Embracing human centric marketing for enhanced firm performance: the role of innovation strategy in India

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Abstract

Purpose – *The purpose of this study is to provide valuable insights to academics as well as practitioners looking for ways to improve their firm performance by judiciously focusing on marketing strategy, i.e. Marketing 5.0.*

Design/methodology/approach – *Using a mixed-method approach, a cross-sectional survey is conducted using 396 responses from an emerging economy setting. Analysis was conducted using a sequential research design, where qualitative interviews are conducted before the quantitative phase.*

Findings – *The findings suggest that firms should focus on building the right strategies using Marketing 5.0, thereby enhancing technology capability and absorptive capacity to promote open and eco-innovations.*

Originality/value – *This paper offers integrative and holistic implications to firms looking for ways to improve their overall performance using open and eco-innovations.*

Keywords *Open innovation, Absorptive capacity, Technology capability, Eco-innovation*

Paper type *Research paper*

1. Introduction

The study of innovation systems and advancements of technology has garnered substantial consideration, especially over the past three decades (Castellacci and Natera, 2013; Autio *et al.*, 2014). Technology has become more popular among marketers and customers as a result of its quick development and the fact that it is now more affordable and easier to use. Technological capability (TC) is described as a company's capacity to activate and implement resources that are primarily information technology-based in amalgamation with other capacities (Lin, 2007). Adoption of digital technology and tactics may assist firms in gaining a competitive edge and improving overall performance (Liu *et al.*, 2013; Priyanto *et al.*, 2023; Raj *et al.*, 2024). Previous researchers identified the dynamic capabilities needed for open innovation (OIN), such as sensing, absorption and collaboration capability (Dabić *et al.*, 2019). OIN and eco-innovation (EIN) are two types of innovation that are increasing in popularity and importance because of the fact that both economic and environmental reasons are of high importance for all companies in every sector. The term "absorptive capacity (AC)" refers to a firm's capacity to both acquire and assimilate innovative, external knowledge as well as to transform and use it for business purposes (Lu *et al.*, 2023). Dabić *et al.* (2019) stated that AC is a strong predictor of innovation performance (IP). Greater absorptive ability positions companies better to acquire competitive advantage from their suppliers (Sugheir *et al.*, 2011).

Industry 4.0. synergetic factories are created by integrating "cyber-physical production systems" with human intelligence (Longo *et al.*, 2020). In industrial systems, human and

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technology variables work together (Ghassoul and Messaadia, 2023). "Human-centricity", "sustainability" and "resiliency" are its three characteristics (Leng *et al.*, 2022). A new marketing strategy called "Marketing 5.0 (M5)" positions technology as a tool for improving humanity (Zarrin *et al.*, 2024). Now is the time when humans and technology work together to develop consumer experiences. We are all prompted to change by a marketing strategy that operates in the digital arena. Transformation is an inevitability, and it should be managed with agility (Wongmonta, 2021).

For businesses to achieve sustainable development, continuous innovation and improved IP are essential. However, it is challenging for individual industries to improve IP when they only rely on their internal resources in the current environment of increased technological complexity, fierce market competition and rapid technological change (Hervas-Oliver *et al.*, 2021). Under this situation, businesses must implement a new development strategy known as "OIN" (Obradović *et al.*, 2021).

Several scholars have recently concentrated on several subjects with a future-oriented perspective, including "Emerging Technologies", "Patent Analysis", "Service Innovation" and "Technology Transfer" (Naeini *et al.*, 2022). Technology and innovation are becoming an increasingly important competitive tool in all sectors. There lies an extant body of literature that examines the relationship between TC and innovation (Aliasghar and Haar, 2021). For instance, according to Guo *et al.* (2021), process innovation requires businesses to improve their technological abilities so that they can quickly acquire, absorb and use outside knowledge and information. An organization's information technology capabilities are determined by how well its management and human resource capabilities support information technology investments and how well it uses technology for internal and external communication with suppliers. On the other hand, there have been various studies on the essential success elements for technology transfer performance; however, the authors found no empirical evidence that examines the relation among TC, innovation, AC and firm performance (FP). Further, existing empirical literature on invention, novelty, technology and advancement has so far ignored the three main issues related to the work. The first is that while there is a considerable extent of investigations on the analysis of the impacts of innovation on financial growth, the inquiry specifically on OIN and EIN has so far garnered only limited interest (Valdez-Juarez *et al.*, 2020). The second issue is that the applied literature has often neglected the impact of potential and realized AC on OIN and EIN. The third issue is that to date there has been no study that has explored the role of M5 on the overall dynamics of TC, AC, innovation strategy and FP. Hence, motivated by the abovementioned research gaps, the authors of this study try to bridge those gaps through investigating the same issues in an Indian supply chain setting. The primary objective is to investigate the relationship between firms' TC, OIN, EIN, AC and FP while also examining the role of M5. The theoretical grounding of the present research is on AC and knowledge management theory (KMT), where the authors explore marketing and innovation strategy. Accordingly, this study seeks to answer to three specific research questions:

RQ1. Is there any relationship between technological capability, absorptive capability, innovation strategy and firm performance?

RQ2. What is the intervening role of potential absorptive capability, realized absorptive capacity, open innovation and eco-innovation in explaining the linkages between technology capability and firm performance?

RQ3. Does M5 influence the strength of association for technology capability, absorptive capacity and innovation strategy?

To address these questions, we conducted a cross-sectional survey where 33 firms based in different states in the northern region of India were approached, and a sample of 396 respondents was collected. In line with Chuang (2020), who argue the role of social media and allied technologies with human centricity is vital for customer satisfaction, we selected

firms engaged in business-to-business (B2B) sales as our sample framework. A two-stage sampling design mixed of probabilistic and non-probabilistic sampling methods was used where the primary sampling unit was a firm located in a leading industrial cluster of India.

2. Literature review

2.1 Technology capability and absorptive capacity

TC refers to a company's ability to acquire new technology in both internal and external dimensions. The internal dimension denotes a company's capacity to gain new technology through internal research and development (R&D), which is the most typical technique of developing new technology. Firms acquire technology from outside sources via a range of hierarchical, market and cooperative forms according to the external dimension (Wu and Chen, 2010). The literature on technology argues that TC improves business performance. According to a theoretical model put forward by Wang *et al.* (2023), the impacts of TC on FP are moderated by operations capability. Data from 278 US and 326 Chinese companies were used to test the research assumptions. Intriguing but contradictory findings included the following:

- At low levels of operations capability, TC reduces FP.
- The link between TC and FP is no longer significant (at medium operations capability).
- TC increases FP (at high operational capability).

On the other hand, according to Dewi *et al.* (2022), individual learning has an effect on TC, and applying new knowledge has a greater effect on achieving TC. The impact of TC on organizational performance is entirely mediated by business process agility. TC exhibits the traits of rarity, appropriability, no reproducibility and no substitutability (Chen *et al.*, 2014). There are two kinds of absorptive capacities: potential absorptive capacity (PAC) and realized absorptive capacity (RAC). Lu and Ramamurthy (2011) highlighted that TC promotes operational agility and market capitalizing agility. As a result, TC can affect the flexibility of an organization. On the other hand, to innovate and improve corporate operations using digital technologies, one essential technical-oriented dynamic capability known as "digital dynamic capability" is required (Li and Chan, 2019). Companies need technology to be able to accelerate their innovations. In order for them to use technology efficiently, technology capabilities are also important.

2.2 Innovation strategy

The last decade was a critically decisive and prolific era for advancing innovation and related strategies (de Souza João-Roland and Granados, 2023). There is a significant surge in terms of academic publications, venturing and support activities across the globe (de Souza João-Roland and Granados, 2023). Digitalization can improve the innovation capability (Arias-Pérez *et al.*, 2021). On the other hand, Massa *et al.* (2023) found a relationship between firms' international strategies and the knowledge processes enabled by applying digital technologies. Innovation strategy significantly impacts the creation of economic and socio-environmental values (Valdez-Juárez and Castillo-Vergara, 2020) by various means such as venture capturing and entrepreneurial diversity (Huang *et al.*, 2023). The majority of the researchers define the strategy in two fundamental terms, namely, OIN and EIN. OIN is primarily defined as "a distributed innovation strategy that incorporates carefully controlled knowledge inflows and outflows across organizational boundaries for both financial and non-financial purposes, in keeping with the firm's business model" (Chesbrough and Bogers, 2014). Small and medium-sized businesses (SMEs) can improve their IP and access external resources using OIN (Lu *et al.*, 2023). According to Lichtenthaler (2008), OIN may help organizations establish a competitive edge by lowering R&D costs, enhancing client acceptability and speeding innovation. OIN is a lengthy

procedure with delayed financial results; thus, it may not be suitable for businesses with a short-term focus. The primary driver of OIN is that it enhances a company's capacity to produce knowledge spillovers and to develop new products both internally and in partnership with outside parties (Obradović *et al.*, 2021). OIN practices are critical to achieving long-term competitive advantage (Hung and Chou, 2013). According to Taghizadeh *et al.* (2021), OIN and FP have a strong relationship.

EIN refers to new methods or technologies that can help the environment. EIN has been defined in a variety of ways across the literature, including green innovation, sustainable innovation, ecologic innovation and environmental innovation. The creation of new, commercially viable products, systems, processes, services and design methodologies that meet human needs while using fewer resources and emitting fewer hazardous substances is referred to as "EIN". The terms environmental, ecological and green innovation are used interchangeably. In contrast, the concept of sustainable innovation broadens the concept and incorporates a social dimension (Schiederig *et al.*, 2012). According to Vence and Pereira (2019), the environmental responsibilities of business must be reframed, and industry must invest in EIN projects that maximize profits while avoiding environmental harm.

