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Assessment of Factors Influencing Agility in Start-Ups Industry 4.0

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Abstract: Agility has a special place in the start-up Industry 4.0 era. More research is required to properly comprehend the agile implications of start-up Industry 4.0 regarding the impact of digitization on the economy, the environment, and society. Investigating the effects of start-up 4.0 agility is still in its early stages. The current study simulates the variables impacting agility in start-up activities in Industry 4.0 to tackle this problem. In addition to the pre-arranged interview, a closed-ended questionnaire was used to gather information. In the context of start-up operations 4.0, the MICMAC technique is used to evaluate and categorize the components that contribute to agility in order to comprehend their interconnections. The research identified eleven characteristics of facilitating agility in start-up operations 4.0. Industry 4.0 concepts have significantly influenced large organizations but deploying agility in start-up 4.0 has been less visible. Hence, this study presents an innovative approach to incorporating agility in modern start-up operations. The significance of artificial intelligence, cloud computing, network and connectivity, technology, and digital twin in this context is evident. The research provides important light on the elements that contribute to the successful use of agility in start-up 4.0, offering useful insights for stakeholders and academics.

Keywords: agility; start-ups 4.0; cyber-physical systems; artificial intelligence; cloud computing; virtual reality

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1. Introduction

The era of Industry 4.0 has begun across the world [1]. Today, a combination of physical and digital technologies governs the production of goods and services. This suggests a move away from production processes that are predominantly machine-based to ones that focus more on digital technologies and service provisions [2]. The implementation of digital technologies across various economic sectors, or start-up industry 4.0, has an opportunity to impact sustainability initiatives significantly. Through a variety of technologies and methods, such as "cyber-physical systems", "internet of things (IoT)", "wireless network system (WNS)", "cloud computing", and "big data analytics", which enable rapid resolution of issues by determining immediate interaction with manufacturing equipment, a synthesis of both physical and virtual environments that facilitate both informational and commercial integration is made possible [3]. Start-ups in Industry 4.0 can use digital technology to advance the circular economy, an economic theory that strives to reduce waste and extend the useful life of resources and goods [4]. Start-ups have many options owing to Industry 4.0 for resource usage effectiveness and accomplishing strategic objectives. However, with the implementation and adoption of Industry 4.0 in start-ups, a fundamental shift in the organization's culture, work structure, and processes is about to be seen, and enormous prospects are to follow [5]. With the widespread adoption of Industry 4.0 across several start-ups, a firm's external and competitive atmosphere is predicted to grow more unpredictable. There will be demand in areas like mass customization and more rapid and effective value and supply chain management than there is currently [6]. This type of outer stress will also have an impact on how resources are prioritized within start-ups, where businesses will be constrained in their ability to direct resources as well as to create, experiment, and commercialize goods and services quickly. Therefore, start-ups in Industry 4.0 must act quickly to handle such ambiguity and stress from inside and outside the organization. However, handling such ambiguity and stress will be significantly aided by the Industrial Revolution 4.0 ecosystem [7]. Organizations involved in the Industry 4.0 ecosystem will benefit from ambidexterity that will let them respond quickly and effectively to developments and pressures [8]. A dynamic ability that is discussed in a variety of academic works is organizational agility.

Organizational agility is defined as a "learned, continually accessible flexible ability that can be performed to a sufficient extent swiftly and effectively, and whenever required" to increase corporate performance in an uncertain marketplace [9]. Experts have extensively debated the benefits of organizational agility on several businesses' performances [10]. However, agility has a special place in the start-up 4.0 era. According to this assertion, agility gives start-ups the competence and direction they need to deploy Industry 4.0 technology successfully, enabling them to manage external uncertainties. Organizational agility is seen as an essential ambidexterity to fully reap the reward of adopting the Industry 4.0 ecosystem and maintaining a competitive advantage [11]. Therefore, research on the factors that impact agility in start-up operations 4.0 is progressing. Furthermore, studies have demonstrated that organizational agility can enhance resilience, which refers to a start-up's ability to recover from disruptions caused by internal, external, or environmental factors [12].

Extensive research is required to fully understand the effects of agility in start-up operations 4.0, particularly with regard to how digitization affects the "economy", "environment", and "society". Additional research is necessary to fully understand the dynamic effects of start-up Industry 4.0, especially in connection to how digitization affects the "economy", "environment", and "society". Since we currently have a limited understanding of the agile implications of start-up industry 4.0 in relation to the impact of digitalization on the "economy", "the environment", and "society" at large, more research is necessary. This study attempts to identify the elements impacting agility for start-up Industry 4.0 in an effort to bridge this knowledge gap. The research's stated objectives are to (a) "recognize the factors influencing agility in start-up Industry 4.0", (b) "use the total interpretive structural modeling (TISM) approach to analyze the interrelationship among these factors", and (c) "use cross-impact matrix multiplication applied to classification (MICMAC) analysis, in order to categorize and rank the elements according to their driving and reliance power". For the benefit of business leaders and experts, this objective seeks to improve awareness of the connections between drivers and their impact on agility in start-up industry 4.0. Additionally, it has the ability to make a big contribution to the current Industry 4.0 hypothesis. This study will address the following research queries: "What elements affect agility in start-up operations 4.0, according to RQ1?", and "How do they impact one another and start-up operations' agility in 4.0?" RQ3 is based on "Which factors influence others and which depend on others? Can the relative importance of each of these things be measured?"

Many researchers have discussed agility in the context of Industry 4.0 [9,13–16]. Previous literature has not addressed the estimation of variables influencing agility in start-up operations 4.0. As highlighted in previous research that has effectively combined methods to analyze element dependency and developed a hierarchical structure, this study employs interpretive structural modeling methodologies to identify the factors that impact agility in start-up operations 4.0.

Motive of the Study

For start-up businesses working in the Industry 4.0 age, characterized by rapid technological breakthroughs and dynamic business landscapes, agility—defined as the capacity to adapt and respond to changing environments quickly—is an essential quality. Nevertheless, despite its acknowledged significance, a thorough study of the variables that affect agility in start-up Industry 4.0 is lacking. This study aims to close this knowledge gap by performing an extensive analysis of the critical variables that affect agility in start-up businesses working in the Industry 4.0 environment. This study seeks to identify and examine these elements to solve a substantial research gap in the sector and offer insightful information to academics, policymakers, and startup practitioners. It also contributes to the body of knowledge on agility and Industry 4.0.

The subsequent sections of the paper are organized as follows. An overview of the subject is given in the introduction, which is followed by a thorough analysis of the body of literature on agility in the context of Industry 4.0. In Section 3, the research technique used in this study is described in depth. Section 4 presents the findings and subsequent discussions. Section 5 describes the research's theoretical and practical contributions, while Section 6 covers the study's conclusion, any obstacles faced, and potential research directions.

2. Agility in Industry 4.0

The term organizational agility is nearly synonymous with flexibility. Flexibility is concerned with single systems (such as manufacturing or services), whilst agility is involved with groups of the system (such as the business network). Organizational agility refers to a firm's capacity to detect and react to environmental alterations and adapt quickly to capitalize on business possibilities [17]. When there is a high level of ambiguity, such as with COVID-19, agility is a useful [18] start-up asset—in the hands of top supervisors. Agility focuses on the execution of Industry 4.0 and would include organizational agility (in determining execution), workforce agility (in the ability to understand and apply the change), and system agility (required changes in technology or process).

