How much do green and digital service innovations matter for firm performance? Understanding the mediating role of product creativity

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Abstract: The sudden outbreak of the COVID-19 pandemic has not only disrupted the world's economy but has also profoundly changed the internal and external circumstances of its development. Amid this crisis, green and digital service innovations have increasingly become two key factors in sustainable development. Firms have become increasingly committed to meeting consumers' growing demand for low-carbon sustainable development. For instance, they have enhanced their engagement in green and digital service innovations. Thus, this research theorises and empirically examines the relationships among green and digital service innovations, product creativity, and firm performance. More specifically, I attempt to examine whether and how the two strategies affect product creativity in enhancing firm performance. I further consider product creativity to have two specific dimensions, namely, product effectiveness and novelty. Then, I explore how these dimensions contribute to the improvement of firm performance. More importantly, I provide an in-depth understanding of the roles of product effectiveness and novelty in mediating the potential effects of green and digital innovations on firm performance. The study provides insights to management scholars and offers practical guidelines on managerial actions that practicing managers can implement to understand and undertake service innovations in their new product development better.

Keywords: green service innovation; digital service innovation; creativity; firm performance; China.

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1 Introduction

As the COVID-19 pandemic continues to spread worldwide, the clash between economic development and environmental protection is becoming increasingly prominent. According to International Monetary Fund (IMF) estimates, the global economy has experienced extraordinary disruptions three times worse than the 2008 global financial crisis over the past two years from the COVID-19 pandemic. For example, the global economy shrunk sharply by 4.4% in 2020, which was described as the worst annual plunge since the Great Depression of the 1930s. More importantly, the COVID-19 pandemic is currently estimated by the IMF to produce persistent effects on the global economy and create the sharpest global recession since World War II, thereby leading to more than $12.5 trillion by 2024. In addition, the COVID-induced global disruption has also posed severe challenges to environments and climate by threatening to slow down or even unravel the progress made on achieving the United Nations Sustainable Development Goals (SDGs). The Global Carbon Project's global carbon budget suggests that the unprecedented social distancing policies implemented to mitigate the spread of COVID-19 have caused huge disruptions to global economic activities. The ongoing outbreak of COVID-19 may become a major threat to the environment and climate by both slowing down the investments in renewable clean energy projects and delaying the expansion of renewable clean energy technologies. There is currently a global prevalence of anxiety that the ongoing COVID-19 pandemic could derail decades of progress on environmental sustainability by forcing some economies and firms to rethink their low-carbon growth policies and strategies.

Through the long history of countries undergoing severe trials in economic and social development, conventional manufacturing and service firms have tended to concentrate on extensive management and operation strategies that emphasise high input, high consumption, and low output. Despite creating material wealth and value for humans, conventional management and operation strategies have also aggravated the conflict between humans and the environment. In particular, environmental pollution, ecological damage, and green trade barriers have emerged, thus bringing a slew of challenges to firms. As a result, there is a growing concern about the effect of industrialisation on the environment (Buysse and Verbeke, 2003; Prahalad and Hamel, 1994), and a growing number of firms have been prohibited from engaging in any business activities or behaviours that may damage the environment. Therefore, how to mitigate environmental burden and achieve sustainable firm growth by rapidly developing clean technologies is becoming increasingly important for firms to mitigate environmental burden and achieve sustainable firm growth. Hence, firms have been expending their efforts on green and digital innovations to create and offer value for their consumers. One of their aims is to reduce the negative effects of their production activities on the environment. Green and digital innovations are undoubtedly the two key concepts to achieve sustainable competitive advantage and industrial expansion. In the current COVID-19 pandemic, new models and business forms based on green and digital service innovations have rapidly taken root and flourished. For example, conventional manufacturing firms are adopting numerous emerging digital technologies, such as big data, artificial intelligence, cloud computing, and mobile Internet, to keep up with the trends and penetrate all levels of economy and society.

Moreover, the government and the business community have become concerned with maximising the utilisation rate of digital technology in the post-COVID-19 world. These

entities are looking into ways to overcome the increasing environmental pressures to gain sustainable competitive advantages. In addition, firms have been seeking ways to meet the rapidly changing customer needs by engaging in green and digital innovations that help lower carbon dioxide emissions, minimise energy consumption, improve recycling processes, reduce environmental pollution, and increase biodiversity (Frenken and Faber, 2009). In particular, firms can place green and digital service innovations at the forefront of their core value and actively promote the organic integration of these innovations and the environment. These organisational tasks are critical as firms implement innovations. Amid the growing demand for responsible and sustainable corporate behaviour, green and digital service innovations are not only targeted toward environmental protection and sustainable development. Instead, these advancements are important strategic options for firms in maintaining and enhancing their core competitiveness and producing more sustainable competitive advantages than their rivals.

Against this background, green and digital innovations have attracted a great deal of attention from scholars of entrepreneurship and strategic management. However, despite the popularity of the subject and the efforts made to test the performance implications of green innovation, no conclusive and consistent evidence has been put forward in the hypothesised link between green innovation and firm performance. Nevertheless, some researchers have suggested that developing and implementing a green innovation-oriented strategy is beneficial to the environmental and financial performance of a firm (Chan, 2005; Eiadat et al., 2008; Judge and Douglas, 1998; Lin et al., 2013). Such a strategy not only directly enhances reputation and image but also indirectly improves economic performance (Roh et al., 2022; Shrivastava, 1995; Sharma and Vredenburg, 1998). In contrast, other strands of research have indicated that green innovation has no significant contribution to firm performance. Additionally, these studies have posited that innovation efforts are only given recognition when their green capabilities are fully developed and promoted within the firm (Amores-Salvadó et al., 2014). More importantly, undertaking green innovation usually requires firms to invest a significant amount of resources and capital to reduce or overcome the negative impact of their production and operation activities on the ecological environment. Such an undertaking is expected to result in higher product prices than those of their main competitors. Hence, the double blow of limited profit margins and insufficient price competitiveness arising from green innovation activities may create challenges for firms and even threaten their long-term competitive market position (Bray et al., 2011). At the same time, firms need to invest a certain amount of financial capital or other resources in waste treatment. Moreover, they must reduce waste emissions through technological upgrades. These substantial technological resources and financial capital investments will undoubtedly increase firms' manufacturing costs and cause difficulties to improve their corporate performance (Ambec and Lanoie, 2008; Olson, 2013; Palmer et al., 1995; Wong et al., 2012).

