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Modelling Critical Barriers to Industry 5.0 Implementation in Supply Chain: An ISM Approach

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ABSTRACT

Industry 5.0 represents the fundamental transitioning of technology-driven Industry 4.0 towards a sociotechnical framework highlighting the human-machine collaboration, sustainability and resilience. A systematic literature review of 21 empirical works have been conducted in this study using frameworks like PRISMA to identify barriers responsible for Industry 5.0 implementation and adoption in supply chain management. 26 barrier codes were recognized across six dimensions: technological, organizational, human, financial, regulatory and external supply chain by the use of thematic coding. From these 26 barriers, 20 barriers from very high to moderate frequency were selected for Interpretive Structural Modelling (ISM) and MICMAC analysis. Financial constraints appeared to be the most reported barrier that was present in 20 studies, followed by organizational resistance and skill gaps present in 18 studies each. A four-level hierarchy was produced through the ISM analysis with weak top management support identified as the root cause and supply chain partner incompetence as the most dependent outcome. MICMAC analysis showed that 17 integrated barriers that are highly interrelated confirm that the adoption of challenges for Industry 5.0 is more systematic than isolated. The study makes it easy for managers and policymakers by providing a barrier interaction framework and contributing an integrated and empirically grounded taxonomy of Industry 5.0 adoption barriers, particularly within supply chain management.

Keywords: *Industry 5.0; Supply Chain Management; Systematic Literature Review; Adoption Barriers; Socio-Technical Systems; PRISMA; ISM; MICMAC.*

1.0 Introduction

Over past decades we have seen rapid developments in digital technologies which have fundamentally transformed industrial systems. It gives a new stage of industrial development, which is known as Industry 4.0 emerged through automation, digitization, and the integration of cyberphysical systems, with having the goal of increasing operational precision, productivity and efficiency.

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The Organizations were able to optimize the manufacturing and logistics processes through intelligent automation, leveraging technologies such as artificial intelligence, robotics, the Internet of Things (IoT) and data analytics [1]. Instead of these advancements, Industry 4.0 has been heavily criticized for its techno-centric orientation which implies that it frequently prioritizes machine automation and efficiency over human wellbeing, sustainability, and broader societal considerations [1, 5]. The next phase of the industrial evolution which is known as Industry 5.0 emerged in response to these limitations, placing strong emphasis on the integration of sophisticated automation with human intelligence. Industry 5.0 encourages human-machine collaborations rather than the replacement of human labor and emphasizes human-centric innovation, environmental sustainability and organizational resilience [4, 3].

The complementary notion of the Society 5.0 which extends this shift further and integrates human and societal needs into the technological ecosystems and positions technology as a tool for enhancing the social welfare and quality of life beyond the industrial productivity [2]. As a result Industry 5.0 represents a framework that shifts and balances the sustainable development with ethical responsibility and technological advancement which is seeking to address the shortcomings of auto-driven industrial models by fusing the technological capability with the human creativity, decision-making and social values [5].

We have three interrelated pillars, which is the human centricity, sustainability and resilience, which forms the core framework of the Industry 5.0 [1, 6]. Human centricity promotes skill development, worker empowerment, and meaningful human-machine interaction by positioning the employees as active collaborators within the intelligent production systems. Unlike previous industrial frameworks that treated labor primarily as an operational resource, Industry 5.0 recognizes human creativity, judgment, and problem-solving as indispensable components of the technological system [5, 3].

Sustainability which is the second pillar that emphasizes on resource efficiency, socially conscious business practices and environmentally responsible production [16]. Resilience, which is the third pillar that refers to the capacity of the industrial and the supply chain systems to absorb the disruptions, manage uncertainty and recovers from the unexpected shocks such as a global crises, geopolitical instability and the demand volatility [4, 8]. The Successful digital transformation depends more on incorporating social and ethical dimensions into the technology adoption strategies than on the automation alone [3].

The Supply Chain Management (SCM) is one of the most critical domains which is for operationalising Industry 5.0 principles which connects the technological systems, human decision making and the organizational coordination across the diverse operational activities [6]. The Organizations are increasingly deploying the collaborative robotics, AI-based planning tools, circular supply practices and the human centric work design to build the more adaptive and the responsive supply networks [4]. This Research demonstrates that the Industry 5.0 technologies which is including AI, IoT sensors, robotics, predictive analytics and the digital twins which enhances the supply chain visibility, to reduce operational errors and to enable real time system coordination [5, 18].

Moreover the Industry 5.0 facilitates the simultaneous achievements of the environmental, social and the economic sustainability goals within the supply chains through the energy efficiency, ethical sourcing and the waste reduction strategies [18, 16]. Beyond the operational improvement the supply chains serve as a practical testbeds for the broader societal shift towards the Society 5.0 which is providing a multi-stakeholder environment in which the human centric digital transformation can be tested, implemented and scaled across the industries [2, 6].

2.0 Literature Review

2.1 Definition and principles of industry 5.0

Industry 5.0 represents the next step in industrial development which is built on the foundations of Industry 4.0 but with a shift in focus which is towards the people and sustainability. Ghobakhloo et al. (2022) [3] define Industry 5.0 as a social-technical framework that goes well beyond the efficiency-driven goals of Industry 4.0 by placing human well-being, environmental sustainability, and organizational resilience at the Centre of industrial transformation.

Rane (2024) [4] characterizes industry 5.0 as a framework where intelligent technologies are deployed not as a replacement for human workforce, but to enhance their capabilities, enabling personalized production and ethical governance of automated systems. Xu et al. (2021) [5] positions in industry 5.0 as the coexistence and collaboration between increasingly powerful smart machines and the creative potential of human workers, stating that technology should serve human needs rather than the other way around.

Industry 4.0 was centered around cyber-physical systems which is artificial intelligence, the Internet of Things (IoT) and data-driven automation for greater efficiency which many experts now highlight that this technology-centric approach which has sometimes neglected the vital human, social and environmental aspects [16, 1, 3]. In the response, Industry 5.0 reimagines the role of the people in the industry, which makes them active partners in the intelligent systems rather than the passive users of the automated technology. The latest research describes Industry 5.0 as a framework for collaborative intelligence, where human creativity, judgment and problem-solving skills are combined with the precision and analytical power of the machines [5, 2]. This partnership between humans and the machines is made possible by technologies such as collaborative robots, advanced human-machine interfaces and better decision support tools [6, 4].