Agility is a firm's capacity to handle change and uncertainty in the environment [13]. Start-ups find it progressively complicated to accomplish production achievement, sustenance, and long-term growth in today's uncertain environment. Due to its internet-based technologies, the significance of Industry 4.0 and its impact on firms is constantly evolving [14]. Apart from being responsive, firms must be self-optimized and self-adjusting. However, a rising pattern is affiliated with the tremendous amounts of unstructured and structured real-time data produced daily, known as big data analytics [15]. Industry 4.0 is still in its initial stages for most countries, so good leadership with an agile mind is always essential for firms that embrace progressive technological changes with international market reach [14]. Gonçalves et al. [19] investigate how automotive start-ups use digital technology to enhance their digital innovation functionality. Sen et al. [20] described and revealed the basic outline of Industry 4.0 and agile businesses for combining theoretical and conceptual facilities with elegant firm applications.

From the fourth industrial revolution perspective, Barlette et al. [15] discuss the capacities provided by big data analytics, which are crucial in a volatile environment. Hassan et al. [21] investigated the connection between flexibility in information technology infrastructure, learning orientation, and organizational agility. Disruptive technologies have made it imperative for companies to modernize their operations and develop innovative solutions using integrated architectures of blockchain and IoT technologies. This allows businesses to enhance their operational agility and keep up with the changing technological landscape [22]. Kurniawan et al. [9] investigate how a business intelligence system that can deliver deep market knowledge and orchestrate the companies' networking capacities in utilizing outer capabilities with internal forces engrained in an agile management structure impacts decision-making precision. In order to comprehend how organizational flexibility influences agility and agility abilities in businesses, Koçyiğit et al. [23] conducted a study.

Chakravarty et al. [24] comprehend how information technology areas of expertise form organizational agility and firm achievement. Lavinsaa et al. [16] evaluate competitive market levels and investigate the connection between Industry 4.0 and competitive edge, with Industry 4.0 as a mediating role. Through the integration of the views of the resource-based view and social exchange theory, Rahman et al.'s [25] goal is to investigate the relevance of Logistics 4.0 in the context of Industry 4.0. Their research focuses on the connections between knowledge management practise, Logistics 4.0 expertise, logistics flexibility, and digital expertise. Pfeifer [26] provides an overview of organizational requirements and configurations required to construct an Industry 4.0-compliant production system. Mohammed et al. [14] concentrate on three aspects of it as information and communication technologies, Industry 4.0, and agile manufacturing. Ciampi et al. [27] suggest a trade-off remedy for big data analytics capable data systems linked with artificial intelligence functionality. It also offers some additional significance to the subject for practitioners and scholars. Zimmerman [28] investigated the impacts of Industry 4.0 technology to understand the benefits of Industry 4.0 adoption better. Kurniawan et al. [8] explore the connection between antecedents and the effect of corporate procedure agility on the company achievement of Indonesian telecommunications equipment businesses. Saengchai et al. [29] conducted a study to examine how supply chain agility affects "organizational", "legal", "strategic", and "technological challenges" in the implementation of Industry 4.0.

The progression of Industry 4.0 has prompted all organizations to undergo a digital transition. The need for swift adaptation has driven organizations to undergo rapid changes. Additionally, the emergence of digital natives in the workforce has further accelerated this transformation. Transitioning and utilizing technology is a trait that digital natives who have grown up with technology are born with. Organizations must be agile to react rapidly to variations. Implementing Industry 4.0 and digital transition becomes more accessible with this mixture [17]. Teece et al. [18] investigate the processes managers can use to fine-tune the requisite level of organizational agility, distribute it cost-effectively, and link it to tactics. Sambamurthy et al. [30] expanded the awareness of IT's strategic role by investigating the theoretical framework system of IT impacts on firm performance. The summarized mapping of past literature dimensions is presented below in Figure 1. Figure 1 shows the connection and importance of being agile in the era of Industry 4.0. A bibliometrics technique called bibliographic coupling can show how agility is related to and important in the context of Industry 4.0. By comparing articles' similarities based on their shared references, the bibliographic coupling can be used to gauge how closely related or connected two pieces of writing are. We can gain insights into the significance of agility in the era of Industry 4.0 by analyzing the bibliographic coupling of research publications across diverse disciplines, such as computer science, engineering, management, and social sciences. As a result, organizations may better understand how agility plays a part in maximizing possibilities and minimizing risks related to the digital transformation of sectors and adjust their strategies, processes, and operations as necessary.

Reviewing the earlier literature from the mapping mentioned above and the discussion has revealed the relevant study gap. While there has been extensive research on the factors that impact agility in the context of Industry 4.0 [7,19–21,25,27], there is a notable gap in the literature regarding the factors that influence agility, specifically in start-up operations in the Industry 4.0 era. In light of this gap, the present study aims to address this research lacuna by exploring the factors that affect agility in start-up operations within the context of Industry 4.0. The identified factors for this study are collaboration and communication (F1), artificial intelligence (F2), cyber-physical system (F3), cloud computing (F4), network and connectivity (F5), virtual reality (F6), flexibility (F7), management agility (F8), technology (F9), digital twin (F10), and blockchain (F11). Table 1 lists the factors that were determined and the sources of each in this study. In light of these issues and the research gap, a research approach is framed and given in the part that follows.

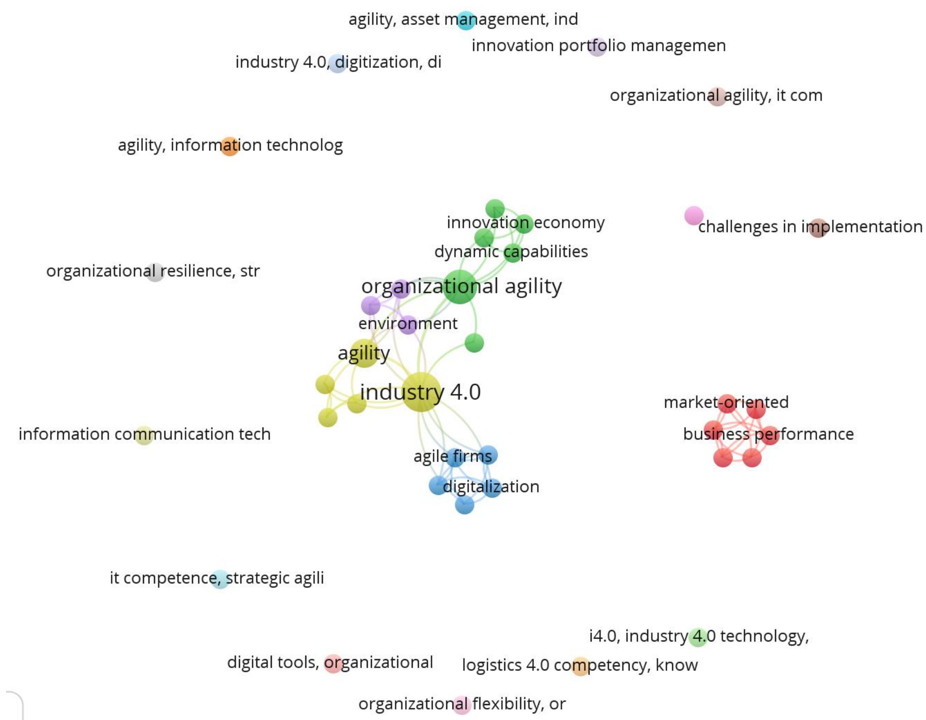

Figure 1. Mapping of dimensions of past literature.

Table 1. Identified factors and reference.

References	F1 $	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11
[19]	×										
[15]		×									
[31]			×								
[13]				×				×			
[32]				×							
[9]					×						
[33]						×					
[20]							×		×		
[23]							×				
[34]										×	
[22]											×

$ Note: F1: collaboration and communication; F2: artificial intelligence, F3: cyber-physical system, F4: cloud computing, F5: network and connectivity, F6: virtual reality, F7: flexibility, F8: management agility, F9: technology, F10: digital twin, and F11: block chain. ×: the factor and corresponding reference sources of each.