Our systematic review suggests that prior research on the relationship between green innovation and firm performance has been largely limited to the impacts of green product and green process innovations on financial performance (Xie et al., 2019). Thus, academic researchers have tended to ignore or have been unaware of the role that green service innovation plays in promoting firm performance (Chang, 2018). As these limitations represent an important research gap in the literature, the current research attempts to explore the question of whether green service innovation indeed matters in

improving the performance of firms. Although consumers have acknowledged the importance of green innovation and realised the need for firms to engage in these innovations further, they may not necessarily be willing to pay more for the firms' green innovation efforts or even find the relevance of doing so. Furthermore, consumers may only be willing to pay more for their favourite green products.

In this study, I theorise and empirically address a central question of whether or not firms that engage in developing green and digital service innovations enjoy greater firm performance and how such effects are mediated by the firms' product creativity. Building upon a resource-based view (RBV) and recent research on green and digital innovations, I argue for the importance of green and digital service innovations for firm performance in emerging markets and further expect these effects are mediated by product creativity. I argue that a firm's engagement in green and digital service innovations may serve as two important capabilities that help the firm gain competitive advantages and thus achieve superior performance. Thus, a firm's active engagement in green and digital service innovations represents important innovative companies that are closely tied to the development and enhancement of the firm's sustainable competitive advantages (Barney, 1991; Hart, 1995). Therefore, this study not only examines how green service innovation contributes to firm performance, but it also aims to help managers by investigating the potential mechanisms (i.e., product creativity) through which green service innovation efforts can generate superior firm performance. More specifically, I propose that green service innovation positively contributes to firm performance through product creativity. I theorise two widely accepted major attributes of creative products: product effectiveness and novelty (Cropley and Kaufman, 2012; Horn and Salvendy, 2006a, 2006b). Product effectiveness refers to the value and utility that creative products can offer and bring to customers. Meanwhile, product novelty emphasises the unique and distinct features of creative products. I empirically test the possible mediating role of the two characteristics of product creativity in the relationship between green service innovation and firm performance. I believe that the theoretical extension and empirical evidence in this study can provide crucial reference and guidance for firms to understand the core creation mechanism of their green service innovation strategies better.

Digital innovation not only brings major adjustments to work content, human resources, and management authority within firms. It also drastically changes the lives of consumers. Many traditional firms, especially small and medium-sized enterprises (SMEs), lack sufficient knowledge and experience in digital service innovation. As such, these firms are willing to pay high R&D expenses and invest additional resources to promote digital innovation, hoping to provide consumers with more value, experience, and utility. However, these firms generally face numerous difficulties and challenges during service innovation processes, thus resulting in a high failure rate of firm digital service innovation (Kleijnen et al., 2009). One crucial factor for this failure is that many consumers prefer to maintain the status quo. For example, innovations in digital services, such as mobile banking, online shopping, e-books, and smartwatches, have increasingly changed consumers' lives. However, consumers sometimes have trouble managing new services. For instance, the frequent need to update platforms can be bothersome to consumers, thus making consumers feel apprehensive to use these innovations (Talwar et al., 2020).

I believe that consumers' reluctance to accept digital products may also be due to the following two potential issues. First, the use of digital products requires adjustment in consumers' behavioural patterns, norms, habits, and traditional lifestyles. For instance,

numerous consumers of Apple products have reported that they will have a difficult time getting used to the Android system because they believe that the two operating systems are largely different (Kleijnen et al., 2009). This scenario is an example of the long journey that firms need to overcome when pushing for digital innovation. Considering the various challenges in digital service innovation, this study explores how digital service innovation contributes to firm performance. The core of this theoretical reasoning is that innovation should be only reflected in the products that consumers buy and use. More importantly, innovation lies in how firms create, deliver, and capture new value (Sorescu and Schreier, 2021). If innovation can be defined as the reflection and implementation of ideas and thoughts at the individual, group, and organisational levels (Ambile, 1996), creativity focuses on the unique activities that generate creative products, processes, or services (Shalley, 1995). In a value-based economy, product creativity represents an important potential resource for firms to gain a competitive advantage; moreover, product effectiveness and novelty are the main characteristics of such product creativity (Horn and Salvendy, 2009). Building upon and extending a perspective of product creativity, I specifically explore and analyse the potential mediating roles of product effectiveness and novelty in the relationship between digital service innovation and firm performance. This investigation aims to assist firms in their digital service innovation practices and promote sustainable development.

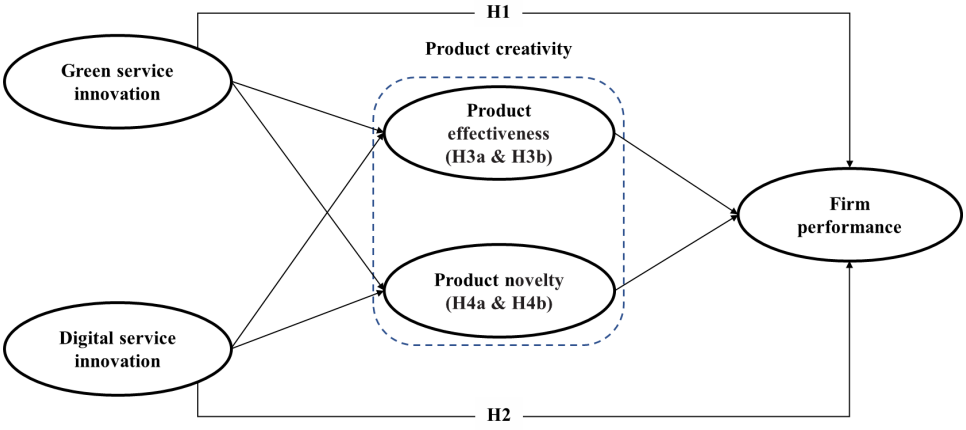
The paper is organised as follows. In the next section, I will discuss our comprehensive framework, which suggests a set of hypotheses on the impact of green and digital service innovations on firm performance. I also propose the mediating role of the characteristics of product creativity in the relationship between green and digital service innovations and firm performance. Then, I will outline the methods and empirical findings. Lastly, I will conclude the paper by discussing both the theoretical and practical contributions.

