Factors influencing competitive advantage in start-ups operations 4.0
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Abstract
Purpose – The ability of a business to outperform its rivals is known as its competitive edge, and it presents special difficulties in the context of the “digital revolution,” or the fourth industrial revolution. To obtain a competitive edge in the startup operations 4.0 era, this study aims to examine the organizational, technological and competence-related challenges presented by Industry 4.0. It does this by concentrating on the tools, competencies, methods, approaches, tools and strategies that are crucial. Using the Total Interpretive Structural Modeling (TISM) technique, the goal is to find, analyze and classify enablers for startup operations 4.0.

Design/methodology/approach – A closed-ended questionnaire and planned interviews were used in the data collection process. In startup operations 4.0, the cross-impact matrix multiplication applied to classification method is used to rank and categorize competitive advantage factors, whereas the TISM technique is used to analyze how components interact.

Findings – The study highlights the critical significance of the “Internet of Things (IoT),” “information technologies,” “technological platforms,” “employee empowerment,” “augmented reality (AR)” and “operational technologies” in its identification of 12 enablers for startup operations 4.0.

Research limitations/implications – The main focus of the study is on the variables that affect startup operations 4.0’s competitive advantage.

Practical implications – Academics and important stakeholders can better understand the factors influencing competitive advantage in startup operations 4.0 with the help of this research.

Originality/value – Large businesses have been profoundly impacted by Industry 4.0 principles; however, startup operations 4.0’s competitive advantage has not received as much attention. This paper offers a fresh take on the concept of competitive advantage in startup operations 4.0 research.

Keywords Competitive advantages, Startups 4.0, Internet of things, Augmented reality, Digital supply chain management, Green marketing

Paper type Research paper

1. Introduction
Progress is fueled by innovation, particularly in the fast-paced, digitally-driven, competitive world of today. To achieve their main objective of smart production – the manufacture of novel and intelligent goods and services – startups that are aiming for success look to technology development for essential assistance (Dos Santos and Vianna Lordelo, 2019).

Over time, the industrial landscape has changed significantly, altering management practices, output standards and production techniques. With the invention of the steam engine in the middle of the 18th century, the first industrial revolution signaled the transition from manual to contemporary mechanical production (Jayashree and Reza, 2020). The second and third industrial revolutions, respectively, brought about innovations in energy technology and ground-breaking products, as well as the fusion of computer technology and the internet (Jayashree et al., 2020). The fourth industrial revolution has
enormous growth potential in the modern day and offers products that are versatile and can quickly adapt to unforeseen changes (Jayashree et al., 2020).

The new industrial era’s technological advancements have caused the world to shift quickly, drastically altering labor processes and giving rise to new and creative company methods. Startup 4.0 might, in this fictitious case, boost output, improve productivity and launch new products and services. In today’s technology-driven business environment, modern technology has increased commercial possibilities and given organizations a competitive and inventive edge that is necessary to stay competitive (Dewi et al., 2020).

Adaptability is critical for start-ups to digest information, quickly reconfigure organizational structures, investigate and exploit new knowledge and navigate markets and new technologies – all of which are necessary for business innovation. A start-up’s long-term survival depends on its capacity to innovate by using new technology to reduce manufacturing costs and serve emerging markets. A key idea in the literature on strategic management is that competitive advantage is intimately related to creative problem-solving, operational effectiveness and forward-thinking thinking (Adamik and Nowicki, 2018).

This study uses the Total Interpretive Structural Modeling (TISM) method to determine the elements driving competitive advantage in startup operations 4.0. The study aims to identify these variables, examine how they interact and use cross-impact matrix multiplication applied to classification (MICMAC) analysis to classify and rank the variables according to their reliance and driving power. The objective is to make a substantial contribution to the current business 4.0 theory by helping managers and practitioners in start-up businesses comprehend enabling relationships and identify essential elements influencing competitive advantage in startup operations 4.0.

Research questions:

**RQ1.** “What are the factors influencing the competitive advantage of start-up operation 4.0?”

**RQ2.** “How do these factors interact within start-up operation 4.0?”

**RQ3.** “Which factors drive others, and which factors depend on others? Can the priority of factor be measured?”

No research has examined the factors influencing competitive advantage in startup operations 4.0, despite the fact that researchers have examined competitive advantage in a variety of contexts, including big data, leadership, strategic management and the Internet of Things (IoT) (Adamik and Nowicki, 2020; Adamik, 2016; Dewi et al., 2020; Futcher and Sunjka, 2018; Malik, 2019; Jermsittiparsert, 2020; Koski, 2019). By using the TISM technique, our work fills this gap in the literature in a novel way.

The principal objective is to acknowledge and pinpoint the particular elements that impact competitive advantage within the framework of startup operations 4.0. This entails a thorough investigation and comprehension of the components that are vital in determining the competitive environment that startups working within the Industry 4.0 paradigm must navigate. Examining the intricate network of connections between the components that have been identified is the goal of the study. Gaining insight into the dynamics of competitive advantage in startup operations 4.0 requires an understanding of how these components interact with one another. This entails modeling and analyzing the relationships using the TISM technique. The study aims to classify and prioritize the detected components according to their reliance and driving strength using the MICMAC analysis. This is a critical stage in determining which elements are more dependent on other factors and in ranking the factors that have a greater impact on competitive advantage. The goal of the study is to give useful insights and advice to managers and practitioners in the
business who are starting up in the Business 4.0 space. Industry professionals can boost competitive advantage by making well-informed judgments and comprehending the essential enablers and interactions revealed by the study.

