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When Does It Pay to Be Green? The Strategic Benefits of Adoption Speed

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Abstract

Does the speed of adopting environmental practices impact financial benefits? The strategy literature discusses the contingencies under which firms can gain an early-mover advantage or a late-mover advantage. This research examines the effect of adoption speed on two types of environmental practices: environmental innovation practices (EIP) and environmental management practices (EMP). The results show that early adoption of EIP increases competitive advantage when firms face intense competition. In comparison, we show that early adoption of EMP increases competitive advantage when firms face extremely low competition or have moderate to high levels of slack resources. The study contributes to the literature by revealing the nuances, contingencies, and boundary conditions of when it pays to be green. Prior research shows mixed results when studying firms' decisions to implement environmental practices, which implies that it may not pay to be green. This study shows that firms can get an early mover advantage from environmental practices, but it depends on the type of environmental practices, the firm's internal slack resources, and the firm's external competitive environment.

Keywords: early-mover advantage, environmental practices, adoption speed, late-mover advantage, early engagement

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1. Introduction

Numerous studies have examined the relationship between environmental practices and financial performance (e.g., Klassen and McLaughlin, 1996; Melnyk et al., 2003; Perotti et al., 2012). Research shows mixed results on the relationship between environmental practices and financial performance (e.g., Albertini, 2013; Golicic and Smith, 2013), which calls into question whether firms can get a competitive advantage from environmental practices. However, assessing the competitive advantage of environmental practices may be more nuanced and complex. This research examines the effect of *when* firms adopt environmental practices, what *types* of practices they adopt, do they face a lot of *competition*, and what *internal resources* the firms have available to them. More broadly, this research looks at the impact of the *adoption speed* of environmental practices, which seeks to answer the question of *when it pays to be green* instead of whether *it pays to be green*.

Instead of looking at the financial impact of the decision to adopt environmental practices, this study draws on the early mover advantage literature (Lieberman and Montgomery, 1998) to examine if a competitive advantage comes from the speed of adoption. From this perspective, firms can follow either an early-mover or a late-mover strategy. An early-mover strategy suggests that firms should strive to adopt early. DuPont illustrates an example of an early-mover advantage where they made an early decision to eliminate the use of chlorofluorocarbons (CFCs). This strategy allowed them to stay ahead of regulations and gain an advantage over their industry peers (Maxwell and Briscoe, 1997). In contrast, a late-mover strategy suggests that firms benefit from adopting practices later. That is, firms should wait and learn from the experience of other firms in their industry. For instance, the EPA mandated that utility companies adopt environmental technologies to reduce carbon dioxide emissions by 32% by 2030. However, firms that adopted new technologies later benefited from declining costs, which resulted in higher financial performance (Miller, 2014; Puko, 2018) and illustrated a late-mover advantage.

Following Hart and Dowell (2011), this research differentiates two broad types of environmental practices: *environmental innovation practices* (EIP), which has a product focus, and *environmental*

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management practices (EMP), which has a process focus. This classification helps understand which type of environmental practices—product-orientated or process-oriented—has an early-mover or late-mover advantage. In addition, as the literature has suggested, the effect of adoption speed may depend on firms' available *internal resources* and *external competitive environment* (Gilbert and Birnbaum-More, 1996; Christmann, 2000; Jacobs et al., 2015; Su et al., 2015). These contextual factors suggest the complexities of getting a competitive advantage, which leads to the following question - *what conditions influence the benefits of an early-mover or late-mover strategy?* Understanding these interrelated issues sheds light on the question of when it pays to be green and explains the mixed results of prior studies that only investigated the question of whether it pays to be green. It further shows that competitive advantage from environmental practices is more nuanced and complex, which has implications for practitioners and scholars.

The analysis begins with the construction of a large-scale longitudinal dataset of the environmental practices firms have adopted from 2007 to 2016 using Refinitiv's Asset4 database. The results first show that both the effects of EIP adoption speed and EMP adoption speed are not statistically significant at the 5% level. However, while the main effects are not significant, the effects of adoption speed depend on a firm's level of capacity slack and competitive intensity. The analysis shows a positive effect of EIP adoption speed when firms are situated in a highly competitive environment, indicating an early-mover advantage for EIP in a highly competitive environment. In addition, the analysis shows a positive effect of early adoption of EMP when firms situated in extremely low competitive environments or have a moderate to high level of capacity slack. In sum, the firm's internal resources and external competitive environment influence the benefits of EIP and EMP adoption speed.

Overall, this study helps understand: (1) *when* firms benefit from which *types* of environmental practices; and (2) the influence of firms' internal resources and external competitive environment on adoption speed. The findings of this study provide managers with guidance in deciding when and what type of environmental practices to invest in and conditions that could lead to greater profitability. The results help managers make better investment decisions in environmental practices by better understanding the conditions under which they can expect improvements in profitability. The results also inform managers

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that they should pay attention to situations where firms may not benefit from an early-mover advantage, as they may take a wait-and-see approach that slows down the adoption of environmental practices. Finally, the analysis has implications for policymakers. That is, we identify conditions where firms may not get much of a competitive advantage from environmental practices. Under these conditions, policymakers may need to employ programs to promote environmental practices since firms lack competitive and financial incentives to implement them.

2. Literature and Hypothesis Development

2.1. Environmental Practices

This study draws on the natural-resource-based view (NRBV) (Hart, 1995) to classify environmental practices. Hart (1995) argued that developing resources in terms of pollution prevention, product stewardship, and sustainable development can bestow a competitive advantage to firms. These resources reflect two generic strategies for competitive advantage: (1) designing and developing products to serve environmentally conscious markets (Hart and Dowell, 2011) and (2) changing a firm's operational processes across the supply chain to reduce damage to the natural environment (Hart and Dowell, 2011).

Accordingly, we classify environmental practices in terms of two generic strategies. We call the first set of practices *environmental innovation practices* (EIP). EIP is a set of policies and practices to improve the environment by designing, developing, and marketing products or services in an environmentally conscious way (Hart, 1995; Melnyk et al., 2003). According to the Commission of the European Communities (2001), green products reduce the negative impacts on the environment, utilize fewer resources, and produce less waste at the end of the product life cycle. Examples of EIP include product development that follows eco-design principles (Luttropp and Lagerstedt, 2006; Szekely and Strebel, 2013), development of clean technologies (Hart and Dowell, 2011; McDougall et al., 2019), development of renewable energy-related products (McDougall et al., 2019), and products that promote environmentally friendly usage (Szekely and Strebel, 2013).

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We call the second type of practices *environmental management practices* (EMP). EMP is a set of policies and practices that reduce environmental damage from a firm's ongoing operations across its supply chain (Hart, 1995; Hardcopf et al., 2019). A similar definition has been proposed by Hardcopf et al. (2019). Examples of EMP include redesigning processes for waste, pollution, or greenhouse-gas emission reductions (Kassinis and Soteriou, 2009; Pullman et al., 2009), green purchasing and logistics (e.g., Zhu and Sarkis, 2004; González-Benito and González-Benito, 2005), initiatives of environmental assessment of internal processes (Sroufe et al., 2002; Buysse and Verbeke, 2003; Sarkis et al., 2010), and environmental training programs (Klassen and Whybark, 1999).

The literature has investigated the effects of adopting EMP (e.g., Sarkis et al., 2010; Hardcopf et al., 2019) and EIP (e.g., Chen et al., 2006; Ghisetti and Rennings, 2014; McDougall et al., 2019) on financial performance (Albertini, 2013; Golicic and Smith, 2013). However, few studies have explored the notion of the early-mover advantage of environmental practices. Studies have proposed a conceptual link between an early-mover advantage and environmental practices. For example, Tetrault Sirsly and Lamertz (2008) proposed that corporate social responsibility initiatives can lead to early-mover advantage if these initiatives are visible to the firms' stakeholders and provide specific benefits to the firms. From a policy perspective, Cleff and Rennings (2012) proposed that the success of environmental innovation policies that encourage firms to become early movers depends on the market characteristics and regulations specific to each country. However, scholars have not empirically examined the early-mover advantage for different types of environmental practices, which may partly explain the mixed results between environmental practices and firm performance.

Research shows mixed results for an early-mover advantage of EMP. Nehrt (1996) showed that paper pulp producers who made early investments in pollution prevention equipment had higher profit growth. Ye et al. (2020) showed that adopting environmental management systems early reduced firms' sales growth. For the early-mover advantage of EIP, one study by Przychodzen et al. (2020) found an early-mover advantage in terms of financial performance. They categorized firms into two groups: the early movers and the others, based on the average number of environmental patents. Their analysis showed that

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firms with a high intensity of environmental innovation had higher financial benefits. However, categorizing early movers based on patent intensity may not fully capture the timing of adopting environmental practices relative to industry peers. Overall, our understanding of the effects of early-mover advantage in environmental practices remains limited. This study aims to provide further empirical evidence and contribute to the existing body of research by investigating how the relative timing at which firms engage in EIP and EMP relative to industry peers affects financial performance.

2.2. **Adoption Speed**

Scholars have defined practice as a defined activity that a firm engages in (Bromiley and Rau, 2014). The adoption of a practice in our context is when a firm indicates that it engages in a particular type of environmental activity. Speed of adoption then refers to the extent to which firms are early or late in engaging in specific activities relative to their industry peers. In this study, adoption speed is the degree to which a firm is early or late in engaging in an activity. An early-mover advantage refers to the benefits firms obtain from taking early actions (Lieberman and Montgomery, 1988). The literature identifies three mechanisms that lead to an early-mover advantage: (1) the learning curve effect, (2) the preemption of scarce resources, and (3) the creation of buyers' set-up and switching costs (Lieberman and Montgomery, 1988). First, early movers can benefit from the learning curve effect because they obtain more experience from their early engagements, which gives them more opportunities to realize efficiency improvements or profit opportunities. Second, an early-mover advantage gives firms more control over resources leading to competitive advantages. Third, early movers can create higher buyer switching costs (Mueller, 1997). Research shows that early movers have more influence on customers' valuation of product attributes, especially in situations where the assessment is ambiguous (Makadok, 1998).

