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Government digital initiatives and firm digital innovation: Evidence from China

[Abstract]

Although the prevalence of digital innovation has attracted increasing attention from policymakers, academics, and practitioners, it remains under-theorized. Using the attention-based view (ABV), we examine why and how government digital-initiative intensity drives a firm's digital innovation. Using a mixed-methods approach and the unique context of China, an aspirant economy, we find that managerial digital attention mediates the link between government digital-initiative intensity and firm digital innovation. Firm political *guanxi* and digital leadership have moderating effects on the relationship between government digital-initiative intensity and managerial digital attention, and the relationship between managerial digital attention and firm digital innovation. These findings have important theoretical and practical implications.

Keywords: digital innovation, government digital initiative, digital leadership, political guanxi, attention-based view

1. Introduction

The digital economy is rapidly developing worldwide and especially in China, a previously emerging economy that is now becoming an aspirant economy (Bruton et al., 2021). Data from two documents: “A New Vision of the Global Digital Economy” and “China’s Digital Economy Development” show that the ratio of the digital economy to gross domestic product (GDP) in China remained significantly lower than that in developed economies (e.g., the U.S., Germany, Japan, France, and South Korea) until 2019 (Table 1 shows the details).[1] To achieve a digital-driven innovation economy, the Chinese government has initiated various policies to develop digital technologies (Zhang and Chen, 2019) to reach its objectives. Digital innovation, including artificial intelligence, cloud computing, the Internet of Things, and 5G, is imperative for firm survival and success (Nambisan et al., 2017; Nambisan et al., 2019; Yoo et al., 2010). For example, Huawei, the Chinese high-tech multinational enterprise, has gained a global competitive advantage in recent years by engaging in almost all of these digital initiatives.[2]

---------------------------Insert Table 1 about here-----------------

Digital innovation refers to developing new combinations of physical and digital components to realize new offerings (Lee and Berente, 2012; Yoo et al., 2010). These new combinations, relying on digital technologies, can produce new products, processes, and business models. Unlike innovations examined in literature (e.g., exploitative, exploratory, and disruptive innovation), digital innovation focuses on digital resources or components that increase the creation of value in the digitalization world (Yoo et al., 2010).

[1] These data are issued annually by the China Academy of Information and Communications Technology (CAICT) (http://www.caict.ac.cn/english/research/whitepapers/index.html)

2 Please see the Appendix for a mini-case study on Huawei’s digital innovation development.

Considering the importance of digital innovation for both countries and firms, prior researchers have studied three factors that drive firm digital innovation: technology (e.g., the use of digital technologies and IT capabilities) (Chan et al., 2019), organization (e.g., digital M&A, innovativeness, firm leadership, and managerial cognition) (Ferreira et al., 2019; Li et al., 2018a; Utoyo et al., 2020; Xiao et al., 2020), and environment (e.g., innovative barriers and external stakeholders) (Nambisan et al., 2019; Teece, 2018). However, current research has ignored the key role of government as an influential environment-related factor (Ferreira et al., 2019; Nambisan et al., 2019; Xiao et al., 2020). Nambisan et al. (2019) called on researchers to consider government initiatives, such as policies and regulations, that shape firms' new digital technologies and innovations.

The government, especially in China, has a significant effect on firm decisions in general and innovation in particular (Bruton et al., 2013; Li et al., 2018b). Governments can affect a firm's innovation through various means (e.g., innovation programs, information and technology resources, and tax incentives) (Li et al., 2018b), and therefore firms are likely to benefit from government initiatives and policies in developing new technologies (Li et al., 2018b). By clarifying the Chinese government's influence on firm digital innovation, the knowledge of external environmental factors in boosting digital innovation can be enriched and deepened. Additionally, clarifying the mechanism by which governments affect firm digital innovation responses to Nambisan et al. (2019) call on the relationship between government and digital innovation.

In the digital era, many governments have initiated agendas to find ways to derive economic and societal benefits from digital usage (Conceição et al., 2001; Zhang and Chen, 2019). For example, in China, digitalization captured a salient place in the Five-Year Plan (FYP) outline for national economic and social development, considered one of the most important regulations. Additionally, although prior research has studied the relationship between government and firm innovation (e.g., Li et al., 2018b), the specific mechanism by which the government affects firm digital innovation remains unclear and untested. In this paper, we study the mechanism by which the government affects a firm's digital innovation and ask the question: *How and why do government digital initiatives affect firm digital innovation?*

To answer this research question, we employ the attention-based view (ABV) as a theoretical lens (Ocasio, 1997, 2011). The ABV proposes that firms depend on where decision makers focus their attention (Joseph and Wilson, 2018; Ocasio, 1997; Tuggle et al., 2010a). Firm decision-makers have limited information-process capabilities, which forces them to attend selectively to essential matters (Tuggle et al., 2010b). Therefore, considering the government's leverage, especially in China, we suggest that government digital initiatives shape the firm managerial attention to digital technologies, thereby driving digital innovation. In addition, we also explore two moderating effects of firm digital leadership, a key factor that will channel managerial digital attention (Lim et al., 2013), and firm political *guanxi*, a key indigenous concept of Chinese management, on the mechanism between government digital initiatives and firm digital innovation.

Our study makes three significant contributions to the literature. First, by exploring the drivers of firm digital innovation from the ABV, we bring a novel theoretical perspective to research the antecedents of digital innovation. We provide a new avenue to understand why firms can achieve more successful digital innovation by empirically investigating the role of the government and firm managerial digital attention. Second, based on the literature review, our study is the first to investigate the role of government in digital innovation, thus responding to Nambisan et al.'s (2019) call to consider government policies and regulations in shaping firm actions regarding digital technologies and innovations. Third, we advance ABV research by simultaneously including situated attention and the structure of attention in the same model (Stevens et al., 2015). Ocasio (1997) has suggested that situated attention and the structure of attention influence organizational behaviors independently and interdependently. Prior studies have mainly focused on either situated attention (e.g., Haas et al., 2014) or the structure of attention (e.g., Cho and Hambrick, 2006; Souitaris and Maestro, 2010). We contribute to ABV research by framing situated attention (e.g., environmental stimuli: government digital initiative) and the structure of attention (e.g., decision makers—that is, digital leadership; procedural and communicational channels: firm political *guanxi*) into one model and investigate the independent and interdependent effects on firm digital innovation. Additionally, we explain why firm digital attention and digital innovation vary when facing same governmental digital initiative by considering firm digital leadership and political *guanxi* as two key moderators (Ocasio et al., 2018).

2. Theory and Hypothesis

2.1. The attention-based view (ABV)

How decision makers allocate their attention is a critical issue in strategic management research (Ocasio, 2011). In the organizational context, attention is defined as noticing, encoding, interpreting, and focusing one's time and effort on the repertoire of organization issues and actions (Ocasio, 1997). Here, decision makers are assumed to have bounded rationality and limited information processing capability, making it impossible to focus on all issues concurrently (Barnett, 2008; Ocasio, 1997, 2011). Thus, a firm's strategy depends on how its decision makers channel and distribute attention (Ocasio, 1997; Tuggle et al., 2010a). Prior research has demonstrated that attention allocation can profoundly influence a firm's behavior, including innovation (Yadav et al., 2007), headquarter-subsidiary relationships (Ambos et al., 2010), and for-profit social enterprises balancing multiple goals (Stevens et al., 2015).

Regarding the ABV, Ocasio (1997) proposed three principles. The first principle, focused attention, represents the selective focus of decision makers' attention. The second, situated attention, represents decision makers' focused attention prompted by the situations in which they find themselves. The third principle, the structural distribution of attention, highlights that controls—including rules, players, structural positions, and resources—regulate the distributed focus of attention among decision makers participating in the firm's procedural and communication channels. Thus, situational context and attention structures shape decision makers' focus and attention allocation (Tuggle et al., 2010a).

The ABV is suitable for exploring our research question of the effects of government's digital initiatives on a firm's digital innovation through firm managerial digital attention. First, government policy is a relevant situational context given its salience to the organizational allocation of attention to environmental scanning (Li et al., 2018b; Tuggle et al., 2010a). Government policy serves as an important external environmental stimulus for structuring organizational decision making (Tian et al., 2021). Government policy often fuels new opportunities and thus stimulates entrepreneurs' proactive responses, which enables entrepreneurs to exploit such opportunities and ultimately reap considerable benefits (Dai et al., 2020a; Lazzarini, 2015). Second, as the firm's decision makers, top executives, including CEOs and board, are dominant and active participants in the firm's attention regulations, as firm-level attention is usually regarded as a manifestation of such individuals' values and biases at decision-making levels (Cho and Hambrick, 2006; Hambrick and Mason, 1984; Tuggle et al., 2010a). Prompted by environmental stimuli, firm top managers are responsible for noticing, encoding, and interpreting such stimuli, ultimately deciding whether such stimuli merit allocation of time and effort. Thus, firm's top executives and managerial teams are an important decision-making group that position the firm's attention through specific skills, beliefs, and values and put it into action (Tuggle et al., 2010a, 2010b).