2.2 Supply chain 5.0: Evolution and current trends

The Supply Chain 5.0 builds on the Industry 5.0 by bringing its people-focused and sustainable approach to the supply chain management. Instead of just creating faster and more automated supply networks where the Supply Chain 5.0 aims to make these networks more human friendly and environmentally responsible. Earlier the Supply Chain 4.0 was all about the automation, data analysis and using smart technology to make the operations more efficient [6, 18]. The Supply Chain 5.0 changes this by blending the smart automation with the human creativity, judgment and ethics.

According to Kazancoglu et al. (2023) [11], all the manufacturing firms that were surveyed were identified financial constraints as the single most important barrier in between the adoption of industry 5.0 technologies in the supply chain operations. Karmaker et al. (2023) [26] found that in developing economies, the skill gap in the workforce was reported as a critical barrier by over 80% of respondents in the survey, where most of the organization were lacking a structured training program for Industry 5.0 competencies.

2.3 Existing studies on industry 5.0 adoption barriers

In the Recent research which demonstrates that the barriers to adopt the Industry 5.0 which extends well beyond the purely technological concerns which is involving the complex interactions between social, organizational, economical and institutional factors [20, 17, 21]. The human-related barriers which is frequently emerge as one of the major constraint which is including the limited

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digital skills and low technology acceptance, safety concerns and the organizational resistance to change [20, 17]. The Organizational factors, such as the rigid structures, insufficient leadership support and the weak change management capabilities which make further hinder adoption readiness across the industries [19, 11].

Technological barriers continues it in the form of interoperability challenges, cybersecurity risks, and a framework that is not present for the deployment of cyber-physical systems [17, 13]. The Sectoral studies present the adoption profiles that are content specific, where integration complexity is being faced by manufacturing supply chains and the infrastructure gaps [22, 10], while the contexts of emerging economy are disproportionately constrained by the financial limitations and skills shortages [23, 26].

SMEs are focused on research which highlights the compounding effect of financial constraints and the organizational unreadiness, which together make structural barriers that are difficult to overcome through isolated technological interventions [15, 25]. Together, these findings confirm that the Industry 5.0 adoption represents a systemic socio-technical transformation rather than a straightforward technological upgrade.

3.0 Research Gaps and Objectives

Though there have been many studies on Industry 5.0 but still major gaps are still a big question and its implementation in supply chain management:

- Most of the studies done previously are completely theoretical without any real evidence [4, 3].
- Adoption for any organization is studied at the individual level, ignoring multiple-level supply chain changes [18, 4].
- Human-centricity, sustainability, and resilience are inspected separately, not studied as interconnected [16, 5].
- SMEs and emerging economies are significantly underrepresented in prior works [15, 23].
- Legal, ethical, and governance dimensions of human-machine are still not studied to a deep extent [19, 20].
- Barrier classifications are divided and technically not consistent across studies [20, 21].
- Previous studies do not connect the adoption barrier that could be used to measure the supply chain outcomes [19, 18].

Based on the research questions derived from the identified gaps, the following objectives guide this study:

- **RO1:** To identify all the barriers and then categorize them systematically for the adoption of Industry 5.0 reported in prior works within supply chain management.
- **RO2:** To develop an integrated barrier coding framework spanning technological, organisational, human, financial, regulatory, and external supply chain dimensions.
- **RO3:** To conduct frequency analysis across 21 empirical studies and determine the occurrence of each barrier and categorise them.
- **RO4:** To apply Interpretive Structural Modeling (ISM) and MICMAC analysis to establish ordered causal relationships among the identified barriers.
- **RO5:** To present a study that shows the interaction between sociotechnical barriers and shows how the barriers are interconnected and influence each other to shape Industry 5.0 adoption results in the supply chain.

4.0 Methodology

4.1 Research design

This study employs the combination of systematic literature review (SLR) and thematic analysis for exploring and categorizing the key barriers that businesses face when implementing Industry 5.0 in the supply chain management context. The systematic literature review approach was chosen as a research methodology due to the absence of empirically-based research on the topic of Industry 5.0 implementation within different industries and geographies. This research strategy provides opportunities for conducting a comprehensive synthesis of empirically-based literature while ensuring a minimum risk of selection bias by means of utilizing certain standardized and replicable methodologies. Systematic reviews are considered more reliable than narrative reviews since researchers use particular protocols in order to select, appraise, and synthesize the selected papers [3]. Thematic manual coding was performed according to PRISMA. Barriers codes from 21 empirical studies were extracted. Each extracted barrier code underwent standardized coding procedures. The frequency was measured by the number of publications that mentioned each code.

4.2 Inclusion and exclusion criteria

To ensure methodological consistency and minimize selection bias, inclusion and exclusion criteria were predefined before conducting the search process. The inclusion criteria were that studies should: [1] examine adoption of the Industry 5.0, Society 5.0, or Supply Chain 5.0; [2] adopt methods of primary data collection, including survey, interview, case study or analysis (AHP, DEMATEL, ISM, and fuzzy methods); [3] highlight adoption barriers, challenges or constraints, and [4] be published within the period from 2018 until 2026. On the other hand, studies were excluded when they were: [1] only conceptual, theoretical, or review-based without any empirical data; [2] concerned solely with Industry 4.0 without mentioning transitions toward the Industry 5.0; or [3] failed to focus on supply chain, manufacturing, or logistics.

4.3 Review Protocol (PRISMA approach)

The review process followed by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 framework to ensure the methodological transparency and reproducibility [4, 3]. This PRISMA methodology consists of four stages:

1. Identification: The studies that are required for the research are found through database searches across Scopus, Web of Science, and Google Scholar using keyword strings, which resulted in a total of 187 initial records.
2. Screening: After the removal of 33 duplicate records, 154 unique records were screened by referencing their titles and abstracts. A further 97 records were excluded as the irrelevant to Industry 5.0 adoption or the supply chain contexts, leaving 57 records for full-text evaluation.
3. Eligibility: The Full-text articles (n = 57) were assessed against the predefined inclusion and exclusion criteria. A total of 44 articles were excluded: 28 were conceptual or review papers without primary empirical data, 11 addressed unrelated sectors or contexts, and the 5 contained insufficient barrier data for extraction.
4. Inclusion: The Twenty-one empirical studies were satisfying all eligibility criteria were retained for final data extraction, barrier coding, and thematic analysis.

(“Industry 5.0” AND “Supply Chain”) AND (“barriers” OR “challenges” OR “adoption”) Secondary search strings were applied to capture the studies using alternative terminology: (“Society

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5.0" OR "Supply Chain 5.0") AND ("barriers" OR "implementation challenges") ("Industry 5.0") AND ("AHP" OR "DEMATEL" OR "ISM" OR "fuzzy") AND ("supply chain" OR "manufacturing")

4.4 Data extraction and coding

A well-structured framework was used for the extraction of all the barrier data which recorder authors, year, methodology, context, barrier identified, and assigned barrier codes. Individual barriers were coded using a standardised taxonomy of 26 codes spanning six categories: human (H1–H6), organisational (O1–O5), technological (T1–T6), financial (F1–F4), regulatory (R1–R3), and external/supply chain (E1–E2). The number of studies were first calculated and then frequency analysis was done, which reported each barrier code that helps in the identification of the barriers in the adoption of Industry 5.0.