Lieberman and Montgomery (1988) also discuss several mechanisms leading to a late-mover advantage. For instance, late movers can leverage the existing demand for sustainable products created by early movers to reduce the uncertainty they face (Lilien and Yoon, 1990), avoiding the costs and risks of making wrong choices or investments. Late movers can benefit from early movers' investments in infrastructure

development. Finally, late movers may be able to exploit new developments in technologies and benefit from the updated technologies for cost efficiency.

In this study, we argue EIP has an early mover advantage for the following reasons. Environmental innovations often take time to develop since they tend to tackle multiple issues such as environmental impacts and economic viability at the same time, which requires a systematic approach involving different stakeholders (Messeni Petruzzelli et al., 2011). Further, compared to non-environmental innovations, environmental innovations often require exploring new knowledge, rather than a recombination or refinement of known knowledge (Orsatti et al., 2017).

Early EIP adopters start their development activities early, thereby moving down the learning curve to establish their competitive leadership in the green products or services they offer (Lieberman and Montgomery, 1998). This also allows them a longer time frame to engage with various stakeholders. Early engagement in environmental innovation activities helps firms develop firm-specific knowledge that is difficult for other firms to replicate (Mansfield, 1985; Nehrt, 1996). For instance, Tesla invested in its home-grown, integrated electronic systems and enjoyed technological leadership in the electronic vehicle market (which reduces emissions), as Japanese carmakers found themselves at least six years behind (Kume, 2020). Another company's green product efforts involve reformulating its detergent products and package design; their efforts resulted in lower weight for transit and reduced transport costs (Berg et al., 2020). Being able to move down the learning curve earlier enables early EIP adopters to further reduce the costs of developing green products or services (Lieberman and Montgomery, 1998).

Most importantly, developing green products allows early movers of EIP to signal their environmental commitment and influence customer perceptions early in the process (Stead and Stead, 1995). They can build a stronger preference among customers (Heikkurinen, 2010) and appeal to environmentally conscious customers with their innovative, environmentally oriented products or services to increase customer satisfaction and sales (Kohtamäki et al., 2013). Collectively, we submit that while late movers may benefit from reduced uncertainty and better operational efficiency, the benefits of the early development of firm-specific knowledge, influencing customer preferences, and setting industry standards for green innovations

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could outweigh the cost disadvantages and allow early EIP adopters to increase profitability through early-mover advantage mechanisms.

Hypothesis 1a (H1a): EIP adoption speed has a positive effect on firm profitability.

The process-oriented environmental practices can lead to cost savings, such as reducing production costs and operations expenses such as waste disposal fees or reducing transportation costs (e.g., Rothenberg et al., 2001). Early movers of EMP could position themselves as leaders in sustainable process-oriented practices. By accumulating experience earlier than their peers, firms can benefit from the learning curve effect to achieve better process efficiency, which translates into more streamlined resource utilization, waste reduction, and improved energy conservation. In contrast, late movers of EMP can benefit from the ability to incorporate and refine existing best practices, capitalizing on the learning curve established by early movers (Terlaak and Gong, 2008; Lieberman and Montgomery, 1988). By observing the market's response to initial environmental process changes, late movers can implement more mature, cost-effective improvements, utilizing more advanced technologies, thus reducing both operational risks and expenses (Lieberman and Montgometry 1988).

In light of the two forces, we argue that EMP has a late-mover advantage for the following reasons. First, past research shows that late movers of process-oriented practices benefit more from having the opportunity to observe others' implementation experience and lower their costs. Jacobs et al. (2015) found that early movers of Six Sigma (a process-oriented practice that focuses on process improvement) adopters faced high uncertainty about the applicability of the practices and lacked knowledge of the implementation. In contrast, late movers of Six Sigma faced fewer uncertainties since they could observe the experiential accounts or mistakes of early adopters (Terlaak and Gong, 2008; Jacobs et al., 2015).

Second, EMP focuses more on processes rather than products or services. Compared to EIP, EMP often requires changing and improving existing internal and external processes. Unlike EIP, which can shape customer perceptions directly, the benefits of environmental process improvement practices are primarily internal, manifesting in enhanced operational efficiency rather than directly influencing customers'

perceptions for sales benefit. As a result, they do not create barriers to switching costs in terms of environmentally friendly product attributes, which disperses an early-mover advantage mechanism. For example, adopting ISO 14000 (an EMP practice) or having environmental criteria for selecting suppliers is viewed as an order qualifier rather than an order winner, which reduces the likelihood of increasing revenue by being early movers of EMP (Curkovic and Sroufe, 2011).

Third, early EMP adopters often lack reference points to guide their implementation. The adoption of EMP can be complex because it often spans multiple functions across firms. Firms could incur high information-seeking costs (Heide and Stump, 1995), such as analyzing the existing processes for using renewable energy or searching for suitable equipment to reduce waste. Besides, over time, the adoption knowledge of process-oriented practices such as EMP is disseminated with the help of third-party consulting firms (Bloom and Van Reenen, 2010). The knowledge can then be transferred from one firm to another, which benefits the late EMP adopters (Cockburn and Henderson, 1996). Research also shows that late EMP adopters can implement environmental practices more effectively with lower costs by learning from the experience of early EMP adopters (Ritchie and Melnyk, 2012) and taking advantage of the lower costs of process technologies (Kroes et al., 2012). In sum, while adopting EMP early could benefit from the similar learning curve effect as EIP, we submit that the above mechanisms suggest the benefits of being a late mover of EMP outweigh the benefits of being an early mover. That is, increasing EMP adoption speed negatively influences financial performance.

Hypothesis 1b (H1b): EMP adoption speed has a negative effect on firm profitability.

2.3. The Role of Competitive Intensity and Capacity Slack

Lieberman and Montgomery (1998) argued that scholars should consider moderators when examining early-mover or late-mover advantage since the benefits may be contingent on other firm and industry characteristics. Scholars have also noted that the external and internal contexts provide important contingencies to understanding the effectiveness of practices (Siggelkow, 2001). Barney et al. (2011) state that the competitive advantage conferred by strategic timing is moderated by the interplay of two forces:

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the preemptive benefits of moving earlier than peers and the benefits gained from maintaining strategic flexibility of moving later than peers. Specifically, preemption provides benefits in the games against competition and flexibility provides benefits against uncertainty in a situated environment (Lieberman and Montgomery, 1988; Ghemawat and Del Sol, 1998). Several empirical studies have found support for this perspective. Gilbert and Birnbaum-More (1996) and Su et al. (2015) both found that industry competition moderates the effect of adoption speed. Christmann (2000) found that firm resources affect the benefits of early environmental management engagement. Drawing on these studies, we conjecture that the effect of adoption speed is moderated by a firm's external competitive intensity and internal capacity slack. That is, while the competition level in an industry affects the benefits of preemption against rivals, the level of slack resources reflects the ability to respond to environmental uncertainties and influences the benefits of strategic timing. We further reason how competitive intensity and capacity slack change the effectiveness of the early-mover advantage of EIP and EMP in the following paragraphs.

Competitive Intensity

We argue that increasing EIP adoption speed is more effective under a high than a low level of competitive intensity. Industries can be characterized in terms of their structure from monopolistic to highly fragmented (Scherer and Ross, 1990). Firms that compete in a highly (lightly) fragmented industry have many (few) competitors, and each has a small (large) market share, which represents a high (low) degree of competitive intensity.

In a high competitive intensity environment, no dominant firm exists, and many firms are not in direct competition with each other due to the existence of strategic groups (McGee and Thomas, 1986). As a result, early-mover firms will be more likely to shape customers' perceptions and benefit from their innovative actions (Gilbert and Birnbaum-More, 1996). Further, in a highly competitive environment, customers have more choices and lower switching costs. Green product innovation directly influences the product or service characteristics, making it salient to customers (Ioannou et al. 2022). Firms that can better satisfy customers' needs by providing unique green products to differentiate themselves from competitors are more likely to

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win over customers and improve their financial performance. For instance, Patagonia has established itself as an early mover in creating eco-friendly outdoor apparel in an industry with many competitors. These early eco-innovative actions have helped build a strong brand loyalty that distinguishes Patagonia from traditional apparel firms.

Second, a high number of competitors makes monitoring competitive movements more difficult. A focal firm's environmentally innovative actions (e.g., offering eco-design products) are less likely to be closely followed or mimicked by others because of the high levels of industry fragmentation; therefore, innovative actions will be less likely or take a longer time to trigger immediate imitations from rivals. Such an environment grants early EIP movers like Patagonia a longer period to carve out a competitive niche with unique green products or services tailored to environmentally conscious customers. Several analytical studies also reach the same conclusion. For instance, Kopel (2021) analytically shows that the early-mover advantage of corporate social responsibility (CSR) is more salient under a high degree of competition between two firms because competition increases the positive demand effect of CSR activities.