3. Research Methodology

The research design of this study is focused on determining the factors that impact agility in the context of start-ups operating in Industry 4.0. To that end, TISM and MICMAC analysis will be used. The structural modeling method known as TISM aids in comprehending the intricate interrelationships and dependencies between numerous components. On the other hand, the factors are categorized using MICMAC analysis depending on the strength of their driving and dependent effects. Primary data for this study is collected through structured interviews and surveys conducted with a purposive sampling approach, targeting experts and practitioners in start-ups and Industry 4.0. The participants are chosen based on their knowledge and experience in the start-up sector. To collect data, preset questionnaires about the variables influencing agility in the 4.0 start-up industry are used to solicit responses. Subject-matter specialists validated the questionnaires after being developed based on a thorough literature examination. TISM and MICMAC analyses are used to examine the data gathered. Several steps are performed to guarantee the veracity of the findings. First, extensive literature research is used to construct and validate the questionnaires that will be used to gather the data. Second, professionals with relevant expertise and experience in the start-up industry participate in structured interviews and surveys. The data analysis is carried out using well-known methods that are generally accepted and validated in strategic management, such as TISM and MICMAC, to increase reliability. The utilization of expert and practitioner perspectives that are vulnerable to bias, potential biases in the data-gathering process, and the generalizability of the findings to various contexts or industries are potential limitations of this study. However, efforts are made to reduce these constraints by employing stringent data collection and analysis processes and clearly outlining the research design and methodology. The informed consent of the participants, data confidentiality, and adherence to ethical principles and standards for research involving human beings are all ethical considerations in this study. Integrity, objectivity, and transparency are also adhered to in reporting the study's conclusions.

The study aims to collect and analyze data, following the recommended research procedures as highlighted by Tashakkori et al. [35]. A "closed-ended questionnaire" has been designed to assess the interrelationships among identified factors, using pairwise comparisons based on factors (e.g., "Does factor A influence factor B? If yes, rate from 2–5; if not, rate as 1"). Semi-structured interviews [36] were selected as the data collection method to gather comprehensive insights from practitioners. The TISM technique, along with MICMAC analysis, was used for data analysis in this study. According to Attri et al. [37], TISM serves as a framework to understand the interdependence of various elements that affect agility in start-up operations 4.0. A comprehensive and systematic model is formulated using the TISM technique to effectively organize various factors that are directly and indirectly related. This model has been proven to generate solutions for complex problems [38,39]. As per Attri et al. [37], the MICMAC analysis is utilized as an indirect method of categorization to assess the magnitude of each factor. The following subsection details the sampling technique employed, the interviews conducted for data collection, and the analysis carried out.

3.1. Data Sampling and Interviews

Probability sampling is frequently used to answer research questions and establish a broad perspective, according to Attri et al. [37], but non-probability sampling is typically utilized to get answers from a particular point of view. Since it better fits our focus on the agile elements of start-up operations 4.0, we chose non-probability sampling for our study. We have employed two sampling techniques, namely purposive sampling and snowball sampling, for our investigation. Purposive sampling is a method of selecting interview subjects who meet specific criteria and are likely to provide valuable insight. In this case, the criteria for selecting interviewees include belonging to a start-up related to information technology, manufacturing, engineering, agriculture, and others. The definition of a start-up in this context includes organizations that have been incorporated and registered for up to ten years. Additionally, the sample of individuals to be interviewed will encompass a diverse range of positions, such as "chief executive officers", "chief technology officers", "analysts", "human resource managers", "operation managers", and "public relations associates".

Over a span of multiple months, interviews took place at multiple start-up companies. Table 2 displays the breakdown of the 15 respondents in detail. Each interview lasted one hour. The timing of interviews was scheduled at the convenience of the respondents. Ethical considerations, such as obtaining consent, protecting privacy, maintaining confidentiality, and ensuring anonymity, have been considered carefully. The questionnaire utilized a five-point Likert scale, where a score of 1 represented no influence and a maximum score of

5 represented a very strong influence. For example, in case of a question in the questionnaire, that is, if factor F1 influences factors F2 to F10, please rate the influence for each combination from 2–5; otherwise, rate the influence as 1.

Table 2. Respondents Details.

Respondents	Total Number of Respondents
Analyst	4
Chief Executive Officer	4
Chief Technology Officer	1
Public Relation Associate	3
Human Resource Manager	3

3.2. Data Analysis and TISM Approach

The interpretive structural modeling (ISM) approach is commonly employed to assess the degree of interconnectedness and interrelationships among different elements. However, it may offer a limited perspective on the comprehensive nature of these linkages [40]. Figure 2 represents the sequence of research methodology or steps adopted in the study [41,42]. The true nature of the relationship is revealed by TISM, which, in contrast, chronicles and demonstrates the causal explanation for each link and the sense of directed links [43]. In this study, TISM is preferred to model the agility in start-up operations 4.0, and this methodology has been utilized by various researchers in their studies [44–48]. To start the TISM modeling process, the first step involves identifying and defining the essential components that contribute to improving the agility of Industry 4.0. These factors are determined through a thorough review of relevant literature and discussions with subject matter experts from academic and start-up backgrounds. For this study, 11 factors were considered for the investigation. The discovered agility factors and their corresponding references can be found in Table 1.

After identifying the factors, the next step in the process is to establish the contextual relationships between them, which is accomplished by utilizing the knowledge and expertise of the subject matter specialists. Based on these contextual relationships, a pairwise interaction matrix determines how each factor influences or enhances the others. TISM answers the question: "how does factor A impact or enhance factor B?" The results populate the initial reachability matrix (IRM), as shown in Table 4 below. Similarly, "if factor A significantly influences factor B, 1 is entered in the IRM; otherwise, 0 is entered" [49–51].

Table 3. IRM for factors influencing agility in startups operations 4.0.

Factors $	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11
F1	1	0	0	0	0	0	1	1	0	0	0
F2	1	1	1	1	1	1	1	1	1	1	1
F3	0	0	1	0	0	1	1	1	0	0	1
F4	1	0	0	1	1	0	1	1	1	1	1
F5	1	0	1	1	1	1	0	1	1	1	1
F6	1	0	0	0	0	1	1	1	0	0	0
F7	1	0	0	0	0	0	1	1	0	0	0
F8	1	0	0	0	0	0	1	1	0	0	0
F9	1	0	0	1	1	0	1	1	1	1	1
F10	1	0	1	1	1	1	1	1	1	1	1
F11	1	0	1	0	0	1	1	1	0	0	1

Note: $ Refer to Table 1.