A review of the literature on competitive advantage in Industry 4.0 (Section 2), a description of the research methodology (Section 3), the presentation of the findings and discussions (Section 4 and Section 5) and closing remarks with suggestions for future research areas and limitations (Section 6) are all included in the following parts.

2. Literature review
2.1 Review of competitive advantage in Industry 4.0
2.1.1 Competitive advantage. A fundamental concept in the literature on strategic management, a competitive advantage (CA), is essential to the process of making all kinds of firms competitive. From the perspective of the entity’s long-term growth and operation, the outcome of this process, or its competitiveness, is a strategic attribute. Because of this, some of its constituents are the researched business’s dynamism, flexibility and efficiency. It is produced by interactions between an organization and its surroundings (Natalia and Ellitan, 2019). The ability of a corporate organization to thrive in a cutthroat industry by providing goods or services that draw in and please clients is known as competitiveness (Fujimoto, 2004). Competitive advantage is the ability of a company to outclass its rivals (Dos Santos and Vianna Lordelo, 2019, October). It enables organizations to increase profit margins and create value for the firm and its stakeholders (Dixon and Pusparini, 2020, December). Any business needs CA since it is critical to its long-term existence and profitability (Arsawan et al., 2022). “A capability (or set of capabilities) or resource (or set of resources) that gives a firm an advantage over its competitors which ceteris paribus leads to higher relative performance” is the definition of competitive advantage (CA) (Baker and Sinkula, 2009). Studies reveal that achieving CA can be improved by the use of a company’s resources, which are difficult for competitors to copy or replace (Wiggins and Ruefl, 2002; Busenitz et al., 1997). Additionally, businesses must be able to fully and effectively utilize the resources available to them for the development and upkeep of their prospective CA. But CA does not mean it will stay forever; rather, it means that rivals will not be able to rival or copy it easily (Busenitz et al., 1997). This competitive advantage could be threatened by any unforeseen developments in the market. Establishing and maintaining a long-term competitive advantage is challenging for businesses due to the swift advancements in technology, intense competition in the market and rising customer expectations. As a result, businesses with a clear strategic focus, cutting-edge technology and innovative skills for exploration and exploitation are better equipped to adapt to the quickly changing environment and preserve CA (Sahi et al., 2020).

2.1.2 Past literatures. Prior studies have demonstrated that technology plays a critical role in producing globally competitive products (Narkhede, 2017). The start-up’s survival relies highly on its capacity to obtain a competitive advantage through innovation, which necessitates versatility, adaptability and ability to respond. For years, academics and practitioners have been interested in developing a company’s competitive advantage (Koski, 2019). A literature evaluation was conducted by Adamik (2016) in the field of “the theory of organization,” “the theory of cooperation,” “the theory of partnering” and “the theory of competitiveness.” Adamik and Nowicki (2018, May) identified crucial requisites for creating a competitive advantage in Industry 4.0. Jayashree and Reza (2020) illustrate the impact of smart technologies on competitive advantage, which can assist in widening the paradigm notion. Jayashree et al. (2020) investigate the role of Industry 4.0 fundamental predictors in accomplishing both sustainability and competitive advantage. Reza and Jayashree (2020)
investigate the significant, influential factors shaping Industry 4.0 and their effect on competitive advantage. Dewi et al. (2020) investigate the adaptability of small and medium enterprises (SMEs) as a firm capacity that will boost competitive advantage through advancement or innovation. Dixon and Pusparini (2020, December) link the theories of systematic innovation and empowerment, which have traditionally been viewed as completely separate in terms of the influence on competitive advantage. Futcher and Sunjka (2018) look into how manufacturing SMEs can stay competitive in the fourth industrial revolution. Menon et al. (2018) investigate the interdependence of sustainability practices, the crucial aspects influencing sustainability within industrial production and, finally, the progressions of Industry 4.0 and various techniques to improve sustainability practices that focus on key performance indicators of social and environmental aspects. Purwanti et al. (2019) clarify the concept of green marketing and its involvement as a source of long-term competitive advantage in the fourth industrial revolution. According to Ding et al. (2023), manufacturing companies must enhance both cost-efficiency and versatility in today’s competitive market by implementing Industry 4.0 technologies. Firms that embrace Industry 4.0 technologies have the chance to gain a prolonged competitive advantage by implementing new Industry 4.0 technologies that can offer or enhance a firm’s position in an industry (Hollander, 2018; Kumar and Sinha, 2018) endeavor to showcase the significance and benefits of supply chain management, as well as how supply chain management can be used to gain a competitive advantage. In the face of the Fourth Industrial Revolution, the best competitive strategy for individuals, businesses and organizations is to adjust to existing shifts. The development of sustainable competitive advantages is an important element in strategic planning because these competitive advantages allow companies to proceed to operate, win the competition and achieve corporate goals (Natalia and Ellitan, 2019; Malik, 2019) focuses on the business surroundings in the Industry 4.0 era, covering the primary goals and difficulties encountered in order to change the challenges that arise in Industry 4.0 into possibilities in the face of competition through innovation. Jermsittiparsert (2020) investigates the impact of leadership styles and Industry 4.0 on the performance of an organization. Furthermore, the immediate and indirect effects of job satisfaction, competitive edge and business viability are investigated. Koski (2019) set out to provide information for one such decision by combining additional insight from six different supply chain professionals with existing literature. Nowicka (2020) investigates the function of digital technology ecosystems in obtaining a competitive advantage in the Smart Industry segment. Karia (2018) explores the importance of knowledge resources in the connection between technological resources and competitive benefits. Theories of global manufacturing networks centered on the local and global aspects of “institutionalization,” “corporatization,” “technologicalization” and “digitization” reflect the evolution of global networking concepts (Dzwigol et al., 2020; Adamik and Nowicki, 2019) recognize and characterize the key contradictions and regions of prospective pathologies in the case of companies functioning in the age of Industry 4.0 to generate competitive advantage through co-creation without CSR. Pietrewicz (2019) investigates how business models and business model innovation interact with technological innovation in shaping firms’ competitive edge in the age of Industry 4.0. The mapping of dimensions of past literature is shown in Figure 1. Table 1 shows the synthesis of the past literature.