2.2. Government digital initiative intensity and firm managerial digital attention

Various digital technologies (e.g., artificial intelligence, cloud computing, the Internet of Things) make innovations possible. Moreover, digital technologies affect people and businesses in fundamental and permanent ways, advancing national and regional development (Conceição et al., 2001; Si et al., 2020). Consequently, digital technologies serve as an important tool to advance economy-wide digitalization through affordances that efficiently create, deliver, and capture economic and societal value (Kwon et al., 2017). As such, more countries, regions, and cities have initiated digitalization to find and promote ways to derive economic and societal benefits from its usage (Conceição et al., 2001). For example, in the Chinese central and local governments' 12th and 13th FYPs for economic and social development, promoting digital technology is one of the most important tasks. Government digital initiatives refer to public digital policies and programs designed to improve economic and social aspects via digital applications accompanied by other governmental efforts and incentives such as tax incentives, financial support, and digital projects. Consequently, firms have incentives and opportunities to gain competitive and business value advantages from government digital initiatives.

Government initiatives in economic and social activities to achieve political and social objectives are a more salient situational context that shapes the firm's attention allocation. This is because these initiatives may be crucial to firm survival and success (Nambisan et al., 2019; Xiao et al., 2020; Yang et al., 2019). For example, Yang et al. (2019) showed that firms pay close attention to environment-related information when the government passes legislations and regulations to address environmental problems. Firm top managers' main function is to help firms identify and evaluate business opportunities for growth-relevant new technologies (Tuggle et al., 2010b). We argue that government digital initiative can spur firm managerial digital attention using two mechanisms.

We argue that government digital initiatives can drive firm managerial digital attention using two mechanisms. First, intensive government initiatives induce new opportunities (hereafter, "initiative-induced opportunities") (Dai et al., 2020a, 2020b; Wei et al., 2020) that shape and manipulate many aspects of a business system. This implies that such initiatives play an important role in developing a business environment with opportunities (Lim et al., 2010). A major source of business opportunities arises from changes in governmental initiatives and policies, especially in emerging economies. For example, Vásquez-Urriago et al. (2016) showed that locating a firm in a science and technology park initiated by a regional government promotes innovation by providing cooperative opportunities with diverse partners.

Second, intensive government initiatives induce resource accumulation within a particular region (hereafter, "initiative-induced resources accumulation") (Lazzarini, 2015), as such resources are distributed to achieve policy goals (Li, 2009; Si et al., 2015). However, the government also shapes a favorable business environment that induces external resources (Eklinder-Frick and Age, 2017). Innovation requires novel resource combinations, and therefore, policy-induced resource accumulation enables firms with access to wider heterogeneous innovation resources to combine various inputs in creative ways (Li et al., 2018a). For example, Lazzarini (2015) argued that regional industry policy triggers particular trajectories of resource accumulation within a region and thus favorable conditions for sparking innovation.

In summary, initiative-induced opportunities and initiative-induced-resource accumulation stimulate firm top managers' attention to such opportunities and resources. Thus, we propose the following hypothesis:

Hypothesis 1 (H1): Government digital-initiative intensity is positively related to firm managerial digital attention.

2.3. Firm managerial digital attention and firm digital innovation

The principle of ABV suggests that decision-makers generally take initiatives to respond to what they selectively allocate their attention (Ocasio, 1997). Organizational attention constitutes a scarce resource due to the bounded rationality of organizational decision-makers (Ocasio, 1997, 2011). As a result, they selectively allocate their attention to aspects that are important to firm survival and success (Hoffman and Ocasio, 2001). Research emphasizes that entrepreneurial attention is valuable, and the way entrepreneurs allocate their attention may determine firm behaviors largely.

In our context, organizational attention to digital technology constitutes the first and necessary step toward digital innovation. As the firm's decision-making group, firm top managers (CEOs, for instance) are responsible for environmental scanning and possess the power necessary to implement their strategies derived from their attention (Hambrick and Mason, 1984). The decision to be digital is increasingly relevant for firm managerial attention. Thus, firm top executives will focus time and effort to support digital innovation.

Furthermore, research on digital innovation shows that digitalization has already impacted societal and organizational behaviors significantly (Huang et al., 2017; Nambisan et al., 2017, 2019; Yoo et al., 2010, 2012). Digitalization is disrupting existing value chains and business models. Thus, digitalization imposes major threats to incumbents and requires them to elaborate new strategies to address these threats (Åberg et al., 2017; Huang et al., 2017). Given the business opportunities and resource accumulation of digital technologies, a firm's top managers, executives, and board may notice opportunities and change their attention to digital innovation (Conceição et al., 2001). Thus, we predict the following hypothesis:

Hypothesis 2 (H2): Firm managerial digital attention is positively related to firm digital innovation.

Integrating Hypotheses 1 and 2, we suggest that firm managerial digital attention is a mediating mechanism between government digital-initiative intensity and firm digital innovation. First, major environmental stimuli will capture a firm's attention (Ocasio, 1997). As an important player and rule maker in business activities, the government launches intense initiatives that aim to capture firm attention, especially in China, a previously emerging, and now aspiring, economy. The intense attention to governmental initiatives helps firms discover new business opportunities in digital innovations.

Second, the attention structure significantly shapes organizational moves and actions (Ocasio, 1997). The intense attention to governmental digital initiatives enables firm managers allocate toward digital technologies. Collectively, intensive government digital initiatives drive firms to promote digitalization by attracting firm managerial attention toward digital technologies, and managerial digital attention directs firms to develop and refine digital innovation. Thus, we propose the following hypothesis:

Hypothesis 3 (H3): Firm managerial digital attention mediates the relationship between government digital-initiative intensity and firm digital innovation.

2.4. The moderating effect of firm digital leadership

Upper echelons theory can help researchers explore how firm leaders' characteristics affect firms' strategic decisions and choices (Hambrick, 2007; Hambrick & Mason, 1984). The bounded rationality theory implies that "informationally complex, uncertain situations are not objectively knowable, but rather are merely interpretable" (Hambrick, 2007, p. 334). Firm digital leadership refers to digital department director or center dean, chief information officer (CIO), and chief technology officer (CTO) (Lim et al., 2013). Following upper echelons theory, we suggest that firm digital leadership will influence firm attention distribution in terms of digital technologies (Abbatiello et al., 2017). Through enabled personalized micro-learning, digital leaders build critical skills in their team that are needed to create and execute a digital mindset in a fast-paced and complex environment (Petrucci and Rivera, 2018).

Digital leadership has four distinctive features: creativity, in-depth digital knowledge, a robust digital network, and loyal participation via vision (Toduk and Gande, 2016). Establishing digital leadership is a key way for firms to direct attention into concrete action. Sasmoko et al. (2019) found that market-orientation in has led to firm specific actions, especially in focusing on products and services that improve customer value through establishing digital leadership. Yadav et al. (2007) found that a CEO's attention affects firm innovation choices and implementation in certain conditions.

Based upon the upper echelon theory and features of digital leadership, we propose that digital leadership will positively moderate the link between governmental digital initiative intensity and firm managerial digital attention. As firm key decision makers, digital leaders are responsible for environmental scanning to identify new opportunities and threat in terms of technology development (Chen et al., 2015; Eklund and Mannor, 2021; Kammerlander and Ganter, 2015). When firms with digital leadership, those firms will channel more time and efforts to analyzing governmental digital initiatives, one key type of firm external environments in China. In addition, another essential function for digital leadership is helping firm top executives, such as CEOs, to interpret and pay attention to new technologies (Li et al., 2021). Li et al. (2021) have found that firm CIO will attract firm attention to new digital technology, such as AI. Therefore, we propose the following hypothesis:

Hypothesis 4a (H4a): Firm digital leadership positively moderates the relationship between government digital-initiative intensity and firm managerial digital attention.

In addition, research has emphasized that digital leadership is valuable, and may determine firm digital innovation. As one type of innovative leadership, digital leadership has five dimensions: creative thinking, the willpower to be innovative, a tolerance of different opinions and various risks, and the establishment of mechanisms for innovation and implementing innovative ideas (Kozioł-Nadolna, 2020). Toduk and Gande (2016) also suggested that digital leadership has four distinctive features: creativity, in-depth digital knowledge, robust digital network, and loyal participation through vision.

Digital leadership will positively moderate the relationship between managerial digital attention and firm digital innovation. Digital leadership leads to more resources and knowledge to build unique digital innovative capability, which is key for digital innovation. Digital leaders are mainly responsible for identifying, purchasing, and supporting overall IT operations as well as implementing cutting-edge technologies

(Weill and Woerner, 2013). For example, Sasmoko et al. (2019) found that digital leadership has a significant impact on firm innovative capability and management in the Indonesian telecommunications industry. Kozioł-Nadolna (2020) found that a digital leadership presence will boost employee creativity and innovative behaviors. Li et al. (2021) have argued that CIOs, as one type of digital leader, are in a position to help other top managers understand a firm's technological capabilities and resources.

Furthermore, research on digital innovation shows that digitalization has significantly impacted societal and organizational behaviors (Huang et al., 2017; Nambisan et al., 2017, 2019; Yoo et al., 2010, 2012). Digitalization disrupts existing value chains and business models. Thus, digitalization poses major threats to incumbents and requires them to develop new strategies to address such threats (Åberg et al., 2017; Huang et al., 2017). Given the business opportunities and resource accumulation of digital technologies, digital leaders may put great effort into digital innovation initiatives by collaborating with teams that have digital knowledge (Conceição et al., 2001). So, firm digital leadership will use their knowledge and resource to more effectively transfer managerial attention to concrete digital innovation output. Thus, we propose the following hypothesis:

Hypothesis 4b (H4b): Firm digital leadership positively moderates the relationship between firm managerial digital attention and firm digital innovation.

