

THE EFFECT OF INDUSTRY 4.0 ON RAPPROCHMENT OF DYNAMIC CAPABILITIES: A LITERATURE REVIEW

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Abstract:

This research paper reviews the available literature about interaction between dynamic capabilities and Industry 4.0. The objective is to understand how Industry 4.0 technologies, like cyber-physical systems, Internet of Things (IoT), and advanced analytics, are impacting the dynamic capabilities within organizations. This review finds that digitalization enhances agility, innovation, and responsiveness of organizations and, allowing them to keep pace with rapidly changing market dynamics. It also highlights that leadership, organizational culture, and strategic alignment are crucial for fully harnessing these advantages. While most of the studies focus on the manufacturing sector, there is evidence that these findings are also relevant across various industries. There are still gaps in research, particularly in services and agriculture sector. Challenges such as limited resources, the need for organizational change, and technology integration stresses upon the importance of balanced strategies that extend beyond just technical implementation. By bringing together recent studies, this review emphasizes the promise of Industry 4.0 in building resilience and gaining a competitive edge. This review is also pointing out areas for future research, such as sector diversity, cultural shifts, and long-term sustainability.

Keywords: Industry 4.0; Dynamic Capabilities; Digital Transformation; Organizational Agility; Innovation; Sustainability

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1.Introduction

The past two decades have seen the advent many internet-based technologies. Cyber-physical systems, Big Data-analytics and Internet of the Things (IoT) are to name a few. These technologies have changed the way the enterprises used to function. The new system of managing the industries incorporating these new technologies has been names as Industry 4.0. These technologies have made manufacturing systems more efficient and responsive (1).

To exploit these technologies to their fullest extent the developing dynamic capabilities is a basic requirement. These capabilities make us understand how enterprises realign and reallocate their resources in response to quick changes (2). The need for innovation and sustainability at the time of uncertainty delineates their requirement. Researchers also claim that these also enhances competitive advantage(3). In recent years, contemporary researchers have documented how Industry 4.0 techniques have changed the dynamic capabilities yielding more agile and resilient business systems(4). The core finding emphasise the role of digital technologies in restructuring the companies and impact of data-driven decision making which enhances agility as well as culture of continuous learning(5). Many studies stress upon significance of factoring in both human and technological advances for creating capabilities to fully exploit the potential of industry 4.0(6).

It is need of the hour for enterprises to connect with other organization in their ecosystem, apart from building their own capabilities. The twin strategy of having external partners along with enhancing their own strength is vital for current rapidly changing environment (7) Even after this, there exists a large gap in comprehending comprehensive effect of Industry 4.0 on dynamic capabilities across different sectors (8). Most of the research has focussed on manufacturing but it is equally relevant to study how it influences the services and agriculture sector to get the broader perspectives(9). There are still unanswered questions about impact of Industry 4.0 technologies adaption on organizational culture and competitive advantage in digital era (10). The role of leadership on shaping dynamic capabilities need to be studied as it plays most important role in making strategic decisions(11). This review intends to probe these topics to find the link between Industry 4.0 and development of dynamic capabilities. It will help us to understand better this transformation process. Another objective of this literature review is to sift through existing literature to find out gaps to set direction of further studies(12). In nutshell, coupling Industry 4.0 technologies with strategic practices is vital. At this point, the junction of Industry 4.0 and dynamic capabilities offers a fertile ground for research to create a path for success in continuously evolving economy (13).

2. Literature Review

Around the middle of the second decade of current century the word Industry 4.0 was coined. This is the new enterprise management system which is grounded in the latest technological innovations. The dynamic capabilities have been defined as enterprise's ability to integrate, build and reconfigure internal and external competencies to adapt to rapidly changing industrial environments (1)(2). Combining Industry 4.0 with dynamic capabilities enhances the organizational capabilities which were previously unimaginable. With the largescale adoption of digital technologies, people started to view industry 4.0 as new means to enhance dynamic capabilities. It was visualized that new tools like IoT and AI will help enterprises in fine-tuning their processes and facilitating more informed decisions(3)(14). This resulted in development of new frameworks demonstrating the relation between digital transformation and dynamic capabilities. It opined that in all likelihood the tech-savvy companies will defeat their competitors(5)(6). In further researches, scholars found impact of the additional factors on dynamic capabilities in the Industry 4.0 ecosystem. A few studies(15)(8) delineated the role of organizational culture and style of leadership in abilities of industries in embracing technological changes. Of late, a few researchers (9)(10) are attempting to crack the balance between innovation and operational efficiency. The impression is that apart from other benefits to enterprises, adaption of Industry 4.0 will create a foundation for future resilience. They are also trying to solve other inherent problems like resource limitations and technology obsolescence (11).

