ISM Model of Driving Enablers Enabling Transition from Traditional to Flexible Manufacturing System

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Abstract: Different Manufacturing is a significant sector of the Indian economy, contributing around to 16% of real GDP in FY12 which employes around 12% of the labor force. Over the past few years, the growth of the sector has been substantial and has outpaced the expansion of the entire GDP. Manufacturing has historically been the foundation of all industrialized and emerging countries. It is where research and development (R&D) begins, where new innovations are created, and where scientists, engineers, and others are challenged to create new and improved methods, items, and technologies. A crucial step in boosting productivity through the flexible manufacturing model is recognizing the risks associated with the conventional production system and taking steps to address those risks. The major Objective of our project is to identify certain risks involved in the manufacturing system and establish the relationship between using ISM modelling. By identifying said risks and finding relationships between them using ISM we can represent them graphically to understand which factors play the major role in manufacturing failure and delay.

Keywords: *interpretive structural modelling; ISM; cross-impact matrix; CIM; flexible manufacturing model; gross domestic product; GDP*

1.Introduction

1.1 Traditional Manufacturing

Today's manufacturing industry is unforgiving. Production is increasingly fast and rapid in international competition. New products may expire within months. The competitive environment continues to fluctuate in the middle as new entrants keep lower pressure on profit margins. Part of the steel products are characterized by small barriers to entry and exit, allowing low-cost providers to enter the market at any time. In order to stay competitive, the existing players have a long-term plan to control operating costs and improve production processes while strengthening customer relationships. The steel industry is built - which includes steel service centers, suppliers, and manufacturers of consumer products - run by small to medium-sized businesses. Many of these people in Zimbabwe are struggling with how they can benefit from their long-term growth while competing with older, less complex computers that control their critical production, labor, trade and financial information, traditional manufacturing route (injection molding) with layer manufacturing processes (stereolithography, fused deposition modelling and laser sintering) in terms of the unit cost for parts made in various quantities. The results show that, for some geometries, it is more economical to use layer manufacturing methods than it is to use traditional approaches for production in the thousands. (Hopkinson, 2003) There is a realization that overcoming the habit of investing under technology puts them at a disadvantage and their limited technical infrastructure can prevent them from performing well in all areas and achieving profitable goals. The way forward will depend on leading the best practices they have gained control of every aspect of their business - from product development to continuous action and improved efficiency that reduces material losses, inventory, and operating costs as well as providing additional coverage genetic services. It is often used in the creation of this program as a hierarchical design method. This approach can create significant demand and well-balanced production capacity in areas where solutions are available, but it is not enough. An older type of production facility does not fully adapt to the changing environment and leads to operational damage.

The use of additive manufacturing technologies over traditional manufacturing in different industries has increased substantially during the past years. Henry Ford introduced the moving assembly line that enabled mass production of identical products in the 20th century. Currently, additive manufacturing enables and facilitates production of moderate to mass quantities of products that can be customized individually. Additive manufacturing technologies are opening new opportunities in terms of production paradigm and manufacturing possibilities. Manufacturing lead times will be reduced substantially, new designs will have shorter time to market, and customer demand will be met more quickly (Attaran, 2017).

Traditional production methods are based primarily on the use of historical cost accounting and forgiveness methods, which are more focused on direct performance because they are easier to measure and understand. Equipment is replaced with the same regardless of the production process. Delays in transitioning to advanced production technology can lead to a competitor gaining market advantages which may be difficult or impossible to reverse. Such a migration to traditional methods is therefore justified on the basis of the resulting product savings, reduced warranty costs, reduced waste disposal and recycling.

1.2 Flexible Manufacturing System

A Flexible Manufacturing System (FMS) is a production method designed to easily adapt to changes in the type and quantity of a product being produced. Computer equipment and systems can be adapted to make different parts and handle changing production levels. A flexible production system (FMS) can improve efficiency and thus reduce a company's production costs. Flexible production can also be an important part of an automated strategy that allows customers to customize the products they want. Such flexibility can come with high costs in the past. Purchasing and installing specialized equipment that allows for such customization may be more expensive compared to conventional systems.

The manufacturing industry is shifting to more efficient, energy-efficient, and flexible production systems. In this regard, this function is responsible for the design of non-centralized control structures in order to enhance the energy efficiency of such systems and to promote their flexibility. Based on both the design of production systems and their integration capabilities, these systems are subdivided into sub-systems, where minor control problems can be identified. Therefore, control / management strategies can also be developed to provide more flexibility in production processes. Then, by using appropriate distributed development strategies, as well as accurately defining the phases of agreement between local controls, the output from such controllers is best integrated to reduce the total amount of power consumption of the entire system. The proposed control strategies are evaluated by mimicking the standard procedure for the automotive parts manufacturing sector, in which large processing units are mechanical tools. Based on the results obtained, production systems and their control strategies may be optimized using non-focused control schemes, where closed-loop operations such as their intermediate counterparts can be achieved (Ocampo-Martinez, 2021).

