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An effectuation and causation perspective on the role of design thinking practices and digital capabilities in platform-based ventures

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ABSTRACT

The evolution of digital platforms and related ecosystems has led to a new and essential context of entrepreneurship. Previous studies have revealed that although high-tech new ventures possess cutting-edge technology, they face significant challenges because of vital resource constraints and limited management capability. Design thinking practices have emerged as a prominent problem-solving approach offering innovation benefits during high uncertainties. However, in the context of high-tech ventures, more research is needed on linking the relationship between design thinking principles, innovation theories (effectuation and causation), and firm performance. The present study investigates how the design thinking principles influence innovation theories and whether it leads to improved high-tech venture performance. Based on a survey of 291 platform-based start-ups in India, the results show that design thinking ways are well integrated into the theories of effectuation and causation, facilitating the growth of platform-based ventures. However, the influence of effectuation and causation on platform-based venture performance is found to be mediated through the digital capabilities acquired by these ventures.

1. Introduction

Proliferated by the massive adoption of digital and Internet-based technologies and devices, online sharing platforms are coming to the front of business and management literature (Long et al., 2022) and are rapidly transforming into a breeding ground for innovative business ideas and models. The central idea behind online platforms is the creation of innovative and digitally supported marketplaces that enable buyers and providers (companies or individuals) to transact remotely (Zhuang et al., 2021). The evolution of digital platforms and related ecosystems has led to a new and essential context of entrepreneurship. These digital platform ecosystems allow start-up firms to develop products and services that complement the growth of the firms (Nambisan and Baron, 2021). The current business models are inclining toward a platform economy, and the literature needs to include integrative insights on this topic and account for social factors in platform firms (Kapoor et al., 2021).

Previous studies have revealed that although high-tech new ventures possess cutting-edge technology, they face significant challenges because of vital resource constraints and limited management capability. The two decision-making logics used by entrepreneurs are effectuation and causation. Effectuation uses short-term experimentations to identify opportunities in the uncertain future, while goal orientation predicts the uncertain future in causation (Sarasvathy, 2001). The other differences include an emphasis on bearing the losses in the worst-case scenario, strategic alliance formation, maintaining flexibility to address environmental emergencies in effectuation compared to maximizing the profits, and the importance of planning and analysis and using the available capabilities in causation. The above differences in the logic suggest that effectuation controls the future while causation is focused

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on predicting the future (Frese and Gielnik, 2014; Laskovaia et al., 2019).

Design thinking practices have emerged as a prominent problem-solving approach offering innovation benefits during high uncertainties (Kolko, 2015; Liedtka, 2018). Design thinking practices put the cognitive principles of effectuation into practice for entrepreneurial innovation and add a normative dimension to effectual decision-making (Brown and Martin, 2015). Most of the studies in the literature provided theoretical foundations of design thinking principles in innovation theories (Klenner et al., 2022; Sengupta and Sena, 2020). Klenner et al. (2022) provide an empirical justification for the relationship between design thinking practices as a significant driver of effectuation. However, the study needs to investigate how effectuation influences venture performance. The literature also lacks studies on whether the design thinking practices affect the causation and how the causation operates in the presence of design thinking practices to impact the venture performance. The new platform-based economy is riding on fast-paced technological innovations. Technological innovation refers to using new technologies in production and consumption that recognize the new technical possibilities and organize the essential human and financial resources needed to transform them into valuable products and processes (Scherer, 2001). Technological innovations and increased online connectivity are driving the growth of platform-based ventures. These ventures are required to develop new capabilities as the changing customer preferences and technical innovations make the platform economy uncertain to predict (Sengupta and Sena, 2020; Upadhyay et al., 2022). The literature on innovation and entrepreneurship needs more answers to critical questions, such as whether effectuation or causation principles are more effective in improving the platform-based venture's performance. In this study, we address this existing literature gap to empirically investigate whether design thinking practices and innovation theories influence the performance of platform-based ventures and, if so, how they are linked.

The present study framework is based on the effectuation and causation theories to understand the platform-based venture's performance comprehensively. A detailed explanation of how these two theories apply to platform-based ventures is essential (Sarasvathy and Venkataraman, 2001; Guo et al., 2016). Furthermore, an organization's current capabilities determine the decision-making behavior of the entrepreneurs (Read and Sarasvathy, 2005; Nohria and Gulati, 1996). The firm characteristics, such as the experience of the entrepreneurs, employee strength, and initial investments, are critical in applying the decision-making logic (Sarasvathy, 2001; Frese et al., 2020). Recently, researchers have started considering the evolution of business models based on digital technologies (Nambisan, 2017; Ojala, 2016) and suggest that businesses must adapt to changing surroundings. Baber et al. (2019) state that the firm's success depends on its capabilities to acquire and configure resources. However, this finding needs more empirical evidence and to be investigated concerning the existing innovation theory. Therefore, our following two research questions aim to determine how the capabilities (digital capabilities) in platform-based ventures are driven by the effectuation and causation theories and how they influence their performance.

In doing so, we use the underpinning theories of effectuation and causation. The digital capabilities of the platform-based venture are leveraged using the dynamic capabilities theory.

The result of the study contributes to the literature on entrepreneurship decision-making principles by interlinking three significant research areas: design thinking practices, digital capabilities, and platform-based ventures, which until recently was investigated in a scattered manner (Guo et al., 2016; Ruiz-Jiménez et al., 2021; Klenner et al., 2022). The critical contribution of this study to the existing literature is the essential insight from the platform-based ventures where digital capabilities are an essential component. The interaction between the effectuation and causation theories and how they shape the digital capabilities in platform-based ventures are rarely addressed empirically in the literature. The study provides critical conclusions on whether the design thinking ways are well integrated into the theories of effectuation and causation, facilitating the growth of platform-based ventures.

The remaining paper is organized as follows. Section 2 presents the theoretical background and research hypothesis. Section 3 discusses the research methodology. The analysis and results are presented in Section 4. Section 5 presents the theoretical contributions and practical implications. The conclusion, limitations, and scope for future research are presented in Section 6.

2. Theoretical background and research hypotheses

2.1. Competitive landscape of the platform-based economy

The platform-based economy is revolutionizing the production and consumption of physical assets and services in the marketplace (Sutherland and Jarrahi, 2018). The dramatic impact of sharing economy on the sustainable dimensions of social, economic, and environmental dimensions has led to its increased acceptance and interest from industry professionals, entrepreneurs, and academics (Sutherland and Jarrahi, 2018). The platform economy is estimated to grow 335 billion by 2025 (PwC, 2015). Another report estimates this industry to expand at a CAGR of 32.08 % to reach USD 600,000 million by 2027 (Proficient Market Insights, 2022).