The term "green innovation" describes the creation of ecologically friendly goods and services (Albort-Morant *et al.*, 2016). The authors refer to "EIN performance" as an innovation that successfully satisfies market demand, adds value to the company and increases yields while minimizing or preventing harm to the environment through waste processing and the use of environmentally friendly raw materials. To combat the destructive effects of waste, pollution, etc. and to support procedures that lead to waste recycling and the best use of resources, green innovation also adds to all other elements of innovation involving green products, activities and services (Schiederig *et al.*, 2012). According to several earlier studies, companies that exhibit EIN outperform their rivals in terms of achievements and notoriety because they can more rapidly and effectively meet customer needs by using their green resources and expertise (Del Giudice *et al.*, 2018).

2.3 Background works

AC has been extensively investigated in the literature regarding marketing, supply chain, strategy, as well as information systems (Najafi-Tavani *et al.*, 2016). AC is a competency that enables businesses to continuously absorb and apply outside knowledge, and it has emerged as a critical step in the process by which businesses use new knowledge to achieve their innovation goals. In addition, strengthening knowledge absorption improves firms' innovation because strengthening knowledge absorption transforms and uses the knowledge by integrating acquired and absorbed knowledge into the firm's operations (Xie *et al.*, 2018). According to Lin *et al.* (2002), without better AC firms cannot successfully assimilate and apply external knowledge. Investigating the critical elements of absorptive ability is important. According to Ying-Chun *et al.* (2009), the effect of spillover is greater in the areas with higher technology AC, indicating the importance of technology AC in influencing the performance of technology spillover. According to Cohen and Levinthal (1990), IP is the result of a corporation's absorption capacity, which is represented in environmental performance. Therefore, when organizations need to absorb outside information, they require a strong knowledge foundation. Cohen and Levinthal (1990) defined AC as the ability to value, assimilate and apply external new knowledge. They described a firm's capacity to recognize the value of outside knowledge or information, to assimilate it, and then to apply the knowledge system to achieve economic benefits. In their R&D investments model, Cohen and Levinthal (1989) stressed the dual objectives of AC, which include creating new information internally and assisting the absorption of externally acquired knowledge. According to Singh *et al.* (2020), innovation capability mediates the relationship between AC and FP.

Key mechanisms are used to transfer technology, and one of these processes is AC (Pagani *et al.*, 2020). Furthermore, the cross-border technological knowledge transfer

depends on the recipient's AC (Mehreen *et al.*, 2022). According to Najafi-Tavani *et al.* (2018), as one of the key elements of organizational learning, AC aids businesses in locating, disseminating and assimilating pertinent knowledge. It is crucial that when technology is obtained from outside sources, such as through inter-organizational contacts, a system of knowledge transfer such as AC be considered. To facilitate technology transfer between partners in networks and, increasingly, ecosystems, AC is a crucial strategic asset (Bolatan et al, 2022). In addition to exploring new knowledge, external sources may aid organizations in developing the skills necessary to innovate the business process. The entire learning process of absorptive ability is influenced by external sources: learning through exploration, change and exploitation (Ferreras-Méndez *et al.*, 2016). Rahomee *et al.* (2014) found that organizational support factors influenced technological innovation and AC significantly. It was also discovered that AC acts as a full mediator between organizational support factors and technological innovation. Furthermore, the size and age of a firm have a significant impact on the development of AC. Furthermore, external pressures and organizational characteristics, such as agility or flexibility, must support technology availability (Marrucci *et al.*, 2023; Lu and Ramamurthy, 2011; Zhu *et al.*, 2010).

2.4 Theoretical underpinning

2.4.1 Knowledge management theory. Knowledge is a vital asset for firms. They leverage it to develop systems that address their challenges, enhance the value of their assets, mitigate uncertainty and maintain efficiency (Ozpamuk *et al.*, 2023). By drawing on theories of organizational structure, KMT creates several significant new concepts that can further our comprehension of these organizations (Edwards, 2016). The principles of KMT may be divided into institutional, environmental and techno-centric forms (Tzortzaki and Mihiotis, 2014). The theory of organizational or institutional knowledge management focuses on the social and structural structuring of organizations to manage knowledge and knowledge processes. According to Baskerville and Dulipovici (2006), knowledge management is more in line with knowledge-based theories that place a greater emphasis on the organization's knowledge pool, identifying the necessary knowledge typologies and choosing the most effective knowledge management techniques. On the other hand, according to KMT, new knowledge is developed by the purposeful sharing of information inside organizations, between enterprises and with external stakeholders. Thus, organizations can maintain their existence and increase revenue by controlling their knowledge (Tzortzaki and Mihiotis, 2014).

2.4.2 Absorptive capacity theory. AC refers to firms' ability to absorb intangible resources in the form of knowledge and expertise and to convert them into distinctive dynamic capabilities, which are not easily imitated by competitors (Fichman, 2004). According to Roberts *et al.* (2012), AC is a firm's capability to recognize, integrate, adapt and leverage valuable external knowledge. Cohen and Levinthal (1990) pioneered the AC model. Hence, it is the ability of a firm to identify, integrate and apply the externally derived newly found knowledge for enhancing the organizations' efficiency through various performance outcomes (Cohen and Levinthal, 1989). AC is a collection of structured routines and processes through which organizations gather, internalize, adapt and use knowledge to create a dynamic capability within the firm (Zahra and George, 2002). According to Mowery and Oxley (1996), AC is a diverse set of skills that address the tacit aspects of transferred technology, along with the common necessity to adapt foreign-sourced technology for local use. AC relies on learning capability and fosters problem-solving skills. Learning capability enables the assimilation of knowledge for imitation, while problem-solving skills facilitate the creation of new knowledge for innovation (Kim, 1998). AC is conceptualized as an organization's potential (i.e. the ability to acquire and assimilate) and realized (i.e. transformation and appropriate exploitation of the newly acquired knowledge) ability to learn from an external environment. Cohen and Levinthal (1990) introduced AC to describe a firm's ability to recognize, assimilate and apply new knowledge for enhancing innovation

and performance. AC enables firms to access and use external knowledge, leading to improved competencies and adaptation to changes. Kranz *et al.* (2016) emphasize that firms must effectively absorb and use new information to develop innovation strategies (Daghfous, 2004).

According to Kotler *et al.* (2021), the definition of M5 is creating value throughout the customer journey; it is the application of technologies that imitate humans to transmit, present and develop an innovative atmosphere within the firm. M5 uses artificial intelligence, neurolinguistic programming (NLP), sensors, robotics, augmented reality, internet of things (IoT) and blockchain technologies. As a result, M5 is related to technology and innovation. Consequently, the increasingly competitive environment pushes companies to pay more attention to technology, innovation and M5. Because technology and innovation help to increase FP, product quality and service quality, these emerging technologies can provide customer satisfaction.

Industry 4.0 is concerned with mass manufacturing through technology (Sharma and Sehrawat, 2020; Sharma *et al.*, 2021) with the assistance of base technologies such as big data, cloud and artificial intelligence (Sharma *et al.*, 2022, 2023). As a result, the concept of Industry 4.0 provides a unique perspective and highlights the importance of research and innovation in assisting the industry in its long-term contribution to humanity (Xu *et al.*, 2021). The factors of M5 can change an organization's TC and knowledge capacity, whereas technology affects aspects of a company's marketing, such as customer reach, sales, price and price adjustments and so forth.

Organizations can increase their competency by forming partnerships with business and governmental partners. Studies have revealed that a variety of factors can affect how well a company performs (Flor *et al.*, 2018). Kim *et al.* (2009) found that IT investment has a positive impact on FP in China, whereby factors such as IT skills and availability, labour costs, regulation levels and economic growth are found to provide contradictory results among developed and developing nations. Ramadani *et al.* (2019) found that, in transition economies, product innovation has a positive influence on FP, which is complemented by a considerable impact of certain control factors including firm size, total labour cost and capital. Many studies highlighted the connections and implications of the close association between OIN and FP (Wilson *et al.*, 2023; Li *et al.*, 2022; Hung and Chou, 2013). According to Jones and de Zubielqui (2017), employees with a high capability of innovation have an effect on the performance of the firm significantly. Innovation in technology can help businesses perform better environmentally as well (Liang *et al.*, 2022).

There is various research about AC. Chatterjee *et al.* (2021) highlight that firms' AC plays a significant role in moderating the relationship between knowledge-sharing activities and various dynamic capabilities, such as sensing, seizing and transforming. On the other hand, Su and Sindakis (2023) addressed a gap in understanding how customer need knowledge impacts market opportunity recognition. Their model shows that the effect of customer need knowledge can be either direct or indirect, with AC mediating the indirect effect and technological knowledge moderating this relationship. This study highlights the roles of AC and technological knowledge in linking customer need knowledge to market opportunity recognition and offers practical insights for effectively leveraging customer knowledge. AC and its four capabilities of acquisition, assimilation, transformation and exploitation provide a useful framework for examining knowledge management in the service industry (Preece, 2015).

3. Hypothesis development

3.1 Direct hypothesis

TC plays a pivotal role in shaping a firm's ability to innovate and respond to market dynamics. As firms face rapidly changing environments, TCs help them assimilate, apply

and create new knowledge (Chen and Tsou, 2012). OIN emphasizes using external knowledge sources and collaborations to foster new products and services.

AC, defined by Zahra and George (2002), enables firms to acquire, assimilate, transform and exploit external knowledge. The two sub-dimensions of AC – PAC and RAC – are crucial for innovation. PAC refers to the firm's ability to identify and acquire external knowledge, while RAC relates to integrating and applying this knowledge to create value (Cegarra-Navarro *et al.*, 2014a, 2014b).

