 (0.05)	0.02 (0.08)	0.05 (0.07)	0.04 (0.07)
Country's Inflation	− 0.02 (0.05)	− 0.02 (0.05)	− 0.01 (0.04)	− 0.01 (0.04)	− 0.01 (0.04)
Innovation Intensity		7.21 (3.12)**	7.39 (3.13)**	9.83 (2.74)***	11.48 (2.92)***
Envir. Techn. Scope			− 0.44 (0.15)***	− 0.47 (0.15)***	− 0.49 (0.14)***
Bargaining Power				0.68 (0.19)***	0.74 (0.15)***
Environmental Expertise					1.36 (0.68)**
R^2 (ΔR^2)	0.0982 (–)	0.1284 (0.0302)	0.2014 (0.0730)	0.2439 (0.0425)	0.2733 (0.0294)

Robust standard errors are in parenthesis

*$p<0.10$; **$p<0.05$; ***$p<0.01$

environmental technological divergence. Because innovation intensity is measured by US dollars invested by each dollar in revenue, and given that environmental technological divergence has values that range from 0.009 to 0.420, this increase of 0.052 may represent a relevant effect. For the relationship between environmental technological scope and environmental technological divergence, the coefficient ($\beta=-0.49$, $p<0.01$) was negative and significant, suggesting that as a firm broadens its environmental technological scope, it tends to converge, as hypothesized in Hypothesis 2. The analysis of economic significance shows that a one-percent increase in environmental technological scope is associated with a 0.082 decrease in environmental technological divergence.

Hypothesis 3 predicts a positive relationship between bargaining power and environmental technological divergence; the results for bargaining power ($\beta=0.74$, $p<0.01$) support our predictions. Economic significance analysis shows that a one-percent increase in bargaining power is associated with a 0.098 increase in environmental technological divergence.

Environmental expertise is positively related to environmental divergence ($\beta=1.36$, $p<0.05$), supporting Hypothesis 4. Here, a one-percent increase in environmental expertise is associated with a 0.024 increase in environmental technological divergence. Hence, as firms increase their expertise in the environmental arena, they tend to invest in less central environmental technological domains.

Regarding control variables, we found a negative relationship between a firm's environmental technological divergence and country energy production ($\beta=-2.45$, $p<0.10$). This shows that firms whose decision makers are located in more polluted countries tend to invest in convergent technologies.

Turning to our fifth and final hypothesis, the results in Table 3 show the relationship between environmental technological divergence and 1-year ahead Tobin's Q. Models 6–10 include each of the independent variables in the first regression to control their potential effects on 1-year ahead Tobin's Q. Model 11 includes environmental technological divergence as an independent variable, measured as the residual value of the variable in the first regression, to avoid the confounding effects of environmental divergence and its antecedents. The positive and significant coefficient on environmental technological divergence ($\beta=9.82$, $p<0.10$) supports our predictions that divergence is positively related to firm performance. Economic significance analysis shows that a one-percent increase in the environmental technological divergence is associated with a 0.067 increase in 1-year ahead Tobin's Q, that is, 0.067 times the firm's market value

Table 3 Result of the regression analysis (dependent variable: 1-year ahead Tobin's Q)

	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11
Age	−0.18 (0.18)	−0.11 (0.17)	−0.10 (0.16)	−0.13 (0.16)	−0.15 (0.14)	−0.14 (0.14)
Total Assets	−1.15 (1.66)	−1.00 (1.70)	−1.08 (1.97)	−.71 (2.00)	−.05 (1.61)	.13 (1.63)
Sales Growth	−0.00 (0.01)	−0.01 (0.01)	−0.01 (0.01)	−0.00 (0.01)	−0.01 (0.01)	−0.00 (0.01)
Country Poll. Level	0.13 (0.27)	0.13 (0.31)	0.12 (0.32)	0.17 (0.33)	0.25 (0.25)	0.26 (0.25)
Country Energy prod	0.31 (2.21)	−0.42 (2.34)	−0.42 (2.35)	0.13 (2.27)	−0.49 (1.65)	−0.48 (1.61)
GDP	−0.07 (0.10)	−0.12 (0.09)	−0.01 (0.09)	−0.05 (0.09)	−0.06 (0.08)	−0.06 (0.09)
Country's Inflation	−0.05 (0.04)	−0.05 (0.05)	−0.05 (0.05)	−0.04 (0.05)	−0.04 (0.04)	−0.03 (0.04)
Innovation Intensity		14.20 (2.81)***	14.19 (2.77)***	12.92 (3.22)***	15.48 (4.73)***	15.43 (4.87)***
Envir. Techn. Scope			0.02 (0.14)	0.03 (0.14)	0.00 (0.13)	0.01 (0.13)
Bargaining Power				−0.45 (0.44)	−0.32 (0.48)	−0.29 (0.49)
Environmental Expertise					2.17 (1.23)*	2.20 (1.22)*
Environm. Techn. Divergence						9.82 (11.61)*
R^2 (ΔR^2)	0.2553 (−)	0.3436 (0.0883)	0.3437 (0.0001)	0.3559 (0.0122)	0.4131 (0.0572)	0.4177 (0.0046)

Robust standard errors are in parenthesis

$^{*}p<0.10$; $^{**}p<0.05$; $^{***}p<0.01$

to the replacement cost of assets. There was no consistent pattern for the dummy variables for the different years.