The relationship between industry 4.0 adaptation and dynamic capabilities is quite complex web of interaction and further research is needed. One fact is certain that digitalization is turning enterprises more responsive. It is also increasing their agility due to real-time data analytics and decision making and thereby quickly repositioning in response to changing market situation(1)(2). It is pertinent to mention that adaptability is interwoven to innovation. The organizations adapting Industry 4.0 are better positioned to streamline processes, and thereby in developing new products(3).

Integration of the new technologies in the existing organizational system in itself is a huge challenge. In many case the transition phase of this integration were hampering the dynamic capabilities(4). Researches (5)(6) found that knowing new technology was one thing but their integration required a cultural shift and intra-department collaboration. Probably the cultural changes are most difficult and vital. Research has found that the organizations, who have culture of innovation, are better placed to take advantage of dynamic capabilities, when they have to respond to rapid changes(15) (Li, 2024a). It is equally important to synchronize adoption of technologies to

goals of organization. strategically integrate Industry 4.0 with their core capabilities perform better and compete more effectively (8)(9). This strategic synchronization has got both short term and long-term effects. In short term these maximize profits and in long term enable firms to stay ahead in comparison to competitors. Thus, Industry 4.0 influences the evolution of dynamic capabilities and needs a cohesive approach to realize their full potential in the era of digitalization.

Scholars have used various research techniques to know the relations between dynamic capabilities and Industry 4.0. These include qualitative, quantitative and mix mode techniques. Qualitative studies are made of case studies. These support the fact that Industry 4.0 technologies enhance organizations' adaptability. These have also supported the fact that there is a link between implementing technology and increasing agility in rapidly changing market conditions (1)(2). Quantitative studies are a means to provide data to support qualitative inferences. These questionnaire based detailed surveys have found the relationship between technology adoption and organizations' dynamic capabilities(3)(14). It has also been found that there are variations in the impact of Industry 4.0. from one industry type to other. This means, selected research approach can reveal specific insights that might otherwise go unnoticed (5)(6). Mixed-method techniques are a mix of both qualitative and quantitative methods. These capture the subtleties of individual cases as well as broader trends across sectors(7)(8).

The authors of this paper could lay hand on a few critical literature review papers on this topic. All the researchers are of the opinion that further researches with objective framework are needed to decipher the complex nature of interactions between dynamic capabilities and Industry 4.0 technologies (9)(10). It was observed that with the higher degree of digitalization of companies, more objective research methods are needed to understand the dynamic interactions involved (11)(12). There is a consensus among researchers that digitalization in technologies will lead to more organizational flexibility and responsiveness (1)(2). Organizations with sufficient resources could deploy latest technologies like AI and IOT and, they were able to streamline their operations, and also strategically reconfigured their resources (16)(14). However, there is also a note of caution. Although technology can enhance the dynamic capabilities, it can also bring risk of disruption and warrants thorough organizational change management (5)(6). Thus, literature provides contradicting opinions. These contradictions need to be resolved by further studies. Merely adopting advanced technologies doesn't automatically lead to improved performance (15)(8). The literature suggests to apply sociotechnical systems theory for resolving dichotomies and to reveal the importance of synchronising technological and human elements

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to achieve successful outcomes(9)(10). Recent researches suggest for a holistic approach, in which, organizations collectively create value through innovative partnerships, reflecting insights from studies on relational capabilities (11)(12). The discussion about the Dynamic capabilities and Industry 4.0 emits both hope and caution making a way for further research.

Summary of Literature Review

Author	Year	Title	Main Focus	Findings
Hammad, et al (1)	2025	"Evaluating Smart Manufacturing Readiness: A Maturity Model Perspective"	Developing a customized tool for Urban Smart Factory maturity model to assess digital preparedness for SMEs and urban manufacturing firms.	Many firms underutilize tools for workforce and technology readiness, leading to inconsistent digital transformation efforts.
Rina Turcan, Daniela Pojar (2)	2024	"Impact of Industry 4.0 technologies on skill requirements and workforce availability in key sectors"	"Exploring the impact of Industry 4.0 technologies on skill requirements and workforce availability in key sectors"	Targeted upskilling and reskilling initiatives are crucial for enhancing workforce capabilities aligned with digital transformation.
Xing Gao(3)	2019	"Developing 'Enclave Agriculture': A New Path of Agricultural Intensive Production Mode in Ethnic Areas"	"Applying the enclave economy model to enhance agricultural development in ethnic and impoverished areas in China".	The enclave economy model can drive agricultural industrialization and sustainable development in ethnic areas.
Ahmed Baha Eddine Aichouni, Cristóvão Silva,	2024	"A Systematic Literature Review of the Integration of Total Quality Management and Industry 4.0"	Integrating TQM and Industry 4.0 to improve operational efficiency, sustainability	Integration can significantly improve operational efficiency, but barriers