In contrast, in a more monopolistic industry, a small number of firms share the marketplace and each commands a large market share, representing a low competitive intensity (Scherer and Ross, 1990). Under a low competitive intensity environment, the number of competitors is small with a few dominant firms, and the benefits of early adoption will not likely last (Gilbert and Birnbaum-More, 1996). The mechanisms of early-mover advantage such as preempting important resources or increasing buyer switching costs are more challenging to execute, and the benefits are more difficult to realize due to the nature of direct competition among the dominant firms. A focal firm's environmentally innovative actions (i.e., adopting EIP) are more likely to be noticed by their rivals and trigger responses due to the mutual awareness among a small number of dominant firms (Bain, 1951). After noticing the focal firm's environmental innovation activities, competitors will likely move in the same direction to compete with the focal firm or undertake actions that render the early movers' activities less effective. Fairphone, known for making sustainable smartphones with modular designs for minimal environmental impact, was an early mover in eco-friendly electronics. However, it is in an industry dominated by a few major firms. As major industry players like

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Apple and Samsung have also started implementing environmental practices in response to growing consumer interest in sustainability, Fairphone's initial competitive advantage as an early mover has lessened, although it still survives in a niche market. As a result, the benefit of engaging in EIP early is reduced in a low competitive intensity environment. In sum, we propose the following hypothesis:

Hypothesis 2a (H2a): The extent of competitive intensity positively moderates the relationship between EIP adoption speed and firm profitability.

For EMP, we argue that increasing EMP adoption speed is more effective in a low competitive intensity environment than in a high competitive intensity environment. The rationale extends from the late-mover advantage of EMP. In a highly competitive environment with many competitors, the late-mover advantages of EMP would become more apparent. The late EMP adopters are more likely to observe the experiences or mistakes of a larger number of industry peers. The opportunity to observe more firms adopting EMP practices leads to less uncertainty, as later adopters can observe a wider range of possible outcomes with greater accuracy, which increases the effectiveness of late EMP adoption.

In a low competitive intensity environment, in contrast, the flexibility benefits of the late-mover advantage of EMP become less salient. In such an environment, where a few dominant firms closely monitor each other's actions, firms may feel compelled to engage in EMP to remain competitive. Therefore, the opportunity to wait and learn from competitors' mistakes or observe their experiences is limited.

In addition, firms in a low competitive intensity environment often occupy a significant market position. Early EMP adopters occupying strong market positions are more capable of leveraging their abundant resources and economies of scale to extend the process efficiency benefits such as costs and energy efficiency derived from the experience curve (Boulding and Christen, 2008). As an illustrative example, BASF, a leading German chemical producer operating in an industry with a few dominant firms, its early adoption of EMP leads to the development of the "Verbund" system. A system focuses on reducing waste,

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energy usage, and emissions by streamlining the internal processes. Commanding a large market share, BASF continues to benefit from the system.[1]

Hence, we contend that although the benefits of early engagement in EMP (e.g., learning curve advantage, preemption of resources) are less pronounced compared to early engagement in EIP as we have argued, firms can still extract financial benefits from early engagement of EMP when competing in a low competitive intensity environment. Based on the above arguments, we hypothesize that increasing EMP speed is more effective in a low competitive intensity environment.

Hypothesis 2b (H2b): The extent of competitive intensity negatively moderates the relationship between EMP adoption speed and firm profitability.

Capacity Slack

Kovach et al. (2015) defined operational slack as "buffer resources available to support the operational activities of a firm and allowing firms to better match variations between supply and demand" (p.1). By this definition, operational slack resources consist of excess production capacity, raw materials, work-in-process, or finished goods inventories (Bourgeois, 1981; Nohria and Gulati, 1996). Firms with slack resources have a cushion of resources that can be used for other purposes (Bourgeois, 1981; Cheng and Kesner, 1997). As such, this study focuses on capacity slack (Azadegan et al., 2013), an internal operational slack (Hendricks et al., 2009) that reduces the negative influence of disruptions to the existing processes (Kleindorfer and Saad, 2005; Hendricks et al., 2009).

We first submit that capacity slack positively moderates the effect of EMP speed. Engaging in EMP requires firms to refine and adjust their internal processes, which can potentially disrupt the existing operational processes (Christmann, 2000). For instance, firms need to test new equipment that can reduce waste or redesign production processes that use fewer raw materials or renewable energy. Firms may also need to adjust their external processes that disrupt existing operations, such as new supplier selection or

[1] https://www.basf.com/global/en/investors/calendar-and-publications/factbook/basf-group/verbund.html

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delivery processes that incorporate environmental criteria. Adopting EMP may also require revamping supply chains to integrate recycled materials or utilizing energy-efficient logistics solutions for pollution reduction and control, such as solar-powered warehouses or electric vehicle fleets, which may temporarily affect delivery schedules or require new partnerships.

In situations where firms operate with a limited amount of capacity slack, they have fewer resources available to accommodate the shift to greener processes when adopting EMP early, without disrupting ongoing operations. However, when firms possess a higher degree of capacity slack, we reason that they are more apt to weather the transient disruptions that accompany the early adoption of EMP (Bourgeois 1981; Kleindorfer and Saad, 2005) and lessen some of the disadvantages of early EMP adoption argued in the previous section. The logic is that capacity slack provides a buffer to minimize disruptions to the existing system while firms adjust their internal and external processes, resulting in better profitability. For example, an extra production line could be used as a testing facility to adjust production processes, additional production capacity helps lessen the disruptions due to switching to environmentally conscious suppliers, or idled storage areas might be repurposed to facilitate the transition efforts without impeding the flow of current operations. As a result, engaging in EMP early is more beneficial under a high level of capacity slack. Together, we propose the following hypothesis.

Hypothesis 3a (H3a): The extent of capacity slack positively moderates the relationship between EMP adoption speed and firm profitability.

For EIP speed, we argue that capacity slack again strengthens the early-mover advantage of EIP. Capacity slack allows early EIP adopters to experiment with new product innovations without creating disruptions to the existing processes. Environmental innovations are often uncertain in nature (Porter and van der Linde, 1995), and early engagement further increases the level of uncertainty and the chances that simple mistakes become costly disruptions due to lack of experience (Liao et al., 2009). However, available slack resources can absorb disruptions arising from early engagements in EIP, safeguarding internal operations during the innovation process (Azadegan et al., 2013). For instance, a firm could utilize excess

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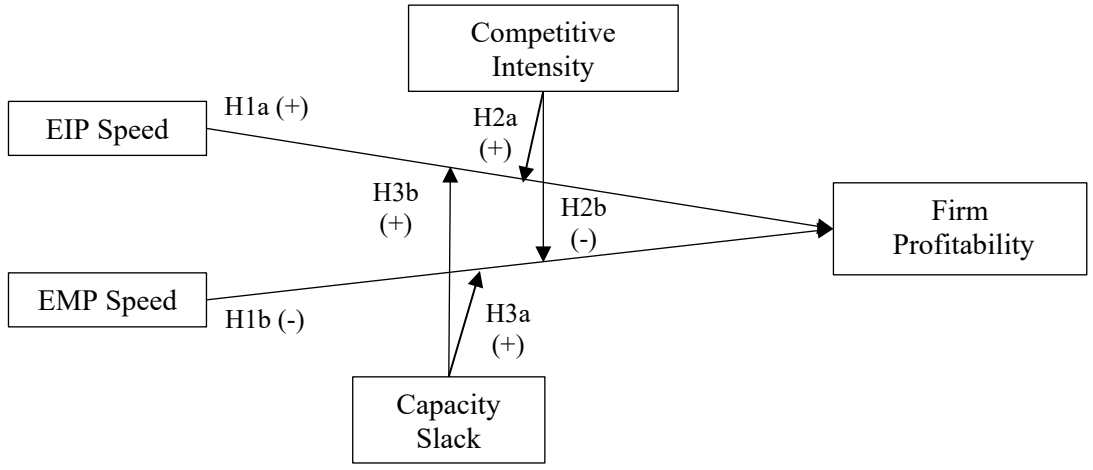
resources to explore alternative eco-friendly packaging solutions that reduce material usage and waste generation, without compromising their main packaging processes. Likewise, a firm could use spare engineering capacity to manage a side project developing eco-friendly product alternatives, like bioplastics or carbon-neutral goods, ensuring that the pursuit of environmental innovation initiatives proceeds without interfering with the storage needs of current inventory.

Finally, a lack of internal fit between practices and existing organizational structure (Siggelkow, 2001) could emerge when adopting EIP early since developing green products or services may require firms to develop new ways of operating that deviate from existing operations and routines, which leads to an internal misfit. Capacity slack resources can help absorb uncertainty due to the lack of internal fit and provide room for the benefits of early engagement of EIP to flourish (Bourgeois 1981). As a result, we reason that engaging in EIP early is more effective in a high slack resources environment.

Hypothesis 3b (H3b): The extent of capacity slack positively moderates the relationship between EIP adoption speed and firm profitability.

Figure 1 summarizes the conceptual model in this study.

Figure 1. Conceptual Model



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3. Empirical Approach

3.1. Data

This study uses Refinitiv's Asset4 database, a leading data source of firms' environmental, social, and governance (ESG) performance for financial investors and institutions (Lubin et al., 2017). Refinitiv collects publicly available ESG information, including firms' annual financial reports and social responsibility reports, articles from non-governmental organizations (NGOs), ESG-related news, and trade journals and publications. The Asset4 database contains about 400 firm-level metrics and covers more than 9,000 firms globally. For example, an Asset4 metric could be an indicator representing the adoption of environmental practice, a quantitative index like the amount of greenhouse gas emissions in tons, or a percentage indicating the diversity of board members. We focus on three specific industries: chemicals and allied products (SIC 28), industrial, commercial machinery and computer equipment (SIC 35), and electronic and other electrical equipment (SIC 36) since they are the three largest manufacturing sectors observed in Asset4 (representing approximately 44% of samples in manufacturing).