Production goes from mass production to 'customization quantity' and 'personalization' (size one part). Therefore, modern production systems must be fast and responsive in changing global markets and closer to customers. Industrial 4.0 technology has structures to deal with these changes in the production paradigm. However, technology should be based on methodological approaches that focus on process improvement, digitalization, and greater flexibility. In this paper, we propose a seamless Human-Computer-Machine Interaction (HCMI) structure to support user monitoring functions in the context of flexible production systems. Proposed interactions are used and validated using laboratory case studies in which we demonstrate that the proposed design of HCMI, in line with Industrial 4.0 design principles, enables the 'near real-time' direction of the production system to adapt. in production changes. (Hernandez, 2020).

The main advantage is to improve the efficiency of production. The downtime is reduced because the production line does not need to be closed in order to set a separate product. The disadvantages of FMS include its high-cost costs and the considerable amount of time required to design system information for various future needs. There are also costs associated with the need for specialists to run, monitor, and care for FMS. Proponents of her case have been working to make the actual transcript of this statement available online.

Objective of this paper

The main objectives of this paper are as follows:

1. Identifying hazardous substances affecting the smooth transition from flexible production systems to book reviews.
2. To obtain analysis using brief comments from productive managers
3. Develop relationships between risk factors using the structural interpreting model (ISM)
4. To divide all risk factors into four categories with the help of a cross-impact matrix method.

It will provide an overview of the most potent risk factors that will affect the desired target through the ISM Model of driving resources that allow for the transition from standard production to flexible production systems.

Theoretical framework

The authors of the present study use the plural method to demonstrate and analyze the relationships between risk-related factors in transforming production systems. The measurement method is done in two stages. For the first phase, descriptive data analysis is done taking into consideration the detailed interviews with the global operations managers of the productive organizations. And moreover, in the second phase, all risk factors are calculated into four categories with the assistance of ISM and a cross-impact matrix. The classification of hazardous substances is based on their influence on other harmful elements and the influence of other forces on them. The framework function is displayed in Figure 2.

Table 1 Theoretical framework

Stage 1 (descriptive data analysis)

1. Identifying risk factors affecting the transition of traditional manufacturing systems to flexible manufacturing systems.
2. Questionnaire design
3. Conduct researches
4. Ranking of different risks.

Stage 2 (ISM and cross-impact matrix)

1. Establish a contextual relationship (X_{ij}) between factors affecting the manufacturing system.
2. Development of a structural self-interaction matrix (SSIM)
3. Finding reachability
4. Partitioning the reachability matrix into different levels
5. Make digraph
6. Replacement of attribute nodes with relationship statements
7. Development of ISM model

2. Literature Review

There are various factors that hinder smooth change from traditional manufacturing system to FMS. Most prominent of these factors are discussed below with their respective literature support.

2.1 Cultural Resistance

HR has become a crucial consideration when assessing a company's competitive advantages. Due to their expertise in human performance, HR executives and professionals are well-positioned to sustain strategic leadership and contribute significantly to the company's competitive advantage. Considering this paradigm change about the importance of human resources, the HR department will have opportunity to play a more strategic role in the management of a company. (Lawler, 2003). The most important assets in a company are its employees. They are the source of expertise and information and assist a company in acquiring long-lasting competitive knowledge. Only when a worker appreciates and emotionally connects with the company can he give it his all. To improve the overall work culture and increase the employee satisfaction and happiness which in turn increase their retention the employers should take certain steps like conducting interactive and incentive based activities which helps in engagement of employees. (Daisy, 2017)

When working with major firms, several competitive techniques, like comprehensive quality management, six sigma, and internationally developed manufacturing, are quite beneficial. Therefore, it is essential to create competitive strategies that suit small and medium-sized businesses (SMEs). This paper addresses the primary personnel hurdles to implementing lean manufacturing in small and medium-sized businesses in this environment. (Ramadas, 2018)

