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Surfing with the tides:
How digitalization creates firm performance through supply chain entrainment

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Surfing with the tides:

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Abstract

Purpose – Digitally oriented firms are faced with new opportunities and risks in today's ever-changing world. Drawing upon organisational entrainment theory, this study investigates how supply chain (SC) entrainment improves the effects of digital orientation on firm performance through absorbing risks and exploiting opportunities.

Design/methodology/approach – Survey data was collected from 307 Chinese manufactures and analysed using structural equation modelling and regression analysis.

Findings – The results show digital orientation absorbs risk through evoking three SC entrainment dimensions (i.e., internal entrainment, entrainment with customers, and entrainment with suppliers). Entrainment with customers and suppliers mediate the relationship between internal entrainment and firm performance. An opportunity exploitation mechanism is evidenced by the moderating effects of internal and external entrainment on the relationship between digital orientation and firm performance.

Practical implications – The empirical findings provide timely insights for managers to fully harness the benefits of digital orientation by using SC entrainment, i.e., to match the tempo and pace of internal and external cyclical activities to reduce the risks and increase the benefits of adopting advanced digital technologies. We show managers how to adjust their organization's actions to keep tempo and synchronous phase with their SC partners.

Original/value – The study introduces and conceptualizes a construct (i.e., SC entrainment) to understand how risks and opportunities arising from digital transformation can be addressed to maximize the value of advanced digital technologies.

Keywords: digital orientation; supply chain entrainment; performance; organisational entrainment theory

Paper type: Research paper

1. Introduction

There is plenty of news claiming success implementation of digital technologies. Titan America claimed to have successfully implemented artificial intelligence (AI) and machine learning at its cement plants, resulting in enhanced equipment throughput and reliability, reduced energy consumption, and improved product consistency and quality (PR Newswire, 2022). Nokia and GSMA Intelligence claimed annual productivity and energy-saving gains of 10% to 20% can be realized through the conversion to smart factories. Pekka Lundmark, President and CEO of Nokia, suggested that digitalization is critical for reducing waste, improved efficiency, and greater productivity. In the agriculture sector, the adoption of digital technology can allegedly increase yields, reduce costs, and cut water use (Globe Newswire, 2021). These claims drive the belief that digital technologies, e.g., big data analytics (BDA), artificial intelligence (AI), internet of things (IoT), and blockchain, can dramatically transform the way firms operate and create value (Ye et al., 2022; Yu et al., 2021a).

Academic research suggests digital technologies in supply chain (SC) are strategic for value creation and operational outcomes (Faruquee et al., 2021; Ye et al., 2022; Mishra et al., 2022; Nasiri et al., 2022a). In pursuit of "digital technology-enabled opportunities to achieve competitive advantage" (Kindermann et al., 2021, p.649), research suggests the needs for *digital orientation*, which is a concept that integrates market orientation (Quinton et al., 2018) and technology orientation (Gatignon and Xuereb 1997). However, not all digitalization projects create market performance (Lumineau and Oliveira, 2020; Tabrizi et al., 2019). For example, JLA experienced increased operational costs from implementing an electronic reporting system for regulatory reports for a client. These failures are common. The reports by McKinsey and Forbes indicate that enterprises wasted a total of $900 billion on digitalisation projects in 2018 (Tabrizi et al., 2019). The reports state GE started a digital service business when the industries were not ready for it. Boston Consulting Group also shows that 70% of digital transformation projects failed (Block, 2021; Forth et al., 2020).

Among many reasons why digital transformation can fail, this study focuses on the issues of fit and timing. In a SC, there are often asymmetric digital capabilities (motives) between buyers and suppliers (Son et al., 2021). Internally, digitalization projects are often not synchronised with efforts to develop competence (Bjorkdahl, 2020). Externally, the opportunities a firm's digital orientation can create are affected by market dynamism (Mishra et al., 2022). Digital

transformation involves coordination of interdependencies among heterogenous actors in a firm's digital ecosystem (Kindermann et al., 2021). Such coordination is required in interconnected SCs wherein the environment is more uncertain and dynamic than ever. Like surfers waiting for the right wave, timing is key. Firms need to coordinate the timing when there is a "safer" state for adopting new technologies (Bjorkdahl, 2020). They must consider both business cycles when digitalization obstructs profit-making activities and occasions (e.g., COVID-19) when digitalization can mitigate disruptions in global SCs (Faruquee et al., 2021; Ye et al., 2022). However, this important issue is under-studied. So, we address the following research question: *how do firms align and synchronise the time and pace of digitalization initiatives with internal functions and SC partners for performance improvement*?

To answer the above research question, we adopt from organizational studies a concept called *entrainment*, defined as "the processes by which organizations cope with temporal change by synchronizing their endogenous cyclic activities to those of the external environment" (Pérez-Nordtvedt et al., 2008, p.788). SC entrainment processes enable tempo matching and/or phase alignment of SC activities and new initiatives (e.g., digitalization) to avoid disturbing operations. However, the question of "how" entrainment strategies used by organizations can impact outcomes has remained largely understudied (Dille et al., 2022; Sandra et al., 2022). We incorporate the *organisational entrainment theory* (Pérez-Nordtvedt et al., 2008) to theorize how a firm's digital orientation can create performance when appropriate SC entrainment strategies are used. Here we extend the organizational entrainment theory by conceptualizing the entrainment processes required for SC digitalization. We also advance the SC collaboration and coordination literature (Cao and Zhang, 2011) that emphasizes coordination of planning routines (Geiger et al., 2021) because less is known about coordinating collaboration to develop new routines (e.g., use of digital technologies) that often involves many uncertainties.

Entrainment theory has been applied at an individual, group (e.g., Ancona and Chong, 1996; Labianca et al., 2005; McGrath et al., 1984), and organisational level (e.g., Dibrell et al., 2015; Khavul et al., 2010; Pérez-Nordtvedt et al., 2008). At an organizational level, entrainment is shown to improve performance of international new ventures (Khavul et al., 2010) and firm innovativeness (Dibrell et al., 2015). Extending the concept of entrainment to a SC level can enrich SCM research. SC entrainment is vital because manufacturers often attempt to synchronize internal SC activities with customers and suppliers (Khavul et al., 2010; Yu et al., 2019). For digitalization,

suppliers must participate when a buyer adopts a technology (e.g., blockchain) that works only when it is used at a SC level.

This study also contributes to the measurement of SC entrainment. Measuring entrainment using a singular categorical descriptor or dimension (e.g., Khavul et al., 2010) is inadequate for a SC context. A multidimensional conceptualisation can improve research reliability and validity, and generate more meaningful research findings (McCarthy et al., 2010). Organizational studies divide entrainment into internal (intra-) and external (extra-) entrainment (Dibrell et al., 2015; Sandra et al., 2022), both of which are necessary. We cannot ignore intra-organizational entrainment because there are many functional decisions that must be aligned with SC partners and the environment (Yu et al., 2021b). For digitalization to benefit the SC, we must also consider inter-organizational entrainment, especially with suppliers and customers. Thus, we divide *SC entrainment* into three dimensions: *internal entrainment*, *entrainment with customers*, and *entrainment with suppliers*. By developing and testing these new constructs and measurement scales, future studies can better understand entrainment practices for digitalization and other applications.

Finally, this study unpacks the mechanisms by which SC entrainment enables tempo matching and/or phase aligning of SC activities with digital transformation to create performance. The literature recognizes firms need to be open to digital technologies (Chavez et al., 2022) and integrate with market orientations (Quinton et al., 2018), but it lacks information on strategies to align supply chains in changing markets. Here we elaborate how the different entrainment strategies address uncertainties and interdependencies facing internal functions, suppliers and customers when they coordinate the adoption of digital technologies. Surfers deal with changing waves with two mechanisms: absorption/mitigation and capturing opportunities. There are bad times when digitalization is better when scaled down to reduce damages. There are times when SC entrainment is used to capture opportunities, e.g., adoption of digital technologies during COVID-19 to serve new markets. We further conceptualize and test how these dual mechanisms of SC entrainment create implications for theory and practice.