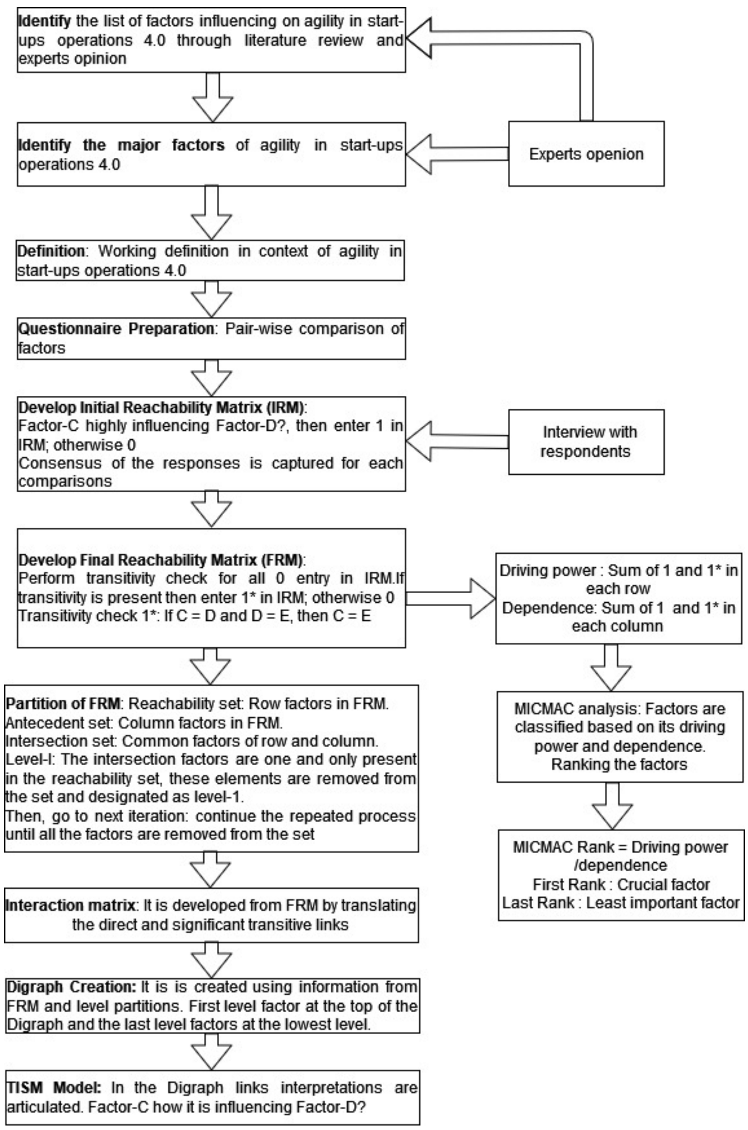

Figure 2. Flow of TISM approach for agility in Startups operations 4.0. *: represents the transitive links.

After identifying the factors, the next step in the process is to establish the contextual relationships between them, which is accomplished by utilizing the knowledge and expertise of the subject matter specialists. Based on these contextual relationships, a pairwise interaction matrix determines how each factor influences or enhances the others. TISM answers the question: "how does factor A impact or enhance factor B?" The results populate the initial reachability matrix (IRM), as shown in Table 4 below. Similarly, "if factor A significantly influences factor B, 1 is entered in the IRM; otherwise, 0 is entered" [49–51].

After establishing the IRM, the transitivity rule is applied to generate the final reachability matrix (FRM), as shown in Table 5 below. In the FRM, any transitive elements that have a value of 0 are replaced with 1 in the IRM after transitivity testing. The next step involves organizing the components in a level-by-level manner. The antecedent set comprises variables and other elements that may impact them. On the other hand, the reachability set for each factor includes other factors that may affect it. The intersection set for each element is determined. The next step is identifying the element that appears in both the reachability and intersection sets, placing it at the top level in the initial iteration. This process results in the interaction matrix, which is presented in Table 6. The factors are visually arranged based on their levels and connected according to the relationships outlined in the FRM to create a directed graph. Therefore, in accordance with the TISM methodology, it is essential to provide a logical definition and explanation for each contextual relationship. After this step, creating an interpretive statement for each significant connection in the directed graph is a crucial task. The TISM approach used to model agility in start-up operations 4.0 is illustrated in Figure 3.

Table 4. IRM for factors influencing agility in startups operations 4.0.

Factors $	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11
F1	1	0	0	0	0	0	1	1	0	0	0
F2	1	1	1	1	1	1	1	1	1	1	1
F3	0	0	1	0	0	1	1	1	0	0	1
F4	1	0	0	1	1	0	1	1	1	1	1
F5	1	0	1	1	1	1	0	1	1	1	1
F6	1	0	0	0	0	1	1	1	0	0	0
F7	1	0	0	0	0	0	1	1	0	0	0
F8	1	0	0	0	0	0	1	1	0	0	0
F9	1	0	0	1	1	0	1	1	1	1	1
F10	1	0	1	1	1	1	1	1	1	1	1
F11	1	0	1	0	0	1	1	1	0	0	1

Note: $ Refer to Table 1.

Table 5. FRM for factors influencing agility in startups operations 4.0.

Factors $	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	Driving Power
F1	1	0	0	0	0	0	1	1	0	0	0	3
F2	1	1	1	1	1	1	1	1	1	1	1	11
F3	1 *	0	1	0	0	1	1	1	0	0	1	6
F4	1	0	1 *	1	1	1 *	1	1	1	1	1	10
F5	1	0	1	1	1	1	1 *	1	1	1	1	10
F6	1	0	0	0	0	1	1	1	0	0	0	4
F7	1	0	0	0	0	0	1	1	0	0	0	3
F8	1	0	0	0	0	0	1	1	0	0	0	3
F9	1	0	1 *	1	1	1 *	1	1	1	1	1	10
F10	1	0	1	1	1	1	1	1	1	1	1	10
F11	1	0	1	0	0	1	1	1	0	0	1	6
Dependence	11	1	7	5	5	8	11	11	5	5	7	

Note: $ Refer to Table 1 and * represents transitive links.

Table 6. Interaction matrix.

Factors $	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11
F1	1	0	0	0	0	0	1	1	0	0	0
F2	1	1	1	1	1	1	1	1	1	1	1
F3	0	0	1	0	0	1	1	1	0	0	1
F4	1	0	0	1	1	0	1	1	1	1	1
F5	1	0	1	1	1	1	1 *	1	1	1	1

Table 6. *Cont.*

Factors $	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11
F6	1	0	0	0	0	1	1	1	0	0	0
F7	1	0	0	0	0	0	1	1	0	0	0
F8	1	0	0	0	0	0	1	1	0	0	0
F9	1	0	1 *	1	1	1 *	1	1	1	1	1
F10	1	0	1	1	1	1	1	1	1	1	1
F11	1	0	1	0	0	1	1	1	0	0	1

Note: $ Refer to Table 1 and * represents significant transitive links.