2 Theoretical background and research hypotheses

The RBV suggests that firms can be depicted as heterogeneous collections of resources and competencies (Barney, 1991; Teece et al., 1997). In particular, the VRIN (valuable, rare, costly to imitate, and non-sustainable) resources and capabilities are the most important ones that drive a firm's sustainable competitive advantages and firm performance improvement. Despite its rich contributions to our understanding of the factors explaining the variation in firms' strategic choices and performance differences, the RBV has been criticised for failing to reflect the potential role of constraints imposed by the natural environment in shaping firm competitive advantages (Hart, 1995). In this regard, prior research has developed a natural-research-based view (NRBV) of the firm by incorporating the natural environment into the RBV. According to the NRBV, a firm can develop sustainable sources of competitive advantages and achieve superior performance by grasping environmentally-oriented resources and capabilities (AlNuaimi et al., 2021; Berrone et al., 2013; Hart, 1995; Hart and Dowell, 2011). Therefore, the NRBV offers an important theoretical perspective to help us understand the crucial connection between environmental challenges and the development of a firm's capabilities. In this study, I apply and extend the NRBV by considering two important innovative capabilities (i.e., green and digital service innovations) and understanding the

links between these two important capabilities and the firm performance of firms in emerging economies. In addition, prior research on the investment theory of creativity has offered important implications for our understanding of why individuals may differ largely in their creativity. According to the investment theory of creativity, each individual is creative, but the difference lies in the types and levels of creativity (Lubart and Sternberg, 1995; Sternberg and Lubart, 1991; Zhang and Sternberg, 2009). In the context of market investments, one example of creativity is buying products at a low price and selling them at a higher price (Sternberg and Lubart, 1996). Building upon this theory, I propose a conceptual framework, as depicted in Figure 1, and subsequently develop a set of research hypotheses. I consider both green and digital service innovations as important firm innovative capabilities and examine their respective contributions to firm performance. I further incorporate two major characteristics of product creativity (i.e., product effectiveness and novelty) into the research model and investigate how different attributes of product creativity mediate the relationship between green and digital service innovation and firm performance.

Figure 1 Conceptual framework



2.1 Green service innovation and firm performance

In an attempt to strengthen environmental regulations, the government actively encourages firms to be committed to caring more about environmental protection issues by implementing innovations (Konara et al., 2021; Roh et al., 2021; Zeng et al., 2021). Given the growing contradiction between economic benefits and environmental protection, the public's awareness of environmental protection is further awakened (Yang and Roh, 2019), thus causing consumers to take action, such as boycotting polluting firms. In addition, the willingness of consumers to recognise and consume green products has strengthened. Against this background, numerous firms have started carrying out green innovation practices and technological improvements. They are also adopting equipment and process technologies with high resource utilisation and low pollutant emissions. Furthermore, firms are actively looking for ways to decrease the detrimental effects of their production and operation activities. As such, green innovation has been regarded as an effective means for firms to strike balance among the economy, resources,

and the environment (Ding et al., 2022). It has also improved the quality of products, optimised technological processes, and created high barriers to competition, thereby leading firms to adapt to environmental changes (Mirata and Emtairah, 2005).

Furthermore, green innovation is conducive to improving firms' environmental and economic performances by saving energy, reducing carbon dioxide emissions, and improving product-recycling rates (Chan, 2005; Eiadat et al., 2008; Judge and Douglas, 1998; Lin et al., 2013). Hence, firms are able to send positive environmental signals to stakeholders, such as the government. These signals positively affect the firms' corporate reputation. By taking the initiative to assume additional environmental responsibilities, firms not only directly enhance their image, but they also indirectly improve their performance (Shrivastava, 1995; Sharma and Vredenburg, 1998).

Green service innovation entails providing and developing a new service or a renewal of an existing service for customers based on environmental concerns, including the selection of environmentally friendly design and packaging (Chen et al., 2015). Green service innovation is different from previously well-researched green product and green process innovations which emphasise the importance of introducing and implementing innovative ways to reduce environmental impacts by changing or modifying product design and production process, respectively (Wang and Liu, 2022; Witell et al., 2016; Xie et al., 2019). If green innovation can positively impact firm performance, then the implementation of green service innovation will help firms gain the favor of consumers, enhance firm market competitiveness, and further consolidate and strengthen their market position, and improve their performance. Therefore, I propose the following hypothesis:

Hypothesis 1 Green service innovation contributes positively to firm performance.

2.2 Digital service innovation and firm performance

Digital innovation is the use of digital technologies and software to improve existing business processes and the overall customer experience (Mendling et al., 2020). Digital technologies are an important element of service innovation and value creation (Akaka and Vargo, 2014), as they can contribute to the integration of resources in service innovation (Yoo et al., 2010). Digital service innovation, which is based on the service-dominant logic, mainly discusses the relationship between digital technology and services. It can be further divided into purely digital products or services, and products or services combined with physical and digital components (Nylén and Holmström, 2015). Using advanced digital technologies, such as information and communication technology and artificial intelligence, firms can quickly track market trends and understand customer needs in the fastest time possible, thus guaranteeing the development of new products that meet consumer needs (Nambisan et al., 2017; Moschogianni, 2021). In the COVID-19 pandemic, the role of digital services has become prominent as firms accelerate the pace of digitalisation. Firms have improved customer satisfaction by launching digital service innovations (Singh et al., 2020) and strengthening communication and cooperation with customers (Jung et al., 2019). Digital service innovation has three aspects, namely, customer-oriented innovation, technological innovation, and collaborative innovation. Among them, customer-oriented digital service innovation is the service innovation in which firms use digital technology to solve customer problems. Technological innovation refers to the use of digital technology by firms to launch new services. Collaborative innovation means that firms use digital

technology to communicate and give feedback to customers in real time. Digital service innovation fosters closer relationships with customers, enhances customer experience, improves the quality of communication between companies and customers, and encourages customer engagement (Sedera et al., 2016; Kim et al., 2021). Customer participation enhances customers' positive evaluation of new products, boosts the firm's market competitiveness, and upgrades the firm's performance (Rust et al., 2004). Therefore, I propose the following relationship:

Hypothesis 2 Digital service innovation contributes positively to firm performance.

2.3 The mediating role of product effectiveness

Product creativity is a classification of observable characteristics that describe the level of creativity of a product (Cropley and Kaufman, 2012). Product creativity must be evaluated, controlled, and managed to allow consumers to recognise the inherent innovativeness of the product (Cropley et al., 2011). Hence, in relation to the subject of the current study, consumers must be able to see the creativity behind green innovations. These innovations are intended to reduce environmental pollution, improve environmental quality, and achieve sustainable development by innovating processes, technologies, products, and systems (Halila and Rundquist, 2011; Rennings et al., 2016; Rasi and Ester, 2016). In addition, by launching green service innovations, such as environmental protection, green design, and cleaner production, firms are able to curb pollution as well as gain a competitive advantage (Chuang and Huang, 2015; Gao et al., 2021).