2.5. The moderating effect of firm political *guanxi*

Based on the ABV, firms function as communication channels that respond to environmental issues and feed this information to decision makers for processing (Ocasio, 1997). Decision makers' attention can be shaped by external factors (Ocasio, 1997; Maula et al., 2013), and social networks are key external social contexts of firms (Bao et al., 2019; Tian et al., 2021; Uzzi, 1997). For instance, Maula et al.

(2013) studied the guiding effects of inter-organizational relationships on top managers' attention either to or away from technological discontinuities. The authors proposed that homophilous relationships (such as alliances with industry peers) guide incumbents' attention to technological discontinuities, while heterophilous relationships (such as with venture capitalists) guide incumbents' attention away from technological discontinuities. In our research setting, firm political *guanxi* draws firms' attention toward governmental initiatives.

Additionally, attention is considered the first step of a tripartite information-processing sequence involving attention, interpretation, and action (Abrahamson and Fombrun, 1994), and acquiring sufficient information involves this sequence. Firms' executives need information to make decisions, and the quality and timeliness of the available information significantly affects their decisions (Zhu et al., 2016). By shaping the attention engagement, procedural and information channels become important, acting as "pipe and prisms" through which information flows (Ocasio et al., 2018; Ocasio, 1997). Procedural and information channels are social interaction processes by which decision makers send and receive information on certain issues and answers.

Research has offered a compelling rationale for linkages between firms and the government by which firms can reduce uncertainty created by their dependence on governments (Hillman et al., 2000, 2009; Pfeffer and Salancik, 1978). Consequently, a firm political *guanxi* with governments is seen as a primary way to absorb the critical elements of uncertainty in government actions. An important function of political *guanxi* is to provide unique information about public policy. This information may often be very expensive or difficult for a firm to obtain because of its complexity (Hillman et al., 1999).

A firm political *guanxi* increases the amount and quality of accessed government information, thus providing insight into whether and how the firm should respond (Hillman, 2005; Sheng et al., 2011; Zhang et al., 2019). For example, Sheng et al. (2011) argued that politically connected firms have better access to policy and aggregate industrial information, as governments regulate industry development plans and policies. Therefore, such firms outperform others that do not have political connections (Sheng et al., 2011). In our context, when governments initiate digitalization, managerial political *guanxi* allows prompt access to relevant information on governmental digital initiatives. Thus, firms are more likely to follow governmental digital initiatives. Therefore, we argue that managerial political *guanxi* helps firms capture the essence of government digital initiatives and notice, encode, and interpret them. This strengthens the link between governmental digital initiatives and firm managerial digital attention. Thus, we propose the following hypothesis:

Hypothesis 5a (H5a): Firm political guanxi positively moderates the relationship between government digital-initiative intensity and firm managerial digital attention.

When firms strategize to pursue digital innovation, political *guanxi* provides valuable information through discussion or consultation with government officials, which makes firms more informed in identifying and developing actionable plans (Sheng et al., 2011). Additionally, political *guanxi* can provide firms with valuable information and resources to help them develop digital innovation (Li et al., 2018b; Zhang et al., 2019). For example, Li et al. (2018b) found that firms affiliated with governments via administrative linkages are well positioned to receive public funding, policy support, and government-supported networks, thus facilitating the firms to develop new standards and technologies. Public support can reduce the cost of digital innovation failure and give firms more confidence in digital innovation investment.

Finally, the ABV proposes that firms function as communication channels that respond to environmental issues and feed this information to decision makers for processing (Ocasio, 1997). Social networks, which are key external social contexts, shape decision makers' attention, (Uzzi, 1997). We suggest that political *guanxi* draws the firm's attention to governmental initiatives based on the argument between social networks and attention direction. When digital innovation is the primary focus, firms will involve more resources and effort to develop digital innovation as we demonstrate in our research setting. Therefore, managerial political *guanxi* strengthens the link between firm managerial digital attention and a firm digital innovation. Thus, we propose the following hypothesis:

Hypothesis 5b (H5b): Firm political guanxi positively moderates the relationship between managerial digital attention and firm digital innovation.

3. A Mixed-methods Design

For this study, we chose a mixed-methods approach, which has been used to examine complex processes, such as the relationship between governmental digital initiatives and firm digital innovation (Bingham and Davis, 2012; George, 2005; Ivankova, 2014; Johl et al., 2012). As qualitative methods enable scholars to connect with details of organizations and interact with firm informants, a qualitative method is ideal for exploring top executives' emotions, thoughts, and attention (Kammerlander and Ganter, 2015). Moreover, qualitative findings are often rich, deep, and insightful.

Unfortunately, the qualitative method is "an interpretive enterprise" that uses a relatively small sample. Scholars often use quantitative methods by leveraging a sample substantially larger than the sample typically used in qualitative studies to enhance generalizability. Considering the merits of both qualitative and quantitative methods, we adopted a mixed-method approach to explore the relationship between governmental digital initiatives, managerial digital attention, firm digital leadership, and political *guanxi*, and firm digital innovation.

3.1. Qualitative study

To conduct a qualitative analysis for our research question, we took a computational approach: topic modeling (Baumer et al., 2017; Nelson, 2020). As an algorithm of machine learning, topic modeling has become increasingly popular for its efficiency of algorithms, interpretable outputs, and justifiable assumptions (Nelson, 2020). Topic modeling can uncover themes within a corpus by detecting the co-occurrence of words. The only input to this algorithm is a set of textual data and a number of topics. The algorithm then outputs a list of topics, suggesting the content of a topic (Hong and Davison, 2010). In this study, we investigated the antecedents, process, and consequences of firm digitalization. Based on textual data, topic modeling may be well suited for us to look into digitalization' antecedent, process, and consequences by detecting topics around digitalization. Following Hannigan et al. (2019), we took three rendering steps to inductively analyze our topic modeling corpus.

First, selecting textual data is a critical step to prepare for rendering a corpus in topic modeling. Prior studies have supported the value of analyzing organizational communications (e.g., managerial meeting transcripts, letters to shareholders) that are usually related to strategic actions (Tuggle et al., 2010a). In our context, managerial meeting transcripts are viewed as relevant documents because they contain important information about a firm's strategies and logically fit in regards to our research question. Managerial meeting transcripts generally record a range of subjects such as internationalization, innovation, social responsibility.[3] Since we focus on digital-related issues, we adopted six major groups of digital elements developed by Eremina et al. (2019) (See Table 1B in the Appendix) and then used text mining to extract digital-related text. Using rounds of selection and trimming, this approach yielded sentences with 60 Chinese characters centered on each basic terms of six major groups of digital elements, which was used as the corpus for the topic modeling technique (Hannigan et al., 2019).

Second, taking the sentence as a unit of analysis, we used the Latent Dirichlet Allocation (LDA) with Python to perform the topic modeling. In doing so, we used the UMass metric of topic coherence to determine the ideal number of topics, which was 8. We then executed the LDA algorithm to derive a topic document matrix.

Finally, to render theoretical artifacts from the topic document matrix, three of the co-authors independently assessed the meaning of these topics and their keywords in order to create second-order codes. In keeping with our research question, we paid particular attention to what drives firm digitalization, how to conduct digitalization, and what is the impact of digitalization. The authors aggregated three relevant second-order codes: government digital initiative, digital leadership, and digital innovation. Table 2 shows three topics with the 10 highest weighted words, suggesting that (a) government acts as an important force that motivates a firm to adopt digital technologies;(b) it is crucial to install digital leaders (e.g., recruit digital talents, establish a digital department) to manage digital technologies; and (c) digital technologies help firms enhance innovation (e.g., develop new products, efficiencies)

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[3] The Chinese Research Data Services Platform provides yearly text data on managerial meeting transcripts for all publicly listed firms in China.

3.2. Quantitative research

3.2.1 Research setting

We used the province's annual government work reports (AGWRs) in China to test our theory and hypotheses. First, as one of the largest emerging economies, China has initiated digitalization and achieved a higher level of the digital economy (Xiao et al., 2020). Similar to the national government work report that the premier delivers annually, the governor of each provincial government delivers a work report to attendees of the provincial People's Congress in January or February.[4] The AGWRs systematically review the socioeconomic development of the province over the past year and provide guidelines for the upcoming year. Scholars have used government work reports to track government policy priorities (e.g., Jiang et al., 2019; Jiang and Zhang, 2020).

Second, in recent years, digital technologies have increasingly promoted economic and social development and thus provinces have written them into government work reports. For example, in 2014, the Hubei province stated that digital development could "accelerate the development of emerging information technologies, such as the mobile Internet, cloud computing, the Internet of Things, 3D printing, and Beidou navigation satellite system" in the AGWR.