We obtain the adoption of environmental practices for our sample firms from Asset4 and their financial metrics from Thomson Reuter's WorldScope database from 2007 to 2016. The final panel data consists of 5,330 firm-year observations. Table 1 shows the summary statistics of the sample firms.

Table 1. Descriptive statistics of sample firms

	Mean	S.D.	Min	Max
ROA	5.927	10.374	-46.61	36.03
Revenue ($M US)	1,046.587	8,645.697	0	228,692.70
Total Capital ($M US)	1,112.107	11,152.320	0	296,044.00
Total Asset ($M US)	1,098.763	9,014.101	0	256,852.90
Number of employees	24,527.290	50,598.430	0	1,290,000

Note: 5330 observations and 854 unique firms

3.2. Variables

Dependent Variable

Firm Profitability: We measure firm profitability using return on assets (ROA), which is the ratio of a firm's net income and total assets (Waddock and Graves, 1997; Kovach et al., 2015). ROA measures a

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firm's profitability through the efficiency of asset utilization (Kovach et al. 2015). Past social responsibility studies have used ROA to examine the effects of environmental practices on firm financial performance (e.g., Hart and Ahuja, 1996; Russo and Fouts, 1997; King and Lenox, 2002).

Independent Variables

The Adoption Speed of Environmental Innovation Practices (EIPSpd) and Environmental Management Practices (EMPSpd): For measuring EIP speed, we adapt a composite measure developed by Ioannou et al. (2022), which consists of practices on the policy and implementation of environmental innovation products or services from Asset4. For measuring EMP speed, we adapt a composite measure from Hardcopf et al. (2019), which consists of a list of environmental practices aiming to reduce negative environmental impacts. For both measures, we remove the practices that no longer exist in the latest version of Asset4 as the result of several revisions. Tables 2 and 3 show the environmental practices used to construct EIP speed and EMP speed, respectively. We examine the number of adoptions of each practice (see Tables 2 and 3) and observe that these practices are adopted by at least one firm in our focal industries, suggesting that firms in these industries engage in these environmental practices actively and broadly.

Table 2. Environmental innovation practices (EIP)

Title	Description	Indicator	# of adoptions and %
Eco-Design Products	Does the company report on specific products which are designed for reuse, recycling, or the reduction of environmental impacts?	ENPIDP069	1748 (32.80%)
Environmental Products	Does the company report on at least one product line or service that is designed to have positive effects on the environment, or which is environmentally labeled and marketed?	ENPIDP019	3074 (57.68%)
Noise Reduction	Does the company develop new products that are marketed as reducing noise emissions?	ENPIDP026	755 (14.17%)
Take-back and Recycling Initiatives	Does the company report about take-back procedures and recycling programs to reduce the potential risks of products entering the environment?	ENPIDP047	1105 (20.73%)
Product Environmental Responsible Use	Does the company report about product features and applications or services that will promote responsible, efficient, cost-effective and environmentally preferable use?	ENPIDP048	3378 (63.38%)

Note: Total observation is 5330 for SIC 28, 35, and 36 for the period between 2007 and 2016

After identifying practices that pertain to EIP and EMP, we construct EIP speed and EMP speed according to the following steps. We first calculate a focal firm's adoption speed of *each* EIP and EMP practice by subtracting the adoption year of the focal firm from the adoption year of the industry leader (by the two-

digit SIC code). If a firm did not adopt a certain practice in the sample, the adoption speed of such practice is set to -10 (i.e., lag for 10 years), indicating that the practice was not adopted by the focal firm across the sample period of 10 years. Next, we utilize principal component analysis (PCA) to construct composite indices of EIP speed and EMP speed to capture the interdependencies and the relative importance of the underlying environmental practices[2]. As a result, EMP speed and EIP speed are composite indices that assess the overall tendency of firms to adopt a set of practices early or late compared to the industry peers. EIP speed and EMP speed for each firm-year are denoted as $EIPSpd_{i,t}$ and $EMPSpd_{i,t}$, respectively.

[2] We thank the review team for suggesting the PCA approach.

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Table 3. Environnemental management practices (EMP)

Title	Description	Indicator	# of adoptions and %
Environmental Supply Chain	Does the company describe, claim to have or mention processes in place to include its supply chain in the company's efforts to lessen its overall environmental impact?	ENRRDP0125	2805 (52.63%)
Materials Sourcing Environmental Criteria	Does the company claim to use environmental criteria (e.g., life cycle assessment) to source or eliminate materials?	ENRRDP029	2519 (47.27%)
Environmental Supply Chain	Does the company use environmental criteria (ISO 14000, energy consumption, etc.) in the selection process of its suppliers or sourcing partners?	ENRRDP058	2989 (25.08%)
Environmental Supply Chain	Does the company report or show to be ready to end a partnership with a sourcing partner, if environmental criteria are not met?	ENRRDP059	901 (16.91%)
Emissions Trading	Does the company report on its participation in any emissions trading initiative?	ENERDP068	740 (13.89)
Emission Reduction Processes/Emissions	Does the company describe, claim to have or mention processes in place to improve emission reduction?	ENERDP0051	3397 (63.74%)
Emission Reduction Processes/Biodiversity	Does the company describe, claim to have or mention processes in place to reduce its impact on biodiversity?	ENERDP019	961 (18.03%)
Waste Reduction Total	Does the company report on initiatives to recycle, reduce, reuse, substitute, treat or phase out total waste?	ENERDP062	3378 (63.38%)
e-Waste Reduction	Does the company report on initiatives to recycle, reduce, reuse, substitute, treat or phase out e-waste?	ENERDP063	765 (14.30%)
Environmental Partnerships	Does the company report on partnerships or initiatives with specialized NGOs, industry organizations, governmental or supra-governmental organizations, which are focused on improving environmental issues?	ENERDP070	2291 (42.99%)
Environmental Restoration Initiatives	Does the company report or provide information on company-generated initiatives to restore the environment?	ENERDP076	1244 (23.34%)
Staff Transportation Impact Reduction	Does the company report on initiatives to reduce the environmental impact of transportation used for its staff?	ENERDP081	1171 (21.97%)
Environmental Investments Initiatives	Does the company report on making proactive environmental investments or expenditures to reduce future risks or increase future opportunities?	ENERDP095	1243 (23.32%)
Environment Management Team	Does the company have an environmental management team?	ENERDP004	3086 (57.98%)
Environment Management Training	Does the company train its employees on environmental issues?	ENRRDP008	3142 (58.95%)
Resource Efficiency Processes/ Water Efficiency	Does the company describe, claim to have or mention processes in place to improve its water efficiency?	ENRRDP0121	2589 (48.58%)
Resource Efficiency Processes/ Energy Efficiency	Does the company describe, claim to have or mention processes in place to improve its energy efficiency?	ENRRDP0122	3496 (65.60%)
Renewable Energy Use	Does the company make use of renewable energy?	ENRRDP046	2262 (42.44%)
Green Buildings	Does the company report about environmentally friendly or green sites or offices?	ENRRDP052	1293 (24.26%)

Note: Total observation is 5330 for SIC 28, 35, and 36 for the period between 2007 and 2016.

The following example illustrates how composite indices of speed measures are constructed in this study. First, consider one EIP practice—*Does the company report about product features and applications or services that will promote responsible, efficient, cost-effective and environmentally preferable use?*

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(ENPIDP048), for firms in the chemical industry (SIC 28). Mitsubishi Chemical reported the adoption of this practice in 2007, and it was the industry leader. Meanwhile, Eastman Chemical adopted it in 2008, and Eli Lilly adopted it in 2012, which are 1 and 5 years behind the leader. As a result, the adoption speed of Mitsubishi for this EIP practice is 0, while the adoption speed of Eastman and Eli Lilly are -1 and -5, respectively.

Although Mitsubishi led in a specific EIP practice, it had not adopted others in 2008. Therefore, its EIP adoption speed vector was [0, -10, -10, -10, -10]. The PCA score of the composite index ($EIPSpd_{i,t}$) was -0.905. Eastman adopted three out of five EIP practices in 2008, and they were all one year behind their corresponding industry leaders. As such, Eastman's speed vector was [-1, -1, -1, -10, -10], and its PCA score was 1.126. The score highlights that Eastman adopted EIP practices faster than Mitsubishi. This example also shows how the speed variable measures the overall adoption speed across a set of environmental practices rather than a specific practice.

Competitive Intensity (CompInt). We use the Herfindahl-Hirschman Index (HHI), a well-established measure for competitive intensity. HHI is the sum of the squares of market shares at the industry level (Russo and Fouts, 1997; Fu et al., 2019). To obtain a more comprehensive measure of competitive intensity around the globe, we first use the Orbis database to obtain HHI at the SIC 3-digit level from 2010-2016. Previously known as Amadeus and maintained by Bureau van Dijk, Orbis is a business information dataset focusing on the ownership of public and private companies around the world. We then supplement the data with Compustat Global to obtain HHI from 2007 to 2009. Specifically, the competitive intensity for company i in industry k, country c, and year t is calculated as

$$CompInt_{i,t} = 1 - \sum_{i \in k}^{N} \left(\frac{Revenue_{c,i,t}}{Revenue_{c,k,t}} \right)^2$$

where N indicates all firms in industry k and country c. The resulting value is $[0, 1]$, and a higher value indicates a stronger competitive intensity.