However, industry experts warn about the long-term challenges threatening its growth and sustainability (Phua, 2019). Many scholars believe such ventures are built on higher trust (Hawlitschek et al., 2016; Voeth et al., 2015) and face governance challenges (Vith et al., 2019). Incidents of customers misbehaving with the suppliers at Airbnb (Vith et al., 2019) and Uber's surge pricing (Lapowski, 2014; Vinik, 2014) have put pressure on the regulatory bodies in many countries to address the issues of unfair competition, tax regime, and consumer safety (Lutz et al., 2017).

Most platform-based ventures have spread into emerging markets worldwide after witnessing considerable success in their home countries (Upadhyay et al., 2022). However, while entering emerging markets, these businesses must localize their services per the customer's requirement and are governed by the countries' regulations (Maalouf et al., 2021). While entering emerging markets or starting new platform-based ventures, businesses face varying factors affecting their competitiveness (Kapoor et al., 2021). More complexity and uncertainty are added when platform-based business models are adopted, which, if not addressed appropriately, can markedly increase their risks of failure (Maalouf et al., 2021; Cao et al., 2023). Platform-based approaches can achieve ambidexterity in balancing exploitative and exploratory innovations. Cao et al. (2023) proposed that different organizational units can appropriate platforms to achieve both exploratory and exploitative innovations. Therefore, entrepreneurs aspiring to start platform-based ventures must adopt innovative strategies involving high-level digital capabilities and offering technical innovations.

In the following sub-section, we discuss the concepts linking entrepreneurship theories with the need to develop design thinking approaches and digital capabilities for a successful platform-based venture.

2.2. Entrepreneurship theories

In new ventures, effectuation is used in the early stages of entrepreneurship, while causation is practiced later (Berends et al., 2014). Large firms mainly adopt the causation logic due to their resources compared to small start-ups restricting themselves from using effectuation (Long and Tang, 2015). However, when the firms operate in an environment of high uncertainty, the interaction between the two logics impacts the venture performance positively; the interaction effect is negative when the environmental uncertainty is low (Yu et al., 2017). Causation and effectuation can be simultaneously used, as they complement each other, as over-dependence on effectuation may lead to a

lack of prediction of consequences and feasible alternatives (Read et al., 2009; Sapienza and Grimm, 1997; Yu et al., 2017). Deployment of each logic allows firms to exploit opportunities productively and deploy the logic at different periods of their development (Zhang et al., 2022; Berends et al., 2014). Case study-based and empirical analyses indicate that the two decision-making logics are positively related and complement each other in enhancing firm performance (Khurana et al., 2022; Zhang et al., 2022).

2.3. Design thinking and decision-making logic

Design thinking is the iterative process through which organizations seek to understand their customers, challenge assumptions, redefine problems, and create innovative solutions they can prototype and test. The design thinking approach helps organizations to solve problems creatively and collaboratively. The literature reveals that design thinking significantly influences the decisions to innovate and create new ventures. Design thinking is a holistic concept that governs the entire innovation process, including idea generation, idea selection, and idea development (Patrício et al., 2020). It is a prevalent tool used for creative problem-solving and overcoming intangible challenges during the early stages of innovation and applied in different organizational settings and industrial contexts (Brown and Martin, 2015; Meyer, 2015). Lee and Benza (2015) and Liedtka (2015) suggest that design thinking integrates three essential innovation skills that include; thinking (problem-solving), telling (involving people and sharing ideas), and doing (learning through experimentation). Further, they use different tools and techniques, including ethnographic observations, customer journey mapping, brain-storming, rapid prototyping, and experimentation (Elsbach and Stigliani, 2018).

2.4. Design thinking practices and effectuation

Klenner et al. (2022) found a reciprocal relationship between design thinking practices and effectuation. Klenner et al. (2022) operationalized effectuation principles using five design thinking practices that centered on practicing "human-centeredness to unlock knowledge," "embracing diversity to integrate with strategic partners," "use of visualization and experimentation to manage innovation trajectory," and "(re) framing to adapt to the changing situations." Integrating design thinking practices in an organization needs support from top management, leadership skills, and an innovation culture requiring the firm to bring a change in its decision-making strategy (Ward et al., 2009). The firm must be conscious of its current strength and ensure that these strengths support design (Wrigley et al., 2020), thus indicating that causation or effectuation could influence design practices. Mansoori and Lackeus (2020) compare design thinking and effectuation as different but interrelated terms. They claim that the effectuation is based on expanding self-knowledge through introspection, whereas design thinking deals with deriving knowledge through other people's observations. The effectuation and design thinking uses the inputs from the customers and stakeholders, although they depend on each other with different objectives. For example, design thinking considers the customer feedback on the prototypes to value creation for others. In contrast, the effectuation primarily focuses on how the inputs create value for oneself and the team. Therefore, in this study, we have hypothesized the following:

H1. Design thinking practices have a positive effect on the effectuation.

2.5. Design thinking practices and causation

Big firms such as IBM, Google, and PepsiCo use design thinking to create new products and services to explore new market opportunities using their existing capabilities (Gruber et al., 2015). This represents an incident of causation where firms adapt themselves to absorb the market turbulence due to the changing customer preferences (Moorman and Miner, 1997; Jaworski and Kohli, 1993). Under such circumstances, the causation leads the organization to experiment with product and service offerings changes based on design thinking principles. Other studies have shown that existing knowledge structures and project plans get affected under more significant turbulence, resulting in learning failures or the non-integration of new information (Sethi and Iqbal, 2008). Therefore, in this study, we have hypothesized the following:

H2. Design thinking practices have a positive effect on causation.

2.6. Effectuation and venture performance

The literature on entrepreneurship suggests that the effectuation enhances venture performance. The dynamic capability theory indicates that a firm's capabilities are developed based on the compelling decision-making logic they apply to quickly react to the changes in the competitive environment, thereby supporting the long-run firm performance (Teece, 2007). Other studies in the literature have found that effectuation principles such as pre-commitment, experimentation, and flexibility positively impact venture performance (Roach et al., 2016; Wiltbank et al., 2006; Guo, 2018). However, few studies negatively associate the above dimensions of effectuation with firm performance. For example, it was found that affordable loss and experimentation dimensions negatively impact venture performance (Deligianni et al., 2015; Urban and Heydenrych, 2015). The findings from the literature on the relationship between effectuation and venture performance are inconclusive (Ruiz-Jiménez et al., 2021). Therefore, we have proposed the following hypothesis in this study:

H3. Effectuation positively impacts the venture's performance.

2.7. Causation and venture performance

The rationality assumption in neoclassical economics drives the relationship between causation and venture performance (Mthanti and Urban, 2014). The causation logic involves developing an optimal plan resulting in high returns through goal determination, screening the available opportunities, and analyzing the environment (Laskovaia et al., 2019). Strategies based on detailed market research data for market positioning relate to causation and improve venture performance (Welter and Kim, 2018). Causation-related decisions impact project performance (Spilker-Attig and Brettel, 2010). However, the literature on causation implies inconsistent conclusions. Few studies indicate the negative impact of causation on venture performance in uncertain environments (Long and Tang, 2015). Hence, it is interesting to test the following hypothesis in the present study:

H4. Causation positively impacts the venture's performance.