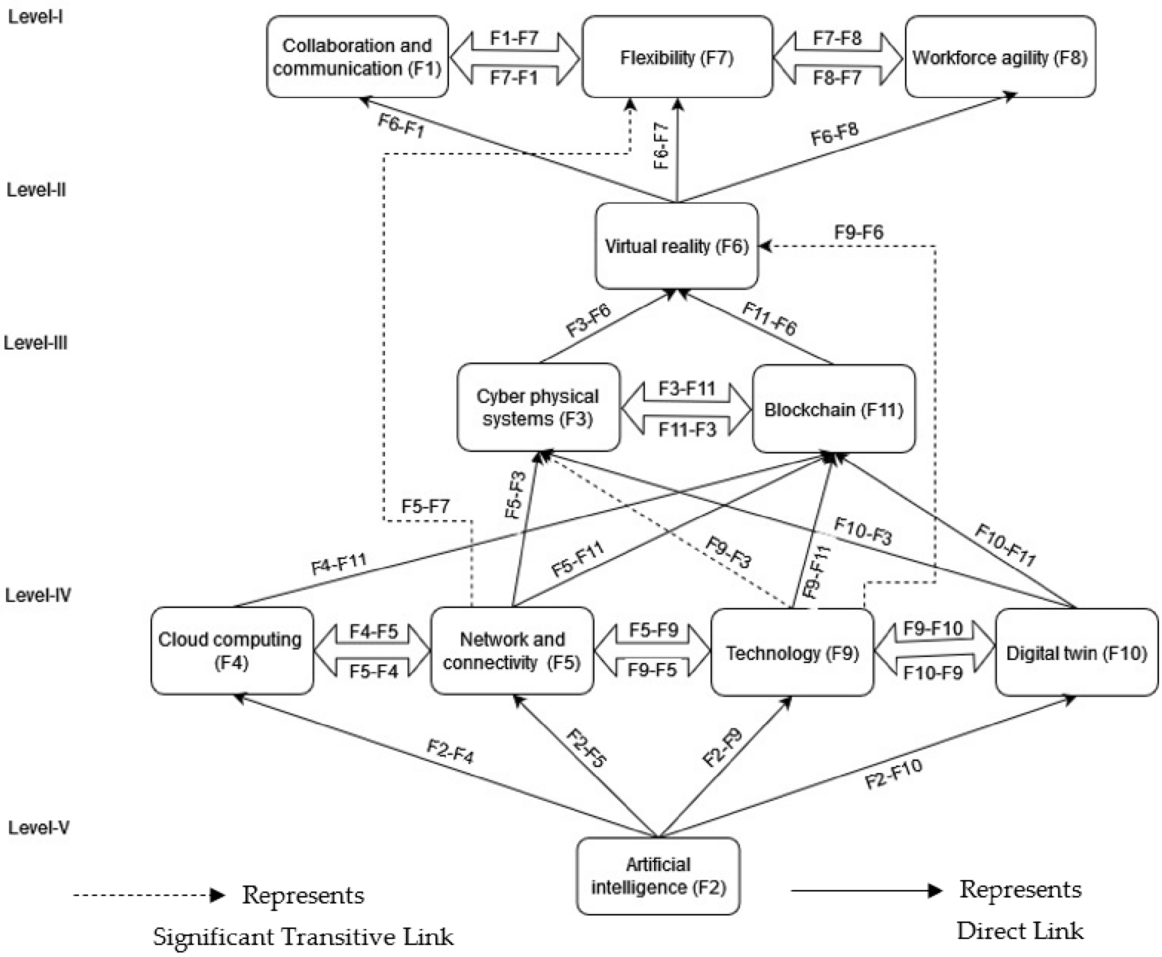

Figure 3. TISM model for factors influencing agility in start-ups operations 4.0.

4. Results and Discussions

The interpretation and discussion from the above Tables 2, 4 and 5 and Figure 3 regarding factors and their interactions influencing agility in start-ups operations 4.0 are presented in the following subsection. Next, in order to assess the interdependence and underlying influences of each of the factors contributing to agility, a MICMAC analysis is introduced in the ensuing subsection.

4.1. Interpretation of Total Interpretative Structural Digraph

Level V: This level has one factor, i.e., artificial intelligence (F2). This factor is influencing almost all other factors. Artificial intelligence facilitates the industrial ability to collaborate and stay connected by automating some chores and giving access to more precise information. Artificial intelligence can also help team members communicate with one another [52]. Artificial intelligence can, for instance, set up meetings and send reminders to enable you and a project partner in a different time zone to work together. Thus, artificial intelligence influences several industries in communication and cooperation (F1).

Similarly, using artificial intelligence in cyber-physical systems has the enormous potential [53]. With the aid of artificial intelligence, one can better monitor and regulate these defence and increase their defence against intrusion. Artificial intelligence is being utilized to strengthen cyber-physical systems' robustness and help protect them from threats. Artificial intelligence is also utilised to improve cyber-physical systems management, supervision, and performance. The usage of artificial intelligence in cyber-physical systems is on the rise, and it is anticipated that in the future, artificial intelligence will play an even bigger part in these systems. So, it is evident that artificial intelligence is influencing cyber-physical systems (F3).

Similarly, artificial intelligence (F2) influences cloud computing (F4). This is evident in the many new cloud computing services that are developed using artificial intelligence to save time and money for organizations and people [54]. It enables the development of sophisticated computer systems that help both organizations and individuals save time and money. Artificial intelligence also influences networks and connectivity (F5), by monitoring network traffic and spotting possible dangers to assist, identify, and stop attacks before they happen. As a result of artificial intelligence's capacity for processing vast volumes of data, it is now possible to connect objects and people in previously unimaginable ways. Artificial intelligence is crucial for connectivity because of this.

It is also evident that artificial intelligence (F2) influences virtual reality (F6), flexibility (F7), and workforce agility. One can observe that nowadays, artificial intelligence developments have expanded the potential uses for virtual reality and flexibility as one of the most important ways to handle repetitive activities across a company. It frees up staff to concentrate on innovative solutions, difficult problems, and significant work is one of the advantages of artificial intelligence for Industry 4.0 business. Lastly, it is also evident that artificial intelligence (F2) influences technology (F9), digital twin (F10), and blockchain (F11) [55,56]. This is possible because artificial intelligence is used in technology to build computer algorithms that mimic human behavior. Similarly, digital twins are digital representations that virtually replicate the real equivalents and integrate with AI to offer a link and accessibility to intelligence in the real world. This will expedite and reduce the cost of the certification procedure.

Level IV: This level has four factors, which are cloud computing (F4), network and connectivity (F5), technology (F9), and digital twin (F10). It is evident that cloud computing (F4) influences collaboration and communication (F1), network and connectivity (F5), flexibility (F7), workforce agility (F8) technology (F9), digital twin (F10), and blockchain (F11). No matter where team members are, they collaborate in real time via the cloud. Each team member has access to files and data in the cloud from a variety of internet-connected gadgets at any time and any place. Data stays secure and protected even if a device is lost or damaged. Similarly, cloud computing has impacted network and connectivity and allowed businesses to share data and applications across the globe in real time, whereas when it comes to computer requirements, cloud computing provides enterprises flexibility and scalability. Cloud computing enables increased adaptability for corporate staff members, both inside and outside the office. Employees can conveniently access files using web-enabled devices such as "cell phones", "laptops", and "notebooks". Employees have access to a virtual workspace due to cloud computing, to view files from any location. Additionally, have access to files from various gadgets, including tablets, computers, and smartphones. Digital twins can substantially speed up product advancement and production procedures when they are put in place using powerful computational technologies, such as cloud-based workspaces, cloud rendering, simulation and analysis, and deep learning/artificial intelligence (AI). On the other hand, better data security, simple traceability, increased system interoperability, decentralization, quicker system discovery, and many other benefits are made possible by the use of blockchain in cloud computing.

Network and connectivity (F5) influence collaboration and communication (F1) and greatly depends on how Industry 4.0 operations relate to and communicate with one another. It can be challenging to do work efficiently if there are frequently interrupted by inadequate connectivity or must use antiquated communication technologies. Businesses that wish to promote employee collaboration and communication must invest in a strong network and communication infrastructure. Similarly, network and connectivity (F5) influence cyber-physical systems (F3), where physical and cyber processes are tightly linked. Cyber-physical systems are used in various industries, from manufacturing and transportation to healthcare and energy. Because of the critical role that cyber-physical systems play, it's important that they are able to operate smoothly and without interruption. Additionally, that is where network and connectivity come in. A well-designed network can help to ensure that cyber-physical systems are able to function as intended, even in the face of challenges like unexpected traffic spikes or data loss. In short, network and connectivity are vital to the success of cyber-physical systems. Networks and connectivity (F5) influencing cloud computing (F4): implementations and workloads can attach to and from one another across clouds, cloud services, on-premises data centers, and edge networks using cloud networking. It depends on speed, safety, and effective management of multi-cloud and hybrid cloud infrastructures. Network and connectivity (F5) influencing virtual reality (F6):

The success of virtual reality is largely due to the network and connectivity, which are growing in popularity. The quality of the virtual reality experience can be significantly improved with a strong network and connectivity. Ensure your network and connectivity are strong to make the most of your virtual reality gear. Network and connectivity can greatly influence how flexible (F7) an industry is. If an Industry 4.0 company has a good network, they can be more easily able to connect with other industries and share information, which leads to more collaboration and a more flexible work environment. Similarly, if network and connectivity are strong, one can be more responsive to change and more adaptable to new situations. It's the foundation that network and connectivity (F5) influence an organization's workforce agility (F8).