Luis Miguel D. F. Ferreira(14)		4.0: Enhancing Sustainability Performance Through Dynamic Capabilities"	performance in manufacturing.	like resource constraints and resistance to change need addressing.
Ghita Chaouni Benabdelah, Kamar Zekhnini, Abba Chaouni Benabdelah, Qing Lu, Jie Wu, Zaheer Khan(5)	2024	"Building dynamic capabilities in supplier selection and industry 4.0 era: A literature review"	Analyzing supplier selection processes and emphasizing dynamic capabilities in the context of Industry 4.0.	Integrating dynamic capabilities enhances supply chain performance and helps firms navigate external challenges effectively.
Kumar Ambedkar, Gyan Prakash(6)	2024	"Evolving Dynamic Capabilities: Exploring Implications of Industry 4.0 Digital Technologies on Manufacturing"	Examining the evolving dynamic capabilities influenced by Industry 4.0 digital technologies in manufacturing.	Industry 4.0 technologies transform existing capabilities and introduce new ones critical for manufacturing transformation.
Qiaolin Li (7)	2024	"The Impact of ESG Disclosure Levels on Corporate Innovation Capabilities: A Case Study of Electronic Equipment Manufacturing Industry"	"Investigating the relationship between ESG disclosure and innovation capabilities in the electronic equipment manufacturing industry".	High levels of ESG disclosure positively correlate with enhanced innovation capabilities, supporting strategic corporate growth.
A. Al-Khatib, Ahmed Shuhaiber, Ibrahim Mashal, Manaf	2024	"Antecedents of Industry 4.0 capabilities and technological innovation: a dynamic	Examining the impact of dynamic capabilities on Industry 4.0 capabilities	Dynamic capabilities positively affect Industry 4.0 capabilities, which in

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Al-Okaily (8)		capabilities perspective	in SMEs in Jordan.	turn influence technological innovation.	Ejsmont, B. Gladysz, A. Kluczek (13)	on Sustainability — Bibliometric Literature Review”	relationships between sustainability and Industry 4.0.	practical application of Sustainable Industry 4.0 initiatives beyond theoretical discussions.
Andreea CORDO S (LABAD ITIS), Adriana Tiron-Tudor (9)	2023	EMPLOYABILITY SKILLS FOR PROFESSIONAL ACCOUNTANTS IN THE MIDST OF INDUSTRY 4.0 – A LITERATURE REVIEW”	Assessing the impacts of Industry 4.0 on the skill requirements for work-ready accountant As.	Accountants need a mix of traditional and contemporary skills to thrive in a digitalized environment.	Yang Xiao, Raja Nerina Raja Yusof, Nor Azura Binti Adzharuddin (17)	“The Relationship of Omni-channel Retailing, Dynamic Capabilities and Firm Performance: Evidence from Chinese Cosmetics Industry”	Investigating omni-channel retailing's impact on firm performance in the cosmetics industry.	Omni-channel integration significantly affects performance, with dynamic capabilities serving as a moderating factor.
Duarte Almeida, A. Simões (10)	2023	“Industry 4.0 technologies’ adoption by industrial companies - a literature review on the impacts in sustainability dimensions”	Understanding how Industry 4.0 technologies affect economic, environmental, and social dimensions of sustainability.	Adoption significantly impacts sustainability dimensions, necessitating assessment in technology adoption strategies.	Cláudia Fabiana Gohr, Bruna Cavalcanti Barros Rodrigues (18)	“Dynamic Capabilities as Enablers for Sustainability-Oriented Innovation: A Case Study in a Footwear Industry”	Analyzing the role of dynamic capabilities in developing sustainability-oriented innovations in footwear company.	Identifies key dynamic capabilities influencing the development of sustainability-oriented innovations.
Claus Nottbrock, Amy Van Looy, S. D. Haes (11)	2023	“Impact of digital Industry 4.0 innovations on interorganizational value chains: a systematic literature review”	Exploring interorganizational capabilities needed for integrating digital innovations into business process management.	Developing a framework for digital interorganizational value chains (DIOVC) to enhance integration and performance.	Novan Wahyudi, Arviansyah Arviansyah (19)	“Navigating Industry 4.0: The Strategic Role of Dynamic Capabilities in Transforming Indonesian Manufacturing”	Identifying challenges and evaluating dynamic capabilities needed for Industry 4.0 integration in Indonesian manufacturing.	Dynamic capabilities are crucial for effectively integrating Industry 4.0 technologies, enhancing competitiveness.
S. Cornago, Y. Tan, C. Brondi, S. Ramakrishna, J. Low (12)	2022	“Systematic Literature Review on Dynamic Life Cycle Inventory: Towards Industry 4.0 Applications”	Reviewing dynamic life cycle inventory methodologies for Industry 4.0 applications.	Emphasizes the need for diverse dynamic component studies beyond electricity, highlighting eight research gaps.	Prerna Malakar, S. Khan, A. Gunasekaran, M. Mubarik (20)	“Digital Technologies for Social Supply Chain Sustainability: An Empirical Analysis Through the Lens of Dynamic	Exploring the impact of Industry 4.0 on social sustainability in supply chains.	Industry 4.0 technologies enhance social sustainability, particularly through traceability
Krzysztof	2020	“Impact of Industry 4.0	Evaluating the	Highlights the need for				