2.8. Digital capabilities as a mediating variable between the decision-making logic and venture performance

The literature acknowledges that innovation theories are advantageous for new ventures to improve performance (Guo et al., 2016). Platform-based firms face higher uncertainty in deploying innovation strategies without dynamic capabilities (Park and Tzabbar, 2016). Dynamic capabilities result from resource combination in firms executing operations (Penrose, 1959). The capabilities result from how the resources are acquired, accumulated, utilized, and developed (Wiklund and Shepherd, 2009; Zahra et al., 2006). These capabilities make ventures recombine the available resources for achieving new goals (Baker and Elson, 2005), thereby maximizing the potential value of the existing capabilities or developing new capabilities (Yang et al., 2021; Haarhaus and Liening, 2020). Ratten (2022) suggests that the increased usage of digital platforms drives transformational entrepreneurship, and

entrepreneurs have started to rethink the use of digital platforms in terms of financial or social outcomes after the COVID-19 crisis.

2.8.1. Innovation theories and digital capabilities

The literature on entrepreneurship suggests increased interest in how decisions on deploying the resources are taken by the entrepreneurs in the new ventures and their impact on the venture performance. The existing firm capabilities result from the interactions with effectual or causal logic that guide the entrepreneur's decisions (Read and Sarasvathy, 2005). New ventures with poor resource capabilities engage within their community through networking to access resource providers and exchange ideas (Hsu, 2007). This suggests that the new ventures use effectuation through alliances and pre-commitments when they are short of resources. In contrast, a new venture with rich resources may lower the use of effectuation, relaxing the incentive to explore and innovate (Nohria and Gulati, 1996). The effectuation theory has more impact on developing digital capabilities as it fulfills the visionary goals of the founder, promoting technical innovation in an uncertain environment (Austin et al., 2012; Dattée et al., 2018; Nylén and Holmström, 2019). This is because the entrepreneurs are pressured to transform the venture into a more digital business or fulfill their vision of possibilities enabled by digital technologies (Baber et al., 2019). Therefore, we hypothesize that:

H5. Effectuation positively affects the digital capabilities of the venture.

The abundance of resources may influence the new ventures to use causation, exploiting the pre-existing capabilities to maximize the expected returns (Alsos et al., 2020; Ruiz-Jiménez et al., 2021). It is found that causation plays an essential role in developing digital value-delivery products. The digital channels replaced the traditional physical channels with low risk, and the transformations were easy to plan and predictable in advance (Baber et al., 2019; Read et al., 2009). This is possible because the delivery platforms are already in their early stages of development (Ojala and Lyytinen, 2018). Thus, we assume that when technologies are more mature and predictable, causation theory is influential in developing digital capabilities. Therefore, in this study, we hypothesize the following:

H6. Causation positively affects the digital capabilities of the venture.

2.9. Digital capabilities and venture performance

Developing capabilities leads to venture growth, increased value, and competitive advantage for overcoming entrepreneurial challenges (Phillips and Tracey, 2007). The dynamic capability theory provides empirical evidence on the importance of capabilities to enhance firm performance and competitive advantage (Barney, 2001; Penrose, 1959; Haarhaus and Liening, 2020). Sufficient resources help organizations confront environmental changes by offering flexibility and improving financial performance (Kamble and Gunasekaran, 2020). The financial, human, organizational, and technological resources positively correlate with firm performance and competitive advantage (Ruiz-Jiménez et al., 2021). Technical resources significantly impact value creation in new technology firms due to their focus on intensive R&D efforts, innovation, and technically skilled human resources (Kamble and Gunasekaran, 2020). Recently, the emergence of Industry 4.0-based emerging technologies has been found to influence the efficiency of organizations. Studies have indicated the effects of innovation, digitization, and automation on production and manufacturing and have addressed the disruptive nature of technology adoption concerning how organizations operate. These capabilities successfully integrate information and communication technologies in virtual space through interoperability and enhanced human-machine interactions (Ghobakhloo, 2018; Kamble et al., 2020). The technical capabilities help the organizations to offer more visibility, reliable products, and services, enabling traceability using real-time information exchange and enhancing the firm's visibility. These capabilities also improve responsiveness reducing the cost of business processes and strengthening the firm's agility (Wolfert et al., 2017). Empirical evidence suggests that digital capabilities have a solid potential to positively influence venture performance, contributing to improved industrial value creation and sustainable objectives (Kamble et al., 2018). Therefore, we hypothesize the following:

H7. Digital capabilities positively affect the venture's performance.

Hypotheses 5, 6, and 7 establish digital capabilities as a mediating variable between the decision-making logic and the platform-based venture performance.

2.10. Control variables

Our proposed model used the entrepreneur's experience as a control variable. The literature has acknowledged the impact of the entrepreneur's experience on the venture's performance (Ruiz-Jiménez et al., 2021; Read and Sarasvathy, 2005; Dew et al., 2009). Prior experience in founding a firm relates to increased knowledge and expertise in managing a business, developing better management practices, and efficiently handling resources (Baron, 2006; Shamsie and Mannor, 2013). In the context of platform-dependent entrepreneurs, the entrepreneur's experience may be a limiting factor as new platform ventures require different technical skills. The platform-dependent entrepreneurs may need help using the same abilities or augmenting their skills due to limited time, energy, and resources (Yao et al., 2022). We also used the venture size defined by the size of employees and capital investment as another critical control variable. Capital and employee-rich ventures usually have more resources, resulting in better capabilities than the smaller ones (Zahra, 2012; Guo et al., 2016). Funding and technically skilled human resources are essential in innovation output in high-tech platform-based ventures. The greater a firm's cash flow and absorptive capacity, the more likely it is to perform better (Dushnitsky and Yu, 2022).

The proposed theoretical model is presented in Fig. 1.

3. Research methodology

3.1. Sampling

Data was collected from a sample of start-up executives from India using start-up databases to test the formulated hypothesis. Data for the study was collected from start-ups incubated in reputed incubation centers in India. These centers include The National Association of Software and Service Companies (NASSCOM) and K-tech Hub in Gurgaon and Hyderabad, India. The data collection was supervised by the author based in India. The selection criteria for the start-up were that they should have existed for at least two years and represented a technology venture. The initial sample consisted of 672 start-ups extracted from the database of these two centers. Completed responses from 291 start-ups were received, with a success rate of 43.30 %. The appropriateness of the sample size of 291 was tested per the guidelines given by Cohen (1992). The test was performed on G-Power v3.1 at a significance level of 0.05 and an effect size of 0.10 (Faul et al., 2009). The results indicated a significant association above the threshold of 0.80 (Cohen, 1992). Google Forms were used to collect the survey data, and only one person from each start-up, preferably the founder, was allowed to respond to the questions. Thus, the analysis unit was maintained at the start-up level, with the effective sample size for this study as 291 technology start-ups. The sample characteristics are presented in Appendix A. The survey was conducted from December 2021 to March 2022.