5.0 Results: Barrier Identification and Frequency Analysis

5.1 Overview of identified barriers

The findings from this paper fall the light on the main barrier which a organizations face when they try to get Industry 5.0 in practices. By analysing the 21 empirical studies of different domains which are having textiles, automotive, manufacturing and supply chains in the growing economies where we differentiate and make the categories of the barriers into the six different categories which are: Technological barriers; Organizational barriers; Human-centric (skill-related) barriers; Economic and financial barriers; Regulatory and policy barriers; and External and supply chain barriers. This foundational classification gives us the right to compare the challenges across studies and highlight the barrier which appears again and again in the study.

5.2 Barrier categories and coding framework

Technological Barriers: This category contains the full range of difficulties which a organisation may face with tools, systems, infrastructure and basic standards which is required to implement the industry 5.0 technologies. Apart from the industry 4.0 which is mostly involved in upgrading the existing digital systems where the industry 5.0 demands the collaboration of cyber-physical systems (CPS), collaborative robotics, high tech human machine interface all of which must operate together within existing and often older infrastructure. In this category we find six sub-barrier categories coded as T1–T6: T1 — interoperability challenges between legacy and emerging systems (9 studies); T2 — system integration complexity across the cyber-physical infrastructure (17 studies); T3 — cybersecurity vulnerabilities and data privacy risk (11 studies); T4 — digital infrastructure limitation and inadequate IT readiness (12 studies); T5 — data quality, availability and standardization (6 studies); T6 — technology immaturity and scalability (8 studies).

Organizational Barriers: Organisational barriers are the internal structural, cultural and managerial barriers that prevent companies from effectively planning, coordinating and implementing the industry 5.0 adoption initiatives. These barriers are particularly spread gradually because they often remain unnoticeable until a transformation initiative is already in process. In this category we find five subcategories: O1 — organisational resistance and change management challenges (18 studies); O2 — lack of top management support and strategic alignment (14 studies); O3 — absence of strategic roadmap and unclear business model (9 studies); O4 — siloed departments and poor cross-functional communication (6 studies); O5 — inadequate performance metrics and KPI misalignment (4 studies).

Human and Skill-Related Barriers: Human and skill related barriers indicate the gap between the capabilities that Industry 5.0 wants from the workforce and the capabilities which currently exist within the organisation and labour markets. Industry 5.0 does not only require technical upskilling, it wants a fundamental re-conception of what human work means in an era of intelligent automation. In this category we find six sub-barriers: H1 — skills gap and lack of workforce training (18 studies); H2 — limited awareness and understanding of Industry 5.0 concepts (7 studies); H3 — cultural resistance to technological change (5 studies); H4 — trust issues toward intelligent technologies (4 studies); H5 — fear of job loss and job displacement concerns (10 studies); H6 — safety and ergonomic concerns in human-machine collaboration environments (6 studies).

Financial Barriers: Financial barriers show as the most important category overall, reported in about 20 out of 21 empirical studies. This finding challenges the assumptions of earlier Industry 4.0 literature, which is purely about technological immaturity or skill gaps as the main adoption barrier. The evidence from this systematic review suggests that the technologies have become more commercially available, and the real bottleneck has shifted to financial capacity. In this category we find four sub-barrier categories: F1 — high investment cost and limited financial resources (20 studies); F2 — unclear return on investment and long payback period (13 studies); F3 — high ongoing operational and maintenance cost (7 studies); F4 — lack of external funding, grants and financial incentives (5 studies).

Table 1: Barrier Coding Framework — 26 Barriers Across Six Dimensions

Code	Category	Standardized Barrier Description
H1	Human	Skills gap and lack of workforce training for Industry 5.0 technologies
H2	Human	Limited awareness and understanding of Industry 5.0 concepts and benefits
H3	Human	Cultural resistance to technological change and new work frameworks
H4	Human	Trust issues toward intelligent technologies and autonomous systems
H5	Human	Fear of job loss and job displacement concerns due to automation
H6	Human	Safety and ergonomic concerns in human-machine collaboration environments
O1	Organizational	Organizational resistance and change management challenges
O2	Organizational	Lack of top management support and strategic alignment issues
O3	Organizational	Absence of strategic roadmap and unclear business model for I5.0 transition
O4	Organizational	Siloed departments and poor cross-functional communication
O5	Organizational	Inadequate performance metrics and KPI misalignment with I5.0 objectives
T1	Technological	Interoperability challenges between legacy and emerging systems
T2	Technological	System integration complexity across cyber-physical infrastructure
T3	Technological	Cybersecurity vulnerabilities and data privacy risks
T4	Technological	Digital infrastructure limitations and inadequate IT readiness
T5	Technological	Data quality, availability, and standardization issues
T6	Technological	Technology immaturity and scalability concerns
F1	Financial	High investment cost and limited financial resources for I5.0 adoption
F2	Financial	Unclear return on investment (ROI) and long payback period
F3	Financial	High ongoing operational and maintenance costs of advanced technologies
F4	Financial	Lack of external funding, grants, and financial incentives (SME-specific)
R1	Regulatory	Regulatory uncertainty and compliance complexity across jurisdictions
R2	Regulatory	Ethical and governance concerns related to AI and human-machine interaction
R3	Regulatory	Absence of industry standards and certification frameworks for Industry 5.0
E1	Ext./SC	Supply chain partner unreadiness and lack of inter-organizational collaboration
E2	Ext./SC	Market volatility, disruption risks, and demand uncertainty

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Regulatory Barriers: Regulatory and legal barriers usually stem from a simple gap — the technology moves fast but the law moves slow. When companies are not sure how to remain compliant, they hesitate to invest, fear potential risks and get bogged down in institutional grey areas. In fact, our ISM analysis identifies Regulatory Uncertainty (R1) as a primary root cause. In this category we find three sub-barriers: R1 — regulatory uncertainty and compliance complexity across jurisdictions (10 studies); R2 — ethical and governance concerns related to AI and human-machine interaction (7 studies); R3 — absence of industry standards and certification framework for Industry 5.0 (5 studies).