Different from conventional approaches, green innovation entails the transformation of the sustainable development of the modern manufacturing industry. It is also an innovative model that comprehensively considers the environmental impact and resource efficiency of firms. Thus, green innovation minimises the negative impact of firms on the environment and improves resource utilisation in the entire life cycle of products through design, manufacturing, packaging, transportation, use, and end-of-life disposal (Guo et al., 2020). With the enhancement of people's living standards and quality, people have paid more attention to physical and mental health, quality of life, and the ideal ecological environment. Green service innovation emphasises the use of green technology and green management methods. It strictly follows the principles of 'saving resources, reducing consumption, and preventing and controlling pollution' to minimise the negative impact of the service process on the ecological environment and human health. Hence, the new products developed by firms through green service innovation can protect the environment and enhance safety and health. In a value-based economy, utility, as the main characteristic of product creativity, is a potential resource for firms to gain a competitive advantage (Horn and Salvendy, 2009).

Based on the above reasoning, the performance of firms improves significantly when their green service innovation is proven effective. In other words, the effectiveness of product creativity can play a mediating role in the relationship between green service innovation and firm performance. Therefore, I propose the following relationship:

Hypothesis 3a Product effectiveness mediates the relationship between green service innovation and firm performance.

For consumers to be sufficiently aware of a firm's product innovation process, product creativity needs to be evaluated, controlled, and managed (Cropley et al., 2011). As digital technologies become more ubiquitous and affordable, numerous firms provide not only tangible but also intangible products; thus, products become the mechanism, medium, or tool through which firms provide services (Lusch and Nambisan, 2015). Firms gain a competitive advantage through digital service innovation (Shrestha et al., 2020; Blichfeldt and Faullant, 2021). Apart from helping consumers buy and use products, digital service innovation also aids firms in creating, delivering, and capturing value in novel ways (Sorescu and Schreier, 2021). User experience is a purely subjective feeling when using a product. Hence, digital service innovation must not only be efficient to use and easy to learn, but it must also provide a rich user experience that makes users perceive the usefulness of the innovation (Nylén and Holmström, 2015). Only when firms offer customers a high level of utility and new products with well-designed aesthetics can these firms evoke good user engagement and experience; doing so can subsequently improve digital innovation management (Moschogianni, 2021).

Consumers will easily recognise new products made through digital service innovation when these products are deemed effective. Moreover, the performance of firms is expected to improve upon the success of the innovation. Therefore, I propose the following relationship:

Hypothesis 3b Product effectiveness mediates the relationship between digital service innovation and firm performance.

2.4 The mediating role of product novelty

According to creativity theory, a creative product should be a response that is novel, appropriate, useful, correct, and valuable to the issue at hand (Amabile, 1983). In relation to green innovations, numerous firms carry out creative solutions from the aspects of design, material selection, products, marketing, and consumption. From research and development to investment, these firms aim to use green innovations to address issues in the ecological environment and save resources and energy.

The development of new products covers the entire experience of product conception, creative screening, product concept formation and testing, marketing strategy formulation, business analysis, product development, market test sales, and commercial realisation transformation (Chang and Taylor, 2016; Ernst et al., 2010; La Rocca et al., 2016). In this process, creative thinking, experience, and professional knowledge are utilised. The product undergoes improvements in terms of its functions, principles, forms, structures, schemes, etc. to conform to the behaviours and needs of users. This process results in a unique product that adheres to environmental protection requirements (Chen et al., 2006). As discussed previously, green service innovation refers to the development of new products and services that address environmental concerns, such as environmentally friendly design and packaging (Chen et al., 2015).

While product creativity entails a subjective judgement of a product, it also has a certain degree of novelty; furthermore, the product is enticing and enjoyable, reflects a high degree of originality and resolution, conforms to customer preferences, and positively affects purchase intention and product satisfaction (Horn and Salvendy, 2006a). When consumers realise that a product developed by a firm through green service innovation is unique and novel, consumers will easily recognise the product, and the

firm's performance is expected to improve. Therefore, I propose the following relationship:

Hypothesis 4a Product novelty mediates the relationship between green service innovation and firm performance.

Creativity refers to the ability to generate, discover, and create new concepts; therefore, higher creativity increases the novelty of a product (Sternberg et al., 2002). Despite its subjective evaluation, product creativity also has measurable objective attributes. Firms can add value by enhancing the originality of their products, thereby positively promoting consumer attitudes and purchase intentions (Horn and Salvendy, 2006a). Driven by the unique needs of consumers, the proliferation of new products using digital technology often starts with a small group of 'innovators', who then drive 'followers' to sue the products (Lynn and Harris, 1997). The demand for uniqueness comes from people's desire to be different from others in the process of acquiring, using, and disposing of products (Tian et al., 2001).

When products become highly popular, consumers may opt to give the items up and start searching for other novel products (Snyder, 1992). New products launched after a digital service innovation can attract consumers who are more willing to buy products only if they maintain novelty (Roehrich, 2004). Thus, I can expect that when firms launch and achieve a successful digital service innovation, the firm performance only improves if the product has novelty. Therefore, I propose the following relationship.

Hypothesis 4b Product novelty mediates the relationship between digital service innovation and firm performance.

3 Methods

3.1 Sample and data collection

To test empirically the hypotheses developed in this study, I conducted surveys to collect primary data on a sample of firms in the Chinese manufacturing sector. I believe China offers an appropriate research setting to test the theoretical arguments on the importance of green and digital service innovations. This setting also allows us to explore how such innovations can contribute to firm performance by enhancing specific characteristics of product creativity. With its accession to the World Trade Organization in 2001, China has not only achieved rapid economic development but also quickly transformed its traditional economy into a green and digital one. These transformations are increasingly becoming two important mechanisms by which the country overcomes its environmental and innovation challenges and addresses the obstacles to the sustainable development of the Chinese economy. With rapid green and digital-oriented transformation, firms in China may need to recognise and fully understand the contributions of green and digital innovation. Subsequently, they may have to exploit and accelerate this transformation. As an active promoter of sustainable development, China has attached great importance to promoting sustainable digital development over the past years. In doing so, the Chinese government has launched a 'mass entrepreneurship and innovation initiative' to accelerate and upgrade the digital transformation of its economy. The central focus of the

mass entrepreneurship and innovation-based development strategy is to encourage the innovation of ideas and economic systems.