2.2 Research gap
Though research on the aspects influencing competitive advantage in Industry 4.0 (de-Lima-Santos et al., 2022; Adamik and Nowicki, 2020; Adamik, 2016; Dixon and Pusparini, 2020, December; Karia, 2018) has been performed, a study on the factors influencing competitive advantage in start-up operations 4.0 has yet to receive the necessary attention. As a result,
efforts have been made in this study to fill this gap. The identified factors for this study are as follows: technology platforms (F1), supplier feedback (F2), delivery (F3), supplier development (F4), customer involvement (F5), employee empowerment (F6), augmented reality (AR) (F7), information technologies (F8), operational technologies (F9), Internet of Things (F10), green marketing (F11) and digitization of supply chain management (F12). The identified factors and their references for this research are shown in Table 2.

3. Research methodology
To investigate a certain topic, research methodology uses a variety of data collecting and analytic tools. So, this section will go into the methods used to gather and analyze the data for this study. When performing scientific research, Tashakkori and Teddlie (2008) emphasized that choosing the right research methodologies is crucial.

A “closed-ended questionnaire” has been constructed to capture the effect of all discovered enablers on each other, implying factor-based pairwise comparisons. Semi-structured interviews were chosen as the data-collecting strategy since they can assist the researchers in obtaining more in-depth data from the practitioners. According to Robson (2002), semi-structured interviews can be highly beneficial for learning what is occurring and exploring fresh perspectives in an exploratory study. In an “exploratory study, they can also be used to look into the connections between the variables.

This research used TISM and MICMAC analysis as the data analysis techniques. According to Atri et al. (2013) “TISM is a framework for understanding the interdependence
of the elements that influence competitive advantage in start-up operations 4.0.” A variety of factors that are indirectly and directly related to each other are organized into a thorough, systematic model by the “qualitative and interpretive TISM technique,” which produces solutions for complex issues. The MICMAC approach is applied to evaluate the influence and reliance on competitive advantage elements. According to Attrit et al. (2013), “MICMAC analysis is an indirect classification technique to evaluate the range of each factor.”
3.1 Sampling technique

“Non-probability sampling” and “Probability sampling” are two basic types of sampling. According to Saunders (2012), “probability sampling” is primarily used to reply to research questions or show an occurrence from a broad perspective, whereas “non-probability sampling” is typically used to deliver results from a specific point of view. “Non-probability sampling” is more appropriate because this study focuses on the competitive advantage aspects of the start-ups’ operations 4.0. “Purposive” and “snowball sampling” are the two sample techniques used in this investigation. Purposive sampling involves choosing people who would be good interview subjects and fit the pre-determined criteria. The pre-determined criteria are as follows:

- The interviewee should be from a start-up covering any of the sectors such as Information Technology (IT), manufacturing, engineering, agriculture and so on.
- Up to ten years after the date of incorporation and registration, an organization shall be regarded as a start-up.
- The interviewee range includes chief executive officers, chief technology officers, analysts, Human Resource (HR) managers, operations managers, product managers and public relations associates.

In relation to the snowball sampling, each participant was asked whether they knew anyone who has an understanding of the phenomenon of competitive advantage in start-up operations 4.0. As a result, suggestions from interviewees would be used to choose a good candidate to respond to the research questions.

3.2 Interviews

Over the course of two months, the interviews were held in a variety of start-ups. Each interview is set for 1 h, with 10 min dedicated to explaining the research and definition of the enablers, and the remaining 50 min were dedicated to feeding data from these experts in the proper manner. The timing of the interview will rely on the convenience and schedule of the respondent. Table 2 displays the experts’ details. Ethical problems such as the use of “consent forms,” “privacy protections,” “confidentiality” and “anonymity” were all carefully examined. The researcher introduced herself and provided a general overview of the research conducted before beginning the interview. The researcher then inquired about the start-up in general. Then specific questions related to start-up operations 4.0 were asked by using the closed-ended questionnaire. The “questionnaire was measured” using a “five-point Likert scale,” with “1” being “no influence” and “5” being “very high influence.” For example: “Factor 1 influencing Factor 2, if yes, rate the influence from 2-5; if no, rate the influence as 1.”