2.2 Disruption Risks

It has been observed that relationships among providers and their customers speedily shift from unique, scattered hyperlinks to modern interconnected networks, depending on each other. At the same time as such adjustments have led to many benefits associated with efficiency and productivity, they could additionally result in foremost troubles, certainly one of that is the threat of delivery chain disruption seen globally over the past few years. As an instance, when the main supplier of brake-fluid proportioning valves for Toyota faced a significant fire in 1997, the production line was disrupted and faced a complete breakdown for 2 weeks. (Reitman, 1997) In another instance the September 1999 Taiwan earthquake caused panic and significant losses for a lot of electronic companies whose major suppliers were the Taiwanese manufacturers. (Sheffi, 2005); A Philips microchip plant located in Albuquerque in March 2000 suffered from a fire which pressured NM's essential buyers, Nokia and Ericsson. Fortunately, Nokia foresaw the impending chip shortage within 3 days and employed their multiple stages dealer system to harvest chips from several sources. On the other hand, since Ericsson was solely sourced from the same factory, Ericsson stopped production. The corporation lost $400 million in revenue as a result. (Latour, 2001)

2.3 Training Challenges

Because of the apparent increase in digitization and automation as well as the complexity of the property, the criteria for preservation, as well as for the preservation personnel themselves, have changed significantly in recent years; thus, it is crucial that staff receive the right training. (Passath, 2019). Technical and vocational education was developed in order to prepare a workforce for process responsibility. To improve the work skills of the workers at the place of business, a series of training manuals and programmes must be set up. Employee competencies are developed through work experiences, attendance at human resources training sessions, and service-learning programmes offered by employers (Hadi, 2015). It is emphasized how crucial increases in education and training are if you want to lower your risk of failing. The HSE (fitness safety govt.) has argued that a particular category of human behavior, namely unintentional "mistakes," may be appropriately handled with academic interventions, and they clearly state that "schooling is the important thing to averting mistakes." This brings us full circle to the argument made in this essay, which is that failure can be avoided by ensuring that the human component of an engineering system is given every opportunity to interact effectively with the mechanical components through appropriate training for appropriately qualified workers. (Le May, 2009). The need for preservation-related education in higher education is examined together with the renovation-related education offered by engineering programmes at both the bachelor's and master's level. Today's engineers need to have a comprehensive understanding of goods and processes. Therefore, engineering education should give students the chance to acquire these kinds of competencies. In order to facilitate the realization of a contemporary engineering education and training, the international project CDIO (Conceive-Design-Implement-Operate) was created. (Kans, 2020).

2.4 Management Challenges

Businesses are increasingly relying on dependable information technology (IT) to stay adaptable in the modern business setting and obtain the upper hand in terms of production. IT ambidexterity, IT governance, and pinnacle control support integrated for organizational agility. In order to properly implement IT governance, a number of procedures are required to make sure that activities associated with IT in production and organizational strategy are aligned. These procedures may come under the joint responsibility of the senior management team. (Zhen, 2021). Behavioral integration (BI), and the level of top management team (TMT) member interaction in group interactions, is a vital component for establishing business success in firm management. However, megaproject research of the manufacturing and other industries has rarely examined this concept. Megaproject organizational complexity contributes to TMT's biases in behavior. TMT oversees making strategic decisions and emerges as a driving force in the megaproject delivery process, in contrast to lower control groups that focus on specific control concerns. (Wang, 2021). Respondents were asked to rate the state of their company's adoption of open innovation (OI) at the cutting edge as well as a number of internal skills. The results of the dataset evaluation revealed a strong association between the control guide for OI and the likelihood that OI would be successfully adopted in manufacturing and other industries. Additionally, the findings provided insight into some of the dynamics of how control assistance effects the adoption of OI. The importance of management support for an effective adoption of open innovation has been recognized in various research articles as one internal skill. (Barham, 2020). Three ambiguous fulfilment factors—the pinnacle control guide, progressive project planning, and stakeholder communication—are essential but no longer always effective. Innovative ventures and their planning have been studied in a variety of sectors, and a large body of literature has developed that offers some near-certainties. Several components, including mission planning, top-down support, and communication, are challenging to include into a web of straightforward connections. (Zala, 2020).

2.5 Employee Performance

Industrial companies are spending more money on sensor-equipped devices to enable internet of things (IoT) networks for more effective production techniques. However, because the interaction patterns and functionalities of IoT-objects are unknown, employees frequently do not use the possibilities provided by those devices appropriately. As a result, depending on whether employees believe they are sufficiently competent and capable of coping with the new needs created by the adoption of IoT, their psychological states, such as their perception of stress or satisfaction, may be affected. (Sievers, 2021). The usage of generation has greatly increased in recent years and has replaced its use as an exception in public administrations. Employee support for or opposition to generation thus has a significant role in regional virtual patterns. The abilities of public sector employees as well as their attitude towards or opposition to change are now more important than ever in this context. Given the broad and diverse range of public sector technology, this is particularly true for technologies that are crucial to a broad spectrum of employees and whose objective is to boost the overall effectiveness of public services. (Oschinsky, 2021). In this context, the workforce's mental requirements—needs for autonomy, competence, and relatedness—are crucial because they impact the motivation of staff members to embrace their future workplaces. Precisely, workers believe a better workplace would help them achieve greater performance, more happiness, and greater personal well-being. (Selimović, 2021).