2. Theory and constructs

2.1. Organisational entrainment theory and SC entrainment

A narrower concept of entrainment means one cyclical process is captured by or synchronized with another process such that they oscillate in rhythm with one another (Shi and Prescot, 2012). The concept of entrainment was first developed in physics and then applied to the social sciences at the individual and team levels (e.g., Ancona and Chong, 1996; Labianca et al., 2005; McGrath et al., 1984) and then the organisational level (e.g., Dibrell et al., 2015; Khavul et al., 2010; Pérez-Nordtvedt et al., 2008). A variety of management disciples have used entrainment to study the importance of time, pace, and rhythm for collaboration practices. A notable work by Pérez-Nordtvedt et al. (2008) used entrainment theory to investigate how firms effectively respond to a temporal misfit caused by temporal environmental changes. They defined organisational entrainment as "the processes by which organizations cope with temporal change by synchronizing (i.e., tempo matching and/or phase aligning) their endogenous cyclic activities to those of the external environment" (Pérez-Nordtvedt et al., 2008, p.788). In organization behaviour, human relations, and any kind of tactical or strategic alliance presuppose orchestrion of tasks, which implies sequencing and timing between parties, namely entrainment (Standifer and Bluedorn, 2006). In project management, entraining temporal structures plays a main role for interorganizational collaboration and synchronization of tasks between project stakeholders (Dille et al., 2022).

SC entrainment is a less-understood concept in the SC and digital transformation literature. This study argues SC entrainment is a much complex concept that involves multiple dimensions. Tempo entrainment is about the pacing of two behaviours (same pace). Temporal coupling is vital for effective coordination of routines and collaboration within firms and with external actors (Geiger et al., 2021). Synchronic entrainment is about having a similar cycle or rhythm. Many business activities affected by endogenous cyclic activities (e.g., financial reporting) and external environment (e.g., seasonal demand, technology, and economic cycles) may affect digitalization efforts. It is important to acknowledge that for two parties to gain benefits from matching the pace and cycle of their respective digitalization and business activities, they must be aligned. To coordinate pace (tempo) and cycle (synchronic), there is also a need for alignment (harmonize) supported by trust and commitment between SC partners (Agndal and Nilsson, 2019). So, we need harmonic entrainment, which occurs when two behaviours as seen by outsiders as going well

together (Ancona and Chong, 1996). In a SC context, collaborative planning, forecast and replenishment (CPFR) involves pacing (tempo) of cyclical (synchronic) demand forecasting, planning, replenishment, and reordering decisions between different functions, suppliers, and customers, supported by aligned goals among all parties (harmonic).

The SC entrainment concept is key to understand how digital orientation creates performance. Specifically, following Pérez-Nordtvedt et al. (2008) and Dibrell et al. (2015), we argue internal or intra-organizational entrainment (e.g., inter-functional coordination of planning cycles) and external entrainment behaviours (e.g., matching market opportunities, buying seasons, or swings in customer spending) help a firm's digitalization efforts to capture value. Depending on the level of complexity, managers need to decide "when different cycles should be entrained and when they should not" and if entrainment is needed, who to entrain e.g., customers, suppliers, or regulators (Ofori-Dankwa and Julian, 2001, p.426). Khavul et al. (2010) show the need to synchronize the degree and scope of internationalization with important international customers. In merger and acquisition literature, intra-entrainment is used to synchronize acquisition and alliance initiatives and extra-entrainment is used to synchronize alliance strategies with competitors (Shi and Prescot, 2012). Both intra-organizational entrainment and inter-organizational entrainment are important. SC managers need to match digitalization with SC activities, technology cycles, financial cycles, and the changing levels of uncertainties in supply and demand. Thus, we draw upon organisational entrainment theory and divide SC entrainment into three dimensions: internal entrainment, entrainment with customers, and entrainment with suppliers, which reflect internal, downstream, and upstream dynamics (Mishra et al., 2022) and interdependencies (Kindermann et al., 2021). The three dimensions are defined as follows.

Internal entrainment. Functional departments within a firm (such as operations, marketing, technology, and product/service development functions) each have their own rhythm or pace, which needs to be coordinated to achieve internal temporal synchronization (McCarthy et al., 2010; Shi and Prescot, 2012). Ofori-Dankwa and Julian (2001, p.426) refer to financial reporting cycles and seasonal demand cycles that are "seemingly differentiated" but can "become captured and oscillate in sympathy with each other." The sales and operations planning cycle is a good example of tempo matching as new products are incorporated into supply plans. Likewise, the implementation of new information systems or technologies can also be phase-matched with daily operations to minimize risks such as poor quality, elevated costs, and supply disruption. Consistent

with organisational entrainment theory, we define internal entrainment as the synchronization of the tempo and pace of internal organizational activities (such as internal task and process planning, coordination of inter-functional activities) across functional areas within a firm (Dibrell et al., 2015; Pérez-Nordtvedt et al., 2008).

Entrainment with customers and suppliers. An effective SC works according to a rhythm that harmonizes the dynamics in the environment or *zeitgeber* (*zeit* means time and *geber* means giver). Digitally oriented firms act according to market dynamics (Mishra et al., 2022). Many stakeholders such as customers, suppliers, and governments put demands on a firm to follow different rhythms (Pérez-Nordtvedt et al., 2008). According to organisational entrainment theory, external entrainment with customers and suppliers is defined as the synchronization of a focal firm's tempo and synchronous phase with a pacer in its external environment, e.g., customer and supplier actions and activities (McCarthy et al., 2010; Shi and Prescot, 2012). Sometimes the supply or customer markets act as the pacer (i.e., the tempo at which the activity cycles are to be performed) and phase of activity cycles (i.e., how aligned business cycles are with each other) to which the firm must entrain (Khavul et al., 2010; Dibrell et al., 2015). By synchronizing internal and external activity cycles with those of the most important business stakeholders like suppliers and customers, SC entrainment helps a firm capitalize on the dynamics of the external environment (Ancona and Chong, 1996; Pérez-Nordtvedt et al., 2008) and mitigate adverse effects that may arise.

While collaboration and coordination efforts require some forms of entrainment principles, the dominant entrainment theory to date has concentrated on the importance of tempo matching or the temporal lens in organizations; however, the impact on organizational outcomes, which emphasises the existence of dependent and independent variables, has been overlooked (Sandra et al., 2022). Specifically, 'what' factors and 'how' entrainment can encourage interorganizational synchronization, coordination and collaboration have remained largely understudied (Dille et al., 2018; 2022). Our integrated theoretical model, which includes external variables (i.e., digital orientation), performance outcomes and interrelationships between internal and external entrainment constructs, provides potential answers to these questions and extends the temporal lens of entrainment.

2.2. Digital orientation

Digital orientation entails the adoption of digital technologies and the support of organizational processes with them (Chavez et al., 2022). However, digital orientation is not simply about technology orientation (Gatignon and Xuereb 1997). Digital orientation is a form of strategic orientation (Kindermann et al., 2021) that integrates market orientation (Quinton et al., 2018) with a technology orientation that considers market dynamics (Mishra et al., 2022). That means digital technologies aimed at creating positive market responses and matching with changes in technological competitive landscapes (Chavez et al., 2022; Nasiri et al., 2022b). In the present study, we define *digital orientation* as a firm's strategic actions to deploy advanced digital technologies and solutions for smart manufacturing, cross-functional integration/communication, new product design, and discovery of new customer needs so that a firm can attract and serve new markets. These advanced digital technologies may include IoT, AI, BDA, and machine learning that support SC information integration e.g., new product and service development, digital systems, and platforms (Kindermann et al., 2021).

3. Research model and hypotheses

3.1. Research model

Grounded in organisational entrainment theory (Pérez-Nordtvedt et al., 2008), we develop an integrated theoretical framework to explain the roles of SC entrainment in the relationship between digital orientation and firm performance. This implies SC entrainment can play two important roles.