Network and connectivity (F5) also influence technology (F9), digital twin (F10), and blockchain (F11). Here, the advantage is in terms of cost-effectiveness, storage efficiency, flexibility, and data security. It also makes it simple for staff to communicate information, enhancing efficiency and productivity. Poor network connectivity can impact digital twins in several ways. First, it will be difficult to collect data from the various devices and sensors needed to represent the physical environment accurately; Second, it can delay or prevent updates to the digital twin, making it less useful for applications that require real-time data. Finally, network disruptions can cause digital twins to fall out of sync with the physical world, which can lead to errors and inaccurate results. To overcome these challenges, organizations must ensure that they have a reliable and robust network infrastructure. This infrastructure should be designed to support the digital twin technology and the data-intensive applications that it supports. In addition, organizations need to consider using redundancy and fault tolerance techniques to minimize the impact of network disruptions. Additionally, it is clear that network and connectivity concerns might significantly influence the blockchain in a world that is becoming more linked. A distributed ledger is only as strong as the nodes supporting it, or the computers and other hardware that are linked to the network. The blockchain will not function if there are not enough nodes or if they are not properly connected.

No matter how far apart they are, people may now effectively communicate thanks to technology. Employees can use corporate communication apps to send messages, share data, hold conferences, and set up online forums, keeping the lines of communication open at all times. It means technology (F9) influences collaboration and communication (F1). Similarly, the use of technology in cyber-physical systems has led to some interesting applications. For example, smart cities use technology to manage traffic flow, optimize resources, and improve public safety. In the healthcare sector, cyber-physical systems are being used to monitor patients and deliver personalized care. The potential for cyber-physical systems is vast, and the role of technology is essential. It is evident to see that integration of physical and cyber systems with that technology (F9) will play a major role in shaping the world's future. Virtualization is frequently the key underlying innovation for cloud computing. Generally, virtualization software is used to divide up physical computing devices into a number of manageable virtual devices that can each be employed for cloud computing (F4). Technology impacts communication by making it simpler, faster, and more effective. Additionally, technology streamlines the process of gathering client data and enhancing the entire customer experience by influencing network and connectivity (F5). Technology (F9) has influenced virtual reality (F6). With the advances in computer graphics and processor speeds, virtual reality has become much more realistic and immersive. However, technology is not just limited to hardware. Software plays a big role in virtual reality as well. For example, the Steam virtual reality platform enables developers to create amazing virtual reality experiences. Technology can indirectly affect flexibility (F7) through the interaction between the organization responsible for technology maintenance and the owners of business processes, the handling of change requests, and other dynamic responses. These collateral consequences demonstrate increased organizational flexibility. The workforce has been significantly impacted by technology (F9). Workers' abilities and resources were formerly constrained by their physical state. Technology can make today's workforce more flexible, efficient, and nimble. Geographical barriers no longer restrict the workforce. Digital twin (F10) models often demand a sizable amount of computer power, whereas cloud computing is one of the key technologies (F9) that makes it possible to process data in a big data setting. Internet-based revolutionized technology (F9) influencing blockchain (F11); in return, it has the ability to fundamentally alter and control how industry exchange value, transfer ownership, and verify transactions.

Digital twins (F10) true worth lies in their capacity to facilitate remote cooperation amongst scattered co-workers and stakeholders. The ability of distant teams to collaborate and communicate (F2) is becoming increasingly important to the modern economy. Digital twins are straightforward; they use sensors to gather real-time data about tangible things, acting as a link between the physical and digital worlds. To comprehend, analyze, manipulate, and optimize these objects, digital copies of them are made using these data. The impact of digital twins on cloud computing (F4) is twofold. First, the increase in the popularity of digital twins is driving the need for more powerful and sophisticated cloud-based solutions. This is because digital twins often generate large amounts of data, which must be stored and processed in the cloud. Second, digital twins are also changing how cloud-based solutions are used. In particular, they are leading to the development of new serverless architectures. In a serverless architecture, all of the processing is done in the cloud, and there is no need for a local server. This can be a more efficient and cost-effective way to use cloud resources. Digital twins are thus having a major impact on cloud computing. Future digital twins are anticipated to play a larger role in wireless network and connectivity (F5) provisioning, performance, security, and compliance. Virtual reality (F6) is influenced in a wider range of contexts through digital twins (F10), which raises the bar for technological advancement.

The digital twin might be applied in various ways to increase flexibility (F7) and worker agility (F8). Digital twins can assist managers in identifying problems before they have a significant negative impact by monitoring the performance of the workforce in real time. Second, you can replicate various events using digital twins. This can be used to test various workforce management strategies and identify flexibility in a given circumstance. Third, using digital twins can give workers immediate feedback. Workers who receive this feedback can enhance their performance and avert possible issues. Digital twins (F10) are digital representations of physical assets, processes, or people. By tracking data points associated with these entities, organizations can gain insights into their performance and make changes as needed. Thus, due to the decentralization and immutability benefits of the blockchain (F11) and technology (F10), digital twins' initiatives can innovate more quickly and effectively by guaranteeing safe and secure data flow.

Level III: This level has two factors cyber-physical system (F3) and blockchain (F11). Recent advances in cyber-physical systems (F3) and virtual reality (F6) technologies are bringing these two fields closer together, and there are indications that cyber-physical systems will significantly impact the development of virtual reality. For example, cyber-physical systems can be used to create realistic virtual environments for training and development purposes. In addition, cyber-physical system can be used to monitor and manage virtual reality systems. The integration of cyber-physical system and virtual reality is expected to lead to new and innovative applications in areas such as start-ups. Flexibility (F7) has been demonstrated to benefit from cyber-physical system, which enables real-time monitoring and control of physical systems. Processes can be improved as a result, and downtime can be decreased. The possible uses of cyber-physical system technology are anticipated to expand as it advances, thus enhancing its influence on flexibility.

Similarly, businesses must be able to adapt swiftly to stay ahead of the competition in a world that is changing quickly. This necessitates having a workforce agility (F8) that is adaptable and fast to react to change. Cyber-physical systems are the one that makes this workforce agility possible. Cyber-physical systems are physical and virtual systems networks that communicate with one another to share information and provide feedback. This makes it simpler for organizations to react to changes in the market or environment by enabling them to monitor and control their operations in real time. Undoubtedly, cyber-physical systems (F3) have profoundly influenced the development of blockchain technology (F11). By definition, a cyber-physical system is a system where physical and cyber systems are integrated and interact with each other to share data and feedback. This interaction between physical and cyber systems is what makes blockchain so powerful. Data integrity could be achieved via blockchain (F11) technology, which relies on cryptography to prevent tampering. In these situations, blockchain can be used to ensure private collaboration and communication (F2) and data security. Blockchain (F11) influences cyber-physical systems (F3), where authorizing and recording data on the network must be transparent and enable network users to confirm the accuracy of the data.

Blockchain (F11) and virtual reality (F9) enable a secure movement of monetary worth from one location to another. A secure technique is required to transfer funds from one system to another in games and any virtual universe. Blockchain (F11) influences flexibility (F7) by streamlining procedures and transactions that offer a high level of confidentiality and transparency, all of which are necessary for conducting business. Blockchain offers a safe and effective flexible means to store and transfer data by allowing data to be disseminated yet not replicated. On the other hand, blockchain (F11) also influences workforce agility (F8) by controlling permissioned users using distributed ledger technology can view the same data concurrently, enhancing efficiency, fostering trust, and reducing friction.