The questionnaire was pre-tested to ensure it was well structured and free from ambiguity to avoid non-response bias and subjective validity (Kamble et al., 2020). Eighteen founders of successful technology start-

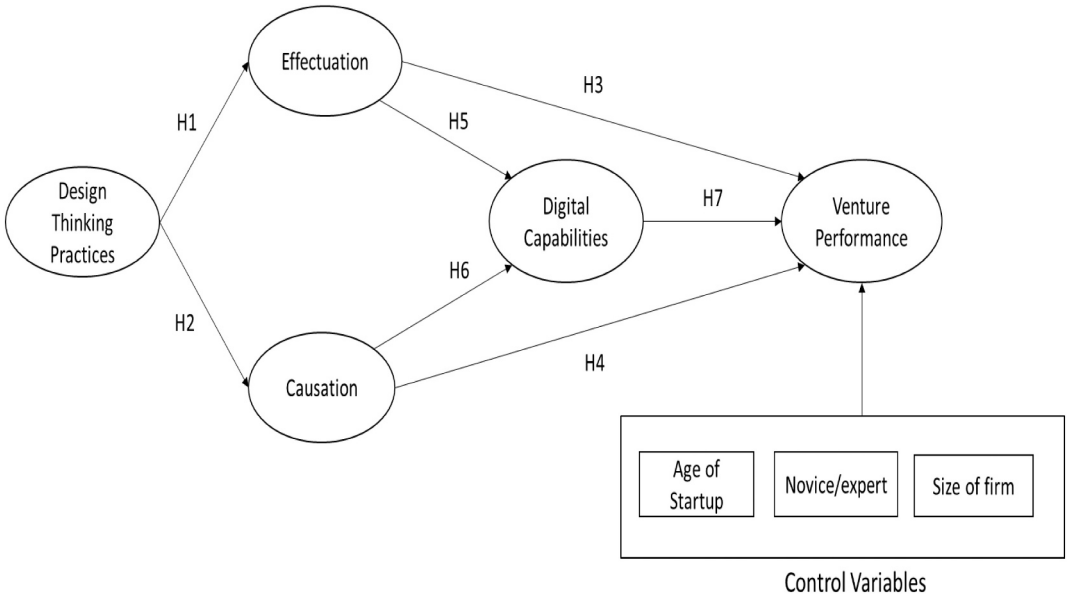

Fig. 1. Research model.

ups, having an average experience of 4.22 years, were used during the validation phase. The pre-testing helped modify the final questionnaire by removing a few items that were not relevant to the technology start-up environment. The completed responses were placed into two categories to test the presence of non-response bias using wave analysis. The first category represented the 106 early responses (December 8, 2021, to February 15, 2022) and 185 late responses (February 16 to March 30, 2022). The *t*-test was used to test the differences between the two categories indicating the absence of non-response bias.

3.2. The measures

A total of 58 measurement items were used in the survey instrument to evaluate the constructs used in the study other than the necessary information about the start-ups and participating executives. The effectuation decision logic was measured as a second-order construct using the dimensions of experimentation, pre-commitment, affordable loss, and flexibility developed by Chandler et al. (2011). The causation was measured as a single factor dimension using seven items created by Chandler et al. (2011). The measurement items for effectuation and causation used in this study are well-established and have been widely used by other researchers indicating good reliability (Ruiz-Jiménez et al., 2021; Rosca et al., 2020). Venture performance is a five-item construct concerning finance, assets, market growth, and competition based on similar studies available in the literature on entrepreneurship (Zahra et al., 2002; Ruiz-Jiménez et al., 2021; Stam and Elfring, 2008). Five measurement items on design thinking practices were conceptualized based on the study by Klenner et al. (2022). The study measured the design thinking practices related to "human-centeredness to uncover tacit resources such as entrepreneurs' empathic knowledge and social identities," "embracing diversity to integrate and balance the conflicting views of strategic partners, including users, investors, and other important stakeholders," "utilizing the power of visualization to create artifacts (such as maps, drawings, and models) that can help others to envision desirable futures, thereby enabling control of the innovation trajectory," "experimenting early and often to provide interim outcomes, which allows for the continuous alignment of goals and thereby limits potential losses along the innovation trajectory," and "practices related to (re) framing to adopt new perspectives on challenging situations, design novel solutions to important problems and thereby effectively turn contingencies into opportunities."

The measurement items concerning the digital capabilities of the start-up's various studies within and outside the domain of entrepreneurship were considered. This was because the recent technologies offer multiple benefits to organizations not covered extensively in entrepreneurship literature, and most of the available literature is qualitative. The digital capabilities construct was developed using the relevant literature and consultation with academicians and practitioners. Firstly, the digital capability was formulated as a reflective factor based on the impactful studies published on innovative technologies (Sharma et al., 2022; Kamble et al., 2020; Ghobakhloo, 2018). Secondly, we added new items based on the interactions with the selected experts. Twenty-four experts, including six academicians and eighteen start-up founders, were consulted for subjective validation. The team critically evaluated the items for ambiguity, clarity, and appropriateness. A total of thirty-one items operationalized in seven dimensions, viz., interoperability, cognitive capability, computing capability, virtualization, cyber security, modularity, and smart human resources (HR), were used in the study. A brief definition of the developed constructs on digital capabilities is given below.

3.2.1. Interoperability

It refers to the capability of the platforms to interact, connect, communicate, and transact using different technologies such as the Internet of Things (IoT), cloud computing, etc. (Ghobakhloo, 2018).

3.2.2. Cognitive capability

The capability of the platform-based systems and subsystems for autonomous decision-making. The cognitive capabilities use artificial intelligence-based technologies enabling intelligent decision-making and self-configuration with minimal or no human intervention (Lee et al., 2015; Tjahjono et al., 2017).

3.2.3. Modularity

Modularity signifies the transitional ability of the platforms. It refers to the shift from inflexible production models to flexible and agile systems for meeting dynamic business requirements (Ghobakhloo, 2018; Kamble et al., 2020).

3.2.4. Cyber security

This capability highlights the unique attributes of the platforms in thwarting any potential unwanted malware attacks and information

security breaches. Monitoring the potential threats, developing detection mechanisms, cyber security policies, and employee awareness are a few measures to mitigate the risks (Pereira et al., 2017).

Virtualization refers to the information system's ability to develop a virtual replica of the physical system or process—virtualization benefits systems modeling and simulation through real-time analysis (Manavalan and Jayakrishna, 2019).

3.2.5. Smart HR

The capability of the ventures that interpret and facilitate employee emotions. Smart HR capabilities reduce work-related stress and good working conditions resulting in fewer industrial hazards and injuries (Badri et al., 2018).

3.2.6. Computing capability

The platform-based ventures can integrate the various components into a single system for delivering the intended functionalities. The success of the decisions is based on how quickly and effectively the data was analyzed. Computing capability (data identification, capture, standardization, tracing, storage and retrieval, and high-speed computing) is the critical building block for a platform-based business (Dalenogare et al., 2018; Ghobakhloo, 2018).