First, SC entrainment mitigates the adverse effects of market dynamics that often compound the risks of digitalization projects. For example, it is not a good idea to develop machine learning applications when there are errors in SC data. SC entrainment is used to match phases of digitalization projects with existing operational plans and uncertainties in the market. In this role, SC entrainment acts as an absorber of risks, meaning it is mediating the relationship between digital orientation and performance (see Figure 1a).

Second, SC entrainment boosts the effectiveness of digital technologies in exploiting opportunities when the timing is right. For example, firms that have adopted appropriate digital technologies to support working from home and the capabilities to develop alternate markets can

turn disruptions caused by COVID-19 into advantages. In this role, SC entrainment acts as a moderator that strengthens the effects of digital orientation (see Figure 1b).

---------- Insert Figures 1a and 1b ----------

3.1. Effect of digital orientation

There are two primary mechanisms that allow a firm to generate performance through digital orientation: the exploitation of technology-enabled markets and using digital technologies to gain efficiency. There are several channels through which digital technologies, when deployed in the market, impact performance. The first is the revenue stream. Digitization facilitates additional revenue from additional features. For example, a consumer can purchase an Audi car with a navigation feature. Audi has digitized the navigation feature by enabling internet connectivity. A consumer can pay a monthly fee for the navigation to be updated with live traffic and dynamic routing. Tesla has leveraged a similar model with turning on and off various options in their vehicles depending on what options the consumer wants, e.g., extra power or battery life. In addition to selling features, companies like Cummins Engine use digitization to enhance maintenance and service of their engines. Sophisticated sensors monitor the operating characteristics of the engine and report them back to Cummins. Cummins then responds by informing the owner that their vehicle needs to be brought in for service. This potentially improves maintenance revenue, but also improves loyalty to the brand that improves repeat purchases. Related to the above examples is the concept of obsolescence. By causing digital features to become outdated or creating new desirable features, companies can induce incremental sales as consumers are stimulated to purchase replacement products sooner than otherwise planned.

Another channel through which performance can be improved is through the creation of an ecosystem. When products are digitized, they can be architected in such a way that they are compatible with a limited range of other technologies. This allows firms such as Apple to benefit from driving their phone adopters into a deeper relationship with them as the value of the customer's phone increases when the customer buys other Apple products such as computers or software. The result is an improvement of revenue for Apple that extends beyond the phone. Companies can leverage technology to better understand the market and the available opportunities. Companies can find profitable niches from sophisticated analytical tools. They can also optimize pricing given the firm's strategy. Pricing can be tailored for market share gain or maximum profit.

The second mechanism is the use of digital technologies to gain efficiency. Examples include ERP systems, production planning, vehicle routing software, and the like. Such digital platforms facilitate the collection and migration of information from various sources to help firms generate new ideas and knowledge or adopt new techniques and methods that enhance communication between marketing and operations functions and result in the development of new products or services (Yu et al., 2019). Machine learning is used to better predict demand and thereby allow for improved delivery performance (Kantasa-ard et al., 2021). Another example is from Mearsk Shipping where procurement activities were automated to reduce errors and thereby capture cost savings (van Hoek et al., 2022). Thus, a digital orientation facilitates information exchange between customers and suppliers externally, as well as employees internally through digital transformation in the SC, which create opportunities for collaboration with various external partners (Nasiri et al., 2020; Singh et al., 2018; Yu et al., 2021a). By adopting digital technologies and develop digital systems and platforms, digitally oriented firms are better connected with stakeholders (internal and external) and the environment and thus able to capitalize on ideas and resources that enable them to identify, predict, and adjust their actions service customers. Therefore, we posit the following baseline hypothesis.

H1: Digital orientation is positively related to firm performance.

3.2. SC entrainment as an absorber of risks

The above arguments for H1 do not account for risks created by digital orientation (Ralston and Blackhurst, 2020). For example, JLA invested in developing and implementing electronic data transmission and custom electronic reporting for a municipal client, but then later the client changed its mind and chose a different protocol. Hence, incorporating digital technologies into products or services requires business or revenue models that may not be well received by customers (Block, 2021; Tabrizi et al., 2019) and there is no guarantee that a data analytic project will work because data availability and quality may not be sufficient (Forth et al., 2020). These issues are partly a question of timing, e.g., the readiness of organizations, technologies, and customer markets that can be addressed by entrainment practices. Managers should phase different activities and initiatives by first building fundamental capabilities before moving on to more advanced digital technologies.

As depicted by Figure 1(a), entrainment acts as an absorber of risks created by digitalization. The question of timing is related to the various internal and external cyclical activities that can compound such risks. Some of these risks are hidden inside various internal and external cyclical activities and are exposed when such cycles are out of phase. To minimize these risks, experienced firms will develop technology roadmaps synchronized with existing and future SC initiatives and activities. Based on experience implementing new technologies or innovation, managers know they need to match or pace such a new investment and innovation projects with market dynamics and internal drivers. Past studies show firms synchronize digital technology adoption with major customers (Khavul et al., 2010), match merge and acquisition and alliance activities (Shi and Prescot, 2012), and align the appointment of new CEO with various types of entrainments (Ancona and Chong, 1996) to minimize the "wrong timing" risks. There are also internal business cycles that are best synchronized with suppliers and customers. For example, a focal firm may appoint a technology company to manage its supplier data and environmental management data (DalleMule and Davenport, 2017). All these internal and external entrainment practices help match different cyclical activities with the changing external environment to absorb the risks of digitalization projects (Dibrell et al., 2015; Ofori-Dankwa and Julian, 2001).

SC entrainment absorbs risks that accompany digital orientation through two steps. First, as digitally oriented firms plan for new digital technologies, they will assess various risks and associated cyclical activities. They will modify existing internal and external practices to entrain in such a way that risks are minimized. That means digital orientation drives the use of entrainment. In the next step, managers implement the entrainment practices to absorb the risks and maximize the benefit from digitalization projects. These actions potentially lead to cost savings and the creation of new products or services that are accretive to firm performance. These two steps are reflected by the following hypotheses.

H2: Digital orientation is positively related to a) internal entrainment, b) entrainment with customers, and c) entrainment with suppliers.

H3: (a) Internal entrainment, (b) entrainment with customers, and (c) entrainment with suppliers are positively related to firm performance.

The above two processes do not reflect a complete picture, particularly the links between internal and external entrainment. Previous research has noted that the separation of internal

entrainment from external environment will develop endogenous rhythms within a firm that can lead to significant temporal misfits when internal entrainment departs from the dynamics of external environment (Pérez-Nordtvedt et al., 2008). Business performance, such as enhanced competitiveness and production efficiency can be achieved through developing temporal alignment and coordination between a firm's internal activities and external environment (Dibrell et al., 2015). The firm's internal activities and processes should be entrained with the external environment to maximize fit and business performance (Dibrell et al., 2015). This requires that functional groups entrain with each other at a system level, particularly in dynamic external environments where external entrainment is an important factor in responding to changes in product portfolios, demand, technology, competition, and regulation (McCarthy et al., 2010).

The above literature suggests there is a hierarchy between intra- and inter-organizational entrainment. When a firm achieves a high level of synchronization of the tempo of internal activities (e.g., seamless transitions from one internal activity to the next and entrainment among internal functional teams), it will be more able to develop temporal strategies to manage external environment changes, e.g., synchronizing activities with more protracted external rhythms of demand fluctuation, customer buying cycle, and new product development (Dibrell et al., 2015). Firms that develop robust internal systems for temporal coordination of internal functions can more effectively entrain to the external rhythms of markets and SC partners. Firms that coordinate their internal organizational activities to the rhythm of the external environment and adjust their rhythms to SC partners are more likely to achieve superior firm performance (e.g., Ancona and Chong, 1996; Shi and Prescot, 2012). Thus, we posit the following hypotheses.

H4: Internal entrainment is positively related to a) entrainment with customers and b) entrainment with suppliers.

H5: The relationship between internal entrainment and firm performance is mediated by a) entrainment with customers and b) entrainment with suppliers.

3.3. SC entrainment as a booster of opportunities

Digitalization brings risks, but also opens new opportunities (Block, 2021; Forth et al., 2020). So, firms need strategies and processes to exploit such opportunities. A digital orientation leads to the adoption of technologies such as product lifecycle management systems (PLM). These systems facilitate a faster response to sensed market changes for functions like product development.