3.1.1 Technological capability and absorptive capacity. TC refers to a firm's capacity to integrate and manage technological resources, which significantly influences AC. Firms with advanced TC are better positioned to scout, acquire and use external knowledge, enhancing both PAC and RAC. Kang and Lee (2017a, 2017b) argue that TC underpins the identification of knowledge opportunities (PAC) and ensures the effective internalization of that knowledge (RAC). Firms work towards TC, which helps in easy integration and quicker transformation of their functions, to implement and take advantage of TC. This connection suggests that TC provides the necessary infrastructure and skills for enhancing AC (Lichtenthaler, 2016). Further, it is strongly suggested in the literature that those firms that successfully combine TC with AC can construe knowledge into innovation, enhancing market and financial performance (Tzokas *et al.*, 2015).

Thus, we hypothesize:

H1a. TC relates positively to PAC.

H1b. TC relates positively to RAC.

3.1.2 Absorptive capacity and innovation. The acquisition and assimilation of external knowledge through PAC provide the foundation for OIN, wherein firms collaborate with external entities to drive new ideas (Chesbrough, 2003). PAC enables firms to scout for external innovation sources and recognize market trends, which enhances their ability to co-create innovative solutions. Additionally, PAC is linked to EIN by driving environmental sustainability through the integration of green technologies and eco-friendly processes (Ghisetti and Pontoni, 2015).

Similarly, RAC plays a vital role in both OIN and EIN by converting external knowledge into practical, value-generating innovations. RAC ensures that external knowledge is transformed and embedded into new product or service offerings (Fosfuri and Tribo, 2008). Studies by Cegarra-Navarro *et al.* (2014a, 2014b) show that firms capable of reconfiguring and using acquired knowledge are more likely to achieve innovation breakthroughs.

It has been evident from the literature that only a handful of empirical works have focused on whether PAC or RAC is linked to OIN and/or EIN. With dynamic needs and evolving strategic priorities, firms pursue goals that can meet regulatory demands as well as consumer expectations for greener products. However, few existing studies have shown that such initiatives require heavy initial investment that might have a negative impact on the financial expectations, especially in the initial years (López Pérez *et al.*, 2024). Further, it has been evident that firms exploit innovation synergies to optimize/maximize return on investment. Hence, it is very critical to understand if synergy between components of AC and innovations helps a firm to flourish or may have a negative impact in the near or far future (Tzokas *et al.*, 2015).

Therefore, we hypothesize:

H2a. PAC relates positively to OIN.

H2b. PAC relates positively to EIN.

H3a. RAC relates positively to OIN.

H3b. RAC relates positively to EIN.

3.1.3 Innovation and firm performance. Firms engaging in OIN often see enhanced FP through faster product development cycles and the commercialization of cutting-edge innovations (Cheng & Shiu, 2015). By leveraging external partnerships and knowledge flows, firms can more effectively meet customer needs and improve competitive positioning (Laursen and Salter, 2006). In the same vein, EIN has been shown to positively influence FP by reducing costs, increasing efficiency and opening new market opportunities for sustainable products (Kemp and Pearson, 2007; Ziegler and Nogareda, 2009).

Chen and Tsou (2012) highlight how TCs contribute to both knowledge management and innovation, further reinforcing the relationship between TC and AC. Lichtenthaler (2016) emphasizes the role of technological infrastructure in building PAC and RAC, suggesting that firms with strong technological bases are better suited to capitalize on external knowledge. Chesbrough (2003) offers foundational insights into OIN and how firms benefit from external collaborations, supporting the link between PAC/RAC and OIN. Ghisetti and Pontoni (2015) show how AC facilitates EIN, underscoring the role of external knowledge in fostering sustainability-oriented innovations. Fosfuri and Tribo (2008) stress the importance of RAC in transforming external knowledge into innovation, strengthening the ties between AC and firm innovation outcomes.

Hence, we hypothesize:

H4a. OIN relates positively to FP.

H4b. EIN relates positively to FP.

By linking TC to AC and further connecting this to OIN and EIN, this theoretical model offers a comprehensive approach to understanding how innovation capabilities ultimately enhance FP.

3.2 Mediation hypothesis

Aliasghar and Haar (2021) researched the relationship between AC and FP. Their research builds on important ideas from the literature on OIN and knowledge management, suggesting that absorptive capabilities are complementary rather than substitutive and that combining the two should help businesses improve their economic performance. They test their model on a sample of 541 New Zealand businesses that actively participate in international partnerships. We find empirical support for the idea that a company's success is more significantly impacted by the balanced development of these competencies. Their results also show that the ability to license technology is not a stand-alone task and that it interacts with AC to significantly influence a firm's performance. Successfully integrating technology that has an impact on the internal strategy of the organization will result in an increase in the performance of supply chain operations (Marchiori *et al.*, 2022). Stoel and Muhanna (2009) found a significant association between information technology (IT) capabilities and business performance in their study, demonstrating that it is more complicated than had previously been postulated. In order for businesses to coordinate activities and use IT resources to produce the required results, Stoel and Muhanna (2009) defined IT capability as a complex collection of IT resources, competencies and know-how developed in the business process. IT resources are a group of infrastructure resources that form the basis of both current and upcoming business systems. Da Silva Florencio and De Oliveira (2022) found that both technology transfer and AC have a positive effect on organizational performance. Accordingly, we hypothesize:

H5. TC relates positively to FP.

A critical variable that affects organizational knowledge production and innovation has been identified absorptive capability (Engelman *et al.*, 2017). According to Lichtenthaler (2008), firms with a limited AC will apply OIN instead of closed innovation. On the other hand, AC is a strong predictor of IP (Dabić *et al.*, 2019). Without AC as an internal competence of innovative organizations, OIN is not achievable. Higher degrees of AC will result in

improved IP because companies with higher levels have stronger abilities to apply pertinent knowledge to commercial purposes (Vanhaverbeke *et al.*, 2008). According to Zhou and Wu (2010), strategic flexibility improves the favourable benefits of technical competence on exploration; therefore, more TC is related to more explorative innovation when strategic flexibility is strong.

Wang and Wang (2022) found that knowledge search successfully encourages an organization's AC while having an important positive impact on IP. In addition, AC plays a mediating function in the relationship between knowledge search and IP, having a major positive impact on the innovation success of companies.

Albort-Morant *et al.* (2018a) showed that businesses typically take in outside knowledge about how their operations affect the environment negatively (e.g. the effects of pollution and waste) and integrate it with their existing knowledge to make it easier for them to implement green innovation techniques. According to Albort-Morant *et al.* (2018b), innovative businesses can incorporate relevant technical knowledge into new products, services, or procedures by absorbing capacity, which promotes the performance of green innovation. The literature on product innovation regularly highlights the benefits of the AC on the effectiveness of product innovation by referring to it as the essential element of successful product innovation (Albort-Morant *et al.*, 2018a; Engelman *et al.*, 2017; Tavani *et al.*, 2014). Previous research has claimed that organizations that practice EIN during product and process innovation gain a competitive advantage over competitors who establish to meet the demands of their customers (Del Giudice *et al.*, 2018; Albort-Morant *et al.*, 2018b). According to Albort-Morant *et al.* (2018a), managers should invest more time and money in improving their AC as a strategic instrument for creating new knowledge.

According to Flor *et al.* (2018), two ideas based on the idea that businesses might use the knowledge produced outside to boost their IP are OIN and AC. Many researchers have examined the relationship between OIN and firms' innovation success in recent years (Lu *et al.*, 2020). Earlier studies showed a strong link between innovation and business performance (Marchiori *et al.*, 2022). According to Marzi *et al.* (2017), the survival and growth of innovative manufacturing firms are commonly quick, contributing to economic growth and development. Rhee *et al.* (2010) demonstrated that innovation had a significant impact on business performance in a sample of 333 South Korean small industrially pioneering businesses. According to Gunday *et al.* (2011), product, marketing and organizational innovations had a positive impact on business performance in their study of 184 industrialized businesses in Turkey. According to Dabić *et al.* (2019), in technology-oriented firms, AC is mediated by knowledge management capacity on innovation output and performance. Collaborative networks have played a significant role in improving product performance through both product and process innovation, as well as influencing firm AC (Najafi-Tavani *et al.*, 2018).

Because a company's technological innovation mode steadily shifts from closed to open, Flor *et al.* (2018) claim that an enterprise's capacity to absorb information and technology from the outside and transform it into its own knowledge through internal AC has become the key to successful innovation (Flor *et al.*, 2018; Albort-Morant *et al.*, 2018b). Furthermore, Albort-Morant *et al.* (2018a) contended that a firm's AC enhances its ability to produce EINs. The impact of R&D collaboration on innovation is determined by a firm's ability to absorb new knowledge and to apply it (Ferreras-Méndez *et al.*, 2016; Toroslu *et al.*, 2023). As a result, AC has a mediating effect on TC and FP. A significant source of AC is TC (Zhou and Wu, 2010). Therefore, we expect:

H6a. PAC and OIN serially mediate the relationship between TC and FP.

H6b. PAC and EIN serially mediate the relationship between TC and FP.

H6c. RAC and OIN serially mediate the relationship between TC and FP.

H6d. RAC and EIN serially mediate the relationship between TC and FP.

3.3 Moderation hypothesis

Innovation capability is defined as the ability to absorb, adapt and turn certain technology into specific management, operations and transaction routines that lead to corporate profitability through innovation (Zhou and Wu, 2010). According to Kotler *et al.* (2021), there is a relationship between technology and M5. In the M5, organizations use NLP, sensors, robotics, augmented reality, IoT and blockchain technologies. It has been observed that if firms put into place a better strategy and position it as technology for humanity, then FP can improve drastically (Enkel and Heil, 2014; Ferreras-Méndez *et al.*, 2016). With an ever-evolving dynamic environment, it is imperative for organizations to broaden their frontiers and exchange knowledge & technology with other external partners. Hence, the right strategy can also help a firm in OIN and EIN (Obradović *et al.*, 2021). Accordingly, we hypothesize:

H7a. M5 positively moderates the relationship between TC and PAC.