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Capacity Slack (CapSlack). Following prior studies, we measure the capacity slack of firm i as the ratio of property, plant, and equipment to sales in year t and denote it as $CapSlack_{i,t}$ (Kovach et al., 2015). We take the natural logarithm of the value to limit the impact of extreme value. To ease the interpretation and avoid potential multicollinearity concerns, we center the moderators by their SIC 2-digit industry median.

Control Variables

We include several time-varying controls to account for firm-level factors that may influence firm profitability.

Firm Size. The literature has indicated that the size of a firm could play an influential role in the firm's performance (e.g., Russo and Fouts, 1997; Klassen and Whybark, 1999; King and Lenox, 2001). We measure firm size as the natural logarithm of the number of employees (Klassen and Whybark, 1999; Su et al., 2015).

Financial Slack. To control for potential relationships between financial slack and profitability examined in the literature (e.g., Modi and Cantor, 2021), we include financial slack, measured as the natural logarithm of the ratio of current assets to current liability.

Capital Intensity. Capital intensity may influence firm profitability, as shown in several prior studies (Hart and Ahuja, 1996; Russo and Fouts, 1997; King and Lenox, 2001). We measure capital intensity as the natural logarithm of the ratio of revenue to total assets (King and Lenox, 2001).

Financial Leverage. The extent of a firm's financial leverage may also affect firm profitability (Hart and Ahuja, 1996; King and Lenox, 2001; Kroes et al., 2012). We measure financial leverage as the natural logarithm of the ratio of debt to total equity (Bae et al., 2011).

R&D Intensity. Prior studies such as McWilliams and Siegel (2000) have shown that Research and Development (R&D) intensity influences firm profitability. Following prior studies, we measure R&D intensity as the natural logarithm of the ratio of R&D expenditure to sales revenue (Hart and Ahuja, 1996; King and Lenox, 2002). To remedy the situation that approximately 50% of our sample firms do not report R&D expenses, we follow the approach suggested by Koh and Reeb (2015) and replace the missing R&D

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intensity with the industry average at the three-digit SIC code level and add a dummy variable indicating firms with missing R&D expenses. Table 4 reports the descriptive statistics and correlations of the study variables.

Table 4. Descriptive Statistics and Correlations

Panel A: Descriptive Statistics

	Mean	S.D.	Min	Max
(1) ROA	5.927	10.374	-46.610	36.030
(2) EIP speed	-0.227	1.693	-2.184	3.272
(3) EMP speed	-0.403	3.015	-4.299	6.068
(4) Competitive intensity	-0.110	0.269	-0.885	0.223
(5) Capacity slack	-0.011	0.885	-5.908	5.251
(6) Firm size	9.192	1.596	1.099	14.070
(7) Financial. Slack	0.104	0.630	-2.494	4.103
(8) Capital intensity	0.276	0.584	-6.488	4.605
(9) Financial leverage	3.509	1.638	-4.605	10.455
(10) R&D intensity	1.323	1.376	-4.605	12.682
(11) R&D missing dummy	0.110	0.313	0.000	1.000

Panel B: Correlations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(2)	-0.005									
(3)	0.071***	0.653***								
(4)	-0.100***	-0.094***	-0.107***							
(5)	-0.286***	0.112***	0.104***	0.104***						
(6)	0.150***	0.472***	0.601***	-0.124***	0.032**					
(7)	-0.019	-0.247***	-0.252***	0.201***	0.030**	-0.406***				
(8)	-0.301***	-0.229***	-0.164***	0.112***	0.311***	-0.324***	0.353***			
(9)	-0.174***	0.135***	0.066***	-0.069***	0.058***	0.194***	-0.479***	-0.082***		
(10)	-0.310***	-0.136***	-0.029**	0.175***	0.089***	-0.226***	0.407***	0.439***	-0.165***	
(11)	0.053***	-0.167***	-0.178***	-0.159***	-0.005	-0.146***	0.005	0.058***	0.006	-0.075***

Note: *** p<0.01, ** p<0.05, * p<0.10.

3.3. **Model Specification**

Past studies have shown that financial performance can be persistent (Choi and Wang, 2009; Suarez et al., 2013). To account for the path dependence, we include the lagged dependent variable as a control (Suarez et al., 2013), which results in a dynamic panel model. While the approach helps control for potential omitted variable biases, the inclusion of the lagged dependent variable makes the ordinary least square (OLS) regression with firm-level fixed effects inappropriate (Wooldridge, 2015). In addition, firms' decisions to engage in environmental practices are likely endogenous. However, the valid external instruments are limited. Therefore, we use the system-GMM approach (Holtz-Eakin et al., 1988; Arellano and Bond, 1991; Roodman, 2009a) to address these concerns. This approach is appropriate for an unbalanced dynamic panel

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with fewer time periods and many units, like our data (Flannery and Hankins, 2013), and has been employed in prior environmental management studies (Sartal et al., 2020; Modi and Cantor, 2021).

The system-GMM approach relies on generating the estimations from a system of equations including the original equation and the equation transformed by the first-difference approach. Arellano and Bover (1995) and Blundell and Bond (1998) show that estimations using the first-difference equation could be biased when the dependent variable is strongly path dependent (i.e., the estimated coefficient of the lagged dependent variable is close to 1). Stacking the original equation with the first differenced equation and solving them as a system of equations addresses this concern, which results in efficient and unbiased estimates. Accordingly, the following models are used to test hypotheses 1a and 1b:

$$ROA_{i,t} = \alpha\, ROA_{i,t-1} + \beta_1\, EIPSpd_{i,t} + \beta_2\, EMPSpd_{i,t} + \beta_3\, CompInt_{c,k,t} + \beta_4\, CapSlack_{i,t} + \gamma Z_{i,t} + \mu_t + \nu_i + \epsilon_{i,t} \quad (1)$$

$$\Delta ROA_{i,t} = \alpha\, \Delta ROA_{i,t-1} + \beta_1\, \Delta EIPSpd_{i,t} + \beta_2\, \Delta EMPSpd_{i,t} + \beta_3\, \Delta CompInt_{c,k,t} + \beta_4\, \Delta CapSlack_{i,t} + \gamma \Delta Z_{i,t} + \mu_t + \Delta u_{i,t} \quad (2)$$

where equation (1) is the level equation, and (2) is the first-difference equation. $Z_{i,t}$ is the set of time-varying firm-level control variables, μ_t represents year dummy variables for time-fixed effects, and ν_i, $\epsilon_{i,t}$ are firm heterogeneity and idiosyncratic errors. In addition, $\Delta u_{i,t} = \Delta \nu_i + \Delta \epsilon_{i,t} = (\nu_i - \nu_i) - (\epsilon_{i,t} - \epsilon_{i,t-1}) = \Delta \epsilon_{i,t}$. That is, the first-differenced equation eliminates the term ν_i and eliminates the potential implications of unobserved firm heterogeneity. To test the remaining hypotheses, we add the corresponding interaction terms:

$$ROA_{i,t} = \alpha\, ROA_{i,t-1} + \beta_1\, EIPSpd_{i,t} + \beta_2\, EMPSpd_{i,t} + \beta_3\, CompInt_{c,k,t} + \beta_4\, CapSlack_{i,t} + \beta_5\, EIPSpd_{i,t} \times CompInt_{c,k,t} + \beta_6\, EMPSpd_{i,t} \times CompInt_{c,k,t} + \beta_7\, EMPSpd_{i,t} \times CapSlack_{i,t} + \beta_8\, EIPSpd_{i,t} \times CapSlack_{i,t} + \gamma Z_{i,t} + \mu_t + \nu_i + \epsilon_{i,t} \quad (3)$$

$$\Delta ROA_{i,t} = \alpha\, \Delta ROA_{i,t-1} + \beta_1\, \Delta EIPSpd_{i,t} + \beta_2\, \Delta EMPSpd_{i,t} + \beta_3\, \Delta CompInt_{c,k,t} + \beta_4\, \Delta CapSlack_{i,t} + \beta_5\, \Delta EIPSpd_{i,t} \times \Delta CompInt_{c,k,t} + \beta_6\, \Delta EMPSpd_{i,t} \times \Delta CompInt_{c,k,t} + \beta_7\, \Delta EMPSpd_{i,t} \times \Delta CapSlack_{i,t} + \beta_8\, \Delta EIPSpd_{i,t} \times \Delta CapSlack_{i,t} + \gamma \Delta Z_{i,t} + \mu_t + \Delta u_{i,t} \quad (4)$$

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The system-GMM approach also exploits the nature of panel data by generating internal instruments using lagged dependent and independent variables under the assumption of lacking valid external instruments. Specifically, lagged dependent variables and endogenous independent variables are used as instruments in the difference equation, and lagged and differenced dependent variables and endogenous independent variables are used as instruments in the level equation. By incorporating these instruments to assess the influence of the variables on the dependent variable over and above their past value, the approach addresses the path dependence of the dependent variable and controls for the potential endogeneity of independent variables (Arellano and Bover, 1995; Blundell and Bond, 1998).

Accordingly, we consider the lagged dependent variable as a valid instrument and generate GMM-style instruments to control path dependence. To mitigate the concern that unobserved variables could drive a firm's decision to adopt practices, we also specify the firm's adoption speeds (i.e., EIP speed and EMP speed) and their interactions with the moderators (i.e., competitive intensity and capacity slack) as endogenous and generate GMM-style instruments similar to the lagged dependent variable. To control for the instrument proliferation issue (Roodman, 2009b) and to avoid the trade-off between model efficiency and sample shrinkage, we follow the suggestion by Roodman (2009a, pg. 108) and include all available lags and use the collapse approach throughout this study. Last, we use the two-step system-GMM estimator with Windmeijer-corrected cluster robust standard errors to account for potential heteroscedasticity and possible autocorrelation within panels (Windmeijer, 2005; Roodman, 2009b).