3.3 Data analysis methods

The flow of research methodology steps is shown in Figure 2. The “Interpretive Structural Modeling (ISM)” technique efficiently evaluates the degree of linkage and relationships between various items. ISM offers a far weaker view of the linkages. ISM reveals whether one factor in a pairing is influenced/affected by the other or not; the connections only show the contextual relationships among items at various stages in regards to the direction of the relationship in paired comparisons (D and Vinodh, 2020). But in the case of TISM, in addition to the perception of directed links, the causal justification behind each link is also documented and shown, which demonstrates how the relationship actually works (Mahajan et al., 2016). Each relation is represented by a logical interpretation in TISM, explaining how one component in a pair drives the other. This distinguishes TISM from conventional ISM.
The TISM technique is used in this study to model the factors influencing competitive advantage in start-up operations 4.0. Many researchers have used this similar methodology for their study (Jayalakshmi and Pramod, 2015; Jena et al., 2017; Rajesh, 2017; Azadnia et al., 2021; Yadav and Sushil, 2014). The following are the steps in the TISM approach:

The first stage in TISM modeling is to determine and define the components that will be modeled.

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<tr>
<th>Steps</th>
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<tr>
<td>1. Identify the list of factors influencing competitive advantage in start-ups operations 4.0 through literature review and experts opinion</td>
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<td>2. Identify the major factors that influencing competitive advantage in start-ups operations 4.0</td>
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<td>3. Define: Working definition in context of factors influencing competitive advantage in start-ups operations 4.0</td>
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<td>4. Questionnaire Preparation: Pair-wise comparison of factors</td>
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<td>5. Develop Initial Reachability Matrix (IRM): Factor-P highly influencing Factor-Q?, then enter 1 in IRM; otherwise 0</td>
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<td>Consensus of the responses is captured for each comparisons</td>
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<td>6. Develop Final Reachability Matrix (FRM):</td>
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<td>Transitivity check for all 0 entry in IRM if transitivity is present then enter 1* in IRM; otherwise 0</td>
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<td>Transitivity check 1*: If P = Q and Q = R, then P = R</td>
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<td>7. Partition of FRM: Reachability set: Row factors in FRM. Antecedent set: Column factors in FRM. Intersection set: Common factors of row and column. Level-I: The intersection factors are one and only present in the reachability set, these elements are removed from the set and designated as level-1. Then, go to next iteration: continue the repeated process until all the factors are removed from the set</td>
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<td>8. Interaction matrix: It is developed from FRM by translating the direct and significant transitive links</td>
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<td>9. Digraph Creation: It is is created using information from FRM and level partitions. First level factors at the top of the Digraph and the last level factors at the lowest level</td>
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<td>10. TISM Model: In the Digraph links interpretations are articulated: Factor-P how it is influencing Factor-Q?</td>
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**Source:** Figure courtesy of Sushil (2012)
The study’s key findings concern the competitive advantage factors/components. These factors are found through a “literature review” and the “conversations with the subject matter specialists” from start-ups and academia. In the current investigation, a total of 22 factors were initially found in the literature, and 12 of those were taken into considerations for the study based on the systematic conversations with specialists. Table 2 lists the discovered competitive advantage factors along with the references.

Determining the contextual links between the components comes the next stage, after the factors are identified. These connections are discovered using the contributions of the subject matter specialists. According to the contextual relationship in this case, “factor A influence or improve factor B.”

A “pairwise interaction matrix” between the items is built on the basis of “expert opinion” gathered in the preceding stage. The classic ISM asks an explanation of the connection between the factors; however, in the TISM, this perception is also explicitly clarified, showing how the relationship actually operates. As a results, TISM outperforms ISM. “What effect/influence does factor A have on or improve factor B?” is answered by TISM. “If factor A has a strong influence on factor B, then enter 1 in initial reachability matrix (IRM) (Table 3); otherwise, 0.”

The “transitivity rule” is added to the IRM to create final reachability matrix (FRM) (Table 4). The transitive elements, represented in the number “0” in the IRM, are substituted with the number “1*” in the FRM after transitivity testing.

The next stage involves level-by-level arrangements of the component. The variables themselves, plus other elements that might impact them, are the “antecedent set,” whereas the “reachability set” for each factor also contains other factors that might impact it. Each element’s “intersection set” is located. The element that shares entities with the “reachability set” and “intersection set” is found and elevated to the top level in the initial iteration. In the subsequent rounds, the components that have been separated into distinct levels are discarded, and the procedure is then repeated for the remained factors until each of the elements’ levels have been determined. The “design of the interaction matrix” is shown in Table 5.

The levels graphically arrange the factors, and they are connected based on the connections in the FRM to form a digraph. The digraph only contains the “transitive links” with a meaningful explanation.

According to TISM, each contextual relationship should be logically defined with a description of how it functions. This stage involves rationally interpreting each major

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Source: Authors’ own creation

Table 3.
IRM for factors influencing competitive advantage in start-ups operations 4.0
connection in the digraph and writing an interpretive assertion. The TISM model (Figure 3) is created by changing the “nodes of the digraph” with the factors based on the information in the “interpretation statements and digraph.”

4. Results and discussions

4.1 Interpretation of Total Interpretive Structural Modeling Digraph

The graphical depiction of TISM analysis of the factors influencing the competitive advantage in start-up operations 4.0 is shown in Figure 2.