Level II: This level has only one factor, which is virtual reality (F6), and influences three factors such as collaboration and communication (F1), flexibility (F7), and workforce agility (F8). It is evident that virtual reality enhances communication and provides a deeper understanding of the advertising messages and the marketed goods. The way we learn and experience new things could be altered by virtual reality. It can be used, for instance, to train staff members to think and act more adaptively. This might significantly affect how we pick up new information and skills, as well as how we solve problems. In order to familiarize themselves with their duties and responsibilities during the interview process, prospective employees could shadow their role using virtual reality. Instead of merely hearing about the office setting from the company, a virtual reality experience would give candidates a visceral sense of it.

Level I: This level has three factors, which are collaboration and communication (F1), flexibility (F7), and workforce agility (F8). Collaboration and communication are important factors in flexibility. When people can collaborate and communicate effectively, it allows for greater flexibility. This is because people can share information and ideas more easily, and are more likely to be able to come to a consensus. There are many benefits to having a flexible workforce. For one, it can lead to increased productivity. When people can be flexible with their hours and work from different locations, it can make it easier to get work done. Additionally, it can lead to increased creativity, as people are more likely to develop new ideas when not constrained by traditional work hours. Collaboration and frequent communication are essential elements for enhancing staff adaptability, which is termed workforce agility. By maintaining choices accessible and decision-making quick, flexibility attempts to offset unpredictability. This is the reason why so many organizations rely on coordination to improve collaboration, communication, and productivity. There are a number of factors that contribute to a workforce's agility. One is, of course, the individual employees. Employees who are adaptable, quick-thinking, and open to change are key to an agile workforce. However, even the most flexible employees will be limited if the company's structure and systems are inflexible. That is why businesses need to create an environment that supports workforce agility. This means having systems and processes in place that can be quickly and easily adjusted to meet changing needs. It also means being open to new ideas and willing to experiment and take risks.

Flexibility is an important quality in the workplace, and it's one that can have a major impact on a company's success. Businesses that are able to embrace change and adapt quickly to the ever-changing landscape will be the ones that thrive in the future. Effective collaboration and communication are essential components of being agile. Everyone in an agile organization must be on the same page and working toward the same objectives. Any organization needs effective communication and collaboration, but agile organizations require it even more. That is because change can occur fast and without warning in an agile organization. Making the necessary changes can be exceedingly challenging if no one is on the same page. Workforce agility is crucial to the success of any organization. Organizations that are agile can adapt to change more quickly and collaborate and communicate more successfully. Similarly, one of the key components of an agile start-up is workforce agility, which can have an impact on a number of competitive factors, including responsiveness, cost-effectiveness, innovation, speed, productivity, and profitability, as well as dependability, competency, and delivery. Flexibility received more attention than all other competitive factors that came along as a result of building agile start-up operations 4.0.

Collaboration and communication (F1), flexibility (F7), and workforce agility (F8) are related to the objective of this study. One of the key components of agility is having a workforce that is both flexible and able to communicate and collaborate effectively. With the ever-changing landscape of the business world, it's more important than ever for companies to be able to adapt quickly. This means changing course quickly when necessary and responding quickly to new situations. One of the key components of agility is having a workforce that is both flexible and able to communicate and collaborate effectively. Collaboration and communication are essential for a workforce to work together effectively. When everyone is on the same page and working towards the same goal, achieving success is much easier. Flexibility is also key to agility. If your workforce is flexible, it can be much easier to adapt to changing situations and make the necessary changes quickly. Workforce agility is essential for any company that wants to be agile. Having a workforce that can communicate and collaborate effectively and is also flexible can set your company up for success.

4.2. MICMAC Analysis

Using MICMAC analysis, which is a technique called "cross-impact matrix multiplication applied to classification", the enablers are classified into "driving", "dependent", "autonomous", and "linkage" factors. The resulting reachability matrix is then utilized to determine the "dependence and driving factors" for agility factors. In this study, it is evident that virtual reality (F6), collaboration and communication (F1), flexibility (F7), and workforce agility (F8) is the dependent factors. There are additional factors that significantly affect these outcomes. Two factors have been identified as linkage factors. Similarly, cyber-physical systems (F3), and blockchain (F11) are the linkage factor. Five of the identified factors are classified as "driving factors". Here, it is observed that artificial intelligence (F2), cloud computing (F4), network and connectivity (F5), technology (F9), and digital twin (F10) are the driving or key factors. According to the MICMAC analysis, the factors that impact agility [57–65] have been arranged and displayed in Table 7 and Figure 4. The MICMAC graph is illustrated in Figure 4, while Table 6 lists the ranking of the factors based on their "driving power and dependence". According to the ranking, artificial intelligence (F2) is ranked 1. Collaboration and communication (F1), flexibility (F7), and workforce agility (F8) are ranked fifth in the MICMAC analysis ranking. This means that it has higher dependence on other factors.

Table 7. MICMAC rank for factors influencing agility in start-up operations 4.0.

Factor [$]	Driving Power	Dependence	Driving Power/Dependence	MICMAC Rank
F1	3	11	0.273	5
F2	11	1	11.000	1
F3	6	7	0.857	3
F4	10	5	2.000	2
F5	10	5	2.000	2
F6	4	8	0.500	4
F7	3	11	0.273	5
F8	3	11	0.273	5
F9	10	5	2.000	2
F10	10	5	2.000	2
F11	6	7	0.857	3

Note: [$] Refer to Table 1.

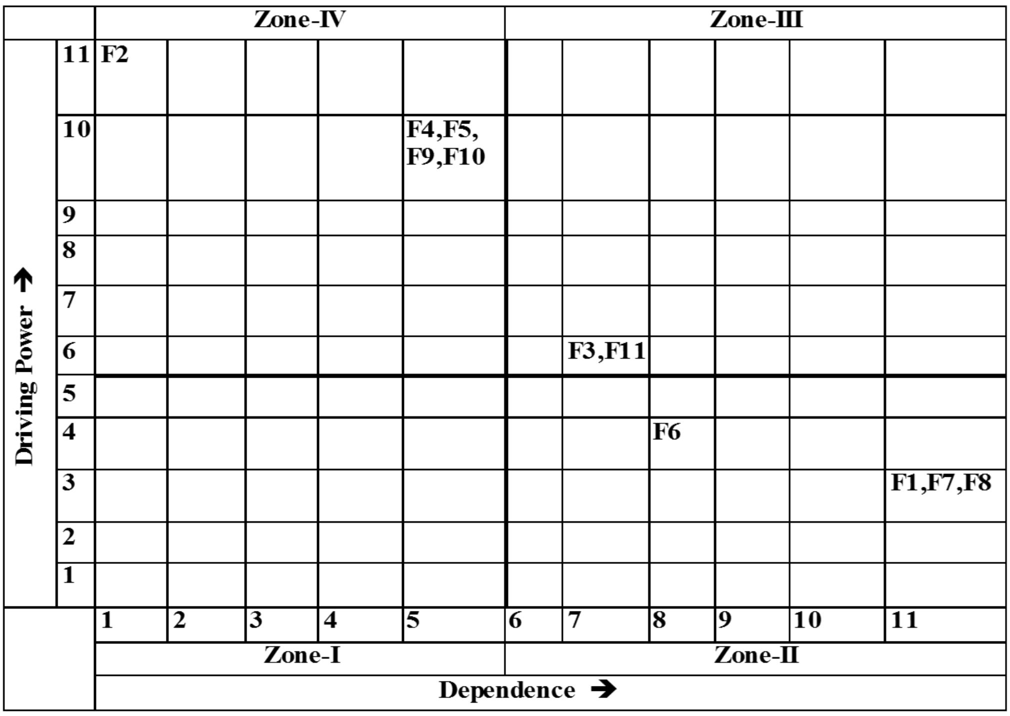

Figure 4. MICMAC graph.

