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Title: Identification of Challenges in Adopting Circular Supply Chain (CSC) In Heavy Industry Taxila

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Abstract

In this paper, the researchers explore obstacles to implementing the Circular Supply Chain Management (CSCM) in heavy industries in Taxila, Pakistan through Interpretive Structural Modeling (ISM) and MICMAC analysis. The results indicate a pyramid-like arrangement of barriers, with initial high implementation costs being the most basic one. The second is the lack of the supportive regulatory frameworks and the lack of awareness and technological constraints are the challenges of the intermediate level. Supplies and complexity of change have been identified to be relatively less a challenge. The study highlights that the challenges of adopting CSCM are structural and requires a combination of measures to address the problem, which includes monetary incentives, policy changes, technology development, and education initiatives. Through the implementation of ISM-MICMAC in the setting of heavy industries within a developing nation, the research study will be relevant within the academic community and will provide practical data to policymakers, industry managers, and stakeholders to promote sustainability. Nevertheless, the research study is limited in generalizability because it is based on a small sample of experts and only one region was studied. Future studies need to be more geographically broad, involve longitudinal designs, and determine the extent to which emerging technologies can be used to overcome CSCM barriers.

Keywords: *Circular Economy: Circular Supply Chain; Challenges; Heavy Industries; Pakistan; ISM-MICMAC*

1. Introduction

Climate change, scarcity of resources and environmental degradation compel the global industrial environment into a paradigm shift towards sustainable processes. Circular supply chain management (CSCM) is a groundbreaking approach that aims at minimizing waste, prolonging the lifecycle of products, and maximizing the efficiency of the resources. Circular Supply Chain Management (CSCM) as an alternative to the linear supply chain model of take-make-dispose suggests reducing, reuse, recycling, and recover the processes to create closed-loop systems that enable sustainable and resilient supply chains (Khan, Waqas, Honggang, Ahmad, & Yu, 2022). According to report by Ellen MacArthur Foundation (2021), by transitioning to a circular economy approach the global economy is projected to gain $4.5 trillion by 2030 and, at the same time, reduce greenhouse gas emissions by 39 percent. The use of CSCM in heavy industries is low due to the presence of significant obstacles in the form of resource-intensive processes and established modes of operation (Waqas et al., 2022).

Though heavy industries such as steel, cement and manufacturing are important in spurring economic growth, they can be considered to be among the leading sources of environmental destruction. The heavy industry taxila (HIT) is a vital part of the economy of Pakistan as Taxila is the strategic area of the country in creating steel and machinery and defense facilities. The industry has associated itself with archaic infrastructure and uses a lot of energy and produces a lot of waste (Mughal et al., 2024). The steel sector is still one of the biggest emitting sources of CO_2 globally because it constitutes about 6 percent of the total and the industrial zones of Pakistan exhibit the same tendencies (World Steel Association, 2022). The concept of the circular economy and its implementation in environmental sectors become larger and the market potential in industries becomes smaller when the principles of the circular economy are not applied in these areas in a world that values green movement (Sattar, Fatima, Shahab, Masood, & Sattar, 2024).

Heavy industries in Taxila encounter multiple obstacles that hinder the application of CSCM despite increasing recognition of its advantages. The adoption and use of CSCM systems face technological and financial constraints that are further aggravated by the lack of policies and organizational change resistance. A study by Govindan, Shankar, and Kannan (2020) managed to map out over 30 barriers to CSCM implementation in various other domains, however, research remains sparse regarding the heavy industry sector in developing nations such as Pakistan. This presents an important gap in the literature: It is important to understand how and why heavy industrial sectors encounter CSCM strategy implementation challenges which are different from other sectors and devise ways to mitigate these challenges.

This research aims to address this gap by analyzing the challenges of CSCM implementation in the heavy industries of Taxila using Interpretive Structural Modeling (ISM) and MICMAC analysis. ISM is a widely utilized method to analyze the relationships among numerous elements while the MICMAC analysis allows the elements to be categorized based on their influence and interdependence. The ISM and MICMAC analysis have been combined to generate a structured framework needed to map the barrier interdependencies and set priorities in the intervention (Ahmad et al., 2021). Through the adoption of these approaches, this research will answer the following research questions: The research will aim at establishing the key barriers that inhibit the shift to CSCM in the heavy industries of Taxila. What are the interactive impacts among these various challenges? What are the solutions to allow the successful transition to the circular supply chain operations?