Third, Chinese regions have experienced uneven economic, social, and technological progress since the market-oriented reforms. As such, governmental digital initiatives across regions vary. Since 1979, the transfer of government authority from the central level to the provincial and local levels has empowered provincial and local officials to enact regional development policies. Following decentralization, provincial governments assumed wider discretionary powers in managing political

[4] The People's Congress and Chinese People's Political Consultative Conference are considered the most important political councils in China, and are referred to as the "Two Meetings."

systems, market structures, legal frameworks, and social mechanisms (Jia et al., 2019). For example, provincial governments can enact tax policies, issue business licenses, arrange funds, and allocate resources. In short, the research setting is suitable for testing our theory regarding digital innovation.

3.2.2. Data

Data were collected from multiple sources. First, provincial AGWRs were manually collected from the official homepage of each province. This information was used to construct the level of each government's digital initiative intensity. Second, firm digital innovation was collected from the Incopat database, one of the most comprehensive patent databases covering patent information issued by more than 120 counties. Third, digital leadership and other firm data were collected from the China Stock Market & Accounting Research Database (CSMAR), which provides comprehensive historical information on the financial statements and corporate governance of firms on the Shanghai and Shenzhen Stock Exchanges, such as digital leadership, firm age, firm size, firm profit, top management team (TMT) position, curriculum vitae, political *guanxi*, and others. After excluding observations with missing key values, our final panel data consisted of 9,000 firm-year observations of 1,676 unique firms from 2012 to 2017.

3.2.3. Measurement

Text mining. Following prior research (e.g., Bao and Datta, 2014), we employed a three-step process of text-mining to code firm digital innovation (FDI), government digital initiative intensity (GDII), and managerial digital attention (MDA). First, to undertake computer-aided text mining, we derived a set of keywords related to digital technologies (Eklund and Mannor, 2021; Eremina et al., 2019). To this end, we adopted six major groups of digital elements and 49 basic terms developed by

Eremina et al. (2019) (See Table 1B in the Appendix).

Second, we developed a Python-based text-mining program (Bao and Datta, 2014; Kwon et al., 2017) to extract text information using the 49 basic terms from the data sources. Before the final extraction, third-party professional programmers specializing in text mining engaged in pilot testing to validate the reliability of the program (Bao and Datta, 2014).

Third, after the final extraction, we removed duplicate and unrelated descriptions to ensure clarity, accuracy, and completeness of our text-mining results. Specifically, we trained three coders with master's degrees and sufficient coding experience to conduct independently coding. Before the final coding began, each coder independently created a pilot code based on 30 randomly selected and identical texts. Next, we compared the results and resolved any disagreements between them. The three coders independently implemented the formal coding tasks following the pilot. Next, a double data checking process was conducted by other coders to correct any problems.

Firm digital innovation (FDI). Prior studies have suggested that patents are a better indicator of firm innovation (e.g., Jia et al., 2019). Thus, we counted the firms' digital patents to measure firm digital innovation (Ferreira et al., 2019). However, there are no signs for us to directly identify whether a patent is digital. To address this issue, we scan patent abstracts through the text mining process. Specifically, we first collected each firm's patent abstracts from the Incopat database. Like a compacted specification, the patent abstract provides information on its functions, processes, features, and technology domains. Second, we filtered each abstract using 49 basic terms individually and retrieved the digital-related patents. Finally, we summed these digital-related patents on a firm-level basis, and thus firm digital innovation was measured as the number of digital-related patents in a given year. We lagged FDI for one year, which accounts for the time delay of managerial attention on firm performance and also improve the accuracy of the causal inference by reducing the possibility of simultaneity.[5] Table 2B in the Appendix shows the annual number of firm digital patents across six major groups from 2013 to 2018.

Government digital initiative intensity (GDII). Using our text-mining process, extracted text contained any of 49 basic terms from the province's AGWRs. To capture the government's "initiate" behaviors, we developed an initial list of words and phrases consistent with related behaviors such as "initiating," "promoting," "subsidizing," and "supporting." We then counted the total number of 49 basic terms in a given year to measure the GDII, which captured the extent to which a provincial government initiated digitalization. Table 3B shows the annual number of government digital initiative in all provincial AGWRs from 2012 to 2017.

Managerial digital attention (MDA). MDA is defined as the overall strategic attention and the aspiration to employ digital technology within an organization (Chen et al., 2015). In our context, managerial meeting transcripts are viewed as key documents because they contained important information about a firm's future strategies. Thus, managerial meeting transcripts were analyzed using the text mining process to understand the extent of a firm's utilization of digital technologies. As a result, we extracted the text containing any of 49 basic terms (see Table 1B in the Appendix). To capture managerial attention to digital technologies, we developed an initial list of words and phrases consistent with behaviors related to "attend," such as seek, follow, notice, and pursue. Finally, we operationalized MDA by countering the total number of 49 basic terms in a given year, capturing the extent of managerial

[5] The windows time of dependent variable is from 2013 to 2018.

attention to digital technologies. Table 4B shows the annual number of managerial digital attention across six major groups from 2012 to 2017.

Digital leadership (DL). Structural power, which was based on formal organizational hierarchies and was the most commonly cited type of power, is used to measure DL (Finkelstein, 1992). The greater a manager's structural power, the greater his or her control over others' actions. The CSMAR database provides information on firm managers such as name, age, gender, education, position, job title, curriculum vitae, and shareholdings. First, we identified digital leaders who would likely take charge of digitalization via managers' job titles such as digital department director or center dean, intelligent department director or center dean, chief information officer, chief science officer, chief technology officer, and director of cloud department (Lim et al. 2013). We then manually scrutinized the role descriptions of these members via their curriculum vitae to identify senior managers who would take charge of digitalization or have worked in digitalization. To represent the structural power, DL is measured as an ordinal variable: we coded DL as 0 if a firm did not have any digital leader, 1 if the digital leader was part of the TMT, 2 if the digital leader sat on the board, and 3 if the digital leader was the CEO or the chairman of the board (Finkelstein, 1992; Lim et al., 2013).

Firm political guanxi (FPGX). Following previous research on political connections, we first identified individual senior managers who had previously acted as members of the central and local governments and the People's Congress of the People's Political Consultative Conference (Chizema et al., 2015; Sheng et al., 2011). We then measured the FPGX as the ratio of senior managers holding political *guanxi* to the size of senior managers (Chizema et al., 2015).

Control variables. We controlled for firm-, province-, and industry-level characteristics (Li et al., 2018b; Zhang et al., 2019). We included *firm age* as the number of years since the company was founded and *firm size* as the natural logarithm of the total asset. Both elements were controlled because large, established firms might have more resources and thus substantial innovation. Research suggests that firms with better performance have substantial financial resources to invest in innovation activities. Accordingly, we controlled for firm financial performance with return on asset (*ROA*). We controlled and operationalized *ownership concentration* as the ratio of shared ownership by the top ten shareholders to capture the effect of ownership on innovation. *Firm leverage*, measured as the ratio of long-term debt to the book value of assets, was included to account for firms' slack. Additionally, firms' *R&D spendings and R&D employee* were included as proxies for recognizing and assimilating external knowledge. We took the logarithm of R&D spendings and R&D employee as the ratio of R&D employees over total employees.

Firm governance significantly influences firm decisions and innovation (Eklund and Mannor, 2021). As such, we controlled for *board size*, *board ownership*, *TMT average age*, *TMT overseas background, CEO age, and CEO duality*. *Board size* was computed as the total number of directors on the board. *Board ownership* was calculated as the total number of shares held by all the directors over outstanding shares. *TMT average age* was operationalized as the average age of all TMT members. We operationalized the *TMT overseas background* as the ratio of the total number of top managers who had studied or worked overseas to TMT size. *CEO age* was computed as the number of years since the CEO's date of birth. *CEO duality* was measured as 1 if the CEO also served as the chair of the board and 0 otherwise.

To account for the underlying provincial-level heterogeneity in China, we controlled for *provincial* GDP (the log transformation was taken) and *province fixed* *effects* (Tian et al., 2021). To control for industrial effects, we considered *industrial concentration* and *industry fixed effects*. Based on the sales information of each firm, we used the ratio of the top ten firms' sales over the total firm sales in the same industry to measure industrial concentration. Province and industry dummies were included in each model to represent province and industry fixed effects, respectively.[6]

3.2.4. Empirical analysis

As our dependent and meditator variable is count, we employed a panel negative binomial regression with the fixed effect to test our hypotheses. Negative binomial regression is advantageous as it does not have the restrictive assumption of a mean equal to variance. The fixed effect can control for unobserved firm heterogeneity. We followed Zhong et al (2020) to test our mediation. Specifically, we regressed (a) firm digital innovation on GDII, (b) MDA on GDII, and (c) firm digital innovation on GDII and MDA in sequence. We next conducted the bootstrapping analyses and Monte Carlo simulations to verify the presence of mediation. We adopted the panel Poisson regression as a robustness check and found that all our results remained the same. We standardized our independent and moderator variables to mitigate the potential multicollinearity issues.

3.3 Results

The descriptive statistics and correlations of the variables are presented in Table 3. GDII is positively correlated to MDA (r = 0.066) and FDI (r = 0.027). MDA is positively correlated with FDI (r = 0.153). These results provide preliminary support for our hypotheses. All VIF values were well below the acceptable level of 5 and had a maximum value of 2.89, suggesting that multicollinearity is not a serious issue.

---------------------------Insert Table 3 about here-----------------------

6 Our sampling firms cover 31 provinces. Industry category was identified by the Guidelines on Industry Classification of Listed Companies enacted by the China Securities Regulatory Commission in 2012.