Specifically, the PLM system can be a repository for designs that can be quickly modified or redeployed so the portfolio is better tuned to market needs. The same system can be used to track quality related information through the life of the product (Jacobs, 2008). This information can be used to either improve the product and market share, or as a revenue enhancer as the company can better price and tailor warranties. In a similar way, the capture and transference of point-of-sale data provides an opportunity to respond to changes in demand. The response may be to initiate a promotion, change production schedules, or modify deliveries.

Entrainment entails focusing on opportunities to create synergies between cyclical activities and the changing environment (Pérez-Nordtvedt et al., 2008). Some opportunities are known before a firm implements new digital technologies, others are discovered as adopters implement such technologies. Based on organisational entrainment theory, we argue that firms that are entrained with SC partners (such as customers and suppliers) and synchronize internal operations are readier to exploit opportunities from digital orientation. Digitally oriented firms will coordinate their internal operations (e.g., inter-functional coordination) across different functional areas of business (operations, marketing, and information technology functions) to identify opportunities to integrate advanced digital technologies into new products and services that their customers value. By coordinating the use of inter-firm communication technologies like EDI, firms use intra- and inter-organizational entrainment to shape cost saving opportunities in digital projects. Sometimes opportunities occur outside a firm, or they can be exploited by collaborating with business partners. External entrainment entails synchronizing business planning with external partners. It is an important mechanism that enables firms to build strategic collaboration with customers and suppliers and communicate more effectively and directly with customers and suppliers when the time is right to act together (Khavul et al., 2010). Digitally oriented firms that are able to adjust tempo and/or phase can effectively adapt to the changing activity cycles of their SC partners and thereby gain performance improvement.

The relationships described above are illustrated in Figure 1(b) where SC entertainment and digital orientation interact to boost firm performance. Drawing upon the earlier arguments for H1, we argue the various opportunities to create new products/services and save costs can be capitalized upon when a firm has already built-up entrainment processes that synchronize with industry cycles. As such we contend that firms that are entrained with SC partners and possess

synchronized internal operations are better positioned to exploit opportunities from digital orientation. Therefore, we posit the following hypothesis.

H6: (a) Internal entrainment, (b) entrainment with customers, and (c) entrainment with suppliers positively moderate the relationship between digital orientation and firm performance.

4. Research method

4.1. Sample

We test our research hypotheses using survey data gathered from Chinese manufacturers because of the emphasis in digitalization under the Made in China 2025 strategic plan. We randomly selected 1,500 firms from the dataset provided by the Contemporary Service Alliance for Integration of Informatization and Industrialization in China. With the help of the Alliance, in total we obtained 307 useable questionnaires, which indicates a response rate of 20.47%. Table 1 provides a summary of respondents and their firms' characteristics. The survey data was collected from respondents with a wide range of backgrounds in terms of firm location, firm age, industry type, and number of employees. Our respondents also held a range of managerial positions, and most of them have been in their positions for more than five years. We therefore believe that the respondents had adequate knowledge to complete the questionnaire.

---------- Insert Table 1 ----------

4.2. Bias assessment

We assessed nonresponse bias by comparing responding firms' characteristics in terms of number of employees and annual sales of early and late respondents (Hair et al., 2010). The results suggest that there were no statistically significant differences in responses to any of the firm characteristics between early and late respondents. Thus, nonresponse bias is not a serious concern in this study.

We assessed the potential common method bias (CMB) using both procedural remedies and statistical methods (Podsakoff et al., 2012). First, when designing the questionnaire, we included theoretical constructs in different sections of the questionnaire, and respondents were not aware of either independent or dependent variables. When administering the questionnaire, in the cover letter we indicated that there was no right or wrong answer and guaranteed to participants that their

participation would remain anonymous and confidential, and no information would be identifiable to them. Second, we used confirmatory factor analysis (CFA) to test a single method factor as pervious research has criticised Harman's single-factor test (Podsakoff et al., 2012). The results show a poor model fit: χ^2/df = 12.123; CFI = 0.592; IFI = 0.594; RMSEA = 0.191 and SRMR = 0.130 (Hair et al., 2010; Hu and Bentler, 1999). Third, following Lindell and Whitney (2001), we further assessed the potential common method bias using the marker variable technique. We included job tiles of respondents as the method variance marker that was theoretically unrelated to other variables in the analysis. The lowest positive correlation (r = 0.048) between the marker variable and other variables was chosen to adjust the inter-construct correlations and statistical significance. As shown in Table 3, the significant correlations remained significant after adjustment. In sum, based on the results of the statistical tests and procedural remedies conducted above, we conclude that CMB was unlikely to be a serious concern in this study.

4.3. Measures and controls

Table 2 shows the measurement items used in this research. Since there has been only limited empirical research on digital orientation in the operations and SC management literature , we adapted measures of digital orientation from studies in the information systems literature (e.g., Sedera et al., 2016; Song et al., 2008) considering aspects of market orientation (Quinton et al., 2018) and technology orientation (Gatignon and Xuereb 1997). The scale captures the extent to which a firm adopts advanced digital technologies for smart manufacturing, new product and service development, digital systems for facilitating internal integration, and the better understanding of customer demand. We conceptualised SC entrainment as a multidimensional construct that includes internal entrainment, entrainment with customers, and entrainment with suppliers. We adapted measures of internal entrainment from Dibrell et al. (2015) and McCarthy et al. (2010). It consists of five items that reflect the use of time-based strategies to synchronize internal operations across different functional units within the firm. We adapted measure of entrainment with customers and suppliers from previous studies (e.g., Dibrell et al., 2015; McCarthy et al., 2010; Pérez-Nordtvedt et al., 2008), which focused on the use of temporal strategies to manage external task environment. The measurement items capture the extent to which a firm identifies, predicts, and adjusts its actions to match tempo and synchronous phase with customers and suppliers. Respondents were required to answer the digital orientation and

entrainment items on a 7-point Likert-scale ranging from "strongly disagree" to "strongly agree". Adapting the measures developed by Yu et al. (2013), we asked respondents, on a 7-point Likert scale (1 = much worse than major competitors; 7 = much better than major competitors), to assess their firm performance by comparing with the key competitor in the same industry in terms of growth in market share, growth in profit, return on investment (ROI), growth in ROI, and return on assets (ROA).

---------- Insert Table 2 ----------

As control variables in our theoretical model, we used firm age (measured in years since incorporation), firm size (measured by the number of employees), and industry type (a dummy variable was used) (see Table 1).

We conducted a pilot-test with both academics and practitioners, which helped to improve the content validity and reliability of the measurement scales. Four researchers in the operations and SC management field and senior managers at three manufacturers in China provided comments and suggestions on the draft questionnaire.

5. Analysis and results

5.1. Reliability and validity analysis

To assess reliability, unidimensionality, and validity (convergent and discriminant validity) of the constructs, we performed CFA and reported the results in Table 2. The measurement model had a good fit: χ^2 / df = 3.061; CFI = 0.928; IFI = 0.928; RMSEA = 0.082; and SRMR = 0.047, which provides evidence of unidimensionality of the constructs (Hair et al., 2010; Hu and Bentler, 1999). Table 2 indicates that all measurement items had adequate convergent validity. The factor loadings ranged from 0.670 to 0.959, and all were statistically significant at the 1% level. The average variance extracted (AVE) values for all 5 constructs ranged from 0.542 to 0.829, exceeding the minimum cut-off of 0.50 (Fornell and Larcker, 1981). In addition, Table 3 provides evidence of discriminant validity: the square root of each construct's AVE had a greater value than the correlations with other latent constructs (Fornell and Larcker, 1981).

---------- Insert Table 3 ----------

We assessed construct reliability by calculating Cronbach's Alpha and composite reliability (CR). As shown in Table 2, Cronbach's Alpha ranged from 0.847 to 0.960 and CR ranged from 0.855 to 0.960, exceeding the widely recognized rule of thumb of 0.70 (Hair et al., 2010).