The study has theoretical importance as it has contributed to the extant body of CSCM research by studying heavy industries in developing nations that are least researched. This paper uses ISM-MICMAC analysis in a novel area to identify systemic obstacles and what they mean in terms of policy. This paper provides a practical solution in form of actionable recommendations that can be applied by policymakers and other industry players and other stakeholders in promoting the idea of having sustainable practices in the heavy industrial sector in Taxila. Identification of key obstacles facilitates strategic investment on technology, training and creation of regulations as well as fostering collaboration between the government and industry. The transition to circular supply chain management is not only an ecological requirement but also one of the strategic benefits of heavy industries to enhance their sustainable performance and position in the market. To achieve this potential, organizations are forced to enhance a rigorous comprehension of the challenges when adopting a methodical approach to conquer them. The study will address the existing gap in knowledge by the way it describes the barriers to the implementation of CSCM in the heavy industrial sector of Taxila. The research offers a way of a sustainable and strong industrial future of Taxila and other similar industrial hubs across the world based on the findings.

2. Literature Review

2.1. CSCM adoption in HIT, Pakistan

Circular supply chain management (CSCM) is a fundamental emerging solution in the global industrial industry as it is able to offer solutions to the increasing environmental, economic and social costs of the traditional linear supply chains. Taxila, Pakistan heavy industries are the one that is first in the transition to the circular supply chain management since they use a lot of resources, need a lot of energy input and cause a lot of waste. The steel, machinery and defense sectors in Taxila are very important to the Pakistani economy yet are also under growing demands to meet international sustainability standards. A shift towards a circular economy based on the policies of reduce, reuse, and recycle demonstrates an increased necessity of the introduction of CSCM into the related industries (Shaikh, Qazi, & Appolloni, 2024). The research studies focus on the ability of CSCM to remedy the inefficiencies in supply chain structure. According to the Ellen MacArthur Foundation, the world economy can benefit by 4.5 trillion in the circular economy by 2030 and the level of greenhouse emissions is going to decrease by 39% (Sangoremi, Abosede, & Adeleke, 2025). Heavily polluting industries with high carbon footprints and large amounts of resource material loss can mitigate sustainability deficits and enhance business efficiency with the use of CSCM. HIT, Pakistan, can accomplish sustainable development through the adoption of CSCM because it enables the local industries to meet global standards and access green markets (Zahid, Hayat, Rahman, & Ali, 2024).

CSCM implementation is quite relevant to resource-consuming industries in Taxila where processes are mainly raw material mining and refining. The remanufacturing and recycling in combination with waste valorization methods can be used by industries to reduce their reliance on virgin materials besides minimizing waste disposal practices. Research indicates that remanufacturing in itself conserves up to 70% of the energy that would be used to manufacture new products, which results in economic and environmental benefits (Iqbal, Fan, Ahmad, & Ullah, 2025). CSCM integration helps in achieving the international obligations of Pakistans treaties like the Paris agreement and UN SDGs which is focused on the more friendly consumption and production patterns.

The adoption of CSCM offers opportunities for Taxila's heavy industries to improve and protect their competitiveness from an economic standpoint. By optimizing resources and minimizing waste, companies can realize cost savings and enhance their profits (Sarkar, Debnath, Chiu, & Ahmed, 2022). All over the world, there is demand for sustainable products which is why industries adopting circular practices are enjoying new market growth. EU laws favor circular economy adopters which makes supply chain management with these economies very important and beneficial for Pakistani exporters. Taxila’s heavy industries are now forced to expand their customer base beyond the borders of the country, which is why the adoption of new marketing approaches is particularly important (Abbas et al., 2025).