All the measurement items were constructed using a five-point Likert scale. The final measurement items used in the study are presented in Appendix B.

4. Analysis and results

In this section, we discuss the findings from our study. The information about the constructs in our proposed model was obtained from entrepreneurs representing 291 start-ups from India. As seen in Appendix A, the majority of them were male (70 %), young (63.91 %), and having a degree or a post-graduation (90 %). The average entrepreneurial experience was 3.82 years (with a standard deviation of 2.53 years), average capital investment was $195,220 (standard deviation of $397,577), and employee strength ranged from 6 to 108 employees.

4.1. Measurement model

Before proceeding with the model testing, Common Method Bias (CMB) was assessed using the Harman one-factor test (Hair et al., 2022). The single-factor contribution value of 41.26 % (<50 %) indicated the absence of CMB. This was followed by evaluating the multi-collinearity between the constructs used in the study using the Variance Inflation Factor (VIF). The VIF was below the recommended threshold value of 10 and ranged between 1.002 and 4.764, indicating the absence of multi-collinearity issues.

Furthermore, the factor loadings, Cronbach's alpha, and Composite reliability were estimated to establish the construct reliability. Partial Least Square Structural Equation Modeling (PLS-SEM) on SmartPLS 3.0 was used to validate the hypothesized model. The convergent and discriminant validity of the first-order constructs was established using the Average Variance Extracted (AVE), Fornell-Larcker criterion, and Heterotrait-Monotrait Ratio (HTMT) (Hair et al., 2022). The threshold values for Cronbach alpha and Composite Reliability were 0.6 and 0.75, respectively (Hair et al., 2022). Based on the initial results of the construct reliability few items (V2, HR4, and VP5) and one dimension (modularity), a sub-construct of digital capability) were dropped from further analysis. The final constructs used for the study satisfied the recommended threshold values for Cronbach alpha and Composite reliability (see Table 1). The AVE scores for the selected constructs ranged from 0.245 to 0.807. The construct modularity was dropped from further analysis as it did not meet the recommended threshold value >0.5 (Hair et al., 2022). Discriminant validity was not an issue as the square root of the AVE for respective constructs was greater than their inter-correlation values with the other constructs, a criterion set by Fornell-Larcker (Hair et al., 2022). All the HTMT values were below the threshold value of 0.9 (maximum observed value = 0.841), supporting the discriminant validity of the selected constructs (Henseler et al., 2015; Hair et al., 2022). The results of the discriminant validity are presented in Table 2.

Table 1
Results of reliability and validity tests.

Constructs	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
Design thinking practices	0.735	0.792	0.583
Effectuation	0.930	0.940	0.571
Experimentation	0.880	0.926	0.807
Affordable loss	0.830	0.898	0.747
Flexibility	0.884	0.920	0.741
Pre-commitment	0.710	0.847	0.750
Causation	0.798	0.855	0.543
Digital capabilities	0.943	0.949	0.621
Interoperability	0.855	0.902	0.699
Cyber security	0.847	0.894	0.635
Modularity	0.693	0.037	0.245
Virtualization	0.745	0.819	0.580
Smart HR	0.851	0.895	0.637
Computing capability	0.846	0.899	0.695
Cognitive	0.747	0.831	0.503
Venture performance	0.765	0.779	0.543

4.2. Findings from the structural model

The bootstrapping technique using SmartPLS 3.0 was used to examine the structural models for path significance and explanatory power (Table 3). The path coefficient revealed some interesting findings.

4.2.1. Control variables

The effect of the control variables on the venture performance was examined. The control variables, namely, the venture's age, the founder's expertise level, and size, were regressed against the venture's performance. The results are presented as Model I in Table 3. The entrepreneur's experience was found to influence the venture's performance significantly. The control variables measuring the size of the venture in terms of capital employed and the number of employees were insignificant predictors. The results signify that the performance of the new technology ventures is not dependent on the capital or team size but on the entrepreneur's experience, implying the selection of appropriate strategies and decision-making logic. The results indicate that the technology ventures can exploit the new technologies to perform most manual activities, minimizing human resource requirements. The need for capital investment is reduced in technology ventures due to the ease of technological scalability compared to conventional manufacturing-focused companies. For further analysis concerning the dependent variable (venture performance), we followed the standard protocol of retaining the control variables, as Neter et al. (1996) suggested.

4.2.2. Hypotheses testing results

The relationship between the design thinking practices and the decision-making logic effectuation and causation (H1 and H2) are depicted in Models II and III. The results in Table 3 show that the relationships are significant and positive, indicating that the design thinking practices drive decision-making logic. Therefore, the design thinking practices in technology ventures can be considered significant estimators to predict the effectuation and causation.

To test the mediation effect of digital capabilities on the relationship between the decision-making logic (effectuation and causation) and venture performance, we adopted the procedure given by Baron and

Table 2
Fornell-Larcker criterion test and Heterotrait-Monotrait (HTMT) ratio test.

Construct	AL	COC	DC	C	CSC	DTP	Effect	EXPT	FLEX	HRC	IOC	VP	VC	CC	Pre-Comm
Affordable loss (AL)	**0.864**														
Cognitive capability (COC)	0.408	**0.709**													
Digital Capabilities (DC)	0.494	0.733	**0.788**												
Causation (C)	0.720	0.417	0.524	**0.737**											
Cyber security Capabilities (CSC)	0.303	0.645	0.852	0.290	**0.797**										
Design thinking practices (DTP)	0.405	0.603	0.498	0.562	0.351	**0.763**									
Effectuation (Effect)	0.914	0.445	0.578	0.727	0.383	0.351	**0.756**								
Experimentation (EXPT)	0.835	0.315	0.397	0.500	0.231	0.227	0.851	**0.898**							
Flexibility (Flex)	0.726	0.349	0.505	0.675	0.355	0.219	0.917	0.645	**0.861**						
HR Capability (HRC	0.132	0.566	0.850	0.252	0.667	0.313	0.258	0.083	0.229	**0.798**					
Interoperability capability (IOC)	0.745	0.546	0.764	0.717	0.511	0.485	0.775	0.622	0.690	0.473	**0.836**				
Venture performance (VP)	0.505	0.192	0.437	0.419	0.404	0.386	0.404	0.373	0.199	0.326	0.365	**0.736**			
Virtualization capability (VC)	0.347	0.662	0.925	0.418	0.727	0.502	0.423	0.347	0.320	0.844	0.632	0.399	**0.761**		
Computing capability (CC)	0.513	0.525	0.914	0.540	0.747	0.437	0.575	0.342	0.543	0.739	0.695	0.425	0.801	**0.833**	
Pre-commitment (Pre-Comm)	0.536	0.546	0.670	0.604	0.498	0.424	0.736	0.371	0.760	0.579	0.600	0.362	0.521	0.632	**0.866**

Note: The values in bold represent the square root of the AVE scores.