In the recent decade, China has exerted substantial efforts to introduce a wide range of policies. Moreover, the country has promoted green practices to encourage firms to seek a cleaner, greener, and more environmentally sustainable development by undertaking green innovations. China has promised to reach peak carbon emissions before 2030 and achieve carbon neutrality before 2060. The Chinese government believes that the greening of China's manufacturing sector and its whole manufacturing system will be the key to realising the two green goals for a more sustainable economic development. With these various policy encouragements and incentives to foster green, low-carbon, digital, and sustainable development, numerous Chinese firms have become highly committed to adopting various green or digital core technologies to build a high-end manufacturing system and upgrade their products, processes, and services. A recent China manufacturing innovation report released by Deloitte in 2021 suggests that 32% of surveyed firms in China have innovated their products and services over the last three years. In addition, 9% of Chinese manufacturing firms are seeking green innovations. However, despite the efforts the firms have made to build digital technology capabilities, I believe that a large number of these firms still lack a full understanding of how to develop clear systematic innovation strategies and mechanisms that are key to boosting their effective innovation.

I argue that a thorough understanding of the importance of green and digital service innovations will undoubtedly benefit a wide range of innovations, such as products, technologies, business models, and corporate management structures. I expect that these different types of innovation activities are closely related and linked in several aspects, thus potentially complementing one another. Amid the challenges in the COVID-19 pandemic, this study is not only appropriate and timely in providing useful and specific feedback on firms' innovation decision-making processes. It is also critical for understanding the underlying mechanisms through which different types of service innovation strategies contribute to the performance of manufacturing firms in general and the performance of those in emerging markets such as China.

I used a survey approach to collect data from manufacturing firms in China. To develop the survey questionnaire, I conducted an extensive and systematic review of the respective literature. I first developed an English version of the questionnaire. Then, I translated it into Chinese with the help of two independent bilingual translators. Finally, the Chinese version of the questionnaire was back-translated into English by two additional independent bilingual translators to ensure conceptual equivalence and accuracy. To ensure the content and validity of the measures to understand the latest trends in the field, I undertook in-depth virtual interviews with three managers of firms that actively engaged in service innovation activities before formally administering the questionnaires. Then, I pilot-tested the survey questionnaires with 18 firms in the Chinese manufacturing sector. On the basis of the feedback from the in-depth interviews and pilot tests, I further modified some items of the questionnaire to improve their relevance and clarity further. I gained a sample list with the assistance of a commercial provider and selected a random sample of 500 Chinese manufacturing firms that actively engaged in innovative activities. Most importantly, prior research had repeatedly suggested the potential challenges in collecting sufficient primary firm data in China and specifically argued for the use of *guanxi* networks to increase both response rate and high-quality

response (e.g., Hoskisson et al., 2000). Thus, I heeded these suggestions and applied them to the approach used in this study. To encourage survey participation and ensure high-quality responses, I conducted the formal survey with the assistance of a renowned professional research firm in China. Through this careful process, I collected 326 questionnaires. After excluding eight incomplete responses, I obtained 318 completed and usable responses, which were used for the final empirical analysis and the final data analysis.

Given the non-response bias that might arise in the survey data and possibly affect the empirical findings, I verified whether this bias existed by comparing the differences in key firm demographic characteristics between responding and non-responding firms as well as between the early and late respondents. The results indicated no significant differences between responding and non-responding firms and between early- and late-responding firms; thus, non-response bias was less likely to be a serious concern in the study (Armstrong and Overton, 1977). In addition to the potential occurrence of non-response bias, common method variance (CMV) might have also occurred if the self-report approach was used to collect data. To rule out the CMV concern, I carefully designed the questionnaires by separating the measures into several subsections; I also used a different format, which was useful in avoiding a simple 'straight line' response pattern (Chang et al., 2010; Johnson et al., 2011). Moreover, I randomised the order of the measures in the questionnaire using a unique survey software and reversed the scaling in some measures. In addition, like all other general survey research, I informed all respondents of the strict anonymity and confidentiality of their responses when introducing the survey purpose in a separate cover letter. I strongly believed that the data were less likely to suffer from serious CMV due to the efforts in reducing it in developing the questionnaire and administering the survey. Nevertheless, I followed Podsakoff et al.'s (2003) recommendation and checked for the possible presence of CMV by performing Harman's one-factor test. More specifically, I performed an exploratory factor analysis (EFA) by entering all the variables used in the study into a non-rotated factor analysis. The results of the non-rotated EFA did not produce a single factor but instead generated five factors with eigenvalues greater than one. In addition, the first factor accounted for only 44.30% of the total variance. Considering that no general apparent factor emerged in the unrotated factor structure and no single factor accounted for the majority of the variance, CMV was less likely to become a major concern in the data. To further check for the potential concern on CMV, I followed Lindell and Whitney's (2001) approach to conduct a marker variable test by including the tenure of the respondent in the model. The results did not demonstrate a significant relationship between the marker variable and all latent variables in the model, again providing evidence that CMV was less likely to be a serious issue in the data.

3.2 Variables and measurement

Unless noted otherwise, all the dependent and independent variables used in the study were measured using multiple-item, seven-point Likert scales ranging from 'strongly disagree' (1) to 'strongly agree' (7). To develop the measures for the variables in this study, I used well-established scales that were adopted from prior literature and modified them specifically for this research.

Following prior studies (Katsikeas et al., 2006; Schilke, 2014; Park and Xiao, 2020), I measured firm performance using six items, namely, profitability, profit growth, sales

growth, new product sales, customer satisfaction, and market share over the previous years relative to their competitors. Moreover, to measure green service innovation, I adopted six items from prior research (e.g., Chen et al., 2015; Chang, 2018). Similarly, building upon existing studies (e.g., Kim et al., 2021; Nylén and Holmström, 2015; Woo et al., 2021), I used five items to capture the degree of a firm's digital service innovation. Then, to measure the two major characteristics of product creativity, I followed prior research (e.g., Cropley and Kaufman, 2012; Horn and Salvendy, 2006b, 2009) and used five items to measure productivity effectiveness and five additional items to measure product novelty. Finally, I included several firm-level controls, including firm size, firm age, firm ownership, and industry category. I measured firm size as the logarithm of the total number of employees of the firm and firm age as the number of years the firm had been operating. I measured firm ownership using a dummy variable, which was equal to 1 if the firm was privately owned. To control for the industry-level effect, I developed a dummy variable, which was equal to 1 if the firm's product domain was industrial.