Here is the integration of CSCM crucial for social impacts in Taxila’s heavy industries. It has been noted that industrial operations in this area have historically resulted in the pollution of air and water which harms the surrounding community. By adopting circular practices, negative relations will be alleviated while developing better living conditions and an augmented quality of life for the residents. New improved socioeconomic opportunities are made possible through the support of CSCM in the areas of recycling, repair and remanufacturing (Zafar & Shaiq, 2025). An International Labor Organization (ILO) study indicates that there is potential for millions of environmentally sustainable jobs to be created across the globe and positive social transformation could also be seen in places like Taxila (Baptista, Ayala, Noh, & Novella, 2024).

The implementation of CSCM in Pakistan's heavy industries is almost non-existent despite its evident benefits. There is an urgent need to carry out research and policy initiatives that fit the peculiar situational context of Taxila. Experts know that effective CSCM approach is largely affected not only by technology but also the legal and cultural environments within the region. Heavy industries in Taxila need to implement CSCM for the sake of the environment, but that decision also needs to be viewed from the perspective of the region's survival and relevance in a globalized world (Grafström & Aasma, 2021).

The large-scale industries of Taxila need to embrace CSCM as it will help solve environmental, economic, and social challenges. Circular approaches allow these industries to reduce their detrimental environmental effects while enhancing performance and finding new opportunities. Besides, CSCM compliments the shift towards a greener economy in Pakistan as well as international sustainability objectives (Zahid et al., 2024). Even with many impediments, CSCM exhibits such change making character that it is indispensable for sustainability and resilient development in Taxila's industrial base. The continued research and implementation of CSCM concepts is cruical for the important industrial zone.

2.2. Challenges in adopting CSCM in HIT

2.2.1. Technological Limitations

Taxila's core industries still rely on outdated equipment and methods which do not align with circular economy strategies. Many companies are unable to reach the advanced technologies that are essential for effective recycling and waste treatment necessary for CSCM execution. There are challenges in the transitions to sustainable practices owing to the existence of a technological gap (Galvão, De Nadae, Clemente, Chinen, & De Carvalho, 2018).

2.2.2. High Initial Investment Costs

The shift to CSCM demands substantial initial investments in new infrastructure upgrades, equipment purchases, and employee training programs. Small and medium-sized enterprises (SMEs) in Taxila find financial barriers to sustainability initiatives especially challenging because they work with limited budgets and face difficulties in obtaining necessary funding (Kirchherr et al., 2018).

2.2.3. Lack of Regulatory Frameworks

Pakistan lags behind in having formulated and outlined policies or laws that provide encouragement or necessitate the adoption of circular supply chain techniques. While the industries in Taxila are striving towards doing business, they continue to focus on old- fashioned methods of cost reduction owing to the absence of defined and enforced sustainability policies (Gedam, Raut, de Sousa Jabbour, Tanksale, & Narkhede, 2021).

2.2.4. Resistance to Organizational Change

Organizations face considerable difficulties due to their inherent resistance and the inertia of their existing cultural systems. Managers and employees used to linear supply chains tend to view CSCM as needless disruption which results in their hesitation to embrace beneficial long-term practices (Jaeger & Upadhyay, 2020).

2.2.5. Limited Awareness and Expertise

Taxila's heavy industrial stakeholders show insufficient knowledge regarding the principles and benefits of CSCM. A limited number of skilled professionals available to create and execute circular strategies continues to block progress toward sustainability objectives (Kumar, Sezersan, Garza-Reyes, Gonzalez, & Al-Shboul, 2019).

2.2.6. Supply Chain Complexity

Different partners and supplier tiers combine to form the supply chains in heavy industries. The main barrier to implementing circular initiatives is that some stakeholders prioritize profit realization over sustainable development (Charef, Morel, & Rakhshan, 2021).

2.2.7. Market Demand for Circular Products

Taxila and its neighboring areas show limited demand for circular products and services. Companies resist investing in CSCM because they believe insufficient consumer awareness and unwillingness to pay extra for sustainable products will prevent them from gaining competitive advantages (Kandasamy, Venkat, & Mani, 2023).

2.2.8. Inadequate Waste Management Infrastructure

Efficient operations in Circular supply chain management relies heavily on the strength of waste management systems, in particular, those systems that incorporate the collection, sorting, and recycling of materials. Taxila lacks sufficient waste management systems which ultimately stops industries from completing the recycling loop and reusing materials within their production cycles (Dissanayake & Weerasinghe, 2022).