External / Supply Chain Barriers: External and Supply chain barriers represent a category that is unique to the Supply Chain management context. These barriers originate beyond the boundaries of any single organization and reflect the fundamental reality that supply chain transformation requires coordinated action across multiple independent actors. Our ISM analysis places E1 (Supply Chain Partner Unreadiness) at Level I, which is the top of the hierarchy as a dependent outcome, reflecting that it is the most visible manifestation of the successive failures of underlying root cause barriers across the supply chain ecosystem. In this category we find two sub-barriers: E1 — Supply chain partner unreadiness and lack of inter-organizational collaboration (9 studies); E2 — market volatility, disruptions, risks and demand uncertainty (5 studies).

5.3 Frequency analysis

As compared to 21 pieces of literature, financial limitation (F1) proves to be the second highest frequency barrier that occurs in 20 out of 21 cases. The organisational resistance (O1) barrier came in second place in 18 pieces of literature. Both human capacity limitation (H1) and technological integration difficulty (T2) barriers occurred in 18 and 17 pieces of literature, demonstrating the interrelation of workforce preparedness and technological integration. The cybersecurity risks (T3) and insufficient technological infrastructure (T4) proved to have 11 and 12 frequencies respectively, whereas regulatory limitations (R1) were cited in 10 pieces of literature. The less frequent barriers such as interoperability issue (T1), lack of awareness (H2), governance mismatch (O2), cultural resistance (H3), and ethical considerations (R2) have fewer than 6 citations each, indicating their contextual importance.

Barrier Financial constraint (F1) emerges as one of the most significant barriers in the entire body of literature, occurring in 20 out of 21 empirical studies. As mentioned above, this indicates a very important difference from the dominant Industry 4.0 paradigm where the technological immaturity and skills gap of workforce were seen as the main barriers to adoption. This makes sense as, by the time Industry 5.0 became relevant and commercially available, the issue was no longer whether the technology could be created but rather whether companies can afford implementing it. Therefore, an entirely new set of strategies has come into play.

Barrier Organizational resistance (O1) was identified in 18 out of 21 reviewed studies, being the second most common barrier overall. This result supports the idea that Industry 5.0 technologies adoption cannot be considered an exogenous process driven by external factors. Instead, organizational resistance indicates that Industry 5.0 implementation faces deep-rooted organizational issues related to leadership, change management, and organizational culture. Barrier System integration complexity (T2) was discussed in 17 out of 21 empirical studies, being the most important barrier of a technological nature and the fourth most common barrier overall.

Table 2: Frequency Analysis of Barriers Across 21 Empirical Studies

Code	Barrier Description	Frequency (No. of Studies)	Relative Importance
F1	High investment cost and limited financial resources	20	Very High
O1	Organizational resistance and change management challenges	18	Very High
H1	Skills gap and lack of workforce training	18	Very High
T2	System integration complexity	17	Very High
O2	Lack of top management support and strategic alignment	14	High
F2	Unclear ROI and long payback period	13	High
T4	Digital infrastructure limitations	12	High
T3	Cybersecurity vulnerabilities and data privacy risks	11	High
R1	Regulatory uncertainty and compliance complexity	10	High
H5	Fear of job loss and job displacement concerns	10	High
T1	Interoperability challenges between systems	9	Moderate
E1	Supply chain partner unreadiness and lack of collaboration	9	Moderate
O3	Absence of strategic roadmap and unclear business model	9	Moderate
T6	Technology immaturity and scalability concerns	8	Moderate
F3	High ongoing operational and maintenance costs	7	Moderate
H2	Limited awareness of Industry 5.0 concepts	7	Moderate
R2	Ethical and governance concerns	7	Moderate
T5	Data quality, availability, and standardization issues	6	Moderate
O4	Siloed departments and poor cross-functional communication	6	Moderate
H6	Safety and ergonomic concerns in human-machine collaboration	6	Moderate
R3	Absence of industry standards and certification frameworks	5	Low-Moderate
F4	Lack of external funding, grants, and financial incentives	5	Low-Moderate
E2	Market volatility, disruption risks, and demand uncertainty	5	Low-Moderate
H3	Cultural resistance to technological change	5	Low-Moderate
O5	Inadequate performance metrics and KPI misalignment	4	Low
H4	Trust issues toward intelligent technologies	4	Low
	Total Frequency Sum	245	n = 21 studies

6.0 Interpretive Structural Modelling (ISM) Analysis

The frequency analysis shows the frequency of barriers that are appearing. It does not show how they are connected through causal relationships, hierarchical dependencies, or structural interactions. To show the list of barriers and show how they are connected and influence each other, Interpretive Structural Modeling (ISM), along with MICMAC analysis, is used. ISM is a well-established method for showing the directional relationships between elements of a complex system, and it has a strong track record in operations management and supply chain research [34]. From the 26 barriers listed in Table 1, we selected 20 barriers for structural modelling.

6.1 Barrier selection for ISM analysis

For the application of ISM methodology, barriers that were reported in the reviewed studies were selected, resulting in 20 barriers for structural modelling. The frequency of number of studies ensures the inclusion of those barriers that have sufficient empirical support across many studies. Barriers that were included in fewer studies and had low moderate importance and lower were

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excluded as they were content specific. Table 3 presents the 20 selected barriers along with the studies that identified each barrier.