4 Empirical analyses and results

4.1 Reliability and validity testing

In this study, I followed the two-step approach to structural equation modelling (SEM) methods as recommended by Anderson and Gerbing (1988) to test the research hypotheses empirically. Before testing the hypotheses, I first checked the reliability and validity of the constructs by assessing the measurement properties of the scales via reliability analyses and confirmatory factor analysis (CFA).

4.2 Measure reliability and validity

Table 1 reports the results of the measurement assessment. The measurement model fit well with the data, as seen in the fit statistics for the measurement model [χ^2 (314) = 578.285, $p < 0.001$, comparative fit index (CFI) = 0.965, Tucker-Lewis index (TLI) = 0.961, incremental fit index (IFI) = 0.965, root mean square error of approximation (RMSEA) = 0.052]. Overall, as all the variables were measured using well-established scales derived from the literature, all measures exhibited strong reliability and validity. To assess the internal reliability, I checked for the Cronbach's alpha values and compositive reliabilities. As shown in Table 1, all the Cronbach's alpha values, ranging from 0.839 to 0.971, and composite reliabilities, ranging from 0.841 to 0.971, were greater than 0.80. Thus, these values exhibited strong internal reliability (Fornell and Larcker, 1981; Nunnally, 1978). To assess convergent validity, I examined factor loadings and found that all the factor loadings were higher than 0.63 and statistically significant. This result indicated the convergent validity of the measures (Anderson and Gerbing, 1988). I also assessed the convergent validity by examining the average variance extracted (AVE) values of each construct. The results showed that all AVE values were above the recommended threshold of 0.50 (ranging from 0.517 to 0.870), thus further indicating the convergent validity of the measures in the study (Fornell and Larcker, 1981). To assess discriminant validity, I compared the square root of the AVE of each construct and the correlation between the construct and other constructs in the model. As shown in Table 2, the results demonstrated that the square

root of the AVE values in italicised bold for each construct along the diagonal was much higher than the correlations between different respective constructs in the corresponding off-diagonal elements of the matrix. Hence, these measures were distinct and provided evidence for discriminant validity.

Table 1 Descriptive statistics and validity assessments

Construct and indicators	*FL*
Green service innovation (GSI) (AVE = 590, Cronbach's alpha = 0.895, CR = 0.896)	
GSI1	0.799
GSI2	0.711
GSI3	0.833
GSI4	0.733
GSI5	0.719
GSI6	0.804
Digital service innovation (DSI) (AVE = 0.870, Cronbach's alpha = 0.971, CR = 0.971)	
DSI1	0.946
DSI2	0.949
DSI3	0.949
DSI4	0.942
DSI5	0.875
Product effectiveness (PE) (AVE = 0.800, Cronbach's alpha = 0.952, CR = 0.952)	
PE1	0.901
PE2	0.928
PE3	0.895
PE4	0.888
PE5	0.859
Product novelty (PO) (AVE = 0.517, Cronbach's alpha = 0.839, CR = 0.841)	
PN1	0.639
PN2	0.728
PN3	0.633
PN4	0.741
PN5	0.834
Firm performance (FP) (AVE = 0.679, Cronbach's alpha = 0.927, CR = 0.927)	
FP1	0.809
FP2	0.834
FP3	0.819
FP4	0.842
FP5	0.814
FP6	0.825

Notes: N = 318. Model summary: $\chi 2$ (314) = 578.285, $p < 0.001$, CFI = 0.965, TLI = 0.961, IFI = 0.965, RMSEA = 0.052. AVE – average variance extracted, CR – composite reliability, FL – factor loading. Given space constraints, detailed measurement items are omitted, which are available from the authors upon request.

Table 2 Construct correlations and discriminant validity

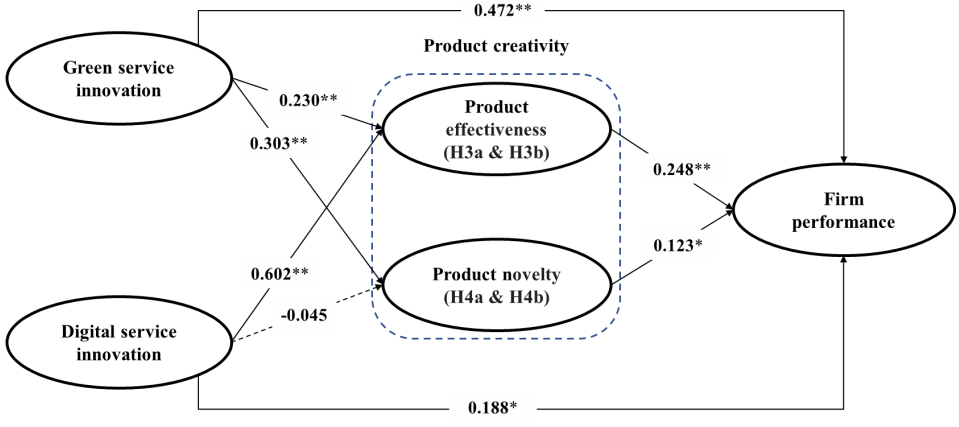
Variables		*Mean*	*STD*	*1*	*2*	*3*	*4*	*5*
1	Green service innovation	5.593	1.072	***0.768***				
2	Digital service innovation	5.686	1.442	0.455**	***0.933***			
3	Product effectiveness	6.045	1.149	0.473**	0.697**	***0.894***		
4	Product novelty	5.058	0.929	0.268**	0.101	0.142*	***0.719***	
5	Firm performance	5.639	1.085	0.657**	0.586**	0.609**	0.283**	***0.824***

Notes: N = 318. Values in italicised bold denote the square root of the average variance extracted (AVE) of each construct. *$p < 0.05$, **$p < 0.01$.

4.3 Hypotheses testing

Following the measurement model estimation, I empirically examined the theoretical model. The results of the SEM are reported in Figure 2. The model fit indices suggested that the SEM reached a satisfactory level of goodness-of-fit [$\chi^2(315) = 578.600$, $p < 0.001$, CFI = 0.965, TLI = 0.961, IFI = 0.965, RMSEA = 0.051]. Overall, the results presented in Figure 2 indicated that the variables were largely related in the theoretically predicted manner. More specifically, the results showed a significant positive relationship between green service innovation and firm performance ($b = 0.472$, $p < 0.001$) and between digital service innovation and firm performance ($b = 0.188$, $p < 0.01$), respectively. These results indicated that both green and digital service innovations positively contributed to firm performance, thus providing support for Hypotheses 1 and 2.