4. Results

Table 5 summarizes the overall results. Model 1 gives the results of the model including only the control variables. All controls except firm size are statistically significant. The lagged ROA is positively related to the current ROA, indicating financial performance is path dependent. Further, the current ROA is positively correlated with financial slack but negatively correlated with financial leverage and R&D intensity.

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Table 5. Effects of adoption speeds (EIP and EMP) on firm profitability (ROA) and the moderating effects of competitive intensity and capacity slack.

VARIABLES	Model 1	Model 2	Model 3
EIPSpd (H1a)		0.884*	0.569*
		(0.462)	(0.311)
EMPSpd (H1b)		0.125	-0.010
		(0.233)	(0.166)
EIPSpd ×			1.754***
CompInt (H2a)			(0.565)
EMPSpd ×			-0.813**
CompInt (H2b)			(0.325)
EMPSpd ×			0.459**
CapSlack (H3a)			(0.225)
EIPSpd ×			0.261
CapSlack (H3b)			(0.370)
CompInt	1.099	0.700	-0.368
	(1.209)	(0.844)	(0.610)
CapSlack	-6.295	-5.798**	-2.742***
	(4.079)	(2.288)	(0.563)
Lagged ROA	0.380***	0.412***	0.410***
	(0.048)	(0.037)	(0.039)
Financial Slack	1.748***	1.680***	1.464***
	(0.381)	(0.379)	(0.421)
Firm Size	0.306	-0.323	-0.075
	(0.198)	(0.210)	(0.193)
Capital Intensity	0.444	0.636	-0.780
	(2.302)	(1.434)	(0.565)
Financial Leverage	-0.437***	-0.415***	-0.511***
	(0.130)	(0.133)	(0.123)
R&D Intensity	-0.955**	-0.829***	-0.537***
	(0.422)	(0.296)	(0.188)
R&D Intensity	1.399*	1.632**	0.948
Missing Dummy	(0.724)	(0.743)	(0.713)
Observations	3,539	3,539	3,539
Number of firms	611	611	611
Wald X^2	2216***	2221***	2540***
Arellano-Bond tests			
AR(1) in first differences	-6.145***	-6.030***	-5.413***
AR(2) in first differences	1.047	1.048	0.907
Over identification			
Hansen test X^2	1.363	27.82	118.7
Hansen test p-value	0.987	0.723	0.491

Note: Cluster robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; Fixed effect estimates for time are omitted.

Model 2 introduces both variables (*EIPSpd* and *EMPSpd*) into the GMM equation system (i.e., equations 1 and 2). The variance-inflation factors (VIFs) range from 1.09 to 2.51, which is below the general guideline of 10 (Kutner et al., 2005). The max conditional index (excluding year dummies) is 12.6, further easing the concern of multicollinearity (Cohen et al., 2013). The estimated coefficients for EIP speed and EMP speed are not statistically significant at the 5% level ($\beta_1 = 0.884$ with $p = 0.055$ and $\beta_2 = 0.125$ with $p =$

0.591). As a result, we do not find strong support for H1a and H1b, but the effects of EIP speed and EMP speed need to be understood in relation to the interaction variables.

To test H2a, H2b, H3a, and H3b, Model 3 incorporates the interaction terms between adoption speeds and competitive intensity (*CompInt*) and capacity slack (*CapSlack*) in the equation system (i.e., equations 3 and 4). The results in Model 3 offer support for H2a ($\beta_5 = 1.754$ with $p = 0.002$) and H2b ($\beta_6 = -0.813$ with $p = 0.012$), indicating a positive moderating effect of competitive intensity on the relationship between EIP speed and ROA and a negative moderating effect of competitive intensity on the relationship between EMP speed and ROA. Further, the results offer support for H3a ($\beta_7 = 0.459$ with $p = 0.041$), highlighting a positive moderating effect of capacity slack on the relationship between EMP speed and ROA. However, the results do not support H3b ($\beta_8 = 0.261$ with $p = 0.480$). Jointly, the results indicate that while adoption speeds do not have a clear direct effect on firm profitability, firms in a more competitive environment are likely to enjoy higher profits from adopting EIP earlier and adopting EMP later. Also, firms with more capability slack are more likely to gain benefits by adopting EMP earlier. Nonetheless, capacity slack does not influence the effect of EIP speed. Figures 2 and 3 show the interaction plots and confidence intervals of the moderating effects of competitive intensity and capacity slack. The interaction plots demonstrate that the effects of EIP speed and EMP speed do change under different levels of competition and capacity slack, which corroborates the main findings.

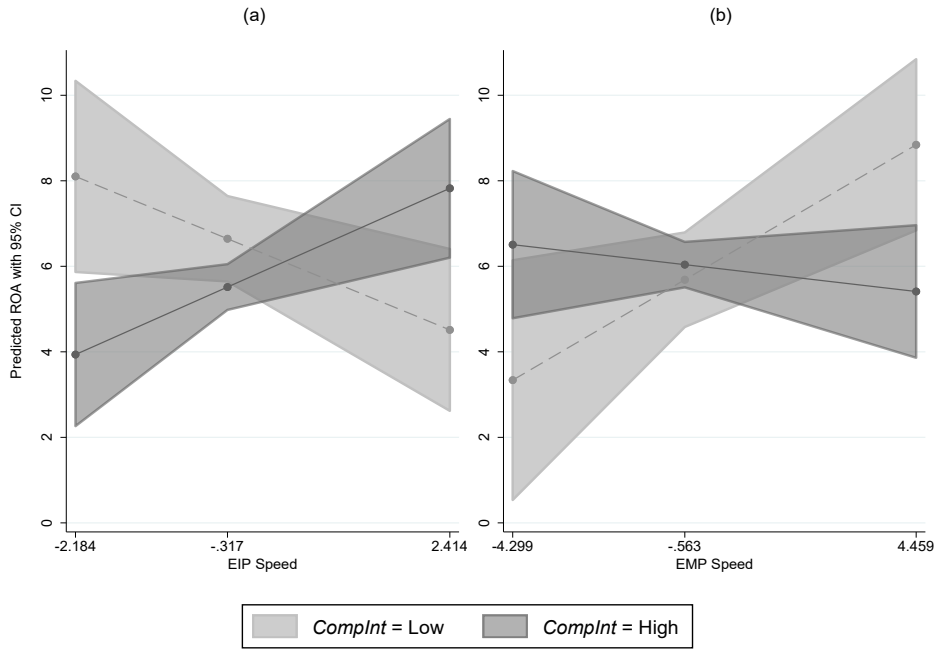
To better understand the specific empirical range of the moderating effects, we construct the Johnson-Neyman plots (Johnson and Neyman, 1936; Potthoff, 1964) shown in Figures 4 and 5. Figure 4(a) demonstrates that the marginal effect of EIP speed is significant when the competition level is relatively high (greater than 0.03, about the 60th percentile) and not significant when the competition level is low. This result implies that increasing EIP speed gains a greater advantage under a high competition level. Figure 4(b) shows that the marginal effect of EMP speed is significant when the competition level is extremely low (below -0.47, about 13th percentile), indicating that increasing EMP speed is more effective under an extremely low competition level. Figure 5(a) demonstrates that the marginal effect of EIP is not

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significant across the entire range of capacity slack, which confirms the main result. Figure 5(b) shows that the marginal effect of EMP speed is significant under a moderate to high level of capacity slack (greater than 0.07, about 54th percentile) and not significant under a low level of capacity slack. This finding suggests that increasing EMP speed is more advantageous under a high level of capacity slack.

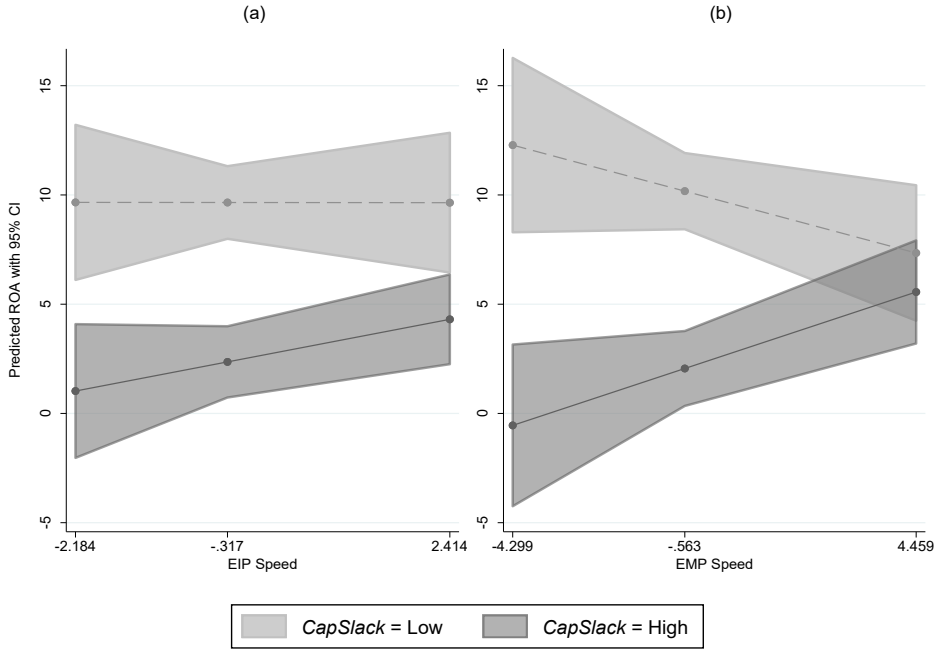
Figure 2. The moderating effects of competitive intensity and capacity slack



Note: To construct Figures 2(a) and 2(b), we use the results of Model 3 in Table 5 to calculate the expected ROA. For 2(b), we set the competitive intensity at its 5th percentile as low and 95th percentile as high (-0.773 and 0.154) and have EIP speed at the 5th, 50th, and 95th percentiles (-2.184, -0.317, and 2.414). All other variables are at their mean. For 2(b), we set competitive intensity as the same as in 2(a) and have EMP speed at the 5th, 50th, and 95th percentiles (-4.299, -0.563, and 4.459).