The results predicting firm digital innovation are presented in Table 4. H1 states that government digital-initiative intensity is positively related to firm managerial digital attention. As shown in Model 2, GDII and MDA have a positive relationship ($\beta = 0.020$, $p < 0.05$), lending support to H1. H2 predicts that managerial digital attention is positively related to firm digital innovation. Model 4 shows that MDA is positively correlated with FDI ($\beta = 0.003$, $p < 0.01$), which supports H2.

Regarding the mediation test, if MDA serves as an underlying mechanism, adding this variable would partially mediate the GDII effects on FDI (Hayes and Preacher, 2014; Zhong et al., 2021). We regressed (a) MDA on GDII (see Model 2), (b) FDI on GDII (see Model 3), and (c) FDI on GDII and MDA (see Model 4) in a sequence. Model 2 and Model 3 show that GDII has a significant and positive effect on MDA ($\beta = 0.020$, $p < 0.05$) and FDI ($\beta = 0.045$, $p < 0.01$), respectively. In Model 4, we find that when MDA is added, the magnitude of the GDII effects on FDI decreases sightly.

---------------------------Insert Table 4 about here----------------------------

To further verify the mediation of MDA, we conducted the bootstrapping analysis and Monte Carlo simulations and (Hayes and Preacher, 2014; Zhong et al., 2021). In Model 1 of Table 6, the bootstrapping analysis shows that the indirect effect of GDII on FDI via MDA is 0.0085 with bias-corrected 95% confidence intervals [0.0040, 0.0129]. Further, the Monte Carlo simulation indicates that the 95% confidence interval for path GDII on FDI via MDA is [0.0001, 0.0012], excluding the value of zero from the range. These tests support the hypothesis that MDA at least partially mediates the effects of GDII on firm digital innovation. Together, these mediation tests support H3.

For moderation, H4 and H5 state that DL and FPGX positively moderates the relationship between GDII and MDA and the relationship between MDA and FDI, respectively. Table 5 reported the results of moderation of DL and FPGX. Model 1 shows that the interaction between GDII and DL is negative and not significant (β = -0.014, $p > 0.1$). Therefore, H4a is not supported. In Model 3, the coefficient of the interaction between DL and MDA is positive and significant (β = 0.034, $p < 0.01$), thus supporting H4b. A possible reason for nonsupport of H4a is that since managerial attention is limited, digital leader may draw out less attention into external political activities when they attended to firm internal digital innovation.

For FPGX, Model 2 shows that the interaction between FPGX and GDII is positively and significantly related to MDA (β = 0.019, $p < 0.05$), thus supporting H4a. In Model 4, the direct effect of the interaction between FPGX and MDA on FDI is significantly positive (β = 0.024, $p < 0.01$), which is supportive to H4b.

----------------------------Insert Tables 5 and 6 about here----------------------------

3.4. Robustness tests

We conducted several supplementary tests to probe the robustness of our results (see Tables 6 and 7). For brevity, we report only the key results of interest.[7] The full results are available upon request.

Alternative measures of firm digital innovation. First, we adopted forward citations of digital patents for a firm in a given year as an alternative measure of our dependent variable to test H2, H3, H4b, and 5b (Jaffe et al., 2000). As shown in Model 1 in Table 7, the effect of MDA on FDI is significantly positive (β = 0.129, $p <$ 0.01), supporting H2. Model 2 in Table 6 shows that for bootstrapping analysis, β is 0.001 ($p < 0.05$); for Monte Carlo simulations, 95% CIs were [0.0001, 0.0007], which supports H3. Model 2 in Table 7 shows that the effect of the interaction between DL

[7] In the robustness check, unless otherwise indicated, all models concluded the same control variables with the main analysis.

and MDA on FDI is positive and significant ($\beta = 0.047$, $p < 0.01$). Model 3 in Table 7 shows that the interaction between FPGX and MDA is significantly and positively related to FDI ($\beta = 0.020$, $p < 0.01$). Therefore, Hypotheses 4b and 5b are supported.

The uniqueness of digital leadership presence as the mediator. To validate the uniqueness of MDA as a mediator, we needed to reduce concern regarding the inferences involved (Pillai et al., 1999). Therefore, we built a competing model to test the possible role of DL and MGPX in mediating the relationship between GDII and FDI. Model 3 (for DL) and Model 4 (for MGPX) in Table 6 show that the 95% CIs in bootstrapping analysis and Monte Carlo simulations include 0, suggesting no mediating effect via DL and MGPX. Therefore, the competing test signifies the unique role of MDA as the mediator.

Alternative measures of firm political* guanxi *(FPGX). We tested CEO political *guanxi* as a moderator, coded as 1 if CEOs acted as members of the central and local governments, and the People's Congress of the People's Political Consultative Conference, and 0 otherwise. Model 4 in Table 7 shows that the coefficient of interaction between CEO political *guanxi* and GDII is positive and significant ($\beta = 0.074$, $p < 0.05$). Model 5 in Table 7 shows that the interaction between CEO political *guanxi* and MDA is positively related to FDI ($\beta = 0.116$, $p < 0.01$). Therefore, this alternative is robust.

Alternative estimate approaches. We replaced the negative binomial regression with a Poisson regression. The Model 6 and Model 9 in Table 7 show that the effect of GDII on MDA and the effect of MDA on FDI are significantly positive, lending support to H1 and H2. Model 5 in Table 6 shows that for the bootstrapping analysis, β is 0.0001 ($p < 0.05$), while for the Monte Carlo simulations, the 95% CIs are [0.0000, 0.0001], lending support to H3. For moderation of DL and FPGX, the alternative estimation replicated the results of Table 5 (see Model 7, 8, 10, and 11 in Table 7).

Finally, to address the concern of the omitted-variable bias, we applied the impact of threshold of the confounding variable (ITCV) analysis (Frank, 2000), and found that to invalidate our results, an omitted variable needs to be simultaneously related to our independent and dependent variable at a level that is not exceeded by any single covariate in our models. Further, the ITCV results indicate that to invalidate estimates of GDII on MDA and MDA on FDI, 22.36% and 63.01% of our observations need to replace cases with an effect of 0, respectively, which seems unlikely (Hill et al., 2019; Larcker and Rusticus, 2010).

---------------------------Insert Table 8 about here-----------------

4. Discussion

4.1. Theoretical implications

Our study contributes to the literature in three ways. First, we advance the literature on digital innovation by responding to the growing demand for new theories on innovation in the digital era (Barrett et al., 2015; Benner and Tushman, 2015; Nambisan et al., 2017). Digital innovation is still in its nascent stages, and more conceptual and empirical research is needed. Specifically, we focus on the antecedents of digital innovation. While an increasing number of firms are adopting digital technologies for innovation, we know little about the factors driving this increase. Based on the detailed literature review, ours is the first study to empirically investigate the role of the government and a firm's digital leadership presence in digital innovation. This helps improve our understanding of the role of governments and leaders in digital innovation.

Second, our study theoretically argues and empirically tests the mediating role of firm managerial digital attention in the relationship between governmental digital initiatives and firm digital innovation, and advances an understanding of the effect of the environment on firm outcomes (Weerawardena et al., 2006). Given the importance of firms' environmental context, there is growing interest in examining its influence in shaping a firm's behavior and performance (Shin and Pérez-Nordtvedt, 2020; Srinivasan et al., 2020). However, few studies have identified the link between environmental factors and firms, and especially between government and firms. We narrow this gap by demonstrating the mediating role of digital leadership presence in the relationship between government initiatives and firm digital innovation.

Third, we complement the extant research using the ABV. We include both situated attention and the structure of attention as described in the ABV (Ocasio, 1997) in the same model to explain why firms are involved in digital innovation. Extant research has mainly focused on only one aspect of ABV (Ocasio et al., 2018; Stevens et al., 2015), such as attention structures (e.g., Cho and Hambrick, 2006; Souitaris and Maestro, 2010) or situated attention (e.g., Hoffman and Ocasio, 2001; Joseph and Ocasio, 2012). We argue that external environmental stimuli can arouse attention and drive organizations. Namely, the link between environmental stimuli and organizational moves is at least partially mediated by players' attention. We endeavor to provide a comprehensive analysis of the ABV by empirically validating the relationship between situated attention and the structure of attention. The role of information channels in developing strategic agendas has attracted little attention from ABV research (Ocasio et al., 2018). We identify firm political *guanxi* and digital leadership as key contexts, allowing firms to interact with the government on digital innovation issues. Also, based upon systematic review on ABV literature, Ocasio et al. (2020) have stated that the interrelationships between the ABV and complementary perspectives in organization theory need additional research efforts. In this paper, we try to integrate ABV with social network theory and upper echelon theory. By doing so, we respond the call and widen our vision on ABV. Last but not least, employing ABV to explore digital innovation will enrich ABV's content. Considering digital innovation will mostly involve firm organizational change, how government digital initiative, firm political *guanxi*, and firm digital leadership will shape firm managerial digital attention and digital innovation will deepen our understanding the role of ABV in a digital world.