Table 3: Barriers Selected for ISM Analysis

S.No	Code	Barrier	Freq.	Supporting Studies
1	F1	High investment cost	20	Kazancoglu et al. (2023); Castillo et al. (2025); Nazarian & Khan (2024); Lekamge (2024); Bernhard et al. (2025); Kannan et al. (2024); Kaswan et al. (2026); Mohamed & Gamal (2023); Hsu et al. (2024); Cevik Aka (2025); Sahu & Mukti (2025); Chrifi-Alaoui et al. (2025); Karmaker et al. (2023); Mukherjee et al. (2023); Masoomi et al. (2023); Garrido et al. (2025); Civelek et al. (2025); Nazarian & Khan (2025); Ahmed et al. (2024); Ahmad et al. (2024)
2	O1	Organizational resistance	18	Kazancoglu et al. (2023); Castillo et al. (2025); Kannan et al. (2024); Kaswan et al. (2026); Mohamed & Gamal (2023); Al Amin & Baldacci (2024); Hsu et al. (2024); Cevik Aka (2025); Chrifi-Alaoui et al. (2025); Karmaker et al. (2023); Garrido et al. (2025); Civelek et al. (2025); Nazarian & Khan (2025); Ahmad et al. (2024); Oukili Garti et al. (2025); Hangl et al. (2022); Cingoz (2025); Sahu & Mukti (2025)
3	H1	Workforce skills gap	18	Kazancoglu et al. (2023); Castillo et al. (2025); Lekamge (2024); Bernhard et al. (2025); Kaswan et al. (2026); Mohamed & Gamal (2023); Hsu et al. (2024); Cevik Aka (2025); Sahu & Mukti (2025); Karmaker et al. (2023); Mukherjee et al. (2023); Masoomi et al. (2023); Garrido et al. (2025); Civelek et al. (2025); Nazarian & Khan (2025); Ahmed et al. (2024); Hangl et al. (2022); Oukili Garti et al. (2025)
4	T2	Integration complexity	17	Nazarian & Khan (2024); Lekamge (2024); Kannan et al. (2024); Kaswan et al. (2026); Mohamed & Gamal (2023); Al Amin & Baldacci (2024); Hsu et al. (2024); Cevik Aka (2025); Sahu & Mukti (2025); Chrifi-Alaoui et al. (2025); Karmaker et al. (2023); Civelek et al. (2025); Nazarian & Khan (2025); Ahmed et al. (2024); Hangl et al. (2022); Oukili Garti et al. (2025); Cingoz (2025)
5	O2	Weak management support	14	Kannan et al. (2024); Mohamed & Gamal (2023); Sahu & Mukti (2025); Karmaker et al. (2023); Mukherjee et al. (2023); Masoomi et al. (2023); Nazarian & Khan (2025); Hsu et al. (2024); Hangl et al. (2022); Oukili Garti et al. (2025); Cingoz (2025); Chrifi-Alaoui et al. (2025); Al Amin & Baldacci (2024); Bernhard et al. (2025)
6	F2	Unclear ROI	13	Garrido et al. (2025); Civelek et al. (2025); Nazarian & Khan (2024); Kannan et al. (2024); Kaswan et al. (2026); Hsu et al. (2024); Sahu & Mukti (2025); Chrifi-Alaoui et al. (2025); Karmaker et al. (2023); Mukherjee et al. (2023); Hangl et al. (2022); Oukili Garti et al. (2025); Bernhard et al. (2025)
7	T4	Infrastructure limitations	12	Nazarian & Khan (2024); Kannan et al. (2024); Al Amin & Baldacci (2024); Hsu et al. (2024); Sahu & Mukti (2025); Chrifi-Alaoui et al. (2025); Mukherjee et al. (2023); Ahmad et al. (2024); Hangl et al. (2022); Oukili Garti et al. (2025); Cingoz (2025); Cevik Aka (2025)
8	T3	Cybersecurity risks	11	Nazarian & Khan (2024); Lekamge (2024); Bernhard et al. (2025); Al Amin & Baldacci (2024); Ahmad et al. (2024); Ahmed et al. (2024); Garrido et al. (2025); Hangl et al. (2022); Oukili Garti et al. (2025); Kaswan et al. (2026); Cingoz (2025)

9	R1	Regulatory uncertainty	10	Castillo et al. (2025); Lekamge (2024); Bernhard et al. (2025); Sahu & Mukti (2025); Karmaker et al. (2023); Mukherjee et al. (2023); Masoomi et al. (2023); Ahmed et al. (2024); Hangl et al. (2022); Oukili Garti et al. (2025)
10	H5	Job displacement fear	10	Cevik Aka (2025); Civelek et al. (2025); Castillo et al. (2025); Hangl et al. (2022); Sahu & Mukti (2025); Karmaker et al. (2023); Chrifi-Alaoui et al. (2025); Nazarian & Khan (2025); Oukili Garti et al. (2025); Mohamed & Gamal (2023)
11	T1	Interoperability challenges	9	Kazancoglu et al. (2023); Kannan et al. (2024); Kaswan et al. (2026); Al Amin & Baldacci (2024); Hangl et al. (2022); Oukili Garti et al. (2025); Cingoz (2025); Sahu & Mukti (2025); Nazarian & Khan (2024)
12	E1	SC partner unreadiness	9	Al Amin & Baldacci (2024); Hsu et al. (2024); Nazarian & Khan (2025); Karmaker et al. (2023); Oukili Garti et al. (2025); Civelek et al. (2025); Sahu & Mukti (2025); Hangl et al. (2022); Cingoz (2025)
13	O3	No strategic roadmap	9	Karmaker et al. (2023); Mohamed & Gamal (2023); Nazarian & Khan (2025); Kannan et al. (2024); Hsu et al. (2024); Chrifi-Alaoui et al. (2025); Oukili Garti et al. (2025); Sahu & Mukti (2025); Cingoz (2025)
14	T6	Technology immaturity	8	Kannan et al. (2024); Kaswan et al. (2026); Nazarian & Khan (2024); Sahu & Mukti (2025); Hangl et al. (2022); Oukili Garti et al. (2025); Mukherjee et al. (2023); Cingoz (2025)
15	F3	High maintenance costs	7	Mukherjee et al. (2023); Garrido et al. (2025); Nazarian & Khan (2024); Ahmad et al. (2024); Hangl et al. (2022); Oukili Garti et al. (2025); Sahu & Mukti (2025)
16	H2	Limited awareness	7	Nazarian & Khan (2024); Mohamed & Gamal (2023); Hsu et al. (2024); Hangl et al. (2022); Oukili Garti et al. (2025); Cingoz (2025); Sahu & Mukti (2025)
17	R2	Ethical governance concerns	7	Al Amin & Baldacci (2024); Cevik Aka (2025); Hangl et al. (2022); Oukili Garti et al. (2025); Sahu & Mukti (2025); Cingoz (2025); Karmaker et al. (2023)
18	T5	Data quality issues	6	Al Amin & Baldacci (2024); Nazarian & Khan (2024); Hangl et al. (2022); Oukili Garti et al. (2025); Sahu & Mukti (2025); Cingoz (2025)
19	O4	Siloed departments	6	Kannan et al. (2024); Hsu et al. (2024); Chrifi-Alaoui et al. (2025); Oukili Garti et al. (2025); Sahu & Mukti (2025); Cingoz (2025)
20	H6	Safety & ergonomic concerns	6	Cevik Aka (2025); Hangl et al. (2022); Oukili Garti et al. (2025); Sahu & Mukti (2025); Castillo et al. (2025); Cingoz (2025)

6.2 Structural Self-Interaction Matrix (SSIM)

The SSIM was constructed by carefully reviewing the findings from the 21 empirical studies. For each pair of barriers, the direction of the relationship was established by examining cause-and-effect patterns, interaction dynamics, and interdependencies documented in the literature [35]. The full picture of pairwise relationships across all 20 barriers is presented in the SSIM [35]. The construction of the SSIM was guided by the interaction patterns observed across the 21 included studies, supplemented by established theoretical frameworks from sociotechnical systems theory and organizational change management literature [35].