H7b. M5 positively moderates the relationship between TC and RAC.

H7c. M5 positively moderates the relationship between PAC and OIN.

H7d. M5 positively moderates the relationship between PAC and EIN.

H7e. M5 positively moderates the relationship between RAC and OIN.

H7f. M5 positively moderates the relationship between RAC and EIN.

3.4 Control variables

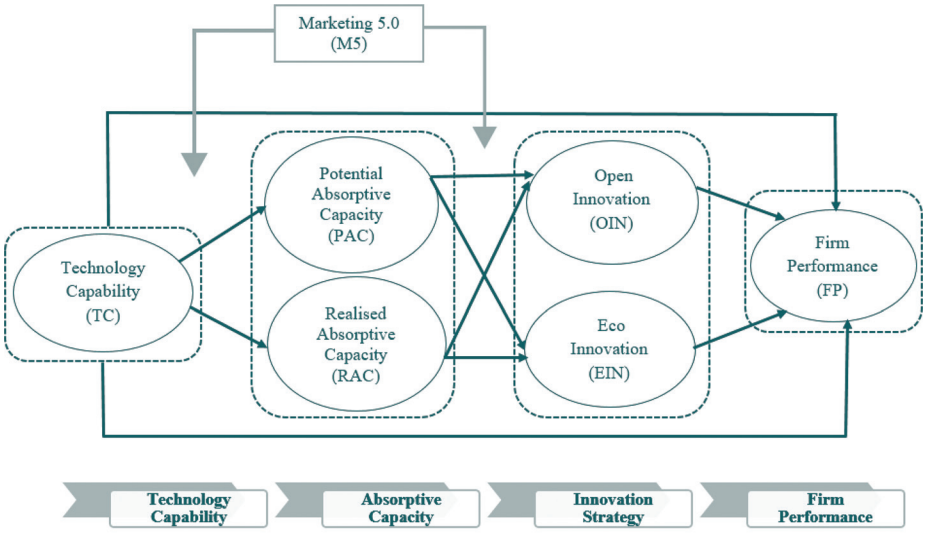
In consensus with seminal studies (Algarni *et al.*, 2022; Ali, 2021; Bag *et al.*, 2021), three firm-level variables are treated as control variables in this study. To eliminate potential bias, this study controls for a firm's size, age, industry type and age of the organization, as they might influence the absorptive capabilities, innovation strategies and FP. Extant literature indicates that large organizations have plenty of resources in terms of financial resources and revenue to engage and support their initiatives compared to small organizations operating with resource constraints (Algarni *et al.*, 2022). Similarly, experienced organizations operating for a longer period of time can increase the capability of firms to attain better productivity with higher accumulative industrial know-hows (Chatterjee *et al.*, 2021). Finally, the differences between industries have the potential to impact the performance of organizations, as each industry has its own sets of peculiarities (Bag *et al.*, 2021). Figure 1 depicts the conceptual framework.

4. Research method

4.1 Qualitative study

In Phase 1 of the research, the authors carried out the interviews with 16 officials (senior managers and managers) in pharmaceutical and chemical manufacturing in Baddi (Himachal Pradesh). The authors have prepared a semi-structured questionnaire, and during the course of interviews, a few questions were also added. The official language for communication used was English; however, authors also hired a language translator who could translate English to the regional language. The manufacturing industry in these areas is booming owing to two reasons: the first is the easy access to skilled labour, and the second is the low prices for property, which has helped with setting up large factories in comparison to other parts of India. To move in the direction of the fourth industrial revolution, firms are looking for improvement measures and opportunities that can help them to implement technological advancements for sustainable products that could be marketed to the right market. To make an educated move in the right direction, firms shared their knowledge and expertise with the authors. The collected data was then analysed using open and axial coding. The transcripts were read and re-read by two authors, both together

Figure 1 The conceptual framework



Source(s): Authors' own work

and then separately. Once they finalized their respective codes and constructs, a common meeting was conducted. The common constructs were finalized, and in the case of discrepancy or where a common consensus was not reached, there were follow-up interviews with the respective officials to understand their viewpoints. The authors then reanalysed the follow-up interviews and repeated the process. Once all the relevant constructs were identified, the authors worked on identifying the underlying relationships. Finally, the authors proposed the constructs and the relationships within a framework using consultations from both academia and industry to confirm the proposition. The academic experts were from reputed business schools as well as industrial engineering institutions in India. The authors approached both types of institutes to understand all of the aspects of the framework from the critical viewpoint of management as well as an engineering standpoint.

5. Quantitative analysis

5.1 Instrumentation

A questionnaire-based survey methodology was used to empirically validate the hypothesized research model where measures were adopted from the prevailing literature. Established reflective scales were used for all constructs (Diamantopoulos and Winklhofer, 2001) where they were measured through multiple items on a five-point Likert-type scale ranging from "strongly disagree" (1) to "strongly agree" (5). To study the technology capability (TC) of a firm, the authors borrowed the technology capability scale from Valdez-Juárez *et al.* (2020). AC was studied through two constructs, namely, PAC and RAC, which were measured through two scales adopted from Albort-Morant *et al.* (2018a) and Mata *et al.* (2023). For OIN and EIN, scale items were adopted from Valdez-Juárez *et al.* (2020). M5 was measured by a five-item scale adopted from Kartajaya *et al.* (2021), while a scale for FP was adopted from Gupta and Gupta (2020). The M5 measurement scale intends to measure the level of implementation by assessing how a firm integrates the power of modern human-mimicking digital technologies across various inbound and outbound activities to enhance overall customer value. Because of the multifaceted nature of different M5

technologies, many organizations are indeterminate regarding the consequences of M5 technologies (Kartajaya *et al.*, 2021). Therefore, following a similar approach in seminal studies (Bhatia and Kumar, 2022), the measuring items capture the "degree of implementation across activities" rather than the success level of M5 technologies. The questionnaire was formulated in the English language, and a short description was provided about each construct to avoid any ambiguity regarding understanding of the constructs (Cai *et al.*, 2018). The survey instrument comprised 88 structured questions related to the measurement of variables of interest (refer to Table S1 in supplementary material).

In consonance with seminal studies establishing the subjective validity of the questionnaire (Kamble and Gunasekaran, 2021), the survey was referred to four industry and three academic experts to ensure the appropriateness of measures. One academic expert was from the field of digital marketing management, while two senior professors were from operations and technology management backgrounds. Industry practitioners with a minimum of ten years' experience in the field of information technology, digitization of manufacturing and industrial marketing were approached for discussion. The subjective validity of the survey instrument was established after duly modifying the questionnaire based on the experts' suggestions, thereby confirming the appropriateness of presentation and relevance of the measuring instrument to the context of the study (Kamble *et al.*, 2020). Furthermore, the final draft of the questionnaire was used for the pilot study to ensure good reliability and validity. The pilot study was conducted on 50 technology executives working in the area of industrial engineering and management enrolled from LinkedIn (Akter *et al.*, 2016). Respondents who had prior work experience in the manufacturing sector and were aware of the concept M5 could participate in the survey. The reliability of the variables was investigated where values of Cronbach's alpha and composite reliability were higher than 0.70, evidencing satisfactory reliability of all variables (Algarni *et al.*, 2022). All scale items with their sources are reported in Table 1.

5.2 Research design and sampling

A cross-sectional study was conducted to empirically analyse the data collected through a survey based in India. With the Indian manufacturing sector projected to surpass US$1tn by 2030 (IBEF, 2023), India is building its manufacturing ecosystem that incorporates the latest trends in digitization, big data analytics and virtual assistants (Kamble and Gunasekaran, 2023). This makes it a suitable context for studying the impact and integration of M5 (Papadopoulos *et al.*, 2022). Also, as innovation is critical for long-term success even for micro, small and medium enterprises (Khurana *et al.*, 2019), there is a strong motivation to investigate the drivers for OIS and EIN, particularly in the context of innovative marketing practices (Chaurasia *et al.*, 2020). In line with Agnihotri *et al.* (2016) and Chuang (2020), who argue the role of social media and allied technologies with human centricity are vital for customer satisfaction, we selected firms engaged in B2B sales as our sample framework. A two-stage sampling design mixed of probabilistic and non-probabilistic sampling methods was used (Gupta and Gupta, 2020; Naruetharadhol *et al.*, 2021), where the primary sampling unit was a firm located in a leading industrial cluster of the north-western region of India. The manufacturing firms that were operating in the pharmaceuticals and chemical industry were based in Baddi, an industrial township situated at the border of Himachal Pradesh and Haryana (Kiran, 2017). These firms are privately held, which is representative of the typical ownership structure within India's manufacturing sector in the Baddi region (egov.eletsonline.com, 2016). The majority of pharmaceutical and chemical companies in Baddi, an industrial hub in the Solan district of Himachal Pradesh, are privately held. Baddi is known for being one of the largest pharmaceutical manufacturing centres in India with a high concentration of private small and medium-sized enterprises (SMEs) as well as large privately owned firms. They were randomly selected from the group where the executives and senior managers were approached following a convenience sampling method. Convenience sampling, which is a non-probability sampling technique, was implemented to

Table 1 Construct details and measurement items

Construct (source)	*Items*	*Factor loadings*	*Cronbach's alpha*
Technology capability (TC) (Valdez-Juárez *et al.*, 2020)	TC1	0.812	0.800
	TC2	0.775	
	TC3	0.698	
Potential absorptive capability (PAC) (Albort-Morant *et al.*, 2018; Mata *et al.*, 2023)	PAC1	0.788	0.901
	PAC2	0.792	
	PAC3	0.795	
	PAC4	0.798	
	PAC5	0.723	
	PAC6	0.767	
Realized absorptive capability (RAC) (Mata *et al.*, 2023)	RAC1	0.740	0.895
	RAC2	0.776	
	RAC3	0.788	
	RAC4	0.793	
	RAC5	0.748	
	RAC6	0.739	
Open innovation (OIN) (Valdez-Juárez *et al.*, 2020)	OIN1	0.633	0.856
	OIN2	0.731	
	OIN3	0.752	
	OIN4	0.739	
	OIN5	0.688	
Eco-innovation (EIN) (Valdez-Juárez *et al.*, 2020)	EIN1	0.765	0.831
	EIN2	0.804	
	EIN3	0.733	
	EIN4	0.584	
	EIN5	0.626	
Firm performance (FP) (Gupta and Gupta, 2020)	FP1	0.738	0.819
	FP2	0.695	
	FP3	0.777	
	FP4	0.713	
Marketing 5.0 (M5) (Kartajaya *et al.*, 2021)	MK1	0.977	0.794
	MK2	0.786	
	MK3	0.746	

Source(s): Authors' own work

reach target respondents, as a probability sampling is not feasible for a target population that is unknown, indefinable and where no sampling frame can be achieved (Ochoa, 2017). More than 33 firms were approached, where, on an average, 12 responses were collected from each firm. The data collection procedure was conducted over a period of approximately three months, spanning from 10 Jan 2023 to the end of March 2023. The demographic profile of the respondents is presented in Table 2.