5. Implications

5.1. Theoretical Implication

This research not only contributes to the limited existing understanding of agility in Industry 4.0 but also provides insights into the factors that influence agility in start-up operations 4.0. The study endeavors to address three inquiries: what? How? Additionally, why?

Answering what: Identifying significant components within a specific research context is the primary stage in conducting a systematic literature review. The manuscript being discussed utilized an exploratory review approach to ascertain the factors of agility in start-up operations 4.0. The search mainly focused on studies related to agility and Industry 4.0. By combining literature review and expert input, a total of eleven factors were selected. They are collaboration and communication (F1), artificial intelligence (F2), cyber-physical system (F3), cloud computing (F4), network and connectivity (F5), virtual reality (F6), flexibility (F7), management agility (F8), technology (F9), digital twin (F10), and blockchain (F11).

Answering how: The TISM approach is utilized to establish the connections among the elements identified in the literature. The procedure commences with step-by-step pairwise comparisons, followed by subsequent comparisons. This method helps to determine the link between the 11 elements and ultimately provides an answer to the question of how they are interrelated.

Answering why: Having an understanding of the connections between the elements would lay the groundwork for addressing the question of why. Experts' input is used to interpret the correlations between the factors, and a single perspective is formed from the varying arguments. A hierarchical digraph is created, and the experts' arguments are utilized to explain each connection between the components in the final model.

In order to enhance the understanding of the drivers of agility, the researchers utilized the MICMAC analysis to categorize these drivers into four distinct categories, namely autonomous, independent, dependent, and linkage factors. This approach allowed the researchers to gain insights into the interconnections and correlations among these factors at various levels, providing a deeper understanding of their influence. The utilization of TISM and MICMAC in this study facilitated the identification of significant connections and relationships among the influencing factors, contributing to a comprehensive analysis of the research findings.

5.2. Managerial Implication

This research provides valuable insights for managers regarding the potential of agility in start-up operations 4.0, as well as the key factors they must consider to achieve agility in an uncertain environment. The hierarchical model developed in this study serves as a useful guide. This study thus contributes to the managerial understanding of agility and its significance in start-up operations 4.0. In this study, artificial intelligence (F2), cloud computing (F4), network and connectivity (F5), technology (F9), and digital twin (F10) are the driving or key factors. Artificial intelligence is facilitating our ability to collaborate and stay connected by automating some chores and giving us access to more precise information. With the aid of artificial intelligence, one can better monitor and regulate these systems and increase their defense against intrusion. Many new cloud computing services are developed using artificial intelligence to save time and money for organizations and people. It enables the development of sophisticated computer systems that help both organizations and individuals save time and money. Cloud computing has definitely had an impact on networks and connectivity. Employees have access to a virtual workspace due to cloud computing. Given that the organization has an internet connection, it allows all the freedom to view files from any location. Digital twins can substantially speed up product advancement and production procedures when they are put in place using powerful computational technologies.

This study's findings have important implications for managing start-ups, as it identifies 11 key factors that impact agility in start-up operations 4.0. Managers can prioritize and focus on understanding the 'driving' and 'dependence' factors to enhance agility in start-up operations 4.0. The model developed in this study illustrates how different enablers are interconnected and mutually influence agility in start-up operations 4.0, offering valuable insights for start-ups aiming to gain agility in the context of the Industry 4.0 era.

Additionally, start-ups must first acknowledge the significance of digital technologies and carefully implement them into their business models and operations. Investments in technology infrastructure, people acquisition, and skill development are needed to utilize digital technologies' promise for sustainability and agility fully. To stay current with the newest developments and advances in digital technologies, start-ups should also work with technology providers, research organizations, and other stakeholders. Authorities must establish a regulatory framework that promotes the uptake and spread of digital technologies in the 4.0 start-up economy. This includes rules that encourage companies to use sustainable practices and policies that support data exchange, data privacy, and cybersecurity. To improve the digital skills of start-ups and develop a qualified workforce for the digital era, policymakers should also fund digital literacy efforts and training programs. Furthermore, to stimulate innovation and sustainability in the Industry 4.0 ecosystem, governments must encourage cross-sectoral alliances and collaborations between start-ups, existing companies, and academics.

6. Conclusions

The aim of this research was to investigate the factors that affect operational agility in start-ups within the context of Industry 4.0. To achieve this objective, the TISM and MICMAC approaches were utilized to identify the key elements and understand the interdependencies among them. The findings showed that artificial intelligence, cloud computing, network and connectivity, technology, and digital twin are the driving or key factors. Machine learning and artificial intelligence are accelerating innovation across industries and operational divisions. New algorithms and artificial intelligence technologies are being developed to optimize existing systems and handle brand-new production challenges. A platform with improved information storage and user capabilities that do not require immediate human supervision is referred to as a cloud computing platform. Data systems become more flexible and agile thanks to cloud computing, which increases system power and self-management with less human involvement. Combining resources and skills, such as technology, increases start-ups' flexibility through servitization, making the company's technology agile as well. Networks and connections are two of the most crucial elements in enabling agility in start-ups operation 4.0. A variety of technological advancements, a unified IoT framework, and zero-touch networks have enabled factories to implement the Industrial Internet of Things (IIoT)" and transform into Industry 4.0 facilities. Consequently, advancements in this domain improve network speed, increase security and efficiency, and lower the cost of network connectivity. It is regarded as an organizational unit in charge of the development and uptake of technology and innovation from a technological perspective. As a result, it is responsible for and a key factor in the company's adoption of start-up operation 4.0 technology. Technological agility within organizations is increased by adopting start-up operation 4.0 technologies. The technology will be able to deal with the environment's uncertainty and will be better positioned to do so. The TISM methodology facilitated the identification of connections between the various elements. The model developed for this study demonstrates the relationships between and effects of several enablers influencing agility in start-up operations 4.0. Start-ups can increase their agility in the Industry 4.0 era in this way.

The results also emphasize the value of partnerships and collaboration in boosting agility in the start-up sector. Start-ups can better access various viewpoints, expertise, and resources when working with external stakeholders, such as consumers, partners, and industry experts. This can support their agility and innovation skills. The report also emphasizes the value of learning and ongoing development in promoting agility in companies. Start-ups are more likely to adapt to shifting market conditions, spot and address weaknesses, and continuously improve their strategy and operations if they prioritize learning, feedback, and iterative processes. Overall, the results indicate that a complex interplay of internal and external elements, such as organizational culture, leadership, resources, the external environment, collaboration, and learning, affect agility in the start-up industry. Start-ups can improve their agility by recognizing and utilizing these characteristics, which are essential for their survival and success in today's fast-paced and cutthroat business environment.

Limitation and Future Research Direction

The current research includes limitations, just as earlier investigations, which should be investigated in follow-up studies. Due to the small sample size, the results cannot be broadly generalized. Therefore, future studies could focus on larger samples from different businesses and countries. The study also significantly relies on professional opinions. They may have biased views due to their inexperience and limited exposure. This study also used the TISM technique to determine how the agility aspects of start-up operations 4.0 relate. To improve the reliability of the results, future studies may include additional decision-making techniques, such as the order of choice by similarity to an ideal solution approach, decision-making trial and assessment laboratories, and others. Additionally, using statistical methods like "partial least squares structural equation modeling", the results can be empirically tested. Despite the fact that Industry 4.0 has significantly improved production techniques, Industry 5.0 introduces fresh problems that start-ups in Industry 4.0 must solve. Additional investigation into the human aspect, ethical and societal ramifications, disruption of business models, and ecosystem collaborations in the context of Industry 5.0 may yield insightful information about the elements that affect start-up agility in Industry 4.0. Start-ups must comprehend and deal with these issues if they are to be adaptable and competitive in the continuously changing environment of Industry 5.0.

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