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		Capabilities and Complexity Theory”		and transparency metrics.
N. M. Nguyen, A. D. Alonso, O. T. K. Vu, Trung Thanh Nguyen, M. akbari (21)	2024	“Exploring Savico's journey: dynamic capabilities and Industry 4.0 integration in organisation-industry actors relationships”	Analyzing the effects of Industry 4.0 adoption on organizational relationships in an emerging economy.	Identifies key dimensions of impact on organization-industry relationships, emphasizing the importance of adaptability.
Rohit Sharma, Sachin S. Kamble, Venkatesh Mani, Amine Belhadi (22)	2022	“An Empirical Investigation of the Influence of Industry 4.0 Technology Capabilities on Agriculture Supply Chain Integration and Sustainable Performance”	Examining the effects of Industry 4.0 technology capabilities on agricultural supply chain integration.	I4TC positively affects sustainable agricultural supply chain performance, emphasizing the role of integration.
Tim Komkowsky, Michael Sony, Jiju Antony, F. Lizarelli, J. Garza-Reyes, G. Tortorella (23)	2025	“Operational practices for integrating lean and industry 4.0 – integrating a dynamic capabilities perspective”	Exploring operational practices for integrating Lean Manufacturing with Industry 4.0.	Identifies essential practices, proposing a framework to guide effective integration of LM and I4.0.
D. Kabel, Jason Martin, Mattias Elg (24)	2024	“Paradoxical tensions during industry 4.0 integration within health care: managing tensions for quality improvement”	Exploring paradoxical tensions in health care organizations during Industry 4.0 integration.	Identifies recurring technology tensions and suggests strategies using a paradox theory lens.
Tim Komkowsky, Jiju	2023	“Integrating Lean Management	“Examining integration	Highlights the need for dynamic
Antony, J. Garza-Reyes, G. Tortorella, Tanawadee Pongboonchai-Empl (25)		with Industry 4.0: an explorative Dynamic Capabilities theory perspective”		strategies for Lean Management and Industry 4.0 within an operations context”.
Guirguis, Katharin a (26)	2020	“From big data to big performance – exploring the potential of big data for enhancing public organizations’ performance: a systematic literature review”		Investigating how big data can enhance organizational performance in the public sector.
Petricevic, Olga, Verbeke, Alain (27)	2019	“Unbundling dynamic capabilities for inter-organizational collaboration”		Exploring distinct subsets of dynamic capabilities required for innovation through inter-organizational collaborations.
Santos, Beatrice Paiva (28)	2023	”An investigation upon Industry 4.0 implementation: the case of small and medium enterprises and Lean organizations”		Investigating challenges and capabilities for implementing Industry 4.0 in SMEs and their integration with Lean Management.
Bhattacharya, Charan, Kwong, Caleb,	2019	“Market orientation, market disruptiveness capability and		Assessing how market-oriented practices
				Market orientation positively influences both