With respect to sample size adequacy for performing factor analysis, extant literature suggests adhering to a 1:5 ratio guideline. Further, Aguinis *et al.* (2008) and Bentler and Chou (1987) advocate that having five participants per variable is sufficient for conducting factor analysis. Hair *et al.* (2010) accentuated that 100 observations can be considered the lower limit for using SEM effectively. Following this, the sample size for the current study is 396, which is beyond the required criteria (5×42 manifesting variables $= 210$). In total, 450 responses were obtained, where 396 responses were complete and found fit for analysis. Most of the sample units comprised of medium and small manufacturing units.

6. Results and analysis

6.1 Analysis approach

The data analysis consisted of a confirmatory factor analysis where reliability and validity of constructs were established by using AMOS Graphics 26.0 software. Covariance-based

Table 2 Demography of sample respondents

Characteristics	*Scale*	*Frequency (%)*
Industry type	Chemical and petrochemicals	186 (46.9)
	Pharmaceuticals	210 (53.0)
Age of organization	3–6 Years	86 (21.7)
	7–10 Years	97 (24.4)
	11–14 Years	112 (28.2)
	More than 15 years	101 (25.5)
Size of organization	Micro (less than 9)	68 (17.1)
	Small (10–49)	115 (29.0)
	Medium (50–249)	123 (31.0)
	Large (more than 249)	90 (22.7)
Employee position	Supervisors/executives	130 (32.8)
	Senior managers/managers	112 (28.2)
	Area heads/vice president/president	94 (23.7)
	Director/CEO/CMO	60 (15.15)

Source(s): Authors' own work

structural equation modelling (CB-SEM) was performed to explicate the direct proposed relationships by testing the main effects. To systematically investigate the mediated and moderated relationships, a Hayes PROCESS macro was used through SPSS 26.0. The chosen methodology was found to be a suitable computational tool to analyse the contingent nature of the underlying phenomenon in the relevant domain (Rialti *et al.*, 2019; Vizcaíno *et al.*, 2021) and overarching field of business and management research (Shankar *et al.*, 2022; Kim *et al.*, 2022). The PROCESS macro simplifies the estimation of complex relationships by assuming a macro-analytical approach that tests a complete research model, implementing a bootstrapping method that enables the inference of statistical results (Hayes, 2018, 2017). Because the SEM was used for testing the hypotheses, adequate measures were taken to ensure the data sufficiency (i.e. sufficiently large sample size and absence of normality and multicollinearity) to perform multivariate analysis (Hair *et al.*, 2010).

6.2 Nonresponse bias and common method bias check

Because the nature of survey research requires respondents to self-report their opinions, procedural and statistical measures were undertaken to ensure there is an absence of common method bias (CMB). Adopting *a priori* approach, the questionnaire was designed with a brief explanatory note that clearly mentioned the nature and purpose of research with a glossary of the key terms. Respondents were instructed that there were no right or wrong answers and that the details of respondents would be kept confidential throughout the research (Benzidia *et al.*, 2021). Furthermore, Harman's single factor test was conducted where CMB would be confirmed if a single component accounted for more than 50% of the accumulated variation. Hence, all indicators were loaded in an unrotated principal component exploratory factor analysis (extracting only one largest factor). The results demonstrated that the single factor accounted for 29.978% (i.e. below the cut-off threshold of 50%) of the variance, ensuring that there was no risk of CMB in the study (Podsakoff *et al.*, 2003).

6.3 Measurement model

Confirmatory factor analysis (CFA) was performed to investigate the internal consistency and validity of each measure by assessing how efficiently the manifesting variable reflects the construct. The standardized factor loadings for all of the items were assessed where loadings for all items were significant and above 0.50. Based on this, these ten items were

systematically dropped where the elimination accounted for higher reliability measures (Flatten *et al.*, 2011; Gupta and George, 2016). Further, data were assessed to warrant convergent and discriminant validity. For ensuring convergent validity, Cronbach's alpha values were above the threshold limit of 0.70 (see Table 1) (Nunnally, 1978). The measures of composite reliability (CR) for each construct were found to be above the threshold limit (above 0.70) (see Table 3) (Hair *et al.*, 2010). Further, the average variances extracted (AVE) values for each construct were higher than 0.50 for all the constructs, ensuring adequate convergent validity (Kim *et al.*, 2022). Discriminant validity among the focal constructs was determined by adhering to the condition advocated by Fornell and Larcker (1981), where the square root of the AVEs was compared with the inter-construct correlations. The square-rooted values of AVEs were higher than the inter-construct correlation coefficient. The maximum shared variance values (MSV) for each construct were also lower than AVEs (Fornell and Larcker, 1981). HTMT (heterotrait–monotrait ratio) was conducted to assess discriminant validity, which ensured that constructs in a model are distinct from one another. The rule of thumb, HTMT ratio, was below 0.90; hence, there was adequate discriminant validity between the two constructs (see Table 4). In addition, the cross-loading values with other constructs were less than the indicator's outer loadings, indicating sufficient discriminant validity (Wang *et al.*, 2019). Finally, the hypothesized measurement model indicated a reasonable fit to the data where various fitness tests were used to determine the overall fit (Hu and Bentler, 1999).

6.4 Structural model

The hypothesized model with seven constructs was tested for the main effects by performing structural equation modelling (SEM). As demonstrated in Table 5, SEM indicated a good model fit (Hu and Bentler, 1999). The analysis shows that there is a

Table 3 Validity and construct reliability measures

	CR	*AVE*	*MSV*	*FP*	*TC*	*OIN*	*PAC*	*EIN*	*RAC*	*M5*
FP	0.821	0.535	0.412	*0.731*						
TC	0.807	0.583	0.282	0.392***	*0.763*					
OIN	0.835	0.504	0.327	0.531***	0.416***	*0.710*				
PAC	0.902	0.605	0.282	0.403***	0.531***	0.442***	*0.778*			
EIN	0.832	0.500	0.174	0.328***	0.250***	0.398***	0.417***	*0.707*		
RAC	0.894	0.584	0.256	0.506***	0.424***	0.348***	0.374***	0.247***	*0.764*	
M5	0.795	0.565	0.412	0.642***	0.428***	0.572***	0.474***	0.315***	0.399***	*0.752*

Fit indices: (χ^2/df = 2.173, comparative fit index [CFI] = 0.922, incremental fit index [IFI] = 0.923, Tucker–Lewis index [TLI] = 0.912, root-mean-square error of approximation [RMSEA] = 0.054)

Note(s): *** $P \leq 0.001$; AVE = average variances extracted; the square root of the AVE values is presented in diagonal of the correlation matrix (italics); items below the diagonal display inter-construct correlation values; MSV = maximum shared squared variance
Source(s): Authors' own work

Table 4 HTMT analysis

	FP	*TC*	*OIN*	*PAC*	*EIN*	*RAC*	*M5*
FP							
TC	0.412						
OIN	0.512	0.417					
PAC	0.409	0.558	0.433				
EIN	0.343	0.257	0.408	0.421			
RAC	0.510	0.430	0.330	0.373	0.258		
M5	0.650	0.450	0.557	0.482	0.331	0.395	

Source(s): Authors' own work

Table 5 Results of main effects hypothesis testing

Hypothesis	*Path*	*Beta (β)*	*SE*	*Significance*	*Support*
H1a	TC → PAC	0.679	0.078	***	Yes
H1b	TC → RAC	0.473	0.069	***	Yes
H2a	PAC → OIN	0.284	0.047	***	Yes
H2b	PAC → EIN	0.273	0.044	***	Yes
H3a	RAC → OIN	0.231	0.050	***	Yes
H3b	RAC → EIN	0.098	0.044	0.027	Yes
H4a	OIN → FP	0.434	0.070	***	Yes
H4b	EIN → FP	0.141	0.061	0.022	Yes
H5	TC → FP	0.210	0.058	***	Yes

Fit indices: (χ^2/df = 2.278, CFI = 0.923, IFI =0.923, TLI = 0.914, RMSEA = 0.057)

Note(s): *** $P \leq 0.001$; RMSEA = root mean square error of approximation; IFI = incremental fit index; CFI = comparative fit index; TLI = Tucker–Lewis index

Source(s): Authors' own work

positive significant effect of TC on PAC ($\beta = 0.679$, $p < 0.001$), TC on RAC ($\beta = 0.473$, $p < 0.001$), PAC on OIN ($\beta = 0.284$, $p < 0.001$), PAC on EIN ($\beta = 0.273$, $p < 0.001$), RAC on OIN ($\beta = 0.231$, $p < 0.001$) and RAC on EIN ($\beta = 0.098$, $p = 0.027$). For the innovation strategy and outcome variables, the effect of OIN on FP ($\beta = 0.434$, $p < 0.001$) and EIN on FP ($\beta = 0.141$, $p = 0.022$) were significant. Finally, TC also exerted a significant effect on FP ($\beta = 0.210$, $p < 0.001$). Thus, *H1a*, *H1b*, *H2a*, *H2b*, *H3a*, *H3b*, *H4a*, *H4b* and *H5* were supported.