**Level VIII:** This level has one factor: the Internet of Things (IoT) (F10). This factor influences nine factors.

The Internet of Things (IoT) (F10) influences technology platforms (F1). Using suitable technology platforms to successfully gain a competitive advantage in start-up operations 4.0 is made possible by software-enabled equipment and data-sensing devices connected to the

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**Note:** *Represents transitive links

**Source:** Authors’ own creation

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**Note:** *Represents significant transitive links

**Source:** Authors’ own creation
Figure 3.
TISM model for factors influencing competitive advantage in start-ups operations 4.0

Source: Authors own creation
Internet of Things (IoT) (F10) influences supplier feedback (F2). The suppliers are informed of the quality and availability of the goods delivered through the data-sensing devices. Internet of Things (IoT) (F10) influences delivery (F3). Delivery notifications and alerts can be managed using IoT delivery management. With the ability to monitor progress in real-time, management may easily learn about unforeseen disruptions and driver placements. This makes managing their network of drivers simpler than ever for start-ups. Internet of Things (IoT) (F10) influences supplier development (F4). IoT helps process and keep supplier data and creates technical networks between business partners. Internet of Things (IoT) (F10) influences augmented reality (F7). IoT sensors gather information from the real world to be analyzed. At the same time, augmented reality equipment renders that digital information back into the real world so that users can observe and engage with it. Internet of Things (IoT) (F10) influences information technologies (F8). The data-detecting device helps in “storing,” “processing” and “transporting data.” Internet of Things (IoT) (F10) influences operation technologies (F9). By modifying environmental controls and generating cost savings, the IoT will enhance efficiency and productivity in upkeep. Additionally, it can contribute to “real-time data processing,” “a rise in the use of predictive maintenance” and “suggested repair procedures.” Internet of Things (IoT) (F10) influences green marketing (F11). IoT aids in implementing green marketing strategies, which give businesses some benefits that can be used to obtain a long-term competitive edge. The Internet of Things (IoT) (F10) influences the digitization of supply chain management (F12). Using global positioning system (GPS) and other technologies, Internet of Things devices offer a reliable means to monitor and verify goods and deliveries. Additionally, they can keep an eye on how things are stored, improving quality control throughout the supply chain.

Level VII: This level has one factor, i.e. information technologies (F8), and influences seven factors.

Information technologies (F8) influence technology platforms (F1). Information technologies help store and process the data, which leads to “platform scalability,” “connectivity with other systems” and “data management.” Information technologies (F8) influence supplier feedback (F2). Information technology provides the tools needed to get suppliers’ input quickly and automatically and to get through bureaucracies and inadequate communication channels. Information technologies (F8) influence delivery (F3). Information technologies helped to improve effectiveness and efficiency in delivery and will continue to do so. Additionally, information technologies lower the cost of products and services and increase a company’s revenue. Information technologies (F8) influence supplier development (F4). Information technology aids in the processing and keeping supplier data and creates technical networks between business partners. Information technologies (F8) influence customer involvement (F5). It benefits organizations and customers when information technologies are used in customer service. It strengthens communication channels, attends to client demands, engages customers proactively via an app and keeps them updated. Information technologies (F8) influence employee empowerment (F6). Increased career prospects, freedom and autonomy among employees are the most significant effects of information technology use on employee empowerment. Information technologies (F8) influence the digitization of supply chain management (F12). Information technology lowers manual difficulties and labor expenses by accelerating data acquisition and eliminating labor-intensive manual processes. The ability to access real-time information about every aspect of the supply chain is changing how businesses operate and how they expect to form their business relationships.
Level VI: This level has two factors, i.e. technology platforms (F1) and employee empowerment (F6). F1 influences eight factors. Also, F6 influences nine factors.

Technology platforms (F1) influence supplier feedback (F2). The right technical platforms must be used in start-up operations 4.0 to gain a competitive advantage effectively. Technology platforms are essential for giving suppliers immediate feedback. Technology platforms (F1) influence delivery (F3). Every item that had earlier been noted with a delivery note would have its “source,” “destination” and “current status” electronically tracked. Technology platforms (F1) influence supplier development (F4). As a result of Start-up 4.0, technological networks are created between various cooperating parties. These networks enable the exchange of tangible resources such as “machinery,” “technology” and “individual knowledge,” as well as intangible assets such as “research and expertise” in the form of “information and data.” Technology platforms (F1) influence customer involvement (F5). Customers are essential to a business’s survival. Hence, the relationship between the two should be highly appreciated. Additionally, Start-up 4.0 heavily uses approaches for market and customer research. Technology platforms (F1) influence employee empowerment (F6). Employees in the start-up operation 4.0 office environment provide honest input on the situation through their smartphones and tablets. Everyone should own a mobile smart device that connects to the launch servers. Technology platforms (F1) influence augmented reality (F7). Most augmented reality programs let users see their surroundings through a computer. Technology platforms (F1) influence operational technologies (F9). Technology platforms help develop software that directly observes hardware objects, procedures and occurrences. Technology platforms (F1) influence green marketing (F11). The potential advantages of era 4.0 can be taken advantage of using green marketing that satisfies current needs. A company can harness the benefits of a green marketing strategy to gain a lasting competitive edge. Technology platforms (F1) influence digitization of supply chain management (F12). The digital supply chain (DSC) completely satisfies the requirements of Industry 4.0. Tying together relevant parties expands the vertical integration of all company functions to the horizontal axis.