2.2.9. Uncertainty in Return on Investment (ROI)

Businesses frequently experience uncertainty regarding the financial outcomes that result from investing in CSCM projects. Decision-makers hesitate because circular practices offer long- term advantages yet proving their short-term outcomes remains difficult (AlJaber, Martinez- Vazquez, & Baniotopoulos, 2023).

3. Research Methodology

The research study uses the ISM and MICMAC techniques to determine the obstacles to the adoption of circular supply chain management (CSCM) in heavy industries in Taxila, Pakistan. The study sample consisted of Practitioners, Researchers, and Industry Specialists dealing with sustainability of heavy industry supply chain and operations. A total of ten experts were intentionally sampled in the study because they were best qualified to be in the study based on their vast knowledge and experience in CSCM, the circular economy, as well as the industrial environment of Taxila.

The expert panel consists of three heavy industrial senior managers of Taxila and two additional supply chain consultants who are experts in sustainable practices. The others are two academic professionals in the field of supply chain management with an environmental orientation and three professionals in the field of regulatory and sustainability policies. The sample of the experts was identified according to 10 to 25 years of professional experience and their perspectives on the implementation of sustainable practices in the heavy industries. The chosen options offer a well-rounded interpretation of the problem because of the varying perspectives of the chosen professionals.

The data was collected through interviews and questionnaires on the challenges to see what is taking place. The development of Structural Self Interaction Matrix (SSIM) was based on the fact that experts did the pairwise comparisons of challenges referred to as V, A, X, and O to criticize the context of a given challenge. Experts were given detailed guidelines on the meaning and implication of each symbol before the collection of the data commenced. Both experts went through two data collection rounds: Round 1, the experts gave preliminary relationships and round 2, the experts involved with SSIM validation and feedback refinement.

The hierarchical model that was formed by expert data analysis using ISM identified driving and dependent challenges. The MICMAC analysis adopted four groups of challenges which included autonomous, dependent, linkage, and independent based on their driving and dependence power. The systematic framework of methodology establishes a rigorous way of studying challenges interdependencies that can provide actionable information to the stakeholders. The study procedure was ethical because all participants provided informed consent and ensured that their contributions were confidential.

4. ISM-MICMAC analysis

The ISM-MICMAC methodology applies a structured procedure to study intricate interconnections between different variables. The research process starts with problem identification which establishes the scope and determines essential variables like CSCM adoption challenges (AlJaber et al., 2023). There are different steps of ISM-MICMAC methodology which are given below:

Table 1. Experts Profile

E1	45	20	Heavy Industry (Steel)	Senior Operations Manager	MBA in Operations Management
E2	50	25	Heavy Industry (Machinery)	Plant Director	B.E. Mechanical Engineering
E3	42	18	Heavy Industry (Defense)	Supply Chain Head	MSc in Supply Chain Management
E4	38	15	Consulting	Sustainability Consultant	PhD in Environmental Sustainability
E5	47	22	Consulting	Circular Economy Specialist	MBA in Sustainable Business
E6	52	25	Academia	Professor of Supply Chain Management	PhD in Industrial Engineering
E7	40	12	Academia	Assistant Professor of Sustainability	MSc in Environmental Science
E8	55	30	Policy Regulation	Director of Industrial Policy Division	MPA (Public Administration)
E9	48	18	Policy Regulation	Environmental Policy Advisor	MSc in Environmental Policy
E10	43	14	Academia	Research Fellow in Circular Economy	PhD in Sustainable Development

- A Structural Self-Interaction Matrix (SSIM) is constructed through expert consultations to define pairwise variable relationships with symbols V, A, X and O to denote direct influence, reverse influence, mutual influence or no influence respectively.
- The SSIM transforms into a Reachability Matrix through symbol replacement with binary values 1 or 0 to represent existing or non-existing relationships.
- The matrix undergoes refinement to achieve transitivity which represents an essential characteristic of ISM because it allows for the detection of indirect connections between variables. The finalized reachability matrix enables level partitioning that arranges variables hierarchically by evaluating their driving power and dependence power.
- An ISM digraph illustrates the hierarchical structure and becomes a final ISM model showing variable interdependencies after removing transitive links.
- MICMAC analysis groups variables into four distinct clusters known as autonomous, dependent, linkage, and independent by examining their driving and dependence power which facilitates the identification of important variables.