4.2. Practical implications

Our findings have several managerial implications. First, in China, local governments have substantial control over the economy (Bruton et al., 2013; Tian et al., 2021) and crucial resources. Business opportunities are created through government policies. Thus, firms should pay close attention to governmental digital initiatives. Additionally, co-opting politician directors into the TMT is a primary way to gain unique information on government initiatives. These practices would likely enable firms to seize new opportunities that emerge from government initiatives.

Second, it is necessary and reasonable for leaders to focus on digitalization to implement digital innovation successfully, because digitization significantly affects organizational behavior and structure (Åberg et al., 2017). Our results show that the digital leadership is an important context of firm transferring digital attention to digital innovation. Accordingly, digital leaders may be critical in achieving strategic change through digitalization.

Third, in terms of policy, the positive effect of digital innovation on economic development indicates that policymakers should focus on the importance of digitalization to promote firms' involvement in digital innovation. Our findings support the positive role of the government in promoting firm digital innovation, suggesting that policies that foster digital innovation should be considered.

4.3. Limitation and future research

This study has some limitations. First, at one level, the idea of firm managerial digital attention as a mediator may not seem theoretically provocative. Questions may arise whether other potential conduits exist toward a firm's digital innovation other than digital attention. For example, Lazzarini (2015) showed that the accumulation and churning of regional resources and governmental capabilities mediate the link between industrial policy and a firm's competitive advantage. Using these two mediators in our context may be interesting and fruitful. Thus, given that the concept of attention is used to describe a variety of distinct yet interrelated mechanisms, processes, structures, and outcomes that work at various levels (Ocasio, 2011), we can envision a wealth of research opportunities in this regard.

Second, our research provides new insights into what drives firms' digital innovation. However, we fail to provide positive evidence on whether digital innovation improves financial performance. Digital technologies result in an environmental shift and create new opportunities (Teece, 2018). Therefore, it would be interesting and important for future research to investigate whether, which, and how firms reap superior performance through digital innovation.

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Table 1 The Ratio of Digital Economy to GDP in Several Major Economies

Countries	2015	2016	2017	2018	2019
USA	0.33	0.58	0.59	0.60	0.61
China	0.10	0.30	0.33	0.34	0.36
Germany	0.26	0.59	0.61	0.60	0.63
Japan	0.19	0.47	0.42	0.46	0.47
France	0.27	0.39	0.38	0.42	0.43
South Korea	\	0.41	0.37	0.47	0.48
India	\	0.18	0.13	0.20	0.20

Table 2 Topic and Top 10 Words Based on Latent Dirichlet Allocation (LDA)

Second-order code	Top 10 words
Digital innovation	Innovation, solution, product, R&D, artificial intelligence, transformation, informatization, data, automation, and efficiency.
Government digital initiative	Internet, government, plan, reform, industry, regulation, information infrastructure, artificial intelligence, market, and project
Digital leadership	Data, management, strategy, talent, control, online, center, technology, coordination, and platform

Notes: according to the salience of terms, the topic modeling produced 8 topics in order. The *digital innovation* is the second topic, the *government digital initiative* is the fifth topic, and the digital leadership is the seventh topic.

Table 3 Descriptive Analysis and Correlations

Variables	Mean	STD	1	2	3	4	5	6	7	8	9
1 Firm digital innovation	10.70	52.85	1								
2 Government digital attention intensity	77.41	42.75	0.027***	1							
3 Managerial digital attention	15.20	29.00	0.153***	0.066***	1						
4 Digital leadership	0.16	0.29	0.009	-0.013	0.058***	1					
5 Firm political guanxi	0.06	0.11	0.001	-0.035***	-0.016	0.021**	1				
6 Firm age	16.04	5.37	0.027***	0.117***	-0.033***	-0.068***	-0.021**	1			
7 Firm size	22.26	1.32	0.228***	0.074***	-0.080***	-0.050***	0.033***	0.184***	1		
8 ROA	5.77	6.37	0.019*	0.009	0.035***	0.054***	0.039***	-0.006	0.063***	1	
9 Ownership concentration	0.58	0.15	-0.003	0.012	-0.047***	0.057***	0.046***	-0.198***	0.153***	0.166***	1
10 Firm leverage	0.43	0.22	0.089***	-0.011	-0.142***	-0.072***	-0.029***	0.205***	0.474***	-0.261***	-0.089***
11 R&D spending	15.59	6.59	0.064***	0.149***	0.117***	-0.002	-0.072***	0.171***	0.087***	-0.023**	-0.042***
12 R&D employee	0.08	0.12	0.095***	0.254***	0.371***	0.046***	-0.082***	0.059***	-0.072***	-0.002	-0.088***
13 Board size	8.68	1.71	0.049***	-0.022**	-0.088***	0.004	0.014	0.087***	0.296***	0.012	0.024**
14 Board ownership	0.28	0.58	-0.050***	-0.018*	0.083***	0.163***	0.030***	-0.209***	-0.297***	0.097***	0.251***
15 TMT average age	47.05	3.55	0.047***	0.056***	-0.107***	-0.031***	0.040***	0.179***	0.334***	-0.028***	0.006
16 TMT oversea background	0.05	0.11	0.032***	0.074***	0.099***	0.051***	0.052***	-0.071***	0.000	0.041***	0.036***
17 CEO age	49.37	6.07	0.028***	0.039***	-0.024**	0.010	0.061***	0.090***	0.143***	0.025**	0.025**
18 CEO duality	0.26	0.44	-0.004	0.024**	0.083***	0.042***	0.136***	-0.101***	-0.178***	0.037***	0.026**
19 Provincial GDP	10.42	0.67	0.056***	0.199***	0.101***	-0.020*	0.010	0.008	-0.090***	0.042***	0.027**
20 Industrial concentration	0.74	0.13	-0.014	0.036***	-0.087***	-0.036***	-0.005	0.087***	0.213***	-0.072***	0.085***

Table 3 Descriptive Analysis and Correlations (Continued)

Variables	10	11	12	13	14	15	16	17	18	19	20
10 Firm leverage	1										
11 R&D spending	-0.014	1									
12 R&D employee	-0.156***	0.306***	1								
13 Board size	0.178***	-0.066***	-0.121***	1							
14 Board ownership	-0.281***	-0.058***	0.031***	-0.151***	1						
15 TMT average age	0.193***	0.099***	-0.020*	0.177***	-0.235***	1					
16 TMT oversea background	-0.052***	0.045***	0.083***	-0.036***	0.037***	-0.031***	1				
17 CEO age	0.063***	0.064***	0.002	0.068***	-0.106***	0.535***	-0.005	1			
18 CEO duality	-0.144***	0.013	0.049***	-0.175***	0.178***	-0.091***	0.082***	0.139***	1		
19 Provincial GDP	-0.110***	0.158***	0.152***	-0.104***	0.111***	-0.144***	0.104***	-0.033***	0.107***	1	
20 Industrial concentration	0.176***	0.040***	-0.071***	0.070***	-0.094***	0.100***	-0.030***	0.014	-0.060***	-0.021**	1

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; $N = 12,764$.

Table 4 Regression Results Predicting Firm Digital Innovation

Variables	Model 1	Model 2	Model 3	Model 4
	DV: MDA		DV: DFI	
Managerial digital attention (MDA)				0.003***
				(0.001)
Government digital initiative intensity (GDII)		0.020**	0.045***	0.043***
		(0.009)	(0.010)	(0.010)
Digital leadership (DL)	0.030*	0.029*	0.011	0.014
	(0.016)	(0.016)	(0.021)	(0.021)
Firm political guanxi (FPGX)	-0.035**	-0.033**	-0.060***	-0.058***
	(0.015)	(0.015)	(0.018)	(0.018)
Firm age	0.035***	0.034***	0.035***	0.036***
	(0.005)	(0.005)	(0.005)	(0.005)
Firm size	0.176***	0.171***	0.308***	0.299***
	(0.018)	(0.019)	(0.022)	(0.022)
ROA	0.004*	0.004*	-0.005**	-0.005**
	(0.002)	(0.002)	(0.002)	(0.002)
Ownership concentration	0.127	0.124	-0.290**	-0.257*
	(0.118)	(0.118)	(0.138)	(0.138)
Firm leverage	-0.008***	-0.008***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
R&D spending	0.026***	0.026***	0.020***	0.020***
	(0.002)	(0.002)	(0.002)	(0.002)
R&D employee	0.579***	0.552***	0.252**	0.159
	(0.077)	(0.078)	(0.106)	(0.107)
Board size	-0.002	-0.002	0.001	0.001
	(0.010)	(0.010)	(0.011)	(0.011)
Board ownership	0.046**	0.048**	-0.013	-0.018
	(0.022)	(0.022)	(0.033)	(0.034)
TMT average age	0.006	0.006	0.014**	0.014**
	(0.005)	(0.005)	(0.006)	(0.006)
TMT oversea background	0.223*	0.205	0.094	0.068
	(0.127)	(0.127)	(0.151)	(0.152)
CEO age	-0.001	-0.001	0.003	0.003
	(0.003)	(0.003)	(0.003)	(0.003)
CEO duality	0.108***	0.108***	-0.008	-0.009
	(0.031)	(0.031)	(0.039)	(0.039)
Provincial GDP	0.308***	0.292***	0.243***	0.224***
	(0.036)	(0.036)	(0.046)	(0.046)
Industrial concentration	-0.168	-0.173	0.164	0.258
	(0.146)	(0.146)	(0.188)	(0.188)
Constant	-7.497***	-7.168***	-10.129***	-9.776***
	(0.541)	(0.557)	(0.695)	(0.698)
Province / industry fixed effect	Yes	Yes	Yes	Yes
Observations	9,000	9,000	9,000	9,000
Log likelihood	-18638.13	-18635.40	-14600.24	-14587.74
Wald chi2	1577.71***	1587.23***	1294.62***	1331.74***

Notes: Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; p-value tests are based on one-tail tests. FDI refers to firm digital innovation.