2.6 Co-ordination Risk

The use of modern technology in manufacturing is helping to bring forth enterprise 4.0, or smart (and statistics-driven) production structures. By providing optimization models at each stage of the decision-making process, the benefits of using such technologies may be fully realized. This entails improving maintenance schedules and production timetables, two essential elements of any manufacturing method. We recall the real-time combined optimization of manufacturing scheduling and refurbishment planning in intelligent production structures. A variable job shop production arrangement has been taken into consideration, and various concerns that frequently arise in practice have been handled. (Ghaleb, 2021). DfS, or Design for Sustainability, is a response to this project. Through integrating social, economic, environmental, and institutional factors and by providing possibilities to become concerned and express one's own identity beyond consuming standardized mass-produced goods, it includes but goes beyond what design for the environment or eco design offers. DEEDS, a Leonardo studies initiative, sought to include sustainability into layout and design. The assignment partners approached the challenge from the perspectives of design, sustainability technology, and sustainable consumption assessment, growing tools, and principles (the SCALES principles) to aid DfS and include it into design education and practice. (Spangenberg, 2010). This gives an extended-term comparison and a standard evaluation of fuzzy logic research from 1965 to 2017 that was obtained over the internet. This analysis looks into fuzzy research's growth, influence, characteristics, and regional localization. There had been use of conventional, advanced, and other bibliometric signals. It compiles the data according to specific tiers and criteria, such as researchers, courses, institutions, or nations. A worldwide perspective has been offered via assessments of regional statistics and compound yearly expansion rates that support the measures used in this piece of work. The findings enable visualization of fuzzy research's influence, significance, evolution, and how well they perform, as well as its relation to and overlap with other areas of study. (López-Guauque, 2020).

An organization cannot function effectively without effective communication. However, we are aware that businesses and employees may not be able to understand, apply, and benefit from effective communication techniques. Nothing would get done at work if there was no contact. (Conrad, 2014). Establishing and maintaining effective working relationships in organizations depends on workplace communication. (Adu-Oppong, 2014). The first and most crucial element for achieving job success is communication. The ability of management and employees to reach consensus on many workplace issues contributes to effective communication ethics' varied productivity-boosting effects. (Alyammahi, 2020).

2.7 Political Risk

In recent years, lean manufacturing has emerged as a crucial pathway for both lecturers and practitioners. Many businesses all over the world have tried to implement it, however lean practices will fail as a result of the lack of a clear understanding of lean overall performance and its measurement. Lean tactics and equipment are covered in numerous papers, articles, and reviews, however there aren't many research that systematically enhance knowledge of lean overall performance evaluation. Presents a novel method for measuring the lean performance of manufacturing systems using fuzzy membership functions to address the current gap caused by political factors. (Behrouzi, 2011). This shows if a project will be authorized, for example, if the scoring mechanism is ignored but the evaluation criteria are. The objective is to construct a frontier function from performance that is above average at the criteria for the approved tasks. An indication of the likelihood that a planned venture will be approved is the distance between it and the frontier. Data from the Topic Research Project's Management II Division of the National Science Council of Taiwan are gathered to demonstrate this strategy. (Kao, 2012). They have an effect on a manufacturing system that is faulty but has a great inspection policy where a certain proportion of the manufactured devices are inspected. Because to the inspection coverage's flaws, type I and type II errors are possible. Products are delivered for sale with a free minimal repair guarantee. Preventive maintenance is carried out following each production cycle. A minor repair is suggested in the event that the manufacturing process fails before the cycle is complete. In order to meet demand while preventative maintenance is still ongoing, a buffer stock is established. We have also considered the fact that defective products we come across while inspecting are dispatched for repair. The model is created with the intention of minimizing the projected total cost per item while taking into account a constraint on average outgoing quality. (Lopes, 2018)

2.8 Workplace Communication Risks

In most businesses, there occurs a breakdown in the transmission of documents from the sender to the receiver. This has happened before in organizations with a top-down hierarchy. It might be challenging for lower-level employees in this sort of structure to learn about changes inside the company. (Mallett-Hamer, 2005) The corporate goals are ultimately jeopardized by lost communication since it has a knock-on effect throughout the organization. The loss of communication with the superiors has an impact on a variety of situations. It causes the grapevine to spread, which lowers morale and decreases both individual and organizational productivity. (Kumari, 2011).