The model maintains its accuracy and reliability through expert validation during the entire process. The method is systematic and provides clarity within complicated systems which makes it easier for stakeholders to make decisions on what needs to be prioritized and how to effectively manage challenges.

5. Results

According to the above-mentioned steps of ISM-MICMAC analysis, results for each step are given below:

In the first there is a filling of SSIM by experts given in Table 1. SSIM developed by experts is shown in Table 2.

Table 2. Structural Self-Interaction Matrix (SSIM)

Variables	1	2	3	4	5	6	7	8	9
Technological Limitations		O	O	O	O	O	O	V	V
High Initial Investment Costs			V	V	V	V	V	V	V
Lack of Regulatory Frameworks				O	V	V	O	O	O
Resistance to Organizational Change					A	A	A	A	A
Limited Awareness and Expertise						V	O	O	V
Supply Chain Complexity							V	V	A
Market Demand for Circular Products								V	O
Inadequate Waste Management Infrastructure									V
Uncertainty in Return on Investment (ROI)									

The second step is about conversion of SSIM into RM which is given in Table 3.

Table 3. Reachability Matrix (RM)

Variables	1	2	3	4	5	6	7	8	9	Driving Power
Technological Limitations	1	0	0	0	0	0	0	1	1	3
High Initial Investment Costs	0	1	1	1	1	1	1	1	1	8
Lack of Regulatory Frameworks	0	0	1	0	1	1	0	0	0	3
Resistance to Organizational Change	0	0	0	1	0	0	0	0	0	1
Limited Awareness and Expertise	0	0	0	1	1	1	0	0	1	4
Supply Chain Complexity	0	0	0	1	0	1	1	1	0	4
Market Demand for Circular Products	0	0	0	1	0	0	1	1	0	3
Inadequate Waste Management Infrastructure	0	0	0	1	0	0	0	1	1	3
Uncertainty in Return on Investment (ROI)	0	0	0	1	0	1	0	0	1	3
Dependence Power	1	1	2	7	3	5	3	5	5	32

The next step is eliminating transitivity and the conversion of RM into FRM which is given in Table 4.

Table 4. Final Reachability Matrix (FRM)

Variables	1	2	3	4	5	6	7	8	9	Driving Power
Technological Limitations	1	0	0	1*	0	1*	1*	1	1	6
High Initial Investment Costs	0	1	1	1	1	1	1	1	1	8
Lack of Regulatory Frameworks	0	0	1	1*	1	1	1*	1*	1*	7
Resistance to Organizational Change	0	0	0	1	0	0	0	0	0	1
Limited Awareness and Expertise	0	0	0	1	1	1	1*	1*	1	6
Supply Chain Complexity	0	0	0	1	0	1	1	1	1*	5
Market Demand for Circular Products	0	0	0	1	0	1*	1	1	1*	5
Inadequate Waste Management Infrastructure	0	0	0	1	0	1*	1*	1	1	5
Uncertainty in Return on Investment (ROI)	0	0	0	1	0	1	1*	1*	1	5
Dependence Power	1	1	2	9	3	8	8	8	8	48

At the next stage, FRM is converted into level partitioning where elements are segregated into different levels as shown in Table 5.

Table 5. Level Partitioning (LP)

Elements (Mi)	Reachability Set R(Mi)	Antecedent Set A(Ni)	Intersection Set R(Mi)∩A(Ni)	Level
1	1,	1,	1,	3
2	2,	2,	2,	5
3	3,	2, 3,	3,	4
4	4,	1, 2, 3, 4, 5, 6, 7, 8, 9,	4,	1
5	5,	2, 3, 5,	5,	3
6	6, 7, 8, 9,	1, 2, 3, 5, 6, 7, 8, 9,	6, 7, 8, 9,	2
7	6, 7, 8, 9,	1, 2, 3, 5, 6, 7, 8, 9,	6, 7, 8, 9,	2
8	6, 7, 8, 9,	1, 2, 3, 5, 6, 7, 8, 9,	6, 7, 8, 9,	2
9	6, 7, 8, 9,	1, 2, 3, 5, 6, 7, 8, 9,	6, 7, 8, 9,	2

Based on these results the final diagraph and ISM model is shown in Figure 1, and Figure 2. Further, results for MICMAC analysis are shown in Figure 3.