Figure 2 Estimated results of the structural equation analysis (see online version for colours)



Notes: Model summary: χ^2 (315) = 578.600, $p < 0.001$, CFI = 0.965, TLI = 0.961, IFI = 0.965, RMSEA = 0.051. Non-significant paths were shown by a dotted line. *$p < 0.01$, **$p < 0.001$.

Hypotheses 3a and 3b posited that product effectiveness played a mediating role in the relationships between green and digital service innovations and firm performance. Following Zhao et al.'s (2010) procedure for assessing mediation, I examined the

potential role of product effectiveness in mediating the respective effects of green service innovation and digital service innovation on firm performance, and Table 3 lists the results. First, the SEM results suggested that the indirect effects of green service innovation and digital innovation ($a \times b$) on firm performance via product effectiveness were positive and statistically significant (green service innovation: $b = 0.058$, $p < 0.01$; digital service innovation: $b = 0.112$, $p < 0.01$). Second, I found a positive and statistically significant direct effect (c) of green service innovation ($b = 0.472$, $p < 0.001$) and digital service innovation ($b = 0.188$, $p < 0.01$) on firm performance. Third, I observed that the direct and indirect effects (via product effectiveness) of green service innovation and digital service innovation on firm performance were in the same direction ($a \times b \times c$). The mediated effects of product effectiveness in the relationship between green service innovation ($b = 0.058$, $p < 0.01$) and digital service innovation ($b = 0.112$, $p < 0.01$) and firm performance ($a \times b$) were positive and statistically significant. In addition, both the direct effects (path c) of green service innovation and digital service innovation on firm performance were significant. Thus, I was able to determine the complementary mediation of product effectiveness, which provided support for Hypotheses 3a and 3b.

Table 3 Results of structural model assessment for direct and indirect effects

Effect	*Estimate*	*P-values*
Direct effects		
Green service innovation → Product effectiveness	0.230	**
Green service innovation → Product novelty	0.303	**
Green service innovation → Firm performance	0.472	**
Digital service innovation → Product effectiveness	0.602	**
Digital service innovation → Product novelty	–0.045	n.s.
Digital service innovation → Firm performance	0.188	*
Product effectiveness → Firm performance	0.248	**
Product novelty → Firm performance	0.123	*
Indirect effects		
Green service innovation → Product effectiveness → Firm performance	0.058	*
Digital service innovation → Product effectiveness → Firm performance	0.112	*
Green service innovation → Product novelty → Firm performance	0.038	*
Digital service innovation → Product novelty → Firm performance	–0.004	n.s.

Note: *$p < 0.01$, **$p < 0.001$. n.s. – non-significant.

Correspondingly, Hypotheses 4a and 4b argued that product novelty played a mediating role in the relationship between green service innovation and digital service innovation, and firm performance. Thus, we tested these hypotheses following the sampling procedure for assessing mediation. First, the SEM results suggested that the indirect effect of green service innovation ($a \times b$) on firm performance via product novelty was positive and statistically significant ($b = 0.038$, $p < 0.01$). However, digital service

innovation had no significant indirect effect on firm performance via product novelty (b = –0.004, n.s.). Second, I determined a positive and statistically significant direct effect (c) of green service innovation (b = 0.472, $p < 0.001$) and digital service innovation (b = 0.188, $p < 0.01$) on firm performance. Third, I observed that the direct and indirect effects (via product novelty) of green service innovation on firm performance were in the same direction ($a \times b \times c$). The mediated effect of product novelty in the relationship between green service innovation and firm performance ($a \times b$) was positive and statistically significant (b = 0.038, $p < 0.01$). Furthermore, the direct effect (path c) of green service innovation on firm performance was significant (b = 0.472, $p < 0.001$). Thus, I was able to determine the complementary mediation of product novelty between green service innovation and firm performance, which provided support for Hypothesis 4a. However, the mediated effect of product novelty in the relationship between digital service innovation and firm performance ($a \times b$) was negative and statistically insignificant (b = –0.004, n.s.). Meanwhile, the direct effect (path c) of digital service innovation on firm performance was positive and statistically significant (b = 0.188, $p <$ 0.01). Hence, I observed a direct-only non-medication effect regarding product novelty. As such, I failed to find support for Hypothesis 4b.

4.4 Robustness checks

I conducted several robustness checks (available upon request) to evaluate the robustness of the findings. For the robustness check, I performed multiple regression analyses by following the three-step mediated regression approach recommended by Baron and Kenny (1986) to examine the hypothetical relationships of the study. The results of the three-step mediated regression analyses remain qualitatively similar to the results from the SEM analyses. In addition, as a robustness check of the SEM results, I also performed SEM analyses by using the partial least squares (PLS) SEM approach and the results are consistent and provide further support to the Amos-based estimation. Finally, I conducted several additional robustness checks to examine the effects of green and digital service innovations on product creativity and firm performance, I conducted several multiple-group analyses by splitting the data based on the size, age, firm ownership, and industry category. The results of the multiple-group analyses remained qualitatively unchanged, further confirming the observed relationships of the study.

5 Discussion and conclusions

5.1 Theoretical and practical implications

To fill the gaps in the research on green and digital service innovations, this study takes Chinese firms as the research sample to explore and analyse the effect of green and digital service innovations on firm performance. It further investigates the potential mediating mechanisms through which green and digital service innovations influence firm performance by enhancing product creative capability. In doing so, I consider product effectiveness and novelty as unique characteristics of product creativity. Then, I empirically examine their potential role in mediating the contribution of green and digital service innovations to firm performance. Contrary to the expectations, I find that digital service innovation does not play a significant role in promoting product novelty. Thus, I

fail to observe the mediating role of product novelty in the association from digital service innovation to firm performance. One possible explanation for this statistically insignificant mediating effect of product novelty is that each firm may have a different understanding of novelty and thus have varying degrees of perception (cf. Szutowski, 2021). Another plausible explanation is that the implementation of digital service innovation to improve productivity and reduce costs may not necessarily create product novelty. Because digital service innovation aims to enhance the communication between firms and their customers in more effective ways by utilising digital technologies, it is likely to play a more important role in solving customer problems and enhancing customer satisfaction, and has substantially less predictive power in explaining product novelty variance. Instead, the products may seem to lack any novelty. The findings indeed reflect the increasing concerns about the use of digital technologies in promoting high-level digital service innovation. In this regard, some recent studies have pointed out similar concerns regarding the use of digital technologies in achieving service innovation. For example, Scherer et al. (2015) examined how a shift from personal service to self-service influences customer–firm relationships. Using longitudinal customer data, they empirically tested how service innovation influences customer defection over time by adopting technology-based self-service channels. Their findings showed that the highest level of self-service likely leads to the highest chance of defection. Thus, they addressed some potential drawbacks of technology-based service innovation and argued for the importance of considering the unique context of technology and understanding real customer experience. Once digital service innovation reaches a certain level, it becomes automated, thereby diminishing its novelty. Similarly, Carr (2014) pointed out that digitisation may have some drawbacks and cannot always benefit firms and customers. Furthermore, the probability will be one in a million or one in 10 million errors. Complete digitisation and automation will bring a fatal crisis to automated systems. Hence, firms should promote human-oriented automation and digitisation and provide multiple supporting services to supply the missing human touch and emphasise real customer experience.