6.5 Serial multiple mediation analysis

The bootstrap procedure with 5,000 subsamples at 95% bias correction, as advocated by Preacher and Hayes' (2008), was used to test serial mediated hypotheses. Bootstrapping is preferred over the traditional mediation tests encompassing the Sobel test (Sobel, 1982) or the Causal Steps process (Baron and Kenny, 1986) as it is a non-parametric resampling procedure free from assumptions on normality of sampling distribution to test indirect effects (Mikalef and Pateli, 2017) and also to exhibit better control of Type 1 errors (Chen *et al.*, 2014; Kang *et al.*, 2021). In consensus with their seminal work (Jessen *et al.*, 2020; Skard *et al.*, 2021), a serial multiple mediator model was tested with two mediators by adopting SPSS PROCESS macro, Model 6 (Hayes, 2017). This analysis enabled the examination of both direct and indirect effects where TC was modelled as affecting FP through four pathways. Mediation, demonstrated through the indirect effect, was established at a 95% level of confidence if confidence interval (CI) does not contain zero.

The four serial pathways capture the AC as first stage facilitators and innovative strategy as second stage facilitators by regressing FP on TC. With regard to predictor variable TC, the direct and indirect effect through first mediator PAC and second mediator OIN on FP are reported in Table 6. The direct effect of TC on FP (B = 0.1483, SE = 0.0510, 95% CI [0.0480, 0.2487]) was significant while the indirect effect (B = 0.0277, SE = 0.0110, 95% CI [0.0091, 0.0526]) was also statistically significant, thus indicating partial mediation effect. Hence, it can be corroborated that PAC and OIN sequentially mediate the effect of TC on outcome variable FP, thus, *H6a* was supported. Further, the direct and indirect effect through PAC and EIN on FP was tested where the direct effect (B = 0.2086, SE = 0.0519, 95% CI [0.1066, 0.3106]) and indirect effect (B = 0.0277, SE = 0.0110, 95% CI [0.0091, 0.0526]) were statistically significant. Similar to the mediation nomenclature adopted in Talwar *et al.* (2022), the result was evincing the presence of complementary partial mediation, thereby supporting *H6b*. This indicates that in the hypothesized framework, future researchers can bank on a probability of considering an omitted mediator, which can further explain the relationship effectively (Zhao *et al.*, 2010). With regard to predictor

Table 6 Results of serial multiple mediation analysis (PROCESS macro model 6)

Hypotheses	*Path associations*	*Beta*	*SE*	*Boot-strapped 95% CI*	*Supported*
H6a	TC → FP (direct effect)	0.1483	0.0510	(0.0480, 0.2487)	Yes
	TC → PAC → OIN → FP (indirect effect)	0.0420	0.0118	(0.0217, 0.0674)	(Complementary partial mediation)
H6b	TC → FP (direct effect)	0.2086	0.0519	(0.1066, 0.3106)	Yes
	TC → PAC → EIN → FP (indirect effect)	0.0277	0.0110	(0.0091, 0.0526)	(Complementary partial mediation)
H6c	TC → FP (direct effect)	0.1190	0.0471	(0.263, 0.2117)	Yes
	TC → RAC → OIN → FP (indirect effect)	0.0201	0.0075	(0.0079, 0.0372)	(Complementary partial mediation)
H6d	TC → FP (direct effect)	0.1778	0.0474	(0.0846, 0.2711)	No
	TC → RAC → EIN → FP (indirect effect)	0.0105	0.0050	(0.0028, 0.0225)	(Complementary partial mediation)

Note(s): Beta = unstandardized regression coefficient, SE = standard error, LL = lower limit, UL = upper limit, CI = confidence interval
Source(s): Authors' own work

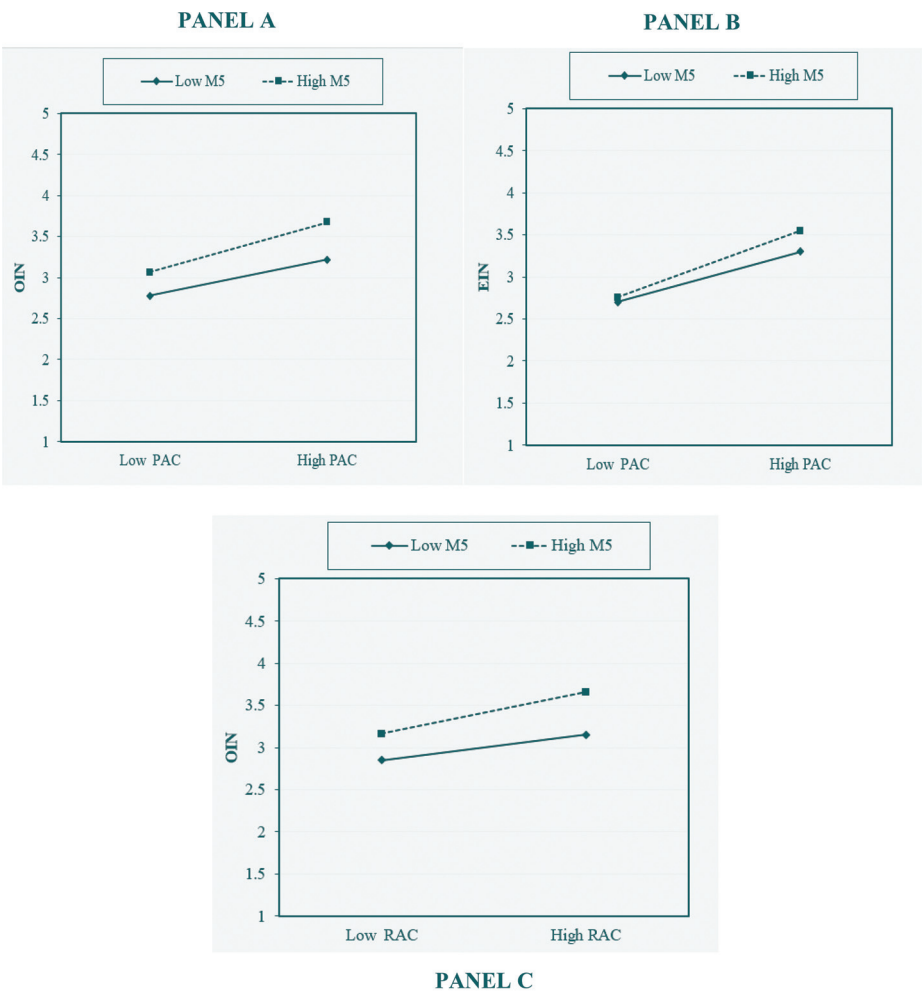
variable TC and its direct and indirect effect through RAC and OIN on FP, the results corroborate significant direct effect (B = 0.1190, SE = 0.0471, 95% CI [0.0263, 0.2117]) and indirect effect (B = 0.0201, SE = 0.0075, 95% CI [0.0079, 0.0372]). Hence *H6c* was supported. Further, the direct and indirect effect through RAC and EIN on FP was investigated. The direct effect (B = 0.1778, SE = 0.0474, 95% CI [0.0846, 0.2711]) and indirect effect (B = 0.0105, SE = 0.0050, 95% CI [0.0028, 0.0225]) were significant. Thus, *H6d* is supported.

6.6 Moderation analysis

To test *H7a*, *H7b*, *H7c*, *H7d*, *H7e* and *H7f* and to investigate the moderating effects of M5, Model 1 in the PROCESS macro with a bootstrapping effect of 5,000 times was performed (Kumar *et al.*, 2021). Firstly, TC was defined as the predictor variable and PAC as the dependent variable. M5 was introduced as a moderator affecting the relationship between TC and PAC. Similarly, RAC was regressed on TC in presence of M5 as moderator. The results showed no significant interaction effect between TC and PAC (B = 0.0355, SE = 0.0388, $p = 0.3612$), and no interaction between TC and RAC (B = 0.0087, SE = 0.0418, $p = 0.8358$). Additionally, OIN was regressed on PAC and RAC in the presence of M5 as a moderator. EIN was similarly regressed on PAC and RAC with M5 as the moderator. The results showed a significant interaction effect between PAC and OIN (B = 0.0860, SE = 0.0419, $p = 0.0407$), PAC and EIN (B = 0.0961, SE = 0.0447, $p = 0.0324$) and RAC and OIN (B = 0.0959, SE = 0.0413, $p = 0.0206$). Thus, *H7c*, *H7d* and *H7e* were supported. However, the moderating role of M5 did not significantly affect the relationship between RAC and EIN (B = 0.0406, SE = 0.0451, $p = 0.3693$), and therefore, *H7a*, *H7b* and *H7f* were not supported.

Finally, the significant interaction effect of M5 was graphically probed for the significant relationships (Adapa *et al.*, 2020). A simple slope analysis was performed where a graph was plotted for one standard deviation above and below the mean value of M5 (see Figure 2). Panel A suggests that firms with higher M5 capabilities are better able to leverage their PAC to enhance OIN efforts compared to firms with lower M5 capabilities. For Panel B, both low M5 and high M5 groups show a positive increase in EIN as PAC increases. However, the effect is much more pronounced for firms with high M5 (the slope is steeper). For Panel C, M5 enhances the impact of RAC on OIN, the difference between low and high M5 is not as large as for PAC. This may be because RAC is focused more on applying existing knowledge and the role of M5 in amplifying that process is somewhat limited compared to the exploratory nature of PAC. The results of moderation analysis are in the below Table 7.