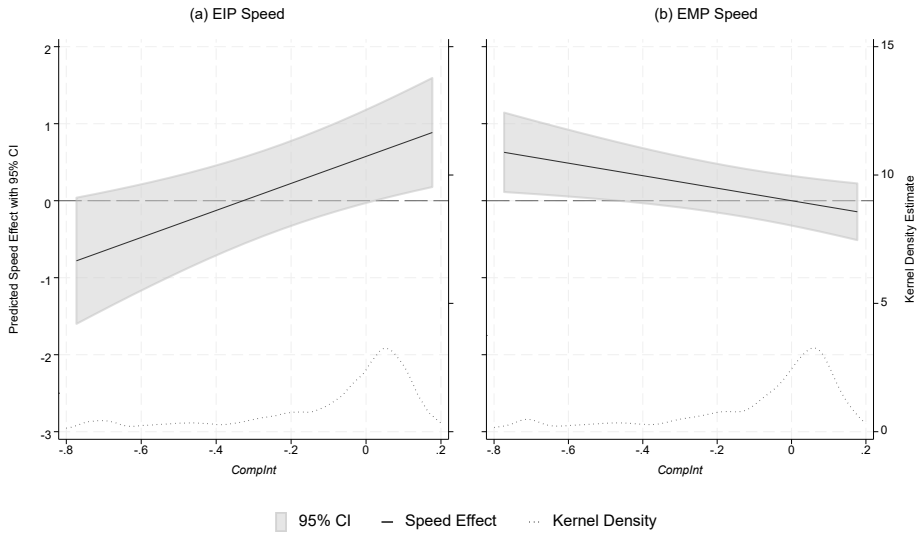
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Figure 3. The moderating effects of capacity slack



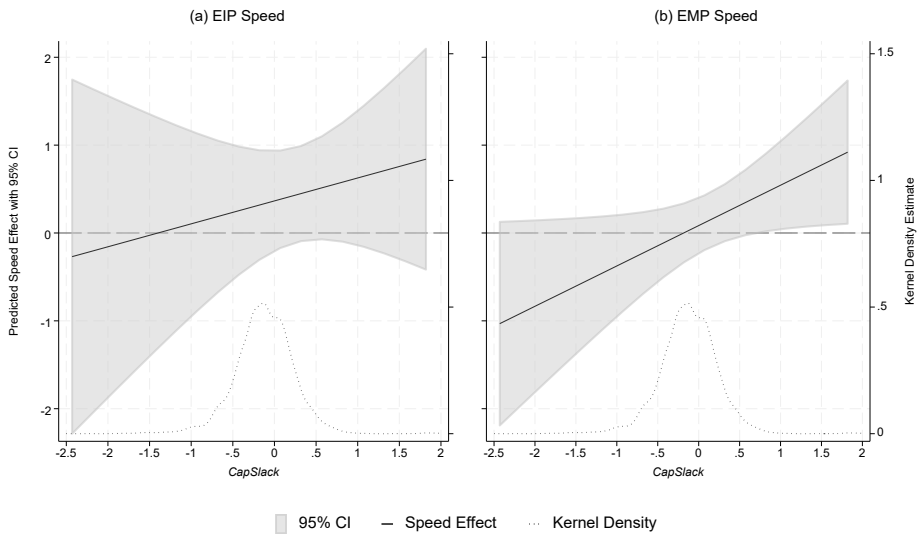
Note: To construct Figures 3(a) and 3(b), we use the results of Model 3 in Table 5 to calculate the expected ROA. For 3(a), we set the capacity slack at its 5th percentile as low and 95th percentile as high (-1.411 and 1.334) and have EIP speed at the 5th, 50th, and 95th percentiles (-2.184, -0.317, and 2.414). All other variables are at their mean. For 2(b), we also set capacity slack as the same as in 3(a) and have EMP speed at the 5th, 50th, and 95th percentiles (-4.299, -0.563, and 4.459).

Figure 4. The average marginal effect of EIP speed (H2a) and EMP speed (H2b) as a function of competitive intensity



Note: To construct Figures 4(a) and 4(b), we use the results of Model 3 in Table 5 to calculate the marginal impact of speed on ROA. For 4(a), we vary the competitive intensity from -0.882 (1st percentile) to 0.192 (99th percentile) and estimate the marginal impact of increasing EIP speed by a unit. All other variables are at their mean. For 4(b), we vary the competitive intensity in the same range to estimate the marginal impact of increasing EMP speed by a unit.

Figure 5. The average marginal effect of EIP speed (H3b) and EMP speed (H3a) as a function of capacity slack



Note: To construct Figures 5(a) and 5(b), we use the results of Model 3 in Table 5 to calculate the marginal impact of speed on ROA as well. For 5(a), we vary the capacity slack from -2.430 (1st percentile) to 2.025 (99th percentile) and estimate the marginal impact of increasing EIP speed by a unit. All other variables are at their mean. For 5(b), we vary the capacity slack in the same range to estimate the marginal impact of increasing EMP speed by a unit.

We further examine the validity of our system-GMM approach. The approach requires the absence of the second-order serial correlation in the error term. The Arellano-Bond tests show serial correlation for AR(1) (-6.145 with $p < 0.001$ for model 1, -6.030 with $p < 0.001$ for model 2, and -5.413 with $p < 0.001$ for model 3) and the absence of AR(2) (1.047 with $p = 0.295$ for model 1, 1.048 with $p = 0.295$ for model 2, and 0.907 with $p = 0.364$ for model 3), indicating that the effect of past ROA on current ROA is limited to an AR(1) autoregressive process and satisfying the requirement. In addition, Hansen's over-identification test has a general rule of thumb between 0.2 and 0.9 (Roodman, 2009b). Although the test result of model 1 indicates potential overfitting (1.363 with $p = 0.987$), the test results of models 2 and 3 are within the acceptable range (27.83 with $p = 0.723$ and 118.7 with $p = 0.491$, respectively), suggesting that the number of lagged variables as instruments is adequate and easing the concern of overfitting the models.

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4.1. Post-hoc Analysis and Robustness Tests

To better understand the underlying driving forces of profitability, which can come from either increasing sales or reducing costs, we conduct an exploratory post-hoc analysis. Building on our arguments that product-oriented EIP may signal a firm's commitment to the environment and attract environmentally conscious customers, while process-oriented EMP likely focuses on improving operational efficiency, we explore the effects of EIP and EMP speed on sales and operating expenses. For brevity, we present the results in the online appendix Table A1.

The results suggest that competitive intensity positively moderates the effect of EIP speed on sales, indicating an early mover advantage of EIP in improving sales in a highly competitive environment. Additionally, the results show that capacity slack negatively moderates the effect of EMP speed on operating expenses, indicating that being an early mover in adopting EMP can reduce costs in a high capacity slack environment. In summary, these exploratory analyses show that early adoption of EIP may increase sales, while early adoption of EMP could reduce costs. We discuss the implications of these post-hoc findings in more detail in the discussion section.

Further, we conduct several additional analyses to test the robustness of the study results. To examine whether the PCA approach drives the existing results, we utilize the average score across EIP and EMP practices as alternative EIP and EMP speed measurements similar to prior studies (e.g., Waddock and Graves, 1997; Waldman et al., 2006). Table A2 in the online appendix shows the results of the models incorporating these measures.

In addition, recall that if a firm did not adopt a practice over the sample period, the adoption speed is set at -10, implying that the firm will adopt the practice right after our 10-year observation window. To examine the sensitivity of this assumption, we vary the non-adoption penalty from -10 to -20 in increments of -1, assuming that non-adopted practices will be adopted 1 to 10 years after our observation window. We report the results in the online appendix Table A3 for brevity. Overall, the sensitivity analysis indicates that as the penalty increases, the estimated coefficients remain generally consistent with the main results.

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We also test our results by alternating the practices included in the measurement of EIP speed and EMP speed. We describe the details in the online appendix and report the results in Tables A4 and A5. In sum, the test results suggest that the main findings are robust to alternative operationalization and measurement approaches.

Moreover, we investigate the effects of adoption speeds on two alternative dependent variables: return on capital employed (ROCE) and return on sales (ROS). ROCE measures solely on the returns from fixed assets and working capital, which is more closely linked to operational related activities (DeSmet, 2021). ROS, on the other hand, measures return from the aspect of sales instead of assets. The results are consistent with the main results (see Table A6 in the online appendix). Finally, we incorporate the adoption level of EIP and EMP as additional controls, measured as the ratio of a firm's number of adopted EIP (EMP) in a given year to the total number of EIP (EMP). The results are reported in the online appendix Table A7 and support our main findings.

5. Discussion

Overall, the analysis finds that the effect of EIP speed depends on the level of competitive intensity, and the effect of EMP speed depends on both the level of competition and capacity slack. Further, while the moderating effects are significant, the resulting Johnson-Neyman plots suggest that these effects fall within specific empirical ranges. This shows the boundary conditions for the benefits of adoption speed on competitive advantage and helps understand why research shows mixed results on the effect of adopting environmental practices on financial performance.