The research offers important contributions to the literature by clarifying the relationships between green service innovation, digital service innovation, product creativity, and firm performance. Thus, the study provides important theoretical implications and guidelines for management scholars. I summarise the major implications as follows. First, this study finds that green service innovation has a positive effect on the performance of firms in China. This result is consistent with the findings in prior studies, which suggested that the successful implementation of green innovation strategies by firms improves the firms' environmental and economic performance (Chan, 2005; Eiadat et al., 2008; Judge and Douglas, 1998; Lin et al., 2013). Furthermore, I propose that effectiveness and novelty are the two main characteristics of product creativity (Horn and Salvendy, 2009). Novelty entails that the creative products launched by firms should be unique and different from the products of other companies. Ensuring the novelty of their products helps firms expand their market share and improve their overall market competitiveness. In addition, a creative product must have good value and bring utility to consumers to be considered effective and for firms to be able to evoke user engagement and experience (Moschogianni, 2021) as well as firm performance. In addition, I theorise that product effectiveness not only has a significant mediating role in the relationship between green service innovation and firm performance, but it also positively mediates the effect of digital service innovation on firm performance. In his seminal work, Gruber

(1988) advocated that creative products must have value, and they can bring utility to customers, and meet their needs. As an important feature, product creativity not only enables firms to gain a competitive advantage (Andrews and Smith, 1996) but also helps the firms improve their performance.

The findings also have important practical implications. First, this research also verifies that a firm's successful implementation of digital service innovation can positively impact the firm's performance. The systematic literature review demonstrates that firms using digital technology to serve customers can fully grasp market trends, understand customer needs (Moschogianni, 2021; Nambisan et al., 2017), increase communication and cooperation with customers (Jung et al., 2019), and improve customer satisfaction (Singh et al., 2020). The findings provide evidence for this reasoning by suggesting that firms can consolidate their competitive advantages and provide customers with more market-competitive products. Green service innovation emphasises using environmentally friendly design and packaging to address environmental concerns and providing and developing innovative products and services for customers based on environmental concerns (Chen et al., 2015). The results suggest that, through the successful implementation of green service innovation, firms can gain more favour from consumers, easily gain recognition from enterprise users, enhance market competitiveness, increase their market share, and expand product sales. Thus, firms can improve their performance by further consolidating and strengthening their competitive market position. As a result, firms enhance their market performance by actively promoting and achieving successful digital service innovations.

Furthermore, the findings also indicate that product effectiveness and novelty contribute positively to firm performance. Therefore, firms should pay closer attention to product creativity. They should understand that the effectiveness and novelty of a product reflect the true creativity of the product (Mayer, 1999). In particular, the findings reveal that firms should recognise the potential benefits arising from green and digital service innovations effectively for them to improve the effectiveness of product creativity fully by ensuring that the creative products are valuable and useful for customers (Amabile, 1983).

In addition, the results demonstrate that some features of product creativity (i.e., product effectiveness) are likely to play an important mediating role in the relationships between both green service and digital service innovations, and firm performance. Therefore, when firms develop and implement green and digital service innovations, they cannot blindly pursue green and digital service innovations. They should carefully evaluate the role of digital service innovation on product creativity, especially product effectiveness, and adjust their digital innovation strategy accordingly. However, firms should not simply aim for uniqueness and novelty. Instead, they should fully consider the level of innovation in digital services that customers can accept. More importantly, given the particular importance of product effectiveness in transforming green and digital service innovations into superior performance outcomes, firms should pay particular attention to developing and improving product effectiveness. Therefore, firms should focus on their unique attribute of product effectiveness during the promotion of green service innovation and digital service innovation. If firms can make customers recognise, experience, and realise a high level of product effectiveness, their efforts to implement green and digital service innovations are expected to help these firms generate superior performance relative to their rivals.

5.2 Limitations and directions for future research

This study offers valuable contributions to understanding how green and digital service innovations account for the different levels of firm performance. It also explains the mediating role of strong product creativity in the relationship between such innovations and firm performance. Like all research, this study is not without its limitations, which should be considered in future research.

First, I empirically tested the theoretical arguments using data collected from firms in China. As the world's largest emerging market, China may raise potential concerns about the generalisability of the findings to other emerging or more advanced market contexts. Thus, future research is encouraged to expand the generalisability of the findings and verify whether the theoretical framework can be extended to firms operating in other major emerging or developed economies. In particular, future researchers may wish to conduct a comparative study among emerging economies, such as BRICS economies, or between emerging and developed economies (e.g., China and the USA).

Second, the findings were based on cross-sectional survey data, which prevented us from exploring the causality relationship and dynamic effect. Future research could benefit from using longitudinal or in-depth interviews to clarify the causality and dynamic effect among the variables examined in the study.

Third, although our study demonstrated that green and digital service innovations were positively associated with firm performance either directly or indirectly via product creativity, the specific mechanisms through which such effects take place should be further investigated. Future research could focus on how a firm can outperform its major competitors by engaging in different innovation strategies.

Fourth, given the different types and development stages of the sample firms, the products and stages of respective service innovations could be largely different. Future research may distinguish between whether service innovations are only engaged during specific stages or are carried over from the early stage. I am confident that these aspects are important research issues. However, given the data constraints, I was unable to explore these additional factors. Nevertheless, I have provided a stepping stone for this line of research. I hope that future researchers can expand the scope of this study by delving into these important issues.

Finally, another potential limitation is the consideration of the constraints in performance measures. Future researchers may wish to investigate how other important service innovations and additional characteristics of product creativity contribute to other dimensions of firm performance.

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