Discussion

Contributions

The risk of competitors' opportunistic appropriation of the value generated by others' innovative efforts can prompt firms to make strategic moves to protect themselves from such threats (Somaya 2012; Ziedonis 2004). Opportunism also has relevant ethical implications because it makes it difficult to maintain collaborations that may be beneficial for firms and society (e.g., Arıkan 2020; Romar 2004). Converging around the same technologies has often been pursued by firms to preserve value from their innovations in the face of opportunism (Hall and Ziedonis 2001; Spencer 2003; Vakili 2016). However, such convergence has also generated negative implications through the exponential growth of litigations costs, mutual blocking between competitors, and a myriad of symbolic innovative contributions instead of more substantial progress (Hall and Ziedonis 2001).

This underdevelopment of innovations is particularly relevant in the case of environmental innovations because they generate positive externalities. Therefore, making efforts to develop more advanced and radical innovation in this area is not only a technological improvement itself but also an ethical duty that firms may pursue in fulfilling their *organizational purpose* beyond profit maximization (Enderle 2009; Wartzman and Tang 2019).

In examining this intersection of patenting strategies and environmental innovation, this study makes three broad contributions to the previous literature. First, our results show that specific organizational factors encourage firms to develop environmental innovations outside the regular technological domains of their industry (i.e., environmental divergence). These results contribute to the strategic innovation literature (e.g., Ethiraj and Zhou 2019; Frésard and Valta 2016; Pan et al. 2019) by extending the discussion regarding how different innovation strategies (divergence in our study) may be more or less appropriate for different firms. Our findings are particularly useful because much of the previous strategic innovation literature has focused on convergence. Specifically, we have found support for the influence of a firm's innovation intensity, environmental technological scope, bargaining power, and environmental expertise on a firm's environmental innovative divergence.

Our findings also suggest that an intensive commitment to environmental innovation fosters the ability of firms to explore less central technological domains in the industry, thereby reducing the risks of value appropriation by competitors (e.g., Somaya 2012; Steensma et al. 2015). Since environmental innovations are usually riskier and more long-term-oriented than general innovations (e.g., Berrone et al. 2013; Montiel and Delgado-Ceballos 2014), an intensive commitment of resources to these types of innovative developments is particularly useful to explore the divergent opportunities in the environmental arena. Additionally, having a broad environmental scope also appears to makes it easier for a firm to pursue a divergent approach to environmental innovation by reducing repositioning costs (e.g., de Figueiredo and Silverman 2007; Menon and Yao 2013). Our result reinforces the previous competitive dynamics literature on the importance of considering repositioning costs when delimitating a firm's approach to innovation strategy. (e.g., Menon and Yao 2013).

Regarding bargaining power, we find that firms with high bargaining power are more open to pursuing divergence in their environmental innovative efforts. Whereas bargaining power may confer advantages in many situations (Ariño et al. 2008; Shervani et al. 2007; Stevens et al. 2016), we consider that it may be more effective when companies use it in less central technological domains rather than in crowded central domains of their industry.

Additionally, we show that a firm's environmental expertise is positively related to its inclination toward innovative divergence in the environmental arena. The expertise gained in environmental areas reinforces general organizational capabilities to accommodate the evolution of regulations, markets, and society (Hart 1995; Shrivastava 1995), and our finding suggest that these general capabilities may be relevant for avoiding opportunistic threats by developing environmental innovations in domains featuring more limited innovation efforts from competitors.

Our second contribution is extending the previous literature on environmental innovation (e.g., Berrone et al. 2013; Berrone and Gomez-Mejia 2009; Shrivastava 1995) by showing a positive relationship between a firm's environmental innovative divergence and firm performance. While previous literature has often focused on the business case of innovative convergence (e.g., Joshi and Nerkar, 2011; Hegde et al. 2009), divergence has received limited attention (Berrone et al. 2013). Our analysis of patenting in the international electrical components and equipment industry showed that environmental technological divergence is positively related to firm performance. These results are relevant because they suggest that developing environmental technologies in less central domains may *simultaneously* yield positive results for firms and discoveries of potential radical improvements that result in greater societal wealth creation (Enderle 2009).