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Table 4: Structural Self-Interaction Matrix (SSIM) of Industry 5.0 Adoption Barriers

Factor	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. F1		A	A	X	A	X	X	A	A	V	A	V	A	A	X	A	O	O	O	V
2. O1			A	V	A	V	O	O	A	X	O	V	A	O	O	A	A	O	X	V
3. H1				V	A	O	O	O	O	V	O	V	A	O	O	X	O	V	O	V
4. T2					A	V	A	A	A	O	A	V	A	A	V	A	O	O	A	O
5. O2						V	V	V	O	V	V	V	V	V	V	V	V	V	V	V
6. F2							O	O	A	O	O	O	A	A	X	A	O	O	O	O
7. T4								V	A	O	V	V	A	X	V	O	O	X	O	O
8. T3									A	O	O	V	O	O	V	O	X	X	O	O
9. R1										V	V	V	O	V	V	O	X	V	O	V
10. H5											O	O	O	O	O	A	A	O	O	X
11. T1												V	O	X	O	O	O	X	A	O
12. E1													A	O	O	A	O	A	A	O
13. O3														V	V	V	V	V	V	V
14. T6															V	O	O	X	O	V
15. F3																O	O	O	O	O
16. H2																	O	O	A	V
17. R2																		O	O	V
18. T5																			A	O
19. O4																				O
20. H6																				

6.3 Initial reachability matrix

Standard conversion rules are used to convert SSIM into initial binary reachability matrix.

Table 5: Initial Reachability Matrix of Industry 5.0 Adoption Barriers

Factor	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Drive
1. F1	1	0	0	1	0	1	1	0	0	1	0	1	0	0	1	0	0	0	0	1	8
2. O1	1	1	0	1	0	1	0	0	0	1	0	1	0	0	0	0	0	0	1	1	8
3. H1	1	1	1	1	0	0	0	0	0	1	0	1	0	0	0	1	0	1	0	1	9
4. T2	1	0	0	1	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	5
5. O2	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	19
6. F2	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3
7. T4	1	0	0	1	0	0	1	1	0	0	1	1	0	1	1	0	0	1	0	0	9
8. T3	1	0	0	1	0	0	0	1	0	0	0	1	0	0	1	0	1	1	0	0	7
9. R1	1	1	0	1	0	1	1	1	1	1	1	1	0	1	1	0	1	1	0	1	15
10. H5	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	3
11. T1	1	0	0	1	0	0	0	0	0	0	1	1	0	1	0	0	0	1	0	0	6
12. E1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
13. O3	1	1	1	1	0	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	15
14. T6	1	0	0	1	0	1	1	0	0	0	1	0	0	1	1	0	0	1	0	1	9
15. F3	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3
16. H2	1	1	1	1	0	1	0	0	0	1	0	1	0	0	0	1	0	0	0	1	9
17. R2	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	1	6
18. T5	0	0	0	0	0	0	1	1	0	0	1	1	0	1	0	0	0	1	0	0	6
19. O4	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0	1	0	1	1	0	7
20. H6	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	2
Dependence	14	9	4	13	1	10	7	6	2	9	7	14	2	7	10	5	5	10	4	11	

Each relationship symbol was converted into a pair of 1s and 0s which is based on the direction of influence: V gives a 1 at position (i,j) and 0 at (j,i); A gives the reverse; X gives 1 in both directions; and O gives 0 in both. Then all the diagonal entries are set to 1. After which initial reachability matrix and driving power are determined [35].

6.4 Final reachability matrix

The first reachability matrix was modified by applying the transitivity principle to factor in any indirect influences. This is because when barrier i can influence barrier k, which in turn can influence barrier j, then barrier i can influence barrier j indirectly, despite there being no link between barrier i and j before. These connections are marked as '1*.' The final reachability matrix takes into account both direct and indirect influences between the barriers, which have their respective driving powers and dependencies assigned [35].

Table 6: Final Reachability Matrix with Driving Power and Dependence

Factor	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Drive
1. F1	1	1*	1*	1	0	1	1	1*	1*	1	1*	1	0	1*	1	1*	1*	1*	1*	1	18
2. O1	1	1	1*	1	0	1	1*	1*	1*	1	1*	1	0	1*	1*	1*	1*	1*	1	1	18
3. H1	1	1	1	1	0	1*	1*	1*	1*	1	1*	1	0	1*	1*	1	1*	1	1*	1	18
4. T2	1	1*	1*	1	0	1	1*	1*	1*	1*	1*	1	0	1*	1	1*	1*	1*	1*	1*	18
5. O2	1	1	1	1	1	1	1	1	1*	1	1	1	1	1	1	1	1	1	1	1	20
6. F2	1	1*	1*	1*	0	1	1*	1*	1*	1*	1*	1*	0	1*	1	1*	1*	1*	1*	1*	18
7. T4	1	1*	1*	1	0	1*	1	1	1*	1*	1	1	0	1	1	1*	1*	1	1*	1*	18
8. T3	1	1*	1*	1	0	1*	1*	1	1*	1*	1*	1	0	1*	1	1*	1	1	1*	1*	18
9. R1	1	1	1*	1	0	1	1	1	1	1	1	1	0	1	1	1*	1	1	1*	1	18
10. H5	1*	1	1*	1*	0	1*	1*	1*	1*	1	1*	1*	0	1*	1*	1*	1*	1*	1*	1	18
11. T1	1	1*	1*	1	0	1*	1*	1*	1*	1*	1	1	0	1	1*	1*	1*	1	1*	1*	18
12. E1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
13. O3	1	1	1	1	0	1	1	1*	1*	1*	1*	1	1	1	1	1	1	1	1	1	19
14. T6	1	1*	1*	1	0	1	1	1*	1*	1*	1	1*	0	1	1	1*	1*	1	1*	1	18
15. F3	1	1*	1*	1*	0	1	1*	1*	1*	1*	1*	1*	0	1*	1	1*	1*	1*	1*	1*	18
16. H2	1	1	1	1	0	1	1*	1*	1*	1	1*	1	0	1*	1*	1	1*	1*	1*	1	18
17. R2	1*	1	1*	1*	0	1*	1*	1	1	1	1*	1*	0	1*	1*	1*	1	1*	1*	1	18
18. T5	1*	1*	1*	1*	0	1*	1	1	1*	1*	1	1	0	1	1*	1*	1*	1	1*	1*	18
19. O4	1*	1	1*	1	0	1*	1*	1*	1*	1*	1	1	0	1*	1*	1	1*	1	1	1*	18
20. H6	1*	1*	1*	1*	0	1*	1*	1*	1*	1	1*	1*	0	1*	1*	1*	1*	1*	1*	1	18
Dependence	19	19	19	19	1	19	19	19	19	19	19	20	2	19	19	19	19	19	19	19	

6.5 Level partitioning

Hierarchical partitioning is achieved by establishing a hierarchy of the barriers using a continuous process of comparing the reachability set of a barrier with the antecedent set of the same barrier. If the reachability set is equal to the intersection between the reachability set and the antecedent set, the barrier is considered part of the current level; this is followed by the removal of the barrier from the list, and the same is repeated until all barriers have been classified [35].