Table 3
Hypothesis testing and mediation results.

Constructs	Model I	Model II	Model III	Model IV	Model V	Model VI	Model VII	Model VIII	Model IX	Model X
Entrepreneurial experience	0.309*			0.150	0.262*		0.194	0.213		0.130
No. of Employees	−0.170			−0.156	−0.164		−0.121	−0.138		0.149
Capital Investment	0.063			0.038	0.039		0.082	0.065		0.043
Design thinking practices (DTP)		0.405***	0.558*							
Effectuation (E)				0.485*		0.548***		0.201		
Causation (C)					0.450*				0.496***	0.448
Digital capabilities (DC)							0.409**	0.318*		0.200
Venture performance (VP)										
R^2	0.119 (VP)	0.164 (E)	0.311 (C)	0.295 (VP)	0.292 (VP)	0.300 (DC)	0.205 (VP)	0.256 (VP)	0.246 (C)	0.357 (VP)
Adjusted R^2	0.091	0.156	0.304	0.265	0.263	0.293	0.171	0.217	0.238	0.323

n = 291
The legend in the bracket for R^2 represents the dependent variable.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$

Kenny (1986). The process involves the following steps.

i. Regress the dependent variable on the independent variable. If this relationship is significant, proceed to the next step or stop the process.
ii. Regress the mediator variable against the independent variable.
iii. Regress the dependent variable against the mediator variable.
iv. If the outcome of both models (steps ii and iii) is significant, then the mediator variable qualifies as a mediator.
v. In this step, we regress the dependent variable against the mediator and the independent variable. If the effect of the independent variable reduces in size or becomes insignificant, we conclude the presence of a mediation effect.

Hypotheses H3 and H4 state the direct positive effect of effectuation and causation on the venture performance. These hypotheses represent the first step of Baron and Kenny's (1986) procedure. The relationships are represented as Model IV and V in Table 3. The results in Table 3 show that both the effectuation and causation positively affect the venture performance, supporting hypotheses H3 and H4. In the next step, we estimate the relationship of digital capabilities with effectuation (Model VI) and venture performance (Model VII). The digital capabilities will qualify as a potential mediating variable if these relationships are significant. Table 3 shows that digital capabilities have a significant positive relationship with effectuation and venture performance (Model VI and Model VII) and qualify as a mediator between effectuation and venture performance. In Model VIII, both effectuation and digital capabilities were entered as predictors of venture performance. The results in Table 3 show that the coefficient of effectuation reduced from a highly significant 0.548 (Model VI) to an insignificant 0.201 (Model VIII). There is a slight reduction in the coefficient of digital capabilities from 0.409 to 0.318, but it remains significant, supporting the mediation procedure (Baron and Kenny, 1986).

In Model VII, we tested the significant positive effect of digital capabilities on venture performance. To test the eligibility of the digital capabilities as a mediator, we must first test the relationship between the causation and digital capabilities (Model IX). Table 3 shows the qualification of digital capabilities as a mediating variable between causation and venture performance due to a highly significant relationship between causation and digital capabilities (Model IX). Next, we tested the effect of causation and digital capabilities as predictors of venture performance (Model X). As seen in Table 3, the results of Model X show that the coefficient between causation and venture performance reduces marginally but becomes highly insignificant, indicating the presence of digital capabilities as a significant mediating variable.

Our findings provide empirical evidence for digital capabilities as the

mediator between the effectuation and causations interaction with venture performance. The design thinking practices also significantly drove the effectuation and causation logic. Specifically, design thinking stimulates causation and effectuation, promoting the firms' digital capabilities and ensuring enhanced performance. Furthermore, it is revealed that the experience of the start-up owner plays a significant role in controlling the venture's performance. The other two control variables were insignificant: employee size and capital investment.

5. Discussion

The outcomes of our study are analyzed in this section through the lens of the RQs identified previously.

5.1. Do design thinking practices influence the effectuation and causation of decision-making logic?

Previous studies in the literature have proposed that design thinking promotes well-focused goals related to reducing cognitive biases during the innovation process (Liedtka, 2015). Design thinking also impacts brand consistency, concept novelty, and certainty in the sales process (Beverland et al., 2016). However, this study primarily aimed to identify the conditions during which the design thinking practices work. Both effectuation and causation are decision logic under uncertainty (Rosca et al., 2020). Previous studies have found that the uncertainty of revenue generation due to market turbulence puts increasing pressure on companies to adapt to unknown demands (Moorman and Miner, 1997; Morgan et al., 2018). The findings of our study suggest that the start-up founders enact design thinking practices promoting the cognitive principles of effectuation (Klenner et al., 2022).

Additionally, we found that design thinking practices can drive the goal orientation principle of causation to predict the uncertain future. The design thinking approach requires rich information on the market requirements, which must be analyzed for insights into developing organizational strategies (Knight et al., 2020). The results reveal that these strategies could be based on effectuation or causation.

5.2. Do digital capabilities mediate the relationship between effectuation and platform-based venture performance?

The platform ventures are found to use the effectuation principle to build and promote digital capabilities required for improved performance. The effectuation stimulates performance by availing internal and external opportunities beyond the platform. The effectuation dimensions, namely, flexibility, pre-commitments, affordable loss, and experimentation, were highly significant. This shows that platform-based ventures are prepared to experiment with new things to take calculated risks. This approach to the platform ventures supports using available resources more efficiently and focuses on building new capabilities to explore the available opportunities. The result supports the previous studies conducted for non-platform-based companies (Chandler et al., 2011; Guo et al., 2016; Kor and Mahoney, 2005). The results support that pre-commitments between the stakeholders, suppliers, customers, and investors require digital capabilities for better connectivity and interactions in platform-based ventures. The effectuation through digital capabilities can help platform-based ventures pursue growth goals in emerging and evolving markets such as India. The results confirm that digital capabilities as the significant mediator between effectuation and platform performance.

5.3. Do digital capabilities mediate the relationship between causation and platform-based venture performance?

Causation involves making minor and incremental changes in the available capabilities compared to the effectuation principle (Guo et al., 2016). The causation focuses on optimizing the existing capabilities, such as offering employees training programs on cyber security laws. The results from the study indicate that platform-based ventures achieve growth through effectively utilizing the available digital capabilities. Hence, platform-based ventures achieve their pre-defined goals by deploying their resources effectively (Carnes and Ireland, 2013). It is observed that platform-based ventures are mainly affected by fast-changing technologies, customer preferences, and business models. Therefore, it is challenging for such ventures to keep up with the changing environment forcing them to follow the strategies of the industry leader and implement incremental innovations (Li et al., 2012). The other reason could be the low costs for incremental improvements in digital capabilities (Kor and Mahoney, 2005). The results confirm that digital capabilities mediate between causation and platform performance.