5.1. Theoretical Contributions

This study contributes to the sustainable operations literature by being the first to demonstrate the effects of adoption speed relating to two distinct orientations of environmental practices and their boundary conditions. The study sheds light on understanding *when* environmental practices can exhibit early-mover advantage, which prior studies have not yet examined.

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We show that, contrary to our expectations, EIP does not have an early-mover advantage, and EMP does not have a late-mover advantage in increasing firms' profitability. In other words, we do not find strong support for the main effects of EIP speed or EMP speed. The non-significant finding of EIP speed is similar to Richey et al. (2014), who showed that being an early or late adopter of green technologies does not influence firm performance. The non-significant finding of EMP speed confirms that consumers may not perceive process-oriented environmental improvements as delivering value to them when compared to product-oriented initiatives. This result also indicates that delaying the adoption of EMP is not a preferred strategy either. Overall, the results of the non-significant main effects could partially explain the inconclusive findings in the literature.

More importantly, the results of the Johnson-Neyman plots show that the early-mover advantage of EIP and EMP depends on distinct contextual factors within specific empirical ranges, allowing for greater precision and specificity in the findings. For example, firms in a relatively high competition level environment should engage in EIP early, supporting our argument that product-oriented innovation is more rewarding under high competition. In contrast, firms in an extremely low competitive intensity environment should engage in EMP early to obtain better profitability, supporting the notion that competing in an environment with a few dominant firms, engaging in EMP early is still a preferred strategy. Together, the results demonstrate that a highly competitive environment favors engaging early in product-oriented environmental innovations while an extremely low competitive environment favors engaging early in process-oriented environmental improvements, which are insights that have not been discussed in the literature.

In addition, firms with moderate to high levels of capacity slack can extract more value from engaging in EMP early. On the other hand, capacity slack does not influence the effect of EIP speed. It is possible that capacity slack, a form of extra operational resources, does not directly impact the effect of EIP speed due to EIP's product-oriented focus. Development of green products requires firms to build new knowledge, in which existing capacity slack may not play a significant role. Other slack resources related to knowledge

development, such as a firm's absorptive capacity, could be more relevant to the effectiveness of EIP adoption speed. We encourage future research to explore this issue further.

Further, the post-hoc findings indicate an early mover advantage of EIP speed on sales in a highly competitive environment, whereas an early mover advantage of EMP speed on operating expenses when there is substantial capacity slack. Serving as a supplement to the main analysis, these findings highlight how early adoption of different types of environmental practices might offer pathways to enhance firm profitability. In sum, an early adopter of product-oriented EIP may appeal to environmentally conscious customers and increase sales (Kohtamäki et al., 2013) under high competition. Conversely, the primary advantage of adopting process-oriented EMP early, particularly in a circumstance with high slack capacity, is likely to be cost reduction from operational efficiency rather than affecting the perception of environmentally conscious customers. These results generally align with our broader perspective that EIP (product focus) influences sales performance and EMP (process focus) influences the firm's asset efficiency. Firms can get a competitive advantage through the speed of adoption. However, the precise mechanism that leads to a competitive advantage differs between the types of practices.

The results of the robustness test incorporating the adoption level also show that the adoption speed of environmental practices has greater explanatory power than the adoption level. The finding reiterates that the adoption speed of environmental practices might be more crucial than how many environmental practices are adopted to explain financial performance, a perspective that prior studies often neglect.

Lastly, we draw on Siggelkow's (2001) notions of internal fit versus external fit to provide an overall understanding of the study results. The internal fit is the alignment between practices and internal structure, while the external fit refers to the alignment between the practices and the external environment. For EIP speed, our findings suggest that obtaining external fit is crucial, that is, getting ahead of competitors is important for engaging in EIP early. On the other hand, for EMP speed, achieving internal fit is more important, that is, adapting the internal structure to achieve better implementation of EMP practices is crucial for engaging in EMP early, as also indicated in Jacobs et al. (2015).

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Together, this research extends past studies (e.g., Jacobs et al., 2015; Su et al., 2015) and demonstrates specific boundary conditions of the competitive advantage derived from adoption speed. More importantly, we point out circumstances under which the early-mover advantage of environmental practices might not exist for firms.

5.2. **Managerial Implications**

This research has several implications for managers. First, this study helps managers quantify the effect of speed given the levels of competitive environment and internal resources. Our results suggest that, for firms under a highly competitive intensity environment (at the 95th percentile), a unit increase in the average EIP speed, i.e., firms adopt on average one year early relative to industry peers across EIP practices, is associated with a 0.58% increase in ROA, holding all other factors constant. A unit increase in the average EMP speed under an extremely low competitive intensity environment (at the 5th percentile) is associated with a 1.01% increase in ROA. As for firms with extremely high levels of capacity slack (at the 95th percentile), adopting EMP one year early is associated with a 1.17% increase in ROA.[3]

Second, Table 6 presents a strategic framework based on the empirical results. It offers the best strategic action for managers based on the levels of external competitive environment and internal resources. For firms situated in an extremely low competitive environment, they should consider adopting EMP early. For firms with a high level of capacity slack and in a highly competitive environment, they should consider adopting both EIP and EMP early. Firms with low levels of capacity slack and situated in a highly competitive environment should adopt EIP early to obtain the most financial benefit. Importantly, our findings do not provide specific recommendations for firms that have limited capacity slack and operate in moderately competitive environments, the sectors where policy-driven incentives might be most needed to encourage the early adoption of environmental practices.

[3] The magnitude of the effects is derived from robustness test using average scores (Table A2 in the online appendix) for better interpretability.

Table 6. The strategic framework of early-mover advantage of EMP and EIP

		Competitive Intensity		
		Low	Moderate	High
Capacity Slack	High	Adopt EMP early	Adopt EMP early	Adopt EMP and EIP early
	Moderate		No competitive advantage from EIP or EMP speed	Adopt EIP early
	Low			

With environmental concerns (e.g., reducing greenhouse gas emissions) increasingly becoming the forefront issue for firm stakeholders, consumers are urging firms to take action (Sarkis et al., 2010). Investors are also putting pressure on firms to adopt environmental practices. For instance, the total US assets under management using sustainable investment strategies grew 38 percent in 2017 (US SIF, 2018). Considering the pressure from these multiple stakeholders, we suggest that managers should move beyond the issue of whether to adopt and focus more on the decision of when to adopt environmental practices. This study provides a potential roadmap to inform managers of these decisions. Understanding these contingencies is important for managers to know under what conditions they can expect improved financial performance.

Furthermore, our findings help policymakers understand the conditions where firms might not have sufficient incentive to adopt environmental practices for competitive advantage. For example, Table 6 highlights that when firms do not have sufficient capacity slack and face moderate competitive intensity, neither EIP nor EMP provides a competitive advantage. In these settings, firms are unlikely to actively engage in environmental practices. As a result, policymakers may have to employ different incentives (Dhanorkar et al., 2018) to encourage firms to implement environmental practices.

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5.3. **Limitations and Future Research**

We discuss several limitations of this study. First, we rely on a secondary data source, Refinitiv's Asset4, for evaluating a firm's adoption of environmental practices. While many prior studies have utilized Asset4 to measure environmental practices (e.g., Hardcopf et al., 2019), we are limited to the practices available in the Asset4 data space and rely on Refinitiv to ensure data quality. Future studies may employ a cross-sectional survey or a case study approach to identify new practices and examine their adoption speed influence on firm performance. Further, we limit our sample to three specific manufacturing industries. While this approach helps control industry heterogeneity, the study results can only be generalized to these three industries. As such, replicating this study by analyzing a broader industry sample is worth consideration.

Additionally, the censored nature of firm adoption is a limitation. While we believe that assuming non-adopting firms will adopt right after our observation window is more reasonable than assuming they will never adopt, our sensitivity analysis reveals that extending the adoption timeline well beyond a reasonable timeframe slightly weakens the moderating effect of capacity slack on EMP speed. While our results remain consistent under varying assumptions, the finding suggests that the timeframe in which an environmental practice remains valid for adoption could be a boundary condition for observing the first-mover advantage. We encourage future research to develop adoption speed measures that could overcome this limitation.

Another potential limitation is that we assess the adoption speed across various environmental practices as a composite index rather than measuring adoption speed for a specific environmental practice, which limits our capability to examine the potential trade-offs among practices and produce more granular actionable recommendations (e.g., firms should adopt practice A earlier than practice B). While we believe that using composite indices is a reasonable compromise for an examination of the strategic implications of adoption speed, examining the impact of adoption speed of certain environmental practices in a granular context warrants a new research path.

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Further, implications of the adoption speed of other types of social or governance practices might also be different, and future research is encouraged to explore the differences. Similarly, the implications of adoption speed could also be different for environmental performance, such as reductions in greenhouse gas emissions (e.g., Fu and Su, 2020). Finally, future research could examine other contextual factors that may influence the early- or late-mover advantage of environmental practices. For example, global governmental regulations such as the Kyoto Protocol pose significant uncertainties for firms (Engau and Hoffmann, 2011). To cope with regulatory uncertainty, firms could either defer decisions and wait for more certainty (e.g., later-mover strategy) or actively try to shape the uncertainties (e.g., early-mover strategy). Future studies could examine the effectiveness of both strategies in responding to global regulatory uncertainties.

In sum, the effect of the adoption speed of environmental practices is still an understudied area in the sustainable operations literature. Therefore, we encourage future researchers to conduct studies that help managers better understand the strategic value of speed and its implications for environmental policies and firm performance.

5.4. **Conflict of Interest**

The authors declare no conflict of interest in preparing this manuscript.

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