5.2. Testing the mediating model (SC entrainment as an absorber of risks)

To test the "risk-absorber" hypotheses (see Figure 1a), we performed structural equation modelling (SEM). The results are reported in Table 4. The structural model had a good model fit (Hu and Bentler, 1999). We included three control variables (i.e., firm size, firm age, and industry type) in the research model, and found that firm age had a significant positive effect on firm performance and Industry1 (automobile) had a significant negative effect on firm performance. As shown in Table 4, the results show that digital orientation has a significant positive effect on the three dimensions of SC entrainment: internal entrainment ($\beta = 0.716$, $p \leq 0.001$), entrainment with customers ($\beta = 0.190$, $p \leq 0.01$), and entrainment with suppliers ($\beta = 0.234$, $p \leq 0.001$), which provided supports for H2a, H2b, and H2c. The results also reveal that both entrainment with customers ($\beta = 0.273$, $p \leq 0.05$) and entrainment with suppliers ($\beta = 0.411$, $p \leq 0.001$) are significantly and positively related to firm performance, but we found no statistically significant effect of internal entrainment on firm performance ($\beta = -0.164$, *n.s.*). Thus, H3b and H3c are supported, but H3a is rejected. H4a and H4b are also supported: a significant positive effect of internal entrainment on entrainment with customers ($\beta = 0.713$, $p \leq 0.001$) and entrainment with suppliers ($\beta = 0.609$, $p \leq 0.001$).

---------- Insert Table 4 ----------

The findings above draw us to further investigate how the three dimensions of SC entrainment deliver performance benefits to firms: the possible mediating roles of external entrainment with customers and suppliers in the internal entrainment–performance relationship. To test the mediation, we used bias-corrected bootstrapping approach based on 10,000 bootstrap samples (Zhao et al., 2010). The results (see Table 5) reveal that the indirect effect of internal entrainment on firm performance via entertainment with customers ($\beta = 0.194$, $p \leq 0.10$; 90% confidence interval [0.028, 0.454]) and entertainment with suppliers ($\beta = 0.250$, $p \leq 0.001$; 90% confidence interval [0.157, 0.485]) is positive and significant. The Sobel test further demonstrates that entrainment with customers ($z = 2.212$, $p < 0.05$) and entrainment with suppliers ($z = 3.749$, $p < 0.001$) fully mediate the internal entrainment–performance relationship, supporting hypotheses H5a and H5b.

---------- Insert Table 5 ----------

5.3. Testing the moderating effect (SC entrainment as a booster of opportunities)

To test whether SC entrainment can help exploit opportunities from digital orientation (see Figure 1b), we tested its moderation effect using moderated regression. To address possible multicollinearity concern, we calculated mean-cantered scores and entered each interaction term into the moderated regression model separately (Sheng et al., 2011; Williams et al., 2013). The results are illustrated in Table 6. The variance inflation factor (VIF) values in all five models are less than 5 (ranged from 1.434 to 3.475), indicating that multicollinearity is not an issue in this study (Hair et al., 2010; Mason and Perreault, 1991). The results (model 2) indicate that digital orientation has a significant and positive effect on firm performance ($\beta = 0.372$, $p \leq 0.001$), supporting H1. As shown in Table 6 (models 3, 4 and 5), we found support for H6a, H6b, and H6c, which proposed that internal entrainment ($\beta = 0.116$, $p \leq 0.05$), entrainment with customers ($\beta = 0.158$, $p \leq 0.001$), and entrainment with suppliers ($\beta = 0.143$, $p \leq 0.01$) significantly moderate the relationship between digital orientation and firm performance.

---------- Insert Table 6 ----------

To obtain further insights into the moderation effect, we plotted the relationship between digital orientation and firm performance to demonstrate how the three dimensions of SC entrainment moderate the relationships (Aiken and West, 1991). Figures 2a, 2b and 2c indicate that higher levels of internal entrainment and external entrainment with customers and suppliers strengthen the positive effects of digital orientation on firm performance.

---------- Insert Figures 2a, 2b and 2c ----------

6. Discussion

6.1. Contributions to theory

While temporal coupling plays an important role for SC collaboration practices such as CPFR, this study applies entrainment theory to elaborate the "what" or "how" (Dille et al., 2022) to use SC entrainment to align digitalization with internal functions, suppliers, and customers. Our concept of SC entrainment extends entrainment research from an organizational (Sandra et al., 2022) to a SC level. Our integrated model not only contributes to theory by showing how SC entrainment can synchronise activities to those of the external environment but also by showing how internal and external organization processes interrelate to make synchronisation more efficient (Dille et al., 2018).

This study shows entrainment is not just for tempo alignment of organisational routines with the external cyclical environment; it is also important for the introduction of new practices or technologies. It also raises an important factor that digital transformation literature misses. Many digitalization projects fail (Block, 2021; Forth et al., 2020; Tabrizi et al., 2019) and yet there is limited theoretical understanding of how firms address the risks and opportunities that arise from such innovation endeavours by avoiding the time when such efforts face greatest risk and harnessing the time when the opportunity arises. Recognizing the importance of entrainment, the study further show firms cannot just develop technology orientation; they need to focus on using technologies to create market opportunities. Thus, this study also advances the digital orientation construct by integrating the characteristics of strategic orientation known to enable firms to achieve competitive advantages (Kindermann et al., 2021) with technology orientation (Gatignon and Xuereb, 1997) and market orientation (Mishra et al., 2022). Here we emphasize the importance of identifying market opportunities that technologies can create or capture. Our conceptualization means not all firms that adopt advanced digital technologies (e.g., BDA, blockchain, and AI) can be labelled as digitally oriented. That means many studies that show evidence of benefits due to the use of technologies provide us with only part of the explanation. Firms that myopically follow others to adopt such technologies will not succeed. Only those who use advanced digital technologies in a strategic manner to develop market opportunities can be classified as digitally oriented. Such a distinction can serve as the basis for developing typology of digital orientation, e.g., pure technology orientation.

An important and yet overlooked issue is that there are risks and opportunities that arise from digital orientation, which can prevent firms from reaping its benefits. This is a serious problem facing digitally oriented firms if they are not careful in finding the right time to implement digital technologies. The challenge here is to explain how firms match and pace digitalization projects with related internal and external business and process cycles, market dynamics (Mishra et al., 2022), and interdependencies (Kindermann et al., 2021). We incorporate the idea of entrainment to delineate the processes by which a firm manages temporal changes in the environment by synchronizing internal and external cyclic activities with its cycles (Pérez-Nordtvedt et al., 2008) into the SC context. By developing the SC entrainment construct, this study reveals the dual roles of SC entrainment: SC entrainment as an absorber of risks, and as a booster of opportunities. Our empirical analysis indicates SC entrainment can align digitalization efforts with SC activities and

dynamics in the external environment, such that risks from digitalization can be absorbed, and the opportunities that it brings can be exploited to maximize firm performance. These two entrainment mechanisms have implications for the organizational entrainment and the SC literatures, as the ideas of entrainment can be extended to many different contexts other than digital orientation.

This study extends previous research by conceptualising the entrainment construct from organization studies (e.g., Ancona and Chong, 1996; Khavul et al., 2010; Pérez-Nordtvedt et al., 2008) to a SC level (i.e., SC entrainment). We show organisational entrainment (Pérez-Nordtvedt et al., 2008) is not complete when it comes to cyclical activities in supply chains that must be matched with the pace of internal processes and the external environment. To explicate the relationships among internal and external entrainment and their roles, we divided SC entrainment into three dimensions – internal entrainment, entrainment with customers, and entrainment with suppliers. By dividing external entrainment in the organizational studies literature into customers and suppliers, as highlighted by Ofori-Dankwa and Julian (2001), we provide a platform to reveal their differences and relationships. Our findings show internal entrainment drives entrainment with customers and suppliers, and there are many more questions about their relationships and configuration that need answers. While we do not find significant difference between the roles of entrainment with customers and with suppliers, future qualitative studies can elaborate their differences. In addition, while we focus on the case of digital orientation, our conceptualization of SC entrainment serves as a foundation for developing SC entrainment theory for a wide range of studies since SC entrainment is also required for the development of new products, services, business models, and other forms of innovation.