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Tasavori, Misagh (29)		social enterprise performance: An empirical study from the United Kingdom”	affect social and economic performance in social enterprises.	performance dimensions while market disruptiveness impacts economic performance only.
Lee, Seung Jun, Shi, Tianqin (30)	2018	“Review of Literature and Curricula in Smart Supply Chain & Management Transportation”	Reviewing smart supply chain and management literature and curricula to identify unexplored implications.	Highlights disconnects between literature and educational offerings, calling for curriculum development that aligns with industry needs.
Huggins, Robert, Johnston, Andrew (31)	2010	“Knowledge flow across inter-firm networks: the influence of network resources, spatial proximity, and firm size”	Analyzing how network resources, spatial proximity, and firm size influence knowledge flows across inter-firm networks.	Establishes that investment in social capital enhances innovation, with spatial proximity benefiting local interactions.
Myrzakhmet, M., Radošević, S. (32)	2006	“Between vision and reality: promoting innovation through technoparks in Kazakhstan”	Analyzing the impact of technoparks on innovation in Kazakhstan.	Technoparks do not effectively promote innovation, with companies more focused on cost-reduction than technological advancement.
Alam, Iam, Kiani, Isar, Seifzadeh, Pouya	2018	“Learning from Semantic Inconsistencies as the Origin of Dynamic”	Investigating the origins of dynamic capabilities in	Identifies critical moderating factors that enhance the quality
(33)		Capabilities in MNCs: Evidence from Pharmaceutical MNCs”	multination al corporation s through learning processes.	of corrective actions taken by subsidiaries.
Denison, Daniel R., Fey, Carl F. (34)	2003	“ORGANIZATIONAL CULTURE AND EFFECTIVENESS: CAN AMERICAN THEORY BE APPLIED IN RUSSIA?”	Exploring the link between organizational culture and effectiveness in foreign-owned firms in Russia.	Effectiveness relies more on adaptability in Russia compared to the USA; cultural dynamics significantly influence outcomes.
Davis, Peter, Gajendran, Thayaparan, Owi, Toinpre, Vaughan, Josephine (35)	2016	“Assessing construction innovation: theoretical and practical perspectives”	Exploring how innovation is assessed in the construction industry from theoretical and practical perspectives.	Identifies that internal organizational innovations dominate improvement narratives, providing clearer frameworks for innovation assessment.
Batocchi, Antonio, Durán, Orlando, Franco, Matheus, Holgado, Maria, Minatogawa, Vinicius, Quadros, Ruy (36)	2020	“Carving out new business models in a small company through contextual ambidexterity: the case of a sustainable company”	Investigating how SMEs manage business model innovation through contextual ambidexterity.	Developed a tool for SMEs to operationalize ambidexterity, showcasing dual benefits in business model enhancements.
Aslam, Haris, Azhar, Tashfeen, Blome, Constantijn, Roscoe, Samuel (37)	2018	“Dynamic supply chain capabilities: how market sensing, supply chain agility and adaptability affect supply chain	Examining the interrelationship of market sensing, and adaptability as dynamic capabilities	Market sensing is crucial for agility and adaptability; agility mediates the interaction between

		ambidexterity	affecting	adaptability
		”	ambidexterity.	and
			ambidexterity.	ambidexterity.

3. Conclusion

Industry 4.0. has metamorphized the functioning of enterprises. This has put focus on how dynamic capabilities as a crucial way for businesses to adapt and remain competitive. This literature review explored how digital technologies, such as cyber-physical systems, IoT, and advanced analytics, enable companies to become more agile and responsive (1). It is commonly accepted that business enabling technologies of Industry 4.0 can conspicuously change their operational models to better deal with uncertain markets (2)(3), and enables the dynamic capabilities, a crucial link in facilitating industrial leadership position. The significance of firm’s culture and leadership for effectively integrating these technologies cannot be over-emphasised (14)(5). Aligning technology adoption with strategic goals is crucial for maximizing outcome. So, it requires a comprehensive planning(6)(7). Thus far the focus of research has been manufacturing sector (8). The research need to further expand in service and agriculture sector (9). A few researchers opine that in the absence of strategy on organizational changes the advantages of technologies cannot be actualized(10)(11). Thus, there is need of more focussed and objective researches. There is need of optimism and caution in tandem(12). The cultural, managerial, and structural shifts are necessary for effectively harnessing Industry 4.0 (38)(17) . Also, there is need to do further research on impact of leadership style on dynamic capabilities facilitating strategic decision-making (18). Research methodology needs to be tailored in sector specific way. Often, mixed method is desirable as it reveals a well-rounded understanding of intricate relationships between technology, capabilities, and organizational performance (39)(20).

The research on relationship between Industry 4.0 and dynamic capabilities is still a work in progress. Industry 4.0 technologies provide an occasion to enhance organizations’ agility and innovation characterized by swift technological changes and intense competition(40)(41)(23). It is obvious that the research in this area is need of the time. Such researches will facilitate businesses to effectively traverse the complexities of an ever-evolving industrial environment (24)(25)(26). This review aims to deepen our understanding of how organizations can create strong dynamic capabilities and maintain their competitive edge in the era of digitalization (27)(42)(29).

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- b) **Conflict of Interest:** The authors have no relevant financial or non-financial interests to disclose.
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