Table 5 Regression Results for Moderation of DL and FPGX

Variables	Model 1	Model 2	Model 3	Model 4
	DV: MDA		DV: DFI	
FPGX × MDA (H5b)				0.024***
				(0.009)
DL × MDA (H5a)			0.034***	
			(0.011)	
FPGX × GDII (H4b)		0.019**		
		(0.010)		
DL × GDII (H4a)	-0.014			
	(0.009)			
Managerial digital attention (MDA)			0.098***	0.094***
			(0.018)	(0.018)
Government digital initiative intensity (GDII)	0.019**	0.023***	0.046***	0.045***
	(0.009)	(0.009)	(0.010)	(0.010)
Digital leadership (DL)	0.027	0.029*	0.004	0.011
	(0.016)	(0.016)	(0.021)	(0.021)
Firm political guanxi (FPGX)	-0.033**	-0.029*	-0.063***	-0.067***
	(0.015)	(0.015)	(0.018)	(0.019)
Firm age	0.034***	0.034***	0.036***	0.036***
	(0.005)	(0.005)	(0.005)	(0.005)
Firm size	0.171***	0.171***	0.299***	0.299***
	(0.019)	(0.019)	(0.022)	(0.022)
ROA	0.003*	0.004*	-0.005**	-0.005**
	(0.002)	(0.002)	(0.002)	(0.002)
Ownership concentration	0.122	0.122	-0.250*	-0.259*
	(0.118)	(0.119)	(0.138)	(0.139)
Firm leverage	-0.008***	-0.008***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
R&D spending	0.026***	0.026***	0.020***	0.020***
	(0.002)	(0.002)	(0.002)	(0.002)
R&D employee	0.554***	0.558***	0.148	0.154
	(0.078)	(0.078)	(0.107)	(0.107)
Board size	-0.002	-0.002	0.001	0.001
	(0.010)	(0.010)	(0.011)	(0.011)
Board ownership	0.047**	0.049**	-0.015	-0.017
	(0.022)	(0.022)	(0.034)	(0.034)
TMT average age	0.006	0.006	0.014**	0.014**
	(0.005)	(0.005)	(0.006)	(0.006)
TMT oversea background	0.203	0.199	0.084	0.083
	(0.127)	(0.127)	(0.152)	(0.152)
CEO age	-0.001	-0.001	0.003	0.003
	(0.003)	(0.003)	(0.003)	(0.003)
CEO duality	0.108***	0.109***	-0.008	-0.008
	(0.031)	(0.031)	(0.039)	(0.039)
Provincial GDP	0.293***	0.291***	0.219***	0.226***
	(0.037)	(0.036)	(0.046)	(0.046)
Industrial concentration	-0.179	-0.178	0.253	0.243
	(0.146)	(0.146)	(0.188)	(0.188)
Province / industry fixed effect	Yes	Yes	Yes	Yes
Constant	-7.205***	-7.156***	-9.706***	-9.723***
	(0.558)	(0.557)	(0.700)	(0.700)
Observations	9,000	9,000	8,998	8,998
Log likelihood	-18634.26	-18633.45	-14584.05	-14584.78
Wald chi2	1590.12***	1593.72***	1350.80***	1346.69***

Notes: Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; p-value tests are based on one-tail tests. FDI refers to firm digital innovation.

Table 6 Results for the Mediation

Test Tools	Model 1		Model 2		Model 3		Model 4		Model 5	
	Coef.	95% CI	Coef.	95%CI	Coef.	95% CI	Coef.	95% CI	Coef.	95% CI
Bootstrapping Analysis	0.0085 (0.002)	[0.0040, 0.0129]	0.0001 (0.002)	[0.0000, 0.0003]	0.0001 (0.001)	[-0.0007, 0.004]	0.0001 (0.001)	[-0.0009, 0.0011]	0.0001 (0.001)	[0.0040, 0.0129]
Monte Carlo Simulations		[0.0001, 0.0012]		[0.0001, 0.0007]		[-0.0012, 0.0107]		[-0.0051, 0.0067]		[0.0000, 0.0001]

Notes: Standard errors in round parentheses and 95% CIs in square parentheses; coef. represents the size of the mediating effect; 95% CI without zero indicates the presence of mediation.

Table 7 Robustness Check Results

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11
		DV: FDI		DV: MDA	DV: FDI		DV: MDA			DV: FDI	
FPGX × MDA (H3b)			0.020***	0.074**	0.116***						0.020***
			(0.007)	(0.030)	(0.035)						(0.003)
DL × MDA (H3a)		0.047***								0.026***	
		(0.011)								(0.004)	
FPGX × GDII (H2b)								0.009**			
								(0.004)			
DL × GDII (H2a)							-0.021				
							(0.013)				
Managerial digital attention	0.129***	0.133***	0.130***		0.073***				0.019***	0.020***	0.012*
(MDA)	(0.009)	(0.011)	(0.009)		(0.019)				(0.006)	(0.006)	(0.006)
Government digital initiative	0.008*	0.009	0.008*	0.017*	0.044***	0.019***	0.016	0.018***	0.011***	0.013***	0.012***
intensity (GDII)	(0.004)	(0.006)	(0.004)	(0.009)	(0.010)	(0.003)	(0.013)	(0.003)	(0.004)	(0.004)	(0.004)
Digital leadership (DL)	0.021**	0.023**	0.021**	0.030*	0.014	0.023***	0.023	0.024***	0.009	-0.015	-0.009
	(0.009)	(0.011)	(0.009)	(0.016)	(0.021)	(0.006)	(0.024)	(0.006)	(0.010)	(0.011)	(0.011)
Firm political guanxi (FPGX)	0.012*	0.016*	0.015**	-0.025	-0.148***	0.008	0.013	0.009*	0.008	-0.004	-0.016**
	(0.006)	(0.009)	(0.006)	(0.044)	(0.046)	(0.005)	(0.022)	(0.005)	(0.007)	(0.008)	(0.008)

Notes: Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; p-value tests are based on one-tail tests. FDI refers to firm digital innovation.

APPENDIX: A mini-case of Huawei

Huawei's digital innovation strategy

Huawei, a global leading provider of IT technologies, has about 180,000 employees operated in more than 170 countries. Huawei's vision is to bring a fully connected world via digitalization, and digital innovation is an essential component of this strategy.

Huawei's type of digital innovation

Huawei's digital technologies, such as cloud data centers, 5G, artificial intelligence (AI), video cloud platforms, and edge computing Internet of Things (EC-IoT) covers several business areas, including R&D, sales, delivery, and logistics. Huawei was one of the first firms to launch the 5G commercial chip worldwide, and is now an important player that provides end-to-end commercial solutions in 5G technology. Huawei has also made breakthroughs in AI algorithms and calculations that include the chip series, the chip enablement layer, the application enablement platform (ModelArts), and training and inference frameworks (MindSpore).

Huawei's digital innovation achievement

Huawei has made outstanding achievements in digital technologies due to robust and consistent efforts in digital innovation. The company has won various awards across novel technology domains in recent years, including the "LTE Innovation and Commercialization" award at the LTE World Summit in the 4G field, the Global Telecom Business Innovation Award, Wholesale Network Innovation and Consumer Voting Innovation Award, and so forth (Zhang et al., 2020). In addition, Huawei's digital patents have increased sharply over the past two decades (Figure 1A shows details), increasing their number of applied digital-related patents from 2,140 in 2002 to 12,699 in 2019. Huawei holds the largest number of 5G patents around the world and is a leader in the global 5G patent race (IPlytics, 2019). Compared with other high-tech firms, such as ZTE, Intel, Nokia, LG, Huawei had largest amount of 5G patents in 2019 as shown in Figure 2A. Singaporean Prime Minister Lee Hsien Loong trusts and supports Huawei's technology, demonstrating that Huawei's 5G technology is ahead (Sahu, 2019). Huawei has also established global partnerships with other technology leaders such as Leica, the German camera producer, to add novel dimensions in digital photography and increasing the quality of smartphone cameras (Cipriani, 2019).

How Huawei achieved digital innovation

How did Huawei arrive at its current place in digital innovation? The first factor was continuous R&D investment, which Huawei increased from 2008 to 2018, as shown in Figure 3A. Its R&D expenditure was more than that of Intel, Apple, and Microsoft in 2018. The number of R&D employees also rose from 51,000 to 76,000 between 2010 and 2014. Huawei has invested substantially in R&D, which directly promotes innovation advancements.

The second factor was a globalization strategy. Huawei has begun establishing R&D centers abroad such as in Silicon Valley in the 1990s (Fan, 2011) and sped up the establishment of more laboratories in North America and Europe between 2004 and 2010. The Huawei Innovation Research Program has also funded research projects around the world.