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Table 7: Level Partitioning of Industry 5.0 Adoption Barriers

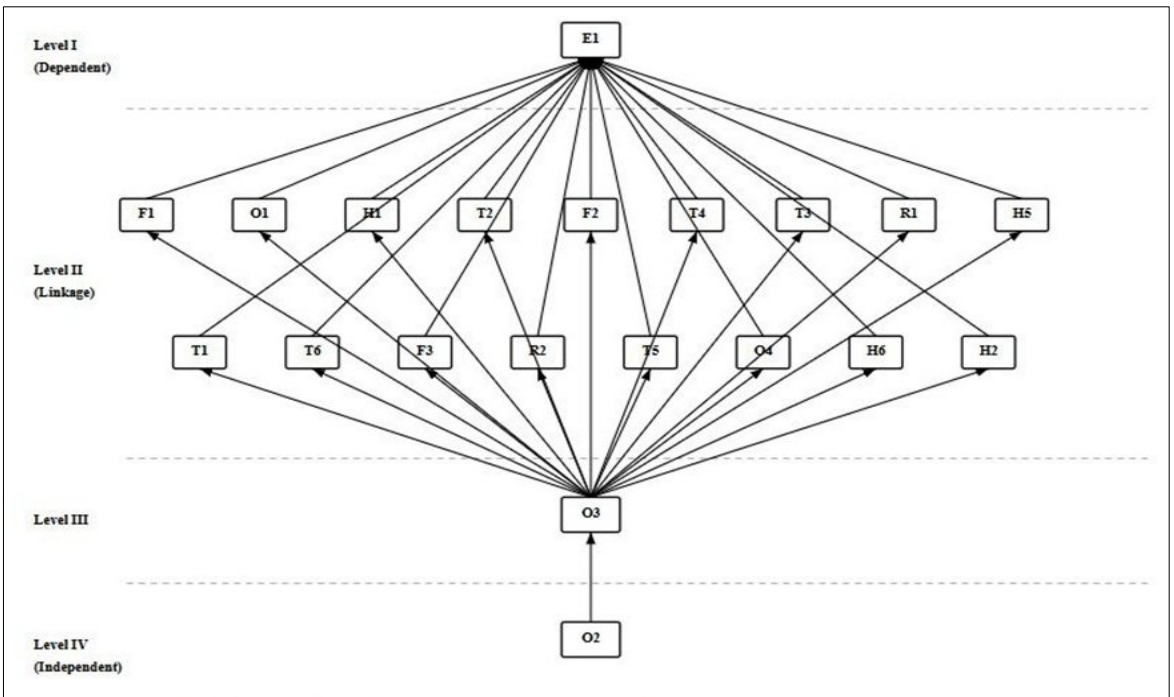
S.No	Code	Barrier	Reachability Set	Antecedent Set	Intersection	Level
1	F1	High investment cost	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20	2
2	O1	Org. resistance	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20	2
3	H1	Workforce skills gap	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20	2
4	T2	Integration complexity	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20	2
5	O2	Weak mgmt support	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20	5	5	4
6	F2	Unclear ROI	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20	2
7	T4	Infrastructure limits	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20	2
8	T3	Cybersecurity risks	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20	2
9	R1	Regulatory uncertainty	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20	2
10	H5	Job displacement fear	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20	2
11	T1	Interoperability	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20	2
12	E1	SC partner unreadiness	12	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20	12	1
13	O3	No strategic roadmap	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20	5, 13	13	3
14	T6	Technology immaturity	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20	2
15	F3	High maint. costs	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20	2
16	H2	Limited awareness	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20	2

17	R2	Ethical governance	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20	2
18	T5	Data quality issues	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20	2
19	O4	Siloed departments	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20	2
20	H6	Safety & ergonomics	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20	2

6.6 Final ISM model

The final ISM model presents the hierarchical structure of Industry 5.0 adoption barriers with barrier codes and names clearly labelled at each level. The model reveals a four-level hierarchy: E1 (SC Partner Unreadiness) at Level I as the most dependent outcome; 17 barriers forming the linkage cluster at Level II; O3 (Absence of Strategic Roadmap) at Level III as a semi-independent driver; and O2 (Weak Top Management Support) at Level IV as the root cause with the highest driving power (20) and lowest dependence (1).

Figure 1: Final ISM Model — Hierarchical Structure of Industry 5.0 Adoption Barriers



Note: Arrows indicate direction of influence (from lower level to upper level). Dashed lines separate hierarchy levels.

Level	Category	Barriers
Level I (Top)	Dependent	E1 — SC Partner Unreadiness
Level II	Linkage	F1, O1, H1, T2, F2, T4, T3, R1, H5, T1, T6, F3, R2, T5, O4, H6, H2
Level III	Semi-Independent	O3 — Absence of Strategic Roadmap
Level IV (Bottom)	Independent (Root Cause)	O2 — Weak Top Management Support

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7.0 MICMAC Analysis

The MICMAC (Cross-Impact Matrix Multiplication Applied to Classification) analysis is used to classify the 20 barriers into four quadrants, which is based on the driving power and dependence values that come from the final reachability matrix. The four quadrants are: quadrants I (Autonomous) that is a weak driver and weak dependence; quadrants II (Dependent), which represents a weak driver and strong dependence; Cluster III (Linkage) is a strong driver and strong dependence; Cluster IV (Independent) represents a strong driver and weak dependence. As per the MICMAC analysis, O2 (Lack of Weak Management Support) and O3 (Lack of Strategic Roadmap) lie in Quadrant IV as independent variables, where both have a very high level of driving power but low dependence, indicating that they are indeed root causes. E1 (SC Partner Unreadiness) stands as the only barrier in Quadrant II as a dependent variable having very low driving power while being highly dependent. The remaining 17 barriers form part of Quadrant III as linkage variables, indicating that all these barriers are inter-related and any change made to one barrier shall reflect across the entire system as they all have a high level of driving power and high dependence on each other.