This finding contributes to a broader effort to better understand the distinct and multidimensional nature of environmental innovation. Specifically, since environmental innovations tend to be long-term in orientation and risky in nature (e.g., Leyva-de la Hiz 2019; Wijethilake et al. 2018); positive externalities and legitimation implications (e.g., Berrone et al. 2013; Montiel and Delgado-Ceballos) likely play an outsized role (relative to other types of innovation) in determining the performance implications of divergence. In general, our results reinforce the growing attention being paid to an ethics-informed perspective on environmental innovation (e.g., Cheng 2020; Huang and Li 2017; Wijethilake et al. 2018). Specifically, our results suggest that an ethical commitment toward major divergent advancement in environmental technologies is not opposed to profit generation.

Third, we contribute to the growing institutional interest in how firms pursue more pioneering environmental innovation. While the rationality of converging around certain domains within an industry has been widely examined, the antecedents and implications of environmental divergence have received more limited attention (Berrone et al. 2013). Environmental regulation (e.g., Jaffe and Palmer 1997; Aragon-Correa et al. 2020) and the normative conditions in an industry (e.g., King and Lenox 2000) have shown their influence on the convergence of a firm's environmental innovations within the technological domains established in its industry.

Future Research

As a complement to these past findings, we show that certain organizational factors may orient firms toward divergent innovative approaches in their industries. Emergent institutional perspectives such as communicative institutional theory (e.g., Cornelissen et al. 2015; Ocasio et al. 2015) and micro-institutionalism (e.g., Glaser et al. 2016; Schilke 2018) emphasize, to a greater extent than classic institutional theory, the holistic nature of the corporate environment and the heterogeneity of managerial responses to external pressures. Future research on firms' environmental innovations could move in this direction to better understand both the tensions between convergence and divergence and the synergies between external and internal conditions for generating divergence.

Additionally, future research might also consider how specific managerial incentives may influence a firm's environmental innovation efforts. Several papers have analyzed incentive schemes for CEOs established by boards of directors in the context of patenting strategies (e.g., Makri et al.

2006; Berrone and Gomez-Mejia 2009). Additionally, the role of personal values in family firms may also generate unique patenting behavior (e.g., Chirico et al. 2020). The availability of appropriate data to test hypotheses in these fields will be a prerequisite for the further exploration of these relevant factors.

Limitations

The most notable limitation in this study is the exclusive use of patent data to measure innovation. Some scholars rightly argue that firms may rely on secrecy instead of patenting their inventions (Blind et al. 2009; Fosfuri 2006; Somaya 2012). However, the rise of the propatent era (Ziedonis 2004) has led firms to tend to patent practically any technical innovation, even when its relevance is dubious (Hall and Ziedonis 2001). In addition, a number of scholars have advocated for the use of patents, as many empirical studies have found a significant positive relationship between patenting and innovation (Chen et al. 2016; Grindley and Teece 1997; Steensma et al. 2015), which is mirrored by the abundant literature based on patent data (Somaya 2012).

Another limitation of this work is that we analyze only a single industry. Since firms' motives and tendency to patent are quite stable within an industry (Clarkson and Toh 2010) and vary widely from one industry to another, which may negatively affect comparability (Cohen et al. 2000), future studies may attempt to overcome these difficulties and extend our work through either cross-sectorial analysis or by taking a similar tact as we do here but in a different industry with both major environmental impact and ongoing innovation efforts.

Implications and Conclusion

In relation to our work's implications for practitioners, our results show that managers should not only seek to increase the number of patents held by their firms to protect their innovations in technical domains central to their industry but also carefully consider the selection and distribution of their patenting activities across differing domains. Hence, managers might want to pay specific attention not only to what their firms are patenting but also to which technological domains their competitors are (or are not) activity patenting in. There is a clear incentive to file patents around central innovations in an industry; however, our results help to show that under certain conditions, there is also a robust business *and* ethical case for divergent innovation.

Our study also has relevant implications for policy makers by suggesting the importance of designing policies to foster the discovery and development of new environmental technologies that can, for example, help meet the UN goals of limiting global warming (UN 2020). Although most patenting regulations provide opportunities for firms to block competitors' threats using a myriad of legal barriers, it is surprising that policies for helping radical innovators protect their innovations (or encouraging managers to make them possible) are much more limited. Keeping in mind the importance of coercive and voluntary environmental regulation on a firm's environmental strategies (Aragon-Correa et al. 2020), future regulation could be more explicit about providing better opportunities and orientation toward technological divergence.

Environmental innovation is key to achieving the much-needed goal of a more sustainable economy. Within this broad effort, divergent innovation is particularly important for both creating pioneering solutions to vexing problems and for helping firms not become bogged down in litigation, opportunism, and defensive patenting in the core technological domains of their industries. Our study offers guidance on managerially actionable ways to pursue such divergence through managing a firm's innovation intensity, scope, bargaining power, and expertise; and highlights how such purposeful and well-crafted divergence can then drive firm performance. In doing so, we provide empirical evidence that we sincerely hope both researchers and practitioners in innovation-based industries can find useful as they contribute to this critical transition to a more sustainable and ethical economic system.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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