Our argument that digitalization brings risks and opportunities can significantly steer the SC digitalization literature because these important yet overlooked factors must be better understood before researchers can provide actionable knowledge to managers. Herein we set the foundation to explicate the types of risks and opportunities associated with cyclical activities that can hamper digitalization efforts as well as provided unique opportunities to make it work. The question here is how to theorize the functioning of various entrainment practices for the different types of risk and opportunities. Our empirical evidence reveals that managers need to consider the hierarchical relationships between internal and external entrainment, because internal entrainment serves as the foundation for external entrainment, and yet it is the entrainment with customers and suppliers that transforms the potential of internal entrainment into firm performance. These new insights

elaborate on McCarthy et al.'s (2010) assertion about the importance of external entrainment. For digitalization, the external environment will be more complex, as we need to consider the digital ecosystem more broadly, including technology lifecycles that have different pace and trajectory. More insights can be created by considering separating the external entrainment further beyond suppliers and customers to identify temporal misfits (Pérez-Nordtvedt et al., 2008) that may have different environment velocity (McCarthy et al., 2010).

6.2. Contributions to practice

Our empirical findings provide several important managerial implications. First, our findings provide managers with concrete knowledge on how to use SC entrainment to maximize the performance benefits of advanced digital technologies. First, managers need to view digital orientation as a strategy to create market opportunities, rather than following others to adopt technologies without understanding the market dynamics that the technologies face. For example, the announcement by Maersk in January 2023 that they decided to stop the Tradelens platform based on blockchain co-developed by IBM, sending a negative blow to many blockchain projects.

Second, as a benchmarking tool, managers may apply the measurement items for our SC entrainment to examine how they can match technology implementation cycles with important business cyclical activities and the external competitive, technology supply and demand landscapes that may change at different paces and directions. For any new digital technology that depends on SC partners, managers should recognize when risks and opportunities are created and how they are affected by both internal and external activity cycles in the SC. To effectively respond to rapid changes in the external environment, firms must not entrain internally among departmental levels, but also synchronize their endogenous cyclic activities to those of suppliers and customers using tempo matching and/or phase aligning. Setting and maintaining such coordinated SC entertainment enables firms to reduce risk and maximize opportunities. This is particularly important for managers who aim to implement advanced digital technologies in the SC.

Third, managers should make sure they develop internal entrainment mechanisms that respond to the needs to entrain with customers and customers because it is essential for ensuring customers and suppliers are coordinate to adopt digital technologies that create firm performance. That does not mean implementing internal entrainment first and external entrainment separately, because they are intricately interdependent, and it is important to pace digitalization efforts with

the changing supply and customer environment. When Walmart decided to directly compete with Amazon, many suppliers had to build up technologies and SC digital infrastructures to support the development of the online version of Walmart. To maximize performance benefits from organisational entrainment, firms need to focus more on keeping tempo and synchronous phase with their SC partners such as customers and suppliers through evaluating and adjusting their SC activities and strategic implementation of selected digital technologies accordingly in a coordinated rhythm.

7. Conclusions and directions for future research

The SC digitalization literature tends to assume digital orientation will enhance performance regardless of the risks and opportunities it brings. This study contributes to both theory and practice. From a conceptual perspective, the study shows why we need to incorporate market orientation (Mishra et al., 2022) into the concept of digital orientation, extend the concept of organizational entrainment into the SC context by developing a multidimensional construct called SC entrainment that considers internal, customers, and suppliers (e.g., Pérez-Nordtvedt et al., 2008). We advance the entrainment and SC digitalization literature by theorizing the dual roles of SC entrainment (as absorber of risk, and booster of opportunities), and further explicate their roles and relationships using data from China. In term of practice, this study informs SC and digital transformation managers why and how they should match and pace their adoption of advanced digital technologies with related internal and external cyclical activities. Notably, the study lays down a foundation for ample opportunities to advance SC entrainment theory.

This study has several limitations that future research should address. First, previous research has suggested that digital orientation is manifested in four dimensions: digital technology scope, digital capabilities, digital ecosystem coordination, and digital architecture configuration (Kindermann et al., 2021). Thus, future research is encouraged to expand our conceptualization of digital orientation from a SC level to an eco-system level and the question of entrainment configurations. Second, we have just begun to understand risks and opportunities arise from digital orientation, and more studies are required to unpack their nature and understand how firms use specific entrainment practices and other strategies to address them. We believe it is beneficial to develop typologies of risk and opportunities and relate them to relevant entrainment strategies. Third, there are many types of entrainments (e.g., Ancona and Chong, 1996), and it is not just

about tempo and pace. Other factors like complexity (Ofori-Dankwa and Julian, 2001) and environmental velocity (McCarthy et al., 2010) can affect entrainment so they can be incorporated to advance our ideas.

Fourth, this study focuses on a single performance outcome (i.e., firm performance). Future research may examine other performance measures, such as operational performance (such as quality, cost, flexibility, and delivery performance) especially for understanding cyclical activities in SC innovation (such as technology and process innovation). It is possible that some of these performance measures are more sensitive to tempo and pace than others. This could lead to useful contingency theory for SC entrainment. Fifth, we encourage future research to test the measures of three SC entrainment dimensions developed in this study by collecting data from different countries and regions, which will also confirm the results generated from this study.

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Table 1: Respondent profile

	%		%
Industries		**Firm location**	
Automobile	35.8	Pearl River Delta	4.6
Chemicals and petrochemicals	5.9	Yangtze River Delta	11.7
Electronics and electrical	10.4	Bohai Sea Economic Area	3.6
Fabricated metal product	17.3	Northeast China	3.3
Food, beverage and alcohol	3.3	Central China	9.4
Rubber and plastics	2.6	Southwest China	65.5
Textiles and apparel	2.0	Northwest China	2.0
Others	22.8	**Job title**	
Number of employees		President / Chief executive officer (CEO)	5.9
1 – 100	6.2	Vice President	7.5
101 – 200	11.1	Director	15.0
201 – 500	17.6	Manager	45.3
501 – 1000	10.4	Other senior executive	26.4
1001 – 3000	28.7	**Firm age**	
> 3000	26.1	≤ 10	16.6
Job tenure		11 – 20	30.6
≤ 5	30.9	21 – 30	22.5
6 – 10	29.0	> 30	30.3
> 10	40.1		

Table 2: Results of reliability and validity analysis

Measurement Items	Factor loadings	α	CR	AVE
1. Digital orientation		0.847	0.855	0.542
We use the most advanced digital technologies (e.g., IoT, artificial intelligence, advanced robotics) for smart manufacturing	0.670			
We develop digital systems for facilitating cross-functional integration	0.833			
We develop digital systems for internal communication (e.g., across different departments, across different levels of the organization, etc.)	0.777			
Where possible, we experiment and trial digital technologies in new ways to develop new products that can help attract and serve new markets	0.693			
Using digital technologies, we continuously try to discover additional needs of our customers (and potential customers) of which they are unaware	0.695			
2. Internal entrainment		0.923	0.924	0.710
We employ regular deadlines to which managers synchronize the speed and intensity of their efforts *	0.795			
We use formal processes to ensure seamless transitions from one activity to the next (e.g., shift from one product-development project or season of merchandise to the next) *	0.851			
We tailor planning and review processes to align with the rate of change in specific markets *	0.870			
Our internal functional teams (e.g., operations, marketing, information technology) are entrained with each other to coordinate changes in the pace and direction of our internal activities **	0.868			
We use time-based mechanisms (e.g., scheduling and project deadlines) to simultaneously coordinate strategic decision-making velocities **	0.826			
3. Entrainement with customers		0.899	0.902	0.697
We align our activities with critical cycles in the market, such as seasons or swings in customer spending *	0.843			
We align our critical processes (e.g., pace of operations, product introductions) with the external rhythms of customers **	0.876			
We constantly align our sales cycle with customer buying cycle *	0.847			
We adjust the operating pace to which customers set **	0.769			
4. Entrainment with suppliers		0.894	0.896	0.684
Our suppliers align the phase of its delivery activity to our purchasing activity *	0.826			
Our suppliers constantly adjust its activity cycles (e.g., availability of material components) to accommodate our new product development *	0.874			
Our key suppliers deliver to our plant in a just-in-time (JIT) basis **	0.788			
We set the operating pace to which suppliers must adjust **	0.818			
5. Firm performance		0.960	0.960	0.829
Growth in profit	0.889			
Growth in market share	0.830			
Return on investment (ROI)	0.959			
Growth in ROI	0.950			
Return on assets (ROA)	0.917			
Model fit statistics: $\chi^2 = 673.427$; df = 220; χ^2 / df = 3.061; CFI = 0.928; IFI = 0.928; RMSEA = 0.082; SRMR = 0.047				