Table 8: MICMAC Classification of 20 Industry 5.0 Adoption Barriers

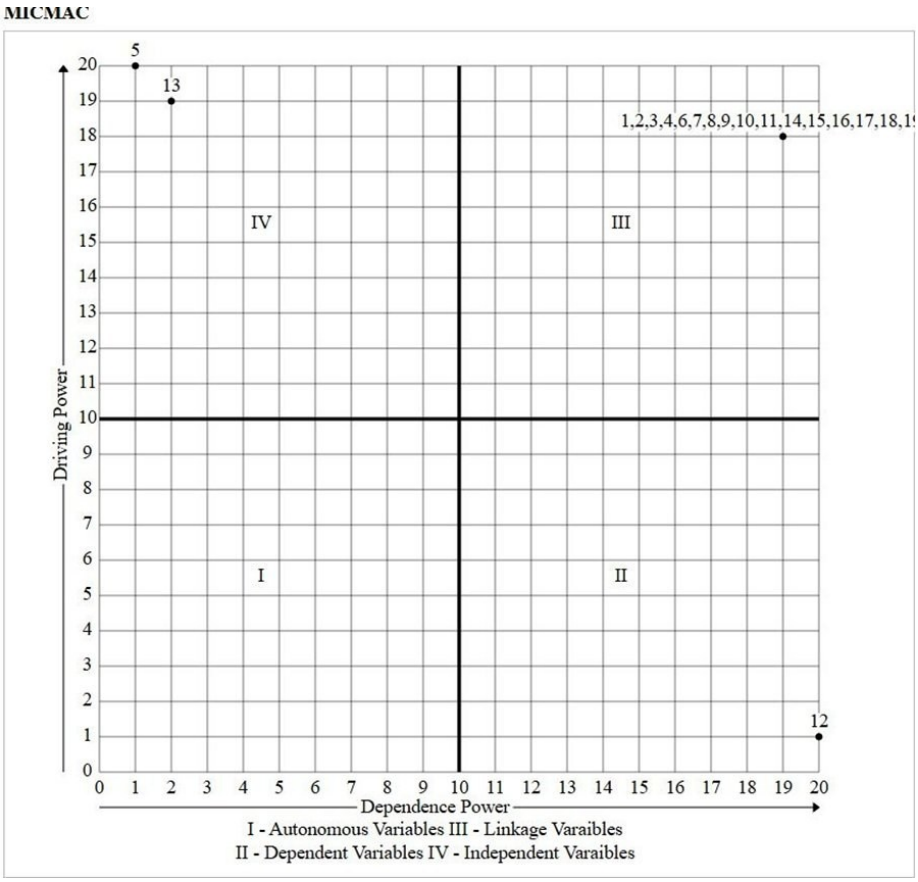
S.No	Code	Barrier	Driving Power	Dependence Power	Quadrant	Category
1	F1	High investment cost	18	19	III	Linkage
2	O1	Organizational resistance	18	19	III	Linkage
3	H1	Workforce skills gap	18	19	III	Linkage
4	T2	Integration complexity	18	19	III	Linkage
5	O2	Weak management support	20	1	IV	Independent
6	F2	Unclear ROI	18	19	III	Linkage
7	T4	Infrastructure limitations	18	19	III	Linkage
8	T3	Cybersecurity risks	18	19	III	Linkage
9	R1	Regulatory uncertainty	18	19	III	Linkage
10	H5	Job displacement fear	18	19	III	Linkage
11	T1	Interoperability challenges	18	19	III	Linkage
12	E1	SC partner unreadiness	1	20	II	Dependent
13	O3	Absence of strategic roadmap	19	2	IV	Independent
14	T6	Technology immaturity	18	19	III	Linkage
15	F3	High maintenance costs	18	19	III	Linkage
16	H2	Limited awareness	18	19	III	Linkage
17	R2	Ethical governance concerns	18	19	III	Linkage
18	T5	Data quality issues	18	19	III	Linkage
19	O4	Siloed departments	18	19	III	Linkage
20	H6	Safety & ergonomic concerns	18	19	III	Linkage

7.2 Interdependence of barriers

Organizational rigidity slows the integration while the regulatory uncertainty raises perceived financial risk. This interconnectedness explains why the isolated tech investments are often a fail. The problem is especially acute for the SMEs and the organizations in emerging economies, where the financial, infrastructure, and skill challenges combine to create the adoption inertia. This supports the social-technical alignment principle where a successful adoption requires progress across all

dimensions, which is financial, organizational, human, technological, and regulatory, rather than a technology-first approach.

Figure 2: MICMAC Driver Power–Dependence Diagram of Industry 5.0 Adoption Barriers



7.3 Implications for supply chain transformation

These findings suggests a reframing for the supply chain managers and the policy makers. In Industry 5.0 adoption, the most faced challenges are financial and organizational challenges not technological.

- Funding: To secure financing mechanisms, stages of investment plans are made and we make public-private partnerships before doing a large scale tech purchase.
- Organizational readiness: To Implemention of change management, the leadership development and the cross-functional collaboration before we do tech integration.
- Workforce development: Here, we treat upskilling of people and human-machine collaboration training as the strategic priorities and not afterthoughts.
- Policy: While providing clear governance standards for AI, cybersecurity, data ownership, and human robot collaboration. Financial risks are reduced and private investment are encouraged by regulatory clarity.

Financial planning, cultural readiness, and workforce development are aligned with technology by the help of supply chain, and the supportive regulation will be better positioned to achieve the resilience and sustainability.

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8.0 Conclusion

Industry 5.0 represents a change point in supply chain management. It shifts the focus to building systems that are human-centered, resilient, and sustainable instead of solely focusing on automation and efficiency. In this study, we reviewed 21 studies to conduct a thematic analysis for a better understanding of the barriers that are present during the adoption of Industry 5.0.

Our study shows that the challenges faces by organizations are not only technological but they are spread across financial, organizational, human, regulatory barriers. Financial constraints was one the most frequently determined barrier that appeared in 20 out of 21 studies which challenges the assumption that technology availability is the main issue. Organizational resistance was identified in 18 studies which showed how the internal changes that are made can often slow down progress.

Human skill gaps and system integration complexity showed up in 18 and 17 studies respectively highlighting a very strong internal connection between workforce rediness and technological integration. This study plays its part in contributing to Industry 5.0 conservation as: It shows proofs from a wide range of industries and provide a clear understanding of barriers to adoption. It mentions financial constraints as the primary barrier in the way that shifts the focus from thech-first mindset if Industry 4.0 towards economic foundations.

It presents a socio-technical framework that integrates financial, organizational, human and regulatory factors which creates a connection between theory and real world applications.

The takeaway for managers and policymakers is: Sustainable Industry 5.0 adoption is not limited to technology, it also requires strategic planning, change management in a structured manner, workforce upskilling and supportive environment. Future researches may receive primary insights through surveys and long-term case studies, conduct cross-national comaprisons.

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