Employee empowerment (F6) influences technology platforms (F1). The use of smart portable devices by staff members that are connected to start-up servers aids with “platform scalability,” “connectivity with other systems” and “data management.” Employee empowerment (F6) influences supplier feedback (F2). Employee empowerment provides the tools needed to get suppliers to input quickly and automatically and to get through inefficient communication channels and bureaucracies. Employee empowerment (F6) influences delivery (F3). Empowerment is the optimal strategy when providing a service that includes managing a connection rather than just carrying out a transaction. The service provider may seek to develop connections with clients to increase client loyalty, gather suggestions for enhancing the service delivery process, or introduce new services. Employee empowerment (F6) influences supplier development (F4). Employee empowerment enables the transfer of tangible resources such as “machinery,” “technology” and “individual expertise,” as well as intangible resources such as “research and expertise” in the form of “information and data.” Employee empowerment (F6) influences customer involvement (F5). Giving staff flexibility, responsibility and appropriate technology, methods and tools allows them to go above and beyond to satisfy customers. Employees must receive comprehensive training to help them recognize and take advantage of chances to improve the support standard if customer service teams are to be empowered. Employee empowerment (F6) influences augmented reality (F7). Employee empowerment facilitates the simple use of augmented reality-enabled devices. Employee empowerment (F6) influences operational technologies (F9). By directly watching and manipulating hardware objects, processes and
occurrences, personnel with greater autonomy can better recognize and cause change. Employee empowerment (F6) influences green marketing (F11). Employee empowerment is a key component of implementing a green marketing strategy, which benefits a company and can be used to obtain a sustainable competitive edge. Employee empowerment (F6) influences the digitization of supply chain management (F12). By linking relevant participants through a sensor network and social technologies, supervised by a centralized power hub and controlled by an all-encompassing data analytics engine, employee empowerment expands the mergers of all company operations to the horizontal dimension.

**Level V:** This level has two factors, i.e. augmented reality (F7) and operation technologies (F9). F7 influences 6 and F9 also influences six factors.

Augmented reality (F7) influences supplier feedback (F2). The tools needed for quick, automatic feedback to suppliers and navigating bureaucracy and inadequate communication channels are made available via augmented reality. Augmented reality (F7) influences delivery (F3). For delivery personnel, augmented reality-enabled smart devices as an all-in-one technology solution enable them to scan several items to locate specific ones inside the vehicle, stay informed of delivery modifications or special directions and digitally record evidence of delivery. Augmented reality (F7) influences supplier development (F4). As a result of Start-up 4.0, augmented reality is created amongst numerous cooperating parties. It enables the transfer of tangible resources such as “machinery,” “technology” and “individual expertise,” as well as intangible resources such as “research and expertise” in the form of “information and data.” Augmented reality (F7) influences customer involvement (F5). Customers connect more with the goods and have a more rewarding purchasing experience when they examine a “3D image” of the package. They can notice product information they might not have seen without interacting with the product packaging via augmented reality. Augmented reality (F7) influences green marketing (F11). The use of augmented reality for green marketing is something that many start-ups are considering. For instance, “AR-based product” representations can create dynamic advertising interactions that emotionally engage consumers. The technology also allows prospective buyers to browse merchandise from just about everywhere. Augmented reality (F7) influences the digitization of supply chain management (F12). Within supply chain management, augmented reality is quickly taking over as the norm, providing ways to mix real-world scenarios with technological innovation to do routine operations more quickly and effectively. AR gives crucial skills for lowering risk in their supply chains as businesses plan to strengthen their defenses in case of future upheaval as the industry adjusts to the new circumstances enforced by the COVID-19 pandemic.

Operations technologies (F9) influence supplier feedback (F2). Operational technologies aid in identifying the insufficient flow of information between start-ups and vendors, which is a significant source of wastage in both the processes and the outcome. Operations technologies (F9) influence delivery (F3). Operation technology aids in recognizing a change in products sold to customers by directly observing the hardware products. Operations technologies (F9) influence supplier development (F4). Operational technologies enable the transfer of tangible resources such as “machinery,” “technology” and “individual expertise,” as well as intangible resources such as “research and expertise” in the form of “information and data.” Operations technologies (F9) influence customer involvement (F5). Operational technology frequently uses methods for analyzing the market and gaining consumer knowledge. Operations technologies (F9) influence green marketing (F11). It is possible to take advantage of operational technologies’ competitive advantage. A start-up can harness the benefits of a green marketing strategy to gain a lasting competitive edge. Operations technologies (F9) influence the digitization of supply chain management (F12). By tying together relevant participants through a network of sensors and social technologies,
supervised by a central control center and managed by an all-encompassing data analytics engine, operational technologies expand the vertical integration of all company processes to the horizontal dimension.

**Level IV:** This level has two factors, i.e. supplier feedback (F2) and digitization of supply chain management (F12). F2 and F12 influence three factors each.

Supplier feedback (F2) influences delivery (F3). Both in terms of the process and the outcome, poor information exchange between startups and suppliers is a significant source of waste. Supplier feedback (F2) influences supplier development (F4). A key strategy for buying companies to boost supplier satisfaction is supplier feedback. The future of commercial relationships can be predicted considerably by supplier development. Supplier feedback (F2) influences green marketing (F11). Start-up operation 4.0 provides the tools necessary to acquire quick and automatic feedback from suppliers and to get through red tape and inadequate communication channels that support green marketing.