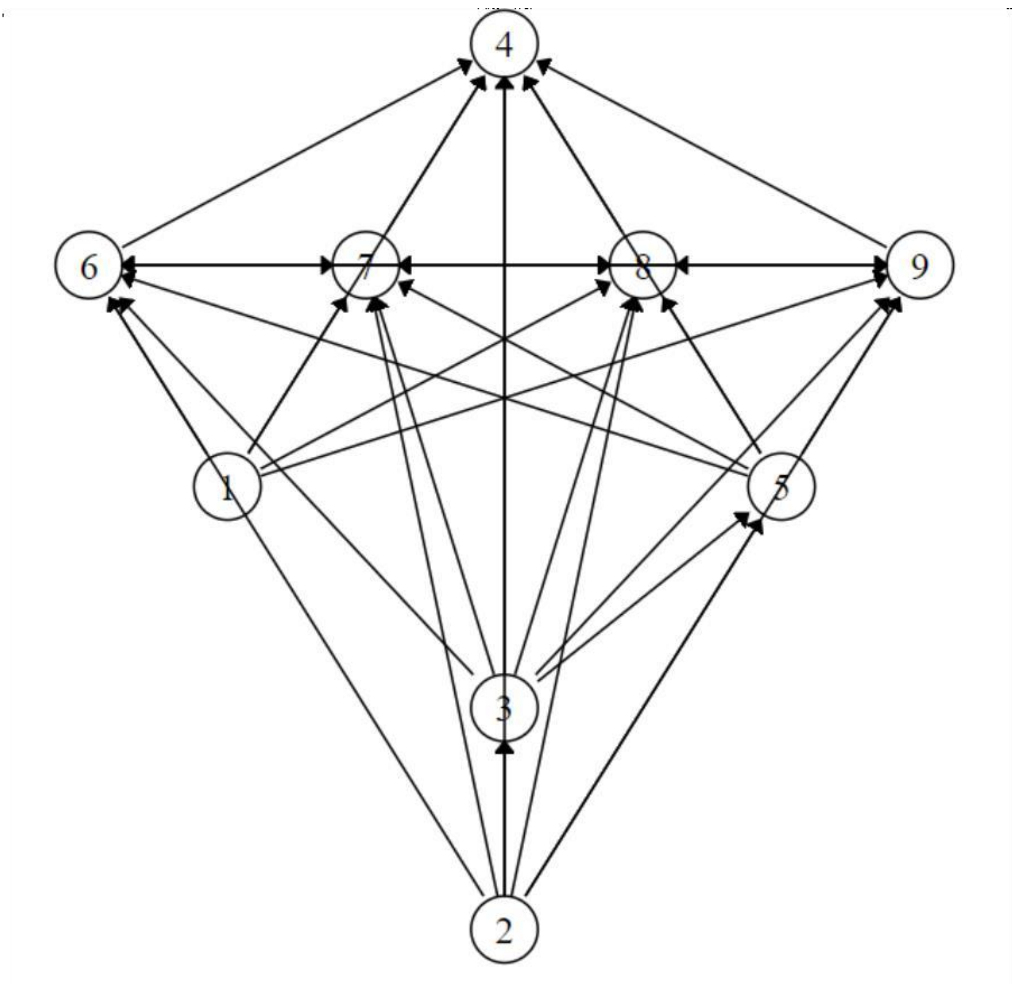

Figure 1 Diagraph of the study

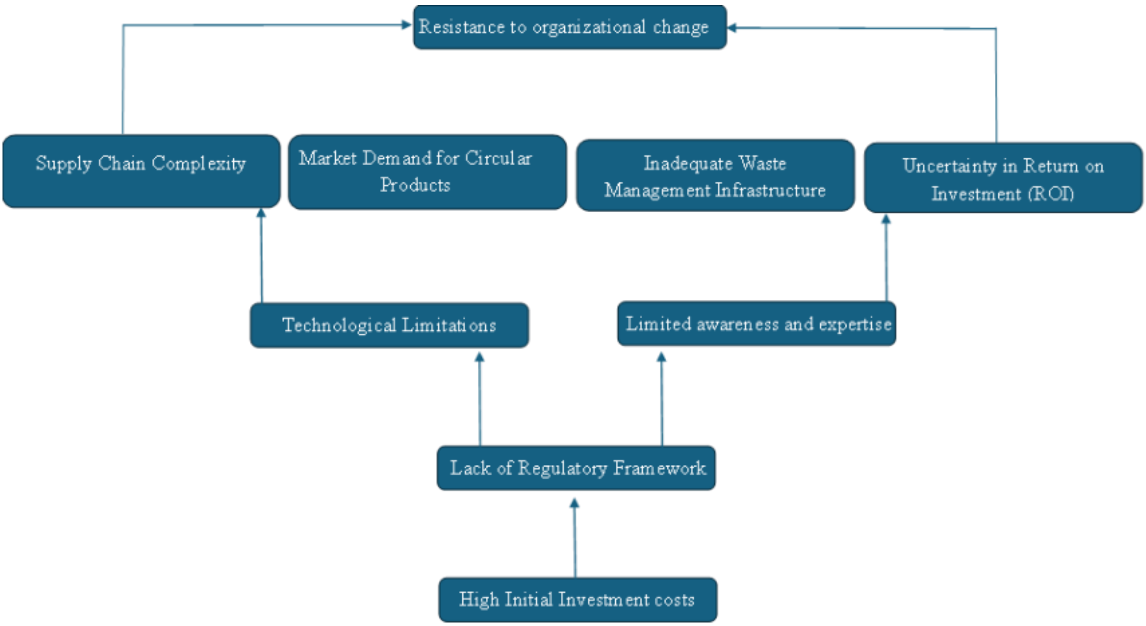

Figure 2 Final ISM model

6. Discussion

The paper provides a framework of barriers to heavy industries in Taxila, Pakistan CSCM strategies. The Interpretive Structural Modeling (ISM) analysis and MICMAC analysis findings reveal that the high cost of investment is the primary hindering factor assistance in the acquisition of resources, and closely behind this factor is the lack of regulatory frameworks on the second level. Essential impediments related to fundamental awareness and professional knowledge, not to mention technological constraints that are imposed at the third stage. Any other challenges are considered small and insignificant across the system. The exposing results of the study facilitate a sophisticated and complicated knowledge of the obstacles to the implementation of CSCM creating an informative framework to key players in the profession.

The most critical challenge observed is that it is costly to install the ISM system because of the high initial investment. The findings align with the literature that has shown that it is economically difficult to transition into sustainable operations (AlJaber et al., 2023). The heavy industries at Taxila have a tremendous challenge of functioning with tight budgets but have to make massive upfront investments in infrastructure upgrades, technology procurement as well as training employees employee training. This barrier is critical in nature hence indicating the need to support industries to adopt CSCM with financial aid in the form of subsidies, tax cuts or low-interest loans. The importance of public-private partnerships comprises an important role in the allocation of financial risks as well as the establishment of collaborative relationships between governments and industrial partners (Iqbal et al., 2025).

Lack of regulatory framework is also another significant barrier in implementation of CSCM in HIT and it occupies the second position in the sixth level of ISM model. Such conclusions should not be unexpected because Pakistan is a developing nation, and the development of the regulations by the corresponding authorities lacks in the majority of cases. The lack of regulations complicates the business as it strives to adhere to requirements of sustainability and casts uncertainty regarding the future benefits of their sustainability practices (Kandasamy et al., 2023). The implementation of the CSCM in the industries might also be a push factor by putting in place more stringent regulatory policies which support the application of the principles of the circular economy and punishes those who do not do so. The addition of sustainability needs related to the HIT will contribute positively to prominence SDGs in Pakistan and will shed light on the Pakistan image in the international level (Khan et al., 2022).