Figure 2 Two-way interaction graph for moderating effect of M5



Note(s): Panel A shows moderation effect of M5 for the relationship between PAC and OIN. Panel B displays it for the relationship between PAC and EIN. Panel C depicts the moderation effect of M5 on the relationship between RAC and OIN. PAC = potential absorptive capacity, RAC = realized absorptive capacity, OIN = open innovation, EIN = eco-innovation
Source(s): Authors' own work

Table 7 Results of moderation analysis

Hypotheses	*Interaction of M5*	*B*	*SE*	*p*	*Boot-strapped 95% CI*	*Supported*
H7a	TC → PAC	0.0355	0.0388	0.3612	(−0.0408, 0.1180)	No
H7b	TC → RAC	0.0087	0.0418	0.8358	(−0.7350, 0.0908)	No
H7c	PAC → OIN	0.0860	0.0419	0.0407	(0.0036, 0.1684)	Yes
H7d	PAC → EIN	0.0961	0.0447	0.0324	(0.0081, 0.1840)	Yes
H7e	RAC → OIN	0.0959	0.0413	0.0206	(0.0148, 0.1770)	Yes
H7f	RAC → EIN	0.0406	0.0451	0.3693	(−0.0482, 0.1293)	No

Note(s): SE = standard error, LL = lower limit, UL = upper limit, CI = confidence interval
Source(s): Authors' own work

7. Concluding discussions

7.1 Summary of findings

M5 is being adopted within diverse industries where firms are using advanced technologies to implement digital marketing policies with human centricity across developed and developing economies (Purcarea, 2021). Within this, this study endeavours to investigate the role of M5 by examining the linkages between dynamic capacities and innovation strategies of the firm to accelerate FP in the context of chemical and pharmaceutical industry based in India. On its face, the most interesting finding of this pioneering research is the moderating role of M5 on the relationship between technology capability on absorptive capacities, and innovation strategy adopted in firms. This study uses AC theory (Cohen and Levinthal, 1990) and knowledge management hierarchy (Kartajaya *et al.*, 2021) as critical theoretical underpinnings to envisage and test a model of technology capability and FP. The findings indicate that TC is critical antecedent to PAC and RAC. Furthermore, PAC and RAC were directly influencing OIN and EIN. In addition, both the strategies OIN and EIN were positively leading to FP. Additionally, PAC and OIN were serially mediating the effect of TC on the outcome variable FP through OIN and EIN. Finally, M5 was moderating the impact of PAC and RAC over OIN and PAC on EIN. In light of these specific findings of this study, critical interpretations and assertions are discussed in detail.

7.2 Discussions

In pursuance of our first research question (*RQ1*), and based on empirical evidence, this study evinces the following findings. The proposed research model investigated the direct linkage between technology capability and AC. It was observed that TC was exerting significant impact on PAC and RAC. As PAC encompasses all activities facilitating assimilative learning processes within an organization by fostering internal discussions to realize shared interpretation of the new knowledge, such deliberation within interdepartmental structural frameworks can be accelerated by higher TC endowment within the firm. Furthermore, the findings dovetail with Cuevas-Vargas *et al.* (2022), Xu and Hu (2024) and Mikalef *et al.* (2019), as higher TC would facilitate penetration of cutting-edge technologies and deploy IT-based resources to design and develop new processes, thereby transforming knowledge for commercial purposes to increase a firm's performance. Our results concur with the findings of seminal studies (Abdullah *et al.*, 2020; Travaglioni *et al.*, 2020), which corroborate that TC provides a nexus of an internally interwoven ecosystem, which improves, intervenes, synchronizes and monitors the operations of the firm by augmenting the use of nuanced management systems. Similarly, Martinez-Caro *et al.* (2020) validated that the assimilation of information technology across organizational projects or work processes as a consequence of enhanced technology capability has the potential to enhance AC and FP.

Extending this, our findings support that knowledge absorption processes are a critical factor for harnessing OIN in the firm. Recent studies based on 125 SMEs in France (Jasimuddin and Naqshbandi, 2019) and 232 Chinese firms (Wu *et al.*, 2021) confirmed that there exists a significant positive association between absorptive capacities and OIN. Notably, Gonzalez (2024) accentuated that OIN is positively related to PAC, suggesting that the firm's capability to acquire and assimilate external knowledge fosters enhanced collaboration between firms, enabling innovation projects with external partners. We concur with these findings, as RAC and PAC together empower the firm to accumulate knowledge and facilitate its access throughout the internal structure of the firm, which, in turn, leads to better interaction among interested stakeholders, thereby engendering favourable relationship dynamics driving OIN. Hence, firms can unleash the benefits of network effects to cultivate innovation as a unique paradigm encompassing integrated systems and architectures to transform and commercialize new knowledge and create co-created value (Naruetharadhol *et al.*, 2021).

With regard to the second research question (*RQ2*), the prevailing scientific literature has studied these mechanisms in piecemeal approaches (Nureen *et al.*, 2023; Müller *et al.*, 2021; Mubarak *et al.*, 2021; Valdez-Juárez and Castillo-Vergara, 2021; Latifi *et al.*, 2021). Nguyen *et al.* (2021) indicated that PAC alone is not adequate; rather, it leads to improved performance by transforming external knowledge into internal resources and capabilities. Notably, no warranted research can be traced that can divulge the serial causal linkages highlighting the significance of efficient transfer of knowledge to predict innovation and performance of a firm. Furthermore, EIN remains a controversial territory because of inadequate evidence supporting the impact of PAC and RAC over EIN (Albort-Morant *et al.*, 2018b). Beyond RAC and PAC, fostering internal innovation ecosystems is crucial for integrating novel expertise that facilitates market expansion. This approach enables firms to enhance their product quality, assimilate emerging technologies and enhance their service offerings and management practices. Consequently, these efforts contribute to the acceleration of EIN, fostering sustained competitive advantage and organizational growth. Creative obliteration of outdated practices and capabilities can foster novel ways to forge systematic environmental-risk reduction (Kemp and Pearson, 2007). Hence, as the international agencies and government are charting new environmental and ecological regulations, firms can orient their absorptive capacities towards efficient utilization of disruptive technologies to assimilate and exploit knowledge. Serial alignment of advanced TC with RAC and PAC is even more critical for EIN, as developing cleaner innovations is a highly complex phenomenon that requires a greater degree of disruptive innovation to improve product designs (González-Moreno *et al.*, 2019). Notably, contrary to the findings stated by Valdez-Juárez and Castillo-Vergara (2021), TC positively influences a firm's performance where such linkage can be attributed to their improved capacity to absorb technology in a much more efficient manner.

Finally, considering the third research question (*RQ3*), this study takes a novel stance by introducing the concept of M5 alongside TC and absorptive capacities within supply chain scholarship to deliberate ways to integrate M5 within the purview of future research. In view of this, empirical evidence demonstrate that M5 positively moderates the impact of PAC on OIN, RAC on OIN and PAC on EIN. However, it fails to moderate the relationship between TC and AC and RAC on EIN. This study is foremost attempting to quantitatively corroborate the pioneering relationship between AC and innovation system in the presence of M5. PAC and RAC when combined with M5 technologies allow firms to leverage external knowledge for broader innovation purposes including product development, customer engagement and process improvement. This is in line with the idea that OIN draws on external knowledge to meet business objectives where M5 technologies allow firms to acquire and assimilate comprehensive external knowledge to make smarter and data-driven decisions. The ability to use AI for predictive analytics or big data for personalized marketing strategies allows firms to apply external knowledge in ways that create more timely and relevant innovations. By integrating these advanced technologies, RAC becomes more effective in transforming knowledge into market-ready innovations, thus strengthening the OIN process.

Because PAC focuses on the early stages of knowledge absorption (recognition and acquisition), it aligns well with the exploratory and sustainability-driven nature of both OIN and EIN. M5 helps firms see the potential of external knowledge to innovate not only for market competitiveness but also for sustainability. However, EIN requires longer-term investments and a broader strategic vision that goes beyond immediate commercial application. While M5 does help with OIN, its primary focus on digital transformation and customer engagement may not directly align with the broader goals of EIN which involve sustainability, regulatory compliance and long-term environmental benefits. Makhloufi (2024) corroborates that big data analytics capabilities which is aftermath of efficient utilization of M5 aid in restructuring business operations systems by introducing innovative solutions which can forecast future market. However, using the contextual data endowed by

advanced technologies to apply it to commercial ends for engendering EIN is yet to be achieved. Therefore, while M5 can optimize customer-centric innovations and market-driven knowledge exploitation, its role in enhancing EIN remains underused unless specific green technologies and sustainable practices are embedded into the innovation process.

Findings of serial mechanism exhibit that internal and external mechanisms associated with AC translates into superior FP through OIN and EIN, therefore the inclusion of both aspects is indispensable for successful implementation of M5. Through an extensive review of the prevailing body of operational research, Zahra and George (2002) state that the majority of empirical investigations points to the direct linkages between absorptive capacities, innovation and performance outcomes in diverse industrial settings. Hence, RAC is equally vital as it will proactively digest, diffuse and exploit the knowledge derived out of big data through AI touchpoints and anthropomorphic interfaces created by firms. Notably, mere sensing and seizing right knowledge will not be beneficial for enabling breakthrough innovation, especially in terms of yielding higher EIN (Albort-Morant *et al.*, 2018a). The focus should be to rapidly streamline its internal business processes and refine cross-functional routines to internalize the new information relating to overall product improvement or service offering, and to extend or create new competencies.