Digitization of supply chain management (F12) influences delivery (F3). "Planning," "sourcing" and "logistics teams" will be able to work together, automate processes and efficiently use analytics as a result of supply chain management digitization. This will enable the start-ups to provide goods and services to customers more quickly. Digitization of supply chain management (F12) influences supplier development (F4). It aids in the interchange of real resources such as machinery, technology and individual knowledge as well as intangible ones such as research and expertise in the form of information and data. Digitization of supply chain management (F12) influences green marketing (F11). As technologies are upgraded and connected, making things easier for all engaged in the supply chain, digitization will inevitably increase efficiency and support green marketing.

**Level III:** This level has two factors, i.e. delivery (F3) and customer involvement (F5). F3 and F5 influence three factors each.

Delivery (F3) influences supplier development (F4). Every item previously noted on a delivery note would be electronically tracked to indicate its origin, destination and present condition, and the information kept would aid in the supplier’s development. Delivery (F3) influences customer involvement (F5). The IoT is equipped with numerous interconnected communication devices that handle information on the movement of products, which assists in fostering positive customer relationships and including them in the process. Delivery (F3) influences green marketing (F11). Delivery of eco-friendly products or services promotes green marketing as start-up operations 4.0 are technology-oriented.

Customer involvement (F5) influences Delivery (F3). The possibility that the customer’s demands will be met and they will receive the desired advantages can be increased with effective customer participation. Customer involvement (F5) influences supplier development (F4). By including the customers, the suppliers should be ready to provide better functional specifications, alter product designs to save production costs or create designs that more closely address customers’ unique demands and issues. Customer involvement (F5) influences green marketing (F11). Green marketing is supported by Start-up 4.0’s comprehensive use of approaches for consumer insight and market analysis.

**Level II:** This level has one factor, i.e. supplier development (F4), and influences one factor, which is green marketing (F11).

F4 influencing F11: Supplier development (F4) influences green marketing (F11). As a result of start-up 4.0, technological networks are created between various cooperating parties. Green marketing is made possible by these networks, which make it easier to share real resources such as machinery, technology and individual expertise as well as intangible ones such as research and expertise in the form of information and data.

**Level I:** This level has one factor, i.e. green marketing (F11).
All other factors influence green marketing (F11) and, therefore, are related to the objective of this study. Modern marketers must meet higher standards than those of earlier eras if start-ups are to survive in the fourth industrial revolution. When promoting their products or services, start-ups must consider the well-being and serenity of society. The start-ups can use some advantages of a green marketing strategy to gain a lasting competitive edge. Benefits include “lower production cost” and “increased brand loyalty” from green marketing.

4.2 Cross-impact matrix multiplication applied to classification analysis
The term “MICMAC” is termed as “cross-impact matrix multiplication applied to classification” (Ramiya and Suresh, 2021). The components or factors are analyzed and divided into “driving,” “dependent,” “autonomous” and “linkage factors” using MICMAC analysis. The FRM is used to calculate the “dependence and driving factors” for each of the competitive advantage factors. Figure 4 presents a summary of the MICMAC study findings.

The model broken down by the MICMAC analysis is shown in Figure 4, which classifies the elements into “driving,” “dependent,” “autonomous,” and “linkage factors.”

4.2.1 Key observations. Autonomous factors (Zone 1): Remarkably, no element is categorized as “autonomous.” This implies that every system component is interconnected and impacted by every other component.

Dependent factors (Zone 2): Delivery (F3), customer involvement (F5), supplier development (F4) and green marketing (F11) are the four factors that are classified as “dependent.” These parameters show a strong dependence on other system components, suggesting that modifications to other components may affect them.

Linkage factors (Zone 3): Supplier feedback (F2) and supply chain management digitization (F12) are the two elements that are designated as “linkage factors.” These elements have substantial “dependency and driving powers,” which makes them important. Changes to these variables can significantly impact the system as a whole.

Driving factors (Zone 4): “Driving factors” include the following six variables: employee empowerment (F6), augmented reality (F7), Internet of Things (F10), information technologies

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Figure 4. MICMAC graph

Source: Authors own creation
(F8), technology platforms (F1) and operational technologies (F9). These variables have strong “driving power” but low “dependence power,” suggesting they majorly impact how other system components are shaped.

4.2.2 Ranking of factors. According to the MICMAC analysis, the Internet of Things (F10) is placed on top, indicating its vital role and strong driving strength. Green marketing (F11) is ranked eighth in the list, suggesting a greater reliance on other systemic elements.

A comprehensive grasp of the interplay between elements, their driving and dependency capabilities, and their relative relevance in determining competitive advantage in start-up operations 4.0 is provided by this in-depth analysis, which is backed up by Table 6.

5. Implication of the study
5.1 Theoretical implication
This study not only adds to the scant amount of knowledge that is currently available about the competitive advantage in Industry 4.0 but also sheds light on the factors influencing the competitive advantage in start-up operations 4.0. The current study tries to answer the three questions, i.e. “what,” “how” and “why.”

“Answering what”: Finding important elements in a particular study setting is the first step in undertaking a “structured literature review.” An “exploratory review” procedure was used in the study described in this manuscript to determine the competitive advantage factors in start-up operations 4.0. Studies related to competitive advantage and industry 4.0 were the main focus of the search. A total of 12 factors were finalized through “literature review” and “experts’ opinion.” They are technology platforms, supplier feedback, delivery, supplier development, customer involvement, employee empowerment, augmented reality, information technologies, operation technologies, IoT, green marketing and digitization of supply chain management.