The third level exposes some critical issues based on the lack of awareness and expertise as well as the lack of technology. The findings of the exploration are consistent with the previous literature which points out the key roles of human capital and technological innovation in promoting sustainability changes. The low level of awareness of stakeholders on the benefits of CSCM leads to low urgency of adopting circular practices and lack of qualified professionals leads to an increase in the difficulty of implementation. To address these challenges the organizations should introduce certain steps that would involve awareness campaigns, employee training as well as collaboration with educational institutions to develop professional specialists. Heavy industries require both research and development efforts as well as cheap access to high- tech solutions in order to overcome any technological limitations (Sarkar et al., 2022).

Supply chain complaxity, market demand for circular products, insufficient waste management infrastructure and uncertain returns on investment are major obstacles that arose the fourth level. These challenges are less important as challenges at the bottom level are considererd critical in the ISM model (Zafar & Shaiq, 2025). Therfoere, at this level, financial limitations and insufficient regulatory requirements contribute to resistance to change but lack of technical know-how along with technological deficiencies, which increase supply chain complexity. Tackling the primary obstacles discussed in this study will help reduce many of these lesser problems indirectly.

The ISM-MICMAC analysis builds a systematical framework that helps to comprehend the interrelated nature of various challenges and discloses fundamental information concerning the systemic nature of these challenges. The findings of the study provide valuable practical implications to the decision-makers and industry executives among other interested parties. The initial high costs of investment and regulation systems give a platform on which to build accurate intervention strategies. Awareness creation and the elimination of technological shortcomings create a conducive environment that facilitates the adoption of CSCM.

The study shows that the implementation of CSCM in the heavy industries in Taxila has a number of multifaceted issues. Stakeholders that focus on critical barriers and take advantage of their connectedness will create an avenue to sustainability and resilience in the industrial sector. The study contributes to the academic CSCM literature and provides particular recommendations that can be applied to the heavy industry of the developing countries like Pakistan.

7. Conclusion

Researchers investigated the obstacles facing the implementation of circular supply chain management (CSCM) strategies in Taxila's heavy industries through Interpretive Structural

Modeling (ISM) and MICMAC analysis. The research results show a barrier hierarchy where high initial investment costs stand as the primary obstacle followed by insufficient regulatory frameworks as the second major barrier. The third level of challenges included significant technological limitations and limited expertise and awareness while other barriers were deemed minor and less influential within the system. The findings show that CSCM adoption barriers are systemic and require focused interventions to overcome foundational obstacles. Stakeholders can establish a supportive environment for sustainable practices in Taxila's heavy industries by focusing on financial support measures while enhancing regulatory frameworks and promoting technology innovation and awareness initiatives.

This study provides theoretical knowledge by providing innovative application to the ISM-MICMAC analysis to examine CSCM adoption within the heavy industries that are still uncharted in the developing nations. The findings of the research provide practical recommendations that can be used by the policymakers and leaders of the industry to promote sustainability in industrial centers like Taxila. Circular practices can be expedited through lowering the initial investment cost through the provision of financial incentivesand regulatory changes and through investing in the fields of education and technology in order to bridge the existing expertise and infrastructure shortages.

The study gives important insights though it has not been without significant limitations. The findings are based on professional opinion of a small group of people who do not represent all the perspectives of stakeholders of CSCM adoption. The research only looks at the heavy industries in Taxila limiting the applicability of the results to other areas and industries. The shifting nature of the supply chain and sustainability trends show that contemporary issues will change thus the need to continue analyzing them.

Industrial regions in Pakistan and other similar regions in other developing countries should be considered in future research in order to expand the scope of the study. Longitudinal studies offer an excellent understanding of the challenges involved in the adoption of CSCM as time goes by because the studies monitor the changes of its dynamics over time. The studies on the potential of new technologies, such as artificial intelligence and blockchain, to deconstruct CSCM barriers should provide important results. Future studies should be conducted to investigate the effects of global sustainability initiatives such as the carbon neutrality targets on the application of CSCM in the heavy industry sectors. Such research studies will widen the scale of knowledge regarding the ability of CSCM to facilitate sustainable industrial transformations.

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