5.4. Theoretical contributions

Our study contributes to the literature on entrepreneurship decision-making principles by interlinking three significant research areas: design thinking practices, digital capabilities, and platform-based ventures. Most previous studies have investigated the linkage between the above concepts in a scattered manner with less attention to understanding how these constructs interact (Guo et al., 2016; Ruiz-Jiménez et al., 2021; Klenner et al., 2022). The study's findings presented in this paper have demonstrated that design thinking practices are significant drivers for effectuation and causation (RQ1). The study emphasizes that effectuation and causation significantly impact the platform-based venture when mediated through digital capabilities (RQ2 and RQ3). This study is novel as the previous studies rarely consider digital capabilities and platform-based ventures. The items used to measure the digital capabilities were explicitly developed for this study and may be relevant for future studies concerning platform-based ventures.

The study builds a more substantial theoretical and empirical basis for validating the effectiveness of design thinking practices in effectuation and causation theories, thereby advancing the innovation theory (Mansoori and Lackeus, 2020; Sarooghi et al., 2019). Based on the findings, the design thinking ways are well integrated into the theories of effectuation and causation, facilitating the growth of platform-based ventures.

The growth of the platform economy has shifted the focus on how these ventures can leverage digital capabilities to challenge the existing business models. The literature suggests that effectuation and causation co-exist in an organization as an integral part of human reasoning (Sarasvathy, 2001). The present study empirically supports that both effectuation and causation co-exist in platform-based ventures contributing to their growth and reveals that their effects are channeled through digital capabilities. Another significant contribution of the study is the identification of digital capabilities as the mediating medium. The previous literature has many studies investigating the effect of effectuation and causation on venture performance, but it needs to identify appropriate mediators. Therefore, the insights on the appropriateness of digital capabilities should be regarded as a promising area for further research.

5.5. Practical implications

This study contributes valuable ideas for platform-based ventures recognizing that there are multiple ways to achieve platform growth. The findings of our study imply that design thinking leads to digital capabilities development and does not start with a new product or service development. The study mainly focused on the design practices adopted in the selected ventures, leaving out the product they created. Usually, platform-based ventures create integrated software and hardware products, unlike conventional companies focusing on physical product development. Moreover, platform-based ventures' design and development life cycles are shorter. Such a design thinking approach

requires them to break out of a product area to create a new product, as characterized by Google, Apple, and Amazon, who go beyond their software to redesign traditional products. Therefore, these ventures must constantly think to target those conventional products that their digital capabilities can combine to offer digital innovation. The finding aligns with the study by Yoo et al. (2012).

This study's results imply that causation and effectuation can influence performance in uncertain environments. Therefore, it is suggested that the firms use effectuation to innovate products using different effectuation strategies such as pre-commitments, partnerships, and experimentation, as suggested by Alzamora-Ruiz et al. (2021). The use of effectuation should be done without delay from the perspective of seeking new opportunities in an uncertain environment. While applying causation, the firms can set management goals to fulfill their plans and deliverables by thoroughly analyzing competitors, consumers, and industry trends to inspire new ideas for innovative products and processes.

During the validation survey, an entrepreneur shared that the product he launched during COVID-19 exploited an existing market gap in e-learning and represented a causation move. He later signed numerous advantageous deals with local schools in Bangalore, India. Initially meant to be a platform offering learning solutions in mathematics, they later bought companies specialized in science and other courses. The entrepreneur had previous experience in the education sector and had broad awareness of the operating environment that helped him plan the moves. However, he stated that the situation after three years has changed and is still being determined, with many players operating in the e-learning domain putting him under pressure to have new product innovations. He added, "I do not know how to innovate with the available resources and value network." The current position of the entrepreneur demonstrates an effectual move as he is presently developing some artificial intelligence plug-ins with no confirmed market in mind. Another entrepreneur in the gaming platform mentioned the co-existence of the causation and effectuation moves during different stages of his business. When he launched the gaming platform, he launched games making incremental changes to existing popular games in his selected customer segment. This move was calculated and predictable as he planned according to the requirements of his customers. However, he must take risks and foray into new customer segments with new games with no confirmed market for improved venture performance.

The results imply that these logics may generate tension in the competition for resources and process alignment, leading to appropriate capabilities and finding support in the previous literature (Li et al., 2012; Webb et al., 2013; Haarhaus and Liening, 2020). Hence the firms must develop the right digital capabilities to apply this strategy successfully. Effectuation may be a valuable logic for non-routine growth as it encourages the development of new digital capabilities combining external partners. The ventures deploying causation would be focused on optimizing the available capabilities. The study implies that platform-based ventures should pay attention to the benefits of causation and should get equal importance. Both the logic should be balanced for creative and balanced growth. Every business needs to follow the general rules of business success: the ability to set and achieve goals (Guo et al., 2016).

The results also reveal a significant impact of the founder's experience on the venture's performance. Therefore, the firms should require a strong leadership focus based on risk tolerance and adaptability to guide the process. Experienced entrepreneurs use business planning tools and optimize their resources very well compared with inexperienced ones. They can learn from their earlier decisions. The experience gained from the previous learning may help entrepreneurs better to use causation and effectuation in rapidly changing environments.

Furthermore, the study supports the emergence of design thinking practices as a significant way for entrepreneurs to enhance their products and services based on rich customer insights. These practices also influence entrepreneurs to use customer data in their routine strategic planning activities, as Knight et al. (2020) suggested. Entrepreneurs seeking to leverage design thinking in their organizations should be clear about their engagements with their stakeholders, such as competitors, customers, and investors. These engagements should focus on enriching strategy conversations and actions. Entrepreneurs should be aware of the shortcomings of business planning to draw upon the use of appropriate logic. This study provides the organizational conditions of effectuation and causation required for design thinking to attain long-term impact that was less explored until now. The results imply that an entrepreneur must have expertise in facilitating multi-disciplinary teams and navigating strategic and operational activities within a firm.

6. Conclusion, limitations, and future research directions

For a firm's success in a dynamic, turbulent resource-scare system, the organizations must incorporate design thinking practices to promote a balanced effectuation and causation approach for improved performance. Organizations search for new digital capabilities to improve their growth prospects in uncertain environments. The firms may develop new capabilities (effectuation) or optimize existing ones (causation) depending on the situation. The present study attempts to evaluate the interlinkages between design thinking practices, effectuation, causation, digital capabilities, and their impact on venture performance, providing empirical justifications for the organizations.

Based on data collected from 291 platform-based ventures, we tested several hypotheses from the literature review. Some interesting results include identifying design thinking practices as a significant driver of effectuation and causation and the presence of digital capabilities as a mediator between the effects of effectuation and causation on venture performance. Developing design thinking approaches helps develop and manage digital capabilities efficiently and effectively while leveraging the effectuation and causation-based decision logic and improved performance in response to inherent environmental uncertainties.