“Answering how”: To clarify the links between the elements found in the literature, the “TISM process” is applied. “Stepwise pair comparisons” in the form of subsequent comparisons are used to start the procedure. Therefore, the answer to the question “how” is derived from the link between the 12 elements.

“Answering why”: Understanding the connections would provide a foundation for answering the question “why?” The TISM technique outlines hermeneutic and hierarchical linkages to answer “why.” After removing “non-significant transitive relationships” and arranging the component elements as per their levels, the “TISM digraph” is created.

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<td>5</td>
<td>7</td>
<td>0.714</td>
<td>5</td>
</tr>
</tbody>
</table>

Source: Authors’ own creation

Table 6. MICMAC rank for factors influencing competitive advantage in start-up operations 4.0
The inter-factor correlations are interpreted using the experts’ support. A single perspective is created from the various arguments of the experts. After creating a “hierarchical digraph,” linkage interpretations are implemented in the final model. Arguments taken from the experts are used to explain each relationship between the components.

To better comprehend the competitive advantage factors, different categories – “autonomous factors,” “independent factors,” “dependent factors” and “linkage factors” – were created through “MICMAC analysis.” Factors were ranked according to their “driving” and “dependence” powers and were grouped into four levels using the data gathered and the assistance of the experts. Researchers will better understand these connections and correlations as factors are leveled and connected. With the aid of “TISM” and “MICMAC,” this study offers significant methodological and contextual connections and helps researchers understand the connections between the influencing factors at different levels.

5.2 Managerial implications
This study has managerial contributions in that it sheds light on the potential of competitive advantage in start-up operations 4.0 and the factors that managers must consider to gain a competitive advantage successfully in this uncertain environment. The hierarchical model offers guidance for determining the enablers and outlining the step-by-step process a company should follow to achieve a competitive advantage in start-up operations 4.0 properly. The key factors identified are the Internet of Things, information technologies, technology platforms, employee empowerment, augmented reality and operational technologies. The idea of a network of software-enabled devices and data-detecting machinery is covered by the phrase “IoT.” Such detectors can track and recognize tags that can be attached to any item in real time when they are connected to the internet. IoT is ranked as Number 1 in the hierarchy, an important factor influencing the competitive advantage in start-up operations 4.0.

The findings of this study have numerous implications for start-up management. In start-ups, 12 such crucial enablers influencing competitive advantage in start-up operations 4.0 have been identified. To gain a competitive advantage in start-up operations 4.0, the managers can properly understand the “driving and dependence” factors beforehand and can focus on them more. For executives and decision-makers to investigate the impact of each factor on other factors and the level of linkages among them, the TISM technique used in the research will help to determine the interconnections among these factors. Thirdly, the model created for this study shows how different enablers influencing competitive advantage in start-up operations 4.0 are connected and impact one another. In this way, start-ups can gain a competitive advantage in this Industry 4.0 era.

6. Conclusion
The conclusions of the present analysis provide insight into the critical elements that greatly boost one’s ability to obtain a competitive edge in startup operations 4.0. The Internet of Things (IoT), augmented reality, employee empowerment, information technologies, technological platforms and operational technologies were the most important elements, demonstrating their potent impact in successfully pursuing competitive advantage.

Among these powerful drivers is the Internet of Things (IoT), whose sensors gather data from the real world for analysis. This is enhanced with augmented reality, which projects digital data onto the physical world so users can see and engage. IoT devices improve quality control by offering a dependable way to track products, delivery and storage through GPS and other technologies. By speeding up data collecting and doing away with manual chores, information technologies are essential for optimizing workflows, decreasing
manual labor and lowering labor costs. Real-time information availability changes supply chains' operation, impacting expectations and business partnerships. Adaptability is critical for individuals, businesses and organizations to maintain a competitive edge in the context of the fourth industrial revolution. The creation of long-lasting competitive advantages is prioritized by strategic management as it is essential for operating indefinitely, surpassing competitors and accomplishing goals. Developing an entrepreneurial mindset, making strategic plans and using information technology are essential for obtaining a competitive advantage and guaranteeing better financial outcomes. Using strategies and resources to establish a long-lasting competitive advantage is critical to startups' success. Awareness of changing technical advancements and competitive variables helps management keep ahead of changes and act quickly.

The research questions of the study were satisfactorily addressed:

**RQ4.** The Internet of Things, information technologies, technological platforms, employee empowerment, augmented reality and operational technologies are the aspects that impact startup operations 4.0’s competitive advantage.

**RQ5.** These elements work harmoniously in startup operations 4.0, supporting a comprehensive strategy for obtaining a competitive edge.

**RQ6.** While the priority of these elements has been measured, highlighting their crucial roles, some factors stand out as driving others, such as the Internet of Things, information technologies and technological platforms.

Looking ahead, start-ups that embrace technology innovations to take advantage of numerous opportunities have a bright future. Managers and legislators may successfully navigate startup operations 4.0 and obtain a competitive advantage by deeply understanding these enablers.

### 6.1 Limitations and future scope

A total of 12 elements related to competitive advantage in start-up operations 4.0 in India have been found in this study. Similar research might be conducted in many other nations in the future. It is also advised to do a comparative study of the factors that influence the competitive advantage in startup operations 4.0 in developing and developed countries to identify any appreciable differences. “Confirmatory factor analysis and structural modeling” can further validate the model. The theoretical model can be examined using “structural equation modeling”.

### References


Further reading


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