8. Implication

8.1 Theoretical implication

Based on the findings, this study conjectures specific theoretical contributions and offers feasible management recommendations emphasizing the eccentric role of M5 for achieving tangible outcomes. Firstly, the results of the study contribute to the literature on AC, innovation strategy and FP. To begin, this research hypothesizes and validates that absorptive capacities and innovation strategies act as mediators between TC and FP. Particularly, this study enriches literature by testing four serial mediations by explaining the path associations between complementary subsets of absorptive capacities (PAC and RAC) and dual aspects of innovation strategies (OIN and EIN). Secondly, this study contributes towards theory building by envisaging a tighter consensus on the prevalent theoretical framework of AC (Cohen and Levinthal, 1990) and knowledge management hierarchy (Kartajaya *et al.*, 2021) to encompass recent theoretical development with respect to M5. This study takes a novel stance by introducing the concept of M5 within the realms of established operational research to chart an evolving paradigm of investigations, particularly in relation to the supply chain industry in developing economies. Thirdly, in spite of the ongoing scholarly discourse and managers' keen interest in the conceptualization and understanding of M5 in an industry setting, this study is foremost to introduce and empirically test the effect of M5 under the critical entwined linkages between TC, RAC, PAC, OIN, EIN and FP. From a methodological standpoint, this study contributes to strategic management literature by conducting a complex mediation and moderation analysis to gauge the impact of M5 integration, especially in proactive organizations endowed with higher TC. By performing process modelling, which used the PROCESS macro plug-in, this study statistically validates that M5 is a positive moderator between PAC and OIN and RAC and OIN. Enterprises operating in diverse industries such as apparel, consumer packaged goods and automotive are ardently embracing M5. With their high technological prowess, they can make use of their AC to leverage the benefits of M5 for concurrent innovation through OIN. In addition, the insignificant results for the outcome variable EIN call for more research exploring the reintegration of the dynamic capacity processes.

8.2 Managerial implication

The findings of this study propositions critical implications for industry practitioners, top management teams, managerial/supervisory personnel and consultants involved in the implementation of M5 in chemical supply chain industry. Firstly, findings indicate that the

technological endowment in terms of TC integration positively influences the effectiveness of the AC processes to cultivate purposive knowledge-flow management system enabling OIN and EIN processes. Thus, managers are encouraged to invest in building technological ecosystem and enter into new collaborative projects to elevate their learning curve. The growing influence of TC in terms of big data analytics, IoT, blockchain and automation on external and internal supply chain processes accentuates that TC endowment should be regarded as organization's fundamental function. Further, organizational leaders and human resource professionals should forge an adequate corporate culture to assist and train employees in learning new expertise with evolving technologies and encourage cross-functional thinking to define new job structures.

Secondly, as RAC and PAC both are critical antecedents to OIN and EIN, firms should focus on unleashing the benefits of network effects to cultivate innovation, commercialize new knowledge and yield co-created value. TC not only facilitates the acquisition of new knowledge, but also facilitates the design of strategies for interdepartmental knowledge structures that constitutes RAC. Furthermore, the results of serial mediation show the significance of streamlining mechanisms to support the absorptive capacities of a firm, specifically for manifesting distributed OIN. Besides building interdepartmental linkages to exchange knowledge across the value creation network, firms should focus on exploring new partnerships beyond the realm of business transactions and waving pay towards possible knowledge acquisition. In addition, concerted efforts should be directed towards efficient adoption of disruptive technology and designing a thorough architecture of the organizational network for effective dissemination and exploitation of shared knowledge.

Thirdly, as OIN and EIN positively lead to FP, firms must set feasible and appropriate goals, and actively allocate resources for pursuing collaborative research towards innovative product and process development involving other interest groups (government, competitors, allied industry, universities, suppliers, customers and society in general). As the research framework was investigated in the context of chemical and pharmaceutical supply chain industry in India, an economy classified as emerging and a major exporter of pharmaceuticals around the world, it continues to experience sustained and robust growth compared to other sectors of economy. Therefore, EIN can be critical to achieve, as its implementation requires inward-oriented green management and higher degree of integration between PAC and RAC. The top management is required to commit towards shared business goals by streamlining uniform ERP systems through internal workshop cohorts consisting of inter-departmental user-trainees. Additionally, structuring formal mechanisms to ensure regular certifications focused on ecological practices for product development will be a practical approach to motivate employees to proactively engage in developing PAC and RAC to accelerate EIN.

Finally, the breakthrough finding of the study indicates that M5 positively moderates the impact of PAC on OIN, PAC on EIN and RAC on OIN. In light of this, the foundation of M5 rests upon TC, which includes advancing technologies to emulate human marketers for interaction and conversion; integration of physical–digital systems to afford human centricity in marketing strategies is crucial. As transformation is an inevitability, the sphere of TC endowment should encompass disruptive technologies such as NLP, AI, robotics, AR/VR and chatbots to develop human-mimicking capabilities in overall marketing strategy. Further, using social tools within the organization will facilitate employee communication and enhance collaboration. The firm should encourage innovation not merely in terms of product or process development but also in designing customer wholesome experiences through omnichannel presence and superior customer relationship management. Notably, mere sensing and seizing the right knowledge will not be beneficial for enabling breakthrough innovation, especially in terms of yielding higher EIN (Albort-Morant *et al.*, 2018b). To leverage M5 and break the human–machine dichotomy in organizations, there is a need to refine the cross-functional routines to internalize the new information relating to customer

profiling or communication approaches to create new competencies. A firm should involve data scientists, UX designers and IT architects to promote an agile organizational culture where the backend operations are seamlessly integrated with frontline databases.

8.3 Implication for government policy

With regard to the implications for public policies, the results corroborate that firms involved in developing absorptive capacities and yielding higher innovation are able to translate their expertise into higher FP in terms of better financial results. Firstly, governments should monetarily incentivize collaborations to foster entwined cooperation between industrial associations, academic institutions, regulatory bodies, research institutions and political institutions to assist firms in seizing, sharing, exchanging and exploiting knowledge. Thereby, supply chains can be transformed into innovation ecosystems by progressing towards M5. Secondly, providing best practice instances for varied application areas, multi-government policy is required to provide inter-regional access to partner networks, provisions of funds and cross-industry expertise. This is especially true for chemical and pharmaceutical supply chain firms to not only capture and assimilate crucial data, but also to deploy and exploit upcoming opportunities by internalizing M5, which requires implementation support and security to experiment. Particularly, seminal studies have demonstrated that firms' commitment towards EIN is predominantly stimulated by national regulations. To conclude, these deliberations in form of public support are warranted for reaping the success of M5 adoption.

9. Limitations and future directions

The present work should be seen in the light of a few limitations. Although M5 has the potential to enable a firm to focus on sustainability and create inclusivity, our work has not investigated these dimensions. As the present research is cross-sectional in nature and findings are based on responses from Indian manufacturing firms, it may not reflect the influence of cultural nuances of management practices of other regions. Thus, its applicability to other cultural contexts (e.g. the USA, UK, Brazil and other South Asian nations) may be restricted because of differences in organizational communication styles, decision-making processes, leadership styles and attitudes towards innovation. For instance, industry practitioners based in India and other South Asian regions often exhibit indirect communication styles where context and non-verbal cues play a significant role and hierarchical structures in organizations can influence communication flows. On the other hand, communication tends to be more direct and explicit, valuing clarity and efficiency in developed economies such as the USA. Similarly, for India, decision-making can be hierarchical and centralized with senior management holding significant sway, while decision-making tends to be more decentralized and collaborative in developed nations such as the USA and the UK. Also, there is a strong emphasis on disruptive innovation and risk-taking, which is supported by substantial investment in R&D for developed economies. Particularly for industries based in the USA and Europe, participative and transformational leadership styles might foster different responses to M5 adoption and innovation strategies. Thus, even among developed nations, the motivators and barriers to FP vary substantially.

However, this research will open new avenues for future researchers where future works can also explore similar conceptual frameworks in a different economic setting and who may want to adopt other research methods. Researchers may use a longitudinal survey design to understand the real sequence of outcomes, thereby establishing cause-and-effect relationships. Future works on issues such as polarization in society, especially in terms of jobs, ideologies and lifestyles, would also be a good contribution to the body of knowledge. The present work will open avenues to explore how M5 can help a firm to move towards OIN. However, future research can also work on the constraints and knowledge impact of OIN and EIN, and can explore their relationship with M5. In addition, cross-

sectional surveys can be used to check how M5 enables sustainable growth, which is imperative for future generations.

10. Conclusion

This pioneering study is among the foremost to examine how technology capability, AC and innovation strategy enhance FP in the presence of M5. As M5 is being adopted within diverse industries to implement human-centric digital marketing policies in developing economies, this study strives to provide valuable insights to improve FP by judiciously focusing on marketing strategy.

Building on prior research on AC and knowledge management by Ardito *et al.* (2022), Park *et al.* (2024), Lenart-Gansiniec *et al.* (2022), Lee *et al.* (2023) and Hussain *et al.* (2022), this study conducted a cross-sectional survey in India with 396 responses from manufacturing firms operating in the pharmaceuticals and chemical industry. Data analysis was conducted using a sequential research design where qualitative interviews were conducted prior to the quantitative phase. The empirical findings suggest that firms should focus on building the right strategies using M5, thereby enhancing the outcomes of TC and AC to promote OIN. Specifically, the results indicate that TC is a critical antecedent to PAC and RAC, where RAC is directly influencing OIN and EIN. The most intriguing finding is the moderating role of M5 on the relationship between absorptive capacities and innovation strategy adopted in firms. Based on these, this study contributes to nuanced understanding of scholars' and practitioners' by offering integrative implications to firms seeking to enhance their performance by using OIN and EIN. Nevertheless, this study underscores the need for further planning and diligence in understanding the effect of M5 for EIN, especially in emerging markets and diverse geographic contexts.

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Supplementary material

The supplementary material for this article can be found online.

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