6.1. Study limitations and future scope of the study

Several limitations inherent to the design and development of the present study should be recognized. First, the theoretical framework and the constructs used in the study are based on the dynamic capability view, representing the measures to be theory-oriented and may not provide a holistic view of the practical issues associated with digital capabilities. Therefore, future studies can combine qualitative and quantitative methodologies to investigate the relationships proposed in the model. Second, the results are subjected to a time-lapse effect due to its cross-sectional design and data collection procedures. Although no non-response errors have been reported, more in-depth longitudinal studies are recommended to confirm the interrelationships between design thinking practices, effectuation, causation, and digital capabilities (Rana and Dwivedi, 2016). Future studies should use a mixed or multi-method research design and meta-inferences to overcome the limitations posed by cross-sectional design (Maier et al., 2023). Finally, the selected sample represents platform-based ventures without differentiating their service sectors. Future research could triangulate these findings by investigating how innovation theories, digital capabilities, and venture performance are linked in the travel, transportation, and healthcare industries.

CRediT authorship contribution statement

Sachin Kamble: Conceptualization, Project administration, Writing – original draft. **Nripendra P. Rana:** Supervision, Resources, Writing – review & editing. **Shivam Gupta:** Methodology, Writing – original draft. **Amine Belhadi:** Formal analysis, Validation. **Rohit Sharma:** Data curation, Investigation, Visualization. **Praveen Kulkarni:** Data curation, Validation.

Data availability

Data will be made available on request.

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Appendix A. Sample characteristics

Parameter	Details	Total (%)
Gender	Male	206 (70)
	Female	85 (30)
Age	<35 years	186 (63.91)
	Between 35 and 50 years	75 (25.77)
	>50 years	30 (10.3)
Education level	Diploma/certificate	32 (10.9)
	Undergraduate	149 (51.2)
	Postgraduate and above	110 (37.80)
Experience of the entrepreneur	Minimum = 2 years	
	Maximum = 8 years	
	Average = 3.82 years	
	Standard deviation = 2.53 years	
Capital investment	Minimum = $1500	
	Maximum = $ 2,743,902	
	Average = $195,220.0462	
	Standard deviation = $397,577.3503	
Employee strength	Minimum = 6	
	Maximum = 108	
	Average = 13.12	
	Standard deviation = 16.21	

Appendix B. Questionnaire

B.1. Measurement items for effectuation

On a scale of 1–5 rate to what extent you have used the following dimensions of the effectuation theory. 1 = Low————————————5 = High.

Statement	1	2	3	4	5	Source
Experimentation (EXP)						Chandler et al. (2011). Ruiz-Jiménez et al. (2021), Rosca et al. (2020)
Our platforms have experimented with various business models (EXP1)						
Our platform is substantially different from what we had first imagined. (EXP2)						
Our platform tested various approaches until we found the most successful model (EXP3)						
Affordable loss (AL)						
We do not commit more resources than we could afford to lose (AL1)						
We do not risk more money than we were willing to lose with our initial idea. (AL2)						
We do not risk so much money that the company would be in real trouble financially if we fail. (AL3)						
Flexibility (F)						
We have allowed our platform to evolve as opportunities emerged. (F1)						
We adapted and operated within the resources we had with us (F2)						
Our flexible approach helped us to take advantage of opportunities from time to time (F3)						
The actions that restricted our flexibility and adaptability were avoided by us (F4)						
Pre-commitments (PC)						
We always encouraged pre-commitments from customers and suppliers (PC1)						
We have developed a substantial number of agreements with customers, suppliers, and other organizations and are well prepared to mitigate uncertainty risks (PC2)						

B.2. Causation

On a scale of 1–5 rate to what extent you have used the following dimensions of the causation theory. 1 = Low————————————5 = High.

Statement	1	2	3	4	5	Sources
Our strategy is developed to take the best advantage of resources and capabilities.						Chandler et al. (2011); Ruiz-Jiménez et al. (2021); Rosca et al. (2020)
Our business strategies are well designed and planned.						

(*continued on next page*)

(*continued*)

Statement	1	2	3	4	5	Sources
Our control processes are well organized and implemented so that we meet our business objectives.						
Our target markets are selected based on thorough research and competitive analysis.						
Our vision is clear and consistent.						

B.3. Design thinking practices

On a scale of 1–5 rate to what extent you have used the following design thinking practices. 1 = Low————————5 = High.

Statement	1	2	3	4	5	Sources
"Human-centeredness is used to uncover tacit resources such as entrepreneurs' empathic knowledge, social identities"						Klenner et al. (2022)
"Diversity is embraced to integrate and balance the conflicting views of strategic partners that include users, investors, and key stakeholders."						
"Power of visualization is utilized for creating artifacts (such as maps, drawings, and models) to envision desirable futures"						
"Early experimentation helps us to continuously align the goals and limit potential losses."						
"(Re) framing is practiced for developing new perspectives on challenging situations, designing novel solutions effectively turning contingencies into opportunities."						

B.4. Digital capabilities

On a scale of 1–5 rate to what extent you have developed the following digital capabilities in your firm. 1 = Low————————5 = High.

Statement	1	2	3	4	5	Sources
Interoperability (IO)						Sharma et al. (2022). Kamble et al. (2020); Ghobakhloo (2018)
Collaboration among stakeholders (IO1)						
Seamless information exchange and sharing (IO2)						
System communicability (IO3)						
Visibility and traceability of the processes (IO4)						
Computing Capability (CC)						
Data integration (CC1)						
High-performance computing (CC2)						
Data reliability (CC3)						
Data storage (CC4)						
Data visualization (CC5)						Dalenogare et al. (2018); Ghobakhloo (2018); Kamble et al. (2020)
Smart HR Capability (HR)						
Improved working conditions (HR1)						
Training and capacity development (HR2)						
Improved worker safety (HR3)						
Reduced labour claims (HR4)						
Human-Machine Interface (HR5)						Badri et al. (2018); Sharma et al. (2022)
Virtualization (V)						
Degree of virtualization (V1)						
Digital twin capability (V2)						
Simulation and modeling capabilities (V3)						Manavalan and Jayakrishna (2019).
Cognitive Capability (COC)						
Early fault detection and prediction (COC1)						
Process monitoring (COC2)						
Autonomous system (COC3)						
Self-configurable, self-reasoning systems (COC4)						
Self-predictive, self-sensing systems (COC5)						Lee et al. (2015); Tjahjono et al. (2017)
Cyber Security (CS)						
Cyber security policies (CS1)						
Data authentication and encryption (CS2)						
Data espionage (CS3)						
Threat detection and monitoring (CS4)						
Cyber security awareness programs (CS5)						Pereira et al. (2017)

B.5. New venture performance (over the past two years)

On a scale of 1–5 rate to what extent you have achieved improvement on the following performance dimensions. 1 = Low————————5 = High.

Dimension	1	2	3	4	5	Sources
Return on investment Return on equity Customer growth Sales growth Employee growth						Zahra et al. (2002); Ruiz-Jiménez et al. (2021); Stam and Elfring (2008)

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