Note: * Measures the synchronousness; ** Measure tempo

Table 3: Construct-level correlation matrix

	Mean	S.D.	DO	IE	EC	ES	FP
Digital orientation (DO)	4.701	1.083	**0.736**	0.631**	0.590**	0.564**	0.462**
Internal entrainment (IE)	4.878	1.161	0.649**	**0.842**	0.753**	0.683**	0.330**
Entrainment with customers (EC)	5.007	1.118	0.610**	0.765**	**0.835**	0.768**	0.398**
Entrainment with suppliers (ES)	4.945	1.151	0.585**	0.698**	0.779**	**0.827**	0.405**
Firm performance (FP)	4.524	1.328	0.488**	0.362**	0.427**	0.434**	**0.910**
Method variance marker (job titles of respondents)	3.79	1.096	-0.064	-0.051	-0.048	-0.087	-0.126*

Note: Unadjusted correlations appear below the diagonal; adjusted correlations for potential common method variance appear above the diagonal; Square root of AVE is on the diagonal; ** $p \leq 0.01$.

Table 4: Results of hypothesis testing using SEM

	Standardised coefficient	t-value
Structural relationships		
Digital orientation → Internal entrainment	0.716***	9.705
Digital orientation → Entrainment with customers	0.190**	2.987
Digital orientation → Entrainment with suppliers	0.234***	3.269
Internal entrainment → Firm performance	-0.164	-1.141
Entrainment with customers → Firm performance	0.273*	2.267
Entrainment with suppliers → Firm performance	0.411***	4.233
Internal entrainment → Entrainment with customers	0.713***	9.961
Internal entrainment → Entrainment with suppliers	0.609***	8.012
Control variables		
Firm age → Firm performance	0.103†	1.694
Firm size → Firm performance	-0.033	-0.552
Industry1 (automobile) → Firm performance	-0.121*	-2.104
Industry2 (fabricated metal product) → Firm performance	-0.009	-0.167
Industry3 (electronics and electrical) → Firm performance	0.045	0.809
Variance explained (R^2)		
Internal entrainment	0.512	
Entrainment with customers	0.738	
Entrainment with suppliers	0.631	
Firm performance	0.272	
Model fit statistics: $\chi^2 = 924.388$; df = 327; χ^2 / df = 2.827; CFI = 0.909; IFI = 0.910; RMSEA = 0.077; SRMR = 0.064		

*** $p \leq 0.001$; ** $p \leq 0.01$; * $p \leq 0.05$; † $p \leq 0.10$.

Table 5: Results of mediation effect analysis

Structural paths	Direct effect	Indirect effect	90% CI for indirect effect	Sobel test	Mediation test outcome
IE→EC→FP	-0.164	0.194†	0.028–0.454	z = 2.212*	Full mediation
IE→ES→FP	-0.164	0.250***	0.157–0.485	z = 3.749***	Full mediation

Note: IE: internal entrainment; EC: entrainment with customers; ES: entrainment with suppliers; FP: firm performance; SE: bootstrap standard error; CI: bootstrap confidence interval; Standardized effects; 2,000 bootstrap samples; *** $p \leq 0.001$; * $p \leq 0.05$; † $p \leq 0.10$.

Table 6: Results of moderation effect analysis

	Model 1	Model 2	Model 3	Model 4	Model 5
Control variables					
Firm age	-0.021 (-0.305)	0.105 (1.744)†	0.116 (1.933)†	0.112 (1.891)+	0.119 (1.996)*
Firm size	0.100 (1.534)	-0.063 (-1.090)	-0.086 (-1.486)	-0.092 (-1.607)	-0.088 (-1.529)
Industry1 (automobile)	-0.112 (-1.727)†	-0.131 (-2.365)*	-0.121 (-2.197)*	-0.120 (-2.205)*	-0.124 (-2.264)*
Industry2 (fabricated metal product)	-0.097 (-1.540)	-0.036 (-0.655)	-0.030 (-0.558)	-0.029 (-0.531)	-0.030 (-0.565)
Industry3 (electronics and electrical)	0.073 (1.178)	0.005 (0.093)	0.023 (0.420)	0.024 (0.445)	0.017 (0.325)
Independent variable					
Digital orientation (DO)		0.372 (5.510)***	0.369 (5.519)***	0.368 (5.536)***	0.365 (5.481)***
Moderators					
Internal entrainment (IE)		-0.150 (-1.783)†	-0.155 (-1.848)†	-0.119 (-1.422)	-0.133 (-1.597)
Entrainment with customers (EC)		0.146 (1.627)	0.166 (1.859)†	0.145 (1.639)	0.156 (1.759)†
Entrainment with suppliers (ES)		0.237 (2.871)**	0.230 (2.800)**	0.218 (2.671)**	0.226 (2.766)**
Interaction effect					
DO × IE			0.116 (2.357)*		
DO × EC				0.158 (3.245)***	
DO × ES					0.143 (2.948)**
R^2	0.035	0.308	0.321	0.332	0.328
Adjust R^2	0.019	0.287	0.298	0.309	0.305
F-value	2.156†	14.688***	13.978***	14.697***	14.431***
Max VIF	1.434	3.443	3.475	3.443	3.448

Note: Standardized coefficients (betas) and t-values are reported; dependent variable is firm performance; *** $p \leq 0.001$; ** $p \leq 0.01$; * $p \leq 0.05$; † $p \leq 0.10$.