The third factor is that as a corporation, Huawei has various external stakeholders (universities, governments, and others). Since the government is one of the most prominent stakeholders in China, Huawei's cooperation and attention to state policies have played an essential role in advancing digital innovations. In particular, as Chinese government has a put a strong emphasis on indigenous innovation as well as carried out various innovation initiatives, it has resulted in a new industrial revolution involving cloud computing, AI, and big data. For example, inspired by the Chinese government, Huawei has implemented several AI and communication projects over the past decade (Zhang et al., 2020).

---------------------------Insert Figures 1A, 2A, and 3A about here-----------------

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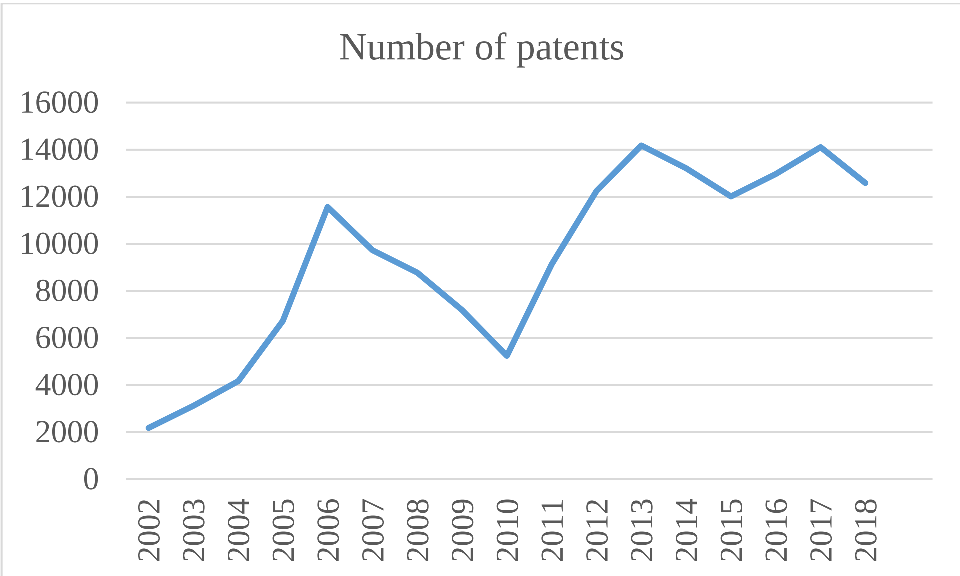

Figure 1A. The Number of Huawei's Applied Digital Patents (Source: Incopat).

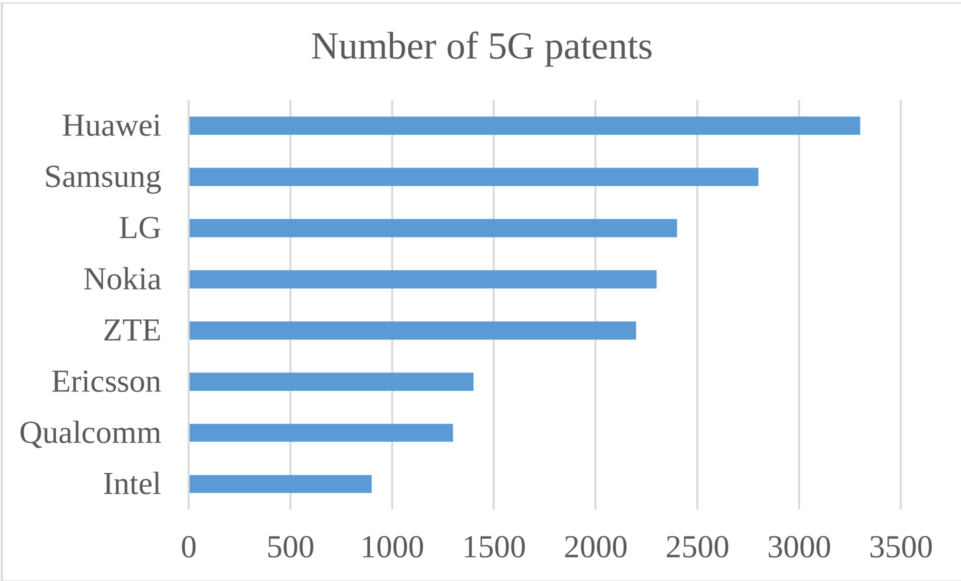

Figure 2A. The Number of 5G Patents in Global High-tech Firms (Source: Pohlmann, 2019).

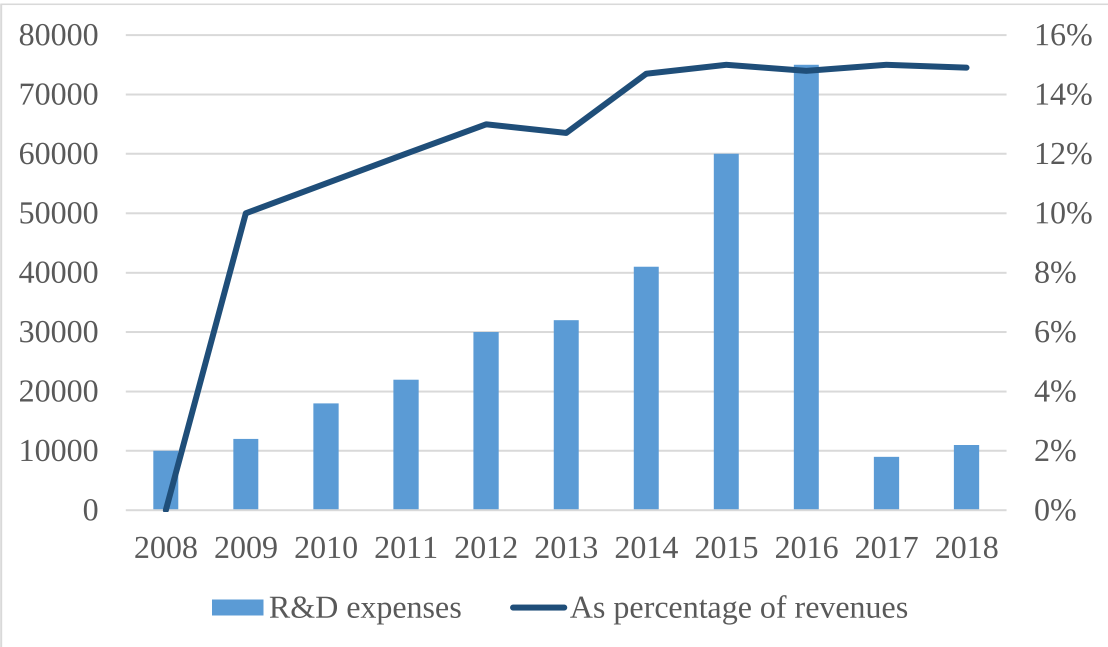

Figure 3A. Huawei's R&D Expenses (Source: Huawei annual reports).

APPENDIX B

Table 1B Six Major Groups of Digital elements by Eremina et al. (2019)

Group	Basic term	Number
General	innovation, technology, R&D, research, software, digital, computer, programming, cloud, platform, wireless, server	12
Internet of things	vehicle to everything, V2V, intelligent things, connectivity, connected objects, V2X, internet of things, sensor, actuator, vehicle to vehicle, intelligent solutions, adaptive architecture, IoT	13
Data science	predictive analytics, big data, user behavior, data analytics, data feed, data science, data management	7
Process automation	automation, robotization, 3D printing, industry 4.0, autonomous devices, asset tracking, smart	7
Artificial intelligence	machine learning, artificial intelligence, neural network, deep learning	4
Online	social network, e-commerce, web, online, internet, website	6

Table 2B The Annual Number of Firm Digital Patents across Six Major Groups

Year	General	Internet of things	Data science	Process automation	Artificial intelligence	Online	Total
2013	1580	1297	136	1239	4	761	5017
2014	2819	2154	209	1998	6	1102	8288
2015	4078	3930	438	3949	12	1421	13828
2016	4972	5499	548	5604	22	1694	18339
2017	6079	6039	699	7828	74	1831	22550
2018	7116	7895	899	9966	249	2154	28279
Total	26644	26814	2929	30584	367	8963	96301

Table 3B The Annual Number of Government Digital Initiative across Six Major Groups

Year	General	Internet of things	Data science	Process automation	Artificial intelligence	Online	Total
2012	1532	19	0	17	0	34	1602
2013	1670	21	3	56	0	41	1791
2014	1480	15	10	31	0	72	1608
2015	1822	36	40	75	1	112	2086
2016	2524	27	91	126	2	111	2881
2017	2280	23	90	134	6	77	2610
Total	11308	141	234	439	9	447	12578

Table4B The Annual Number of Managerial Digital Attention across Six Major Groups

Year	General	Internet of things	Data science	Process automation	Artificial intelligence	Online	Total
2012	4729	824	309	5145	8	489	11504
2013	5104	1201	713	7281	6	814	15119
2014	5421	1561	1431	9859	28	1324	19624
2015	5688	1834	2706	12747	140	1649	24764
2016	6260	2358	3590	16509	719	1563	30999
2017	6387	2650	4071	18664	1802	1242	34816
Total	33589	10428	12820	70205	2703	7081	136826