Figure 1(a): SC entrainment as an absorber

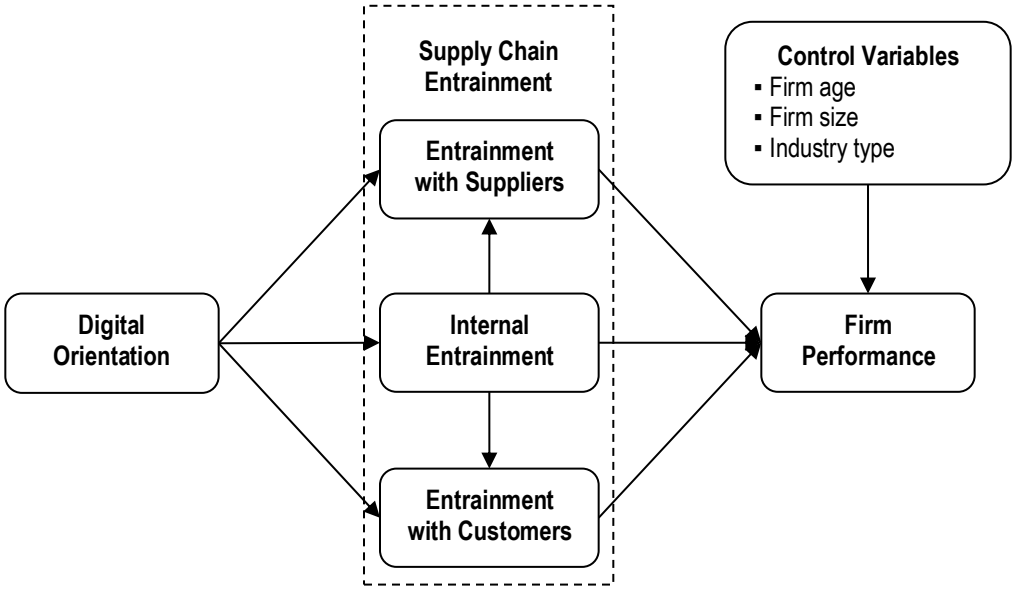

Figure 1(b): SC entrainment as a booster

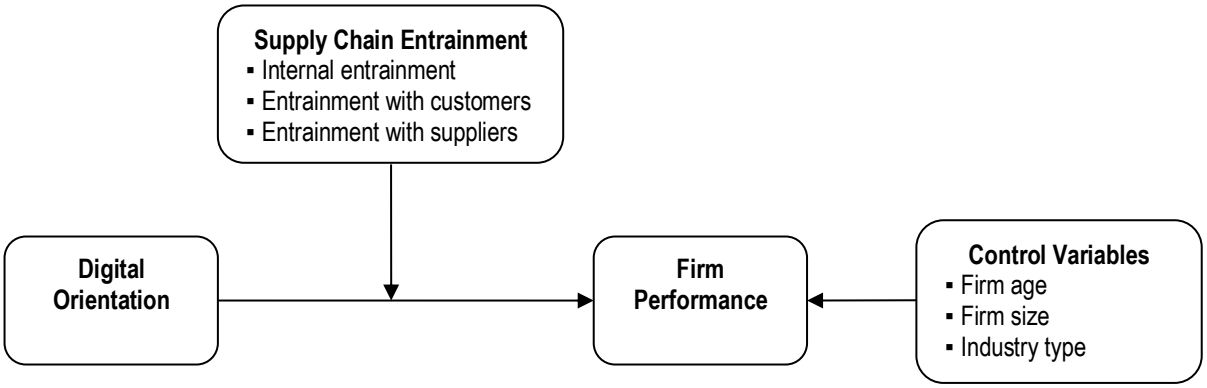

Figure 2(a): The moderating effect of internal entrainment on the digital orientation – firm performance relationship

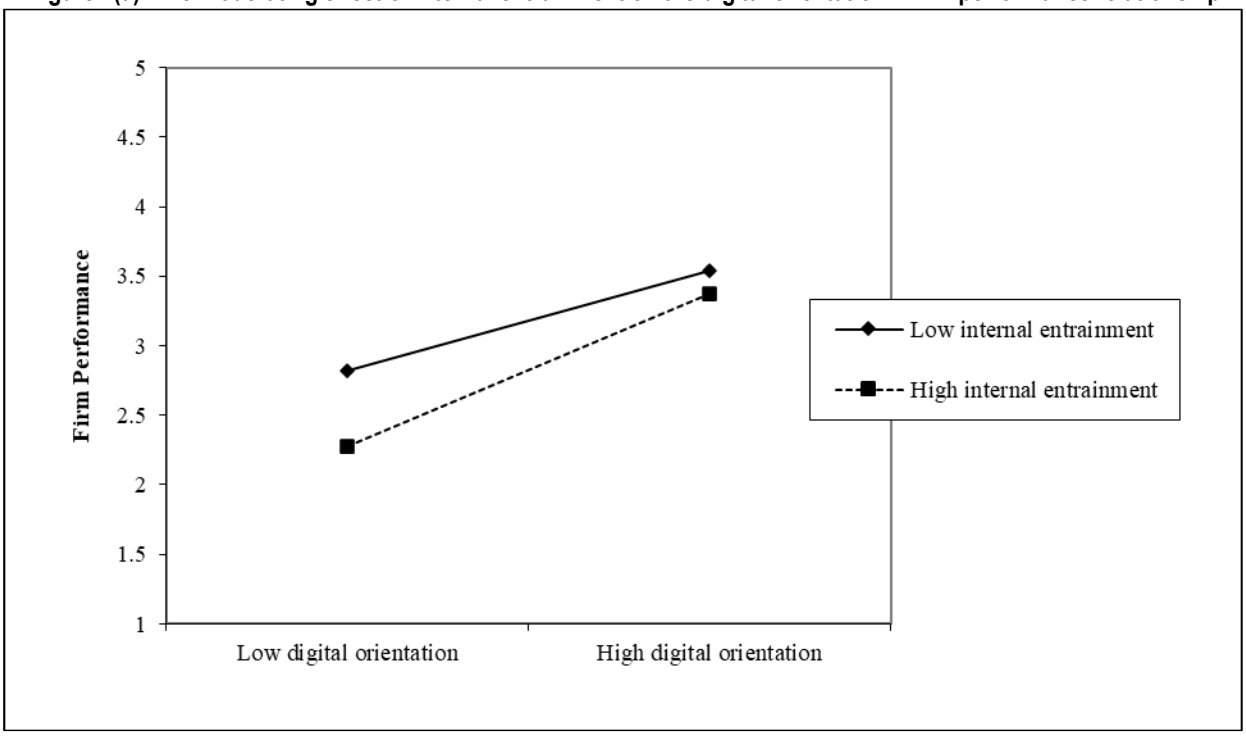

Figure 2(b): The moderating effect of entrainment with customers on the digital orientation – firm performance relationship

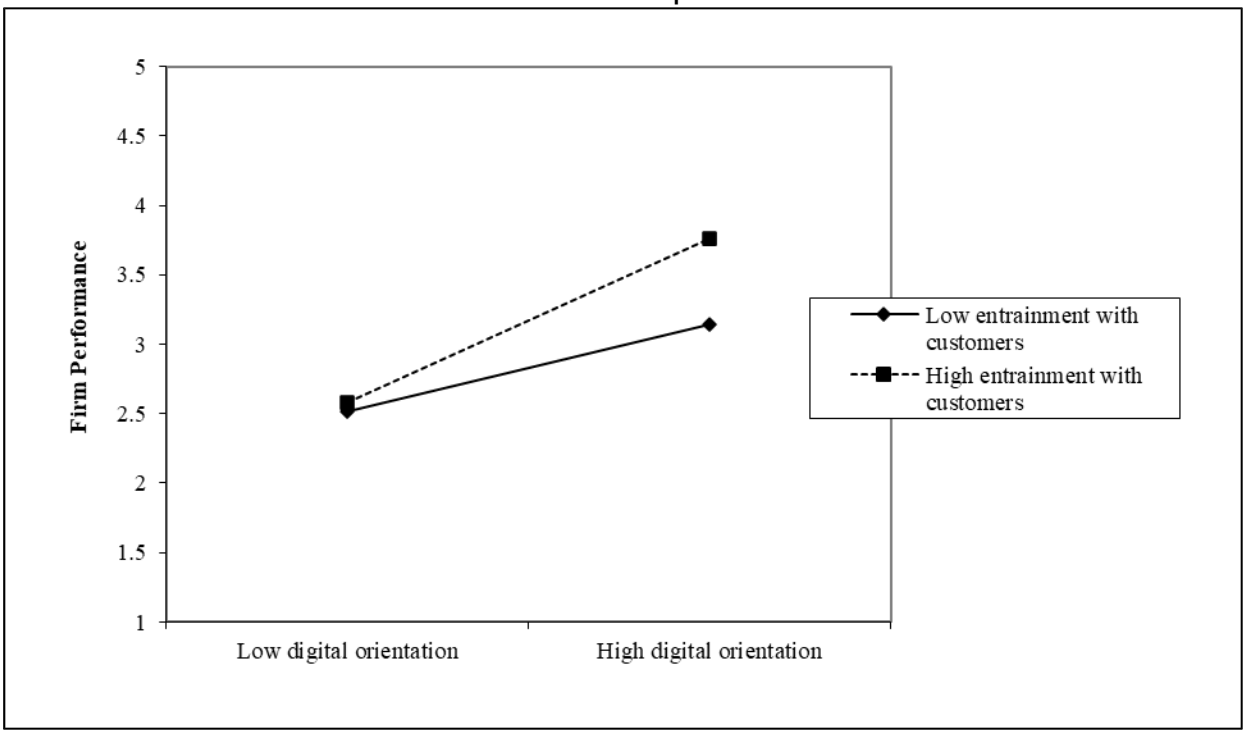

Figure 2(c): The moderating effect of entrainment with suppliers on the digital orientation – firm performance relationship