2.9 Financial Constraints

After accounting for business-specific factors, the productivity of a typical unconstrained firm will grow by 11% in the short term and 16% in the long run if the amount of financial restraints is raised to the level that maximizes productivity. (Jin, 2019). Managers of businesses frequently point to financial limitations as the main roadblock to their internationalization and expansion, particularly in developing and developing countries. We contend that at any other point, and in line with a current trend in the literature on international finance, the simple act of starting to export may desire to strengthen a company's access to external financial resources. (Silva, 2011). The coefficients for financial restraints with regard to capital investment between the institution of small businesses and the group of large corporations may have a great temporal pattern. The susceptibility of large corporations to financial restrictions became most apparent later on in the crisis. When other investment variables are taken into account, however, the effect for small businesses is persistent and does not appear to have risen throughout the crisis. (Driver, 2019). Since enterprises' R&D and exporting operations share some characteristics that make them susceptible to financial constraints, rising R&D investments that lead to new process and product innovations are the only option to create a sustainable competitive advantage in the long term. (Máñez, 2014). Short-term productivity growth is positively correlated with the presence of financial constraints; we interpret this result to mean that constrained firms must reduce costs in order to generate the resources they cannot raise on the financial markets, which leads to increased efficiency. (Musso, 2008).

2.10 Supply Chain Risk Management

Disruptions in the supply chain have had an effect on business performance recently. The 2011 earthquake, tsunami, and nuclear disaster in Japan cut Toyota's manufacturing by 40,000 vehicles, costing the corporation $72 million daily in income. (Pettit, 2013). The disastrous Thailand floods of October 2011 disrupted supply lines for both laptop manufacturers that rely on hard drives and Japanese automakers with Thailand-based operations. (Chopra, 2014) Supply chain risk management (SCRM) is a growing field of multifaceted study that includes, among other things, operations administration, financing, and marketing. The concept of SCRM is studied in light of prior research on risk recognition, risk evaluation, supply chain weaknesses, characteristics of supply chains as facilitators of managing risks, and risk management approaches. (Bandaly, 2012). One aspect of managing corporate risks, which may be generally divided into market, credit, and operational risks, is the supply chain risk. Deliver chain risk is lower than operational risk. Operational risks are managed differently from financial (market and credit) risks because they are more diversified and have a wider range of potential outcomes. (Adhitya, 2009).

3. Analysis

3.1 Interpretive structural modelling

Important dangers that impact the switch from a traditional to a flexible production system are spelled out with the use of a structured study approach. The aforementioned considerations associated to switching from a traditional to a flexible manufacturing system have an impact on the intended output of the production systems and operations to provide the required outcomes. The risk factors should be effectively handled by identifying and classifying the one that has the greatest individual influence over others. ISM and cross impact matrix analysis have been used to build the relationships between the risk factors, and they should be used to appropriately address all the variables stated.

3.1.1 Development of an SSIM

The table given below represents inter-relationship among risk factors as structural self-interaction matrix (SSIM), where V represents influence of i element on j element, A represents influence of j element on i element, X represents influence from both risk factors side and O represents no influence from both sides.

Table 2. Structural self-interaction matrix

S. no	*Risk Factors*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1	Management Challenges		X	A	X	V	X	X	A	A	A
2	Employee Performance			A	A	X	X	X	A	O	O
3	Training Challenges				V	A	V	V	O	O	O
4	Workplace Communication					O	X	X	O	A	A
5	Financial Constraints						V	O	A	A	A
6	Supply Chain Risk Management							A	A	A	A
7	Coordination Risks								A	A	A
8	Disruption Risks									O	O
9	Cultural Resistance										X
10	Political Risks										

3.1.2 Development of the IRM

SSIM is converted to a binary matrix called the Initial Reachability Matrix (IRM) by replacing V with 1 in (i, j) and 0 in (j, i), A with 0 in (i, j) and 1 in (j, i), X with 1 in both sets (i, j) and (j, i) and O with 0 in both sets are also given in the table shown below.

Table 3. Initial reachability matrix

S.no	*Risk Factors*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1	Management Challenges	*1*	*1*	*0*	*1*	*1*	*1*	*1*	*0*	*0*	*0*
2	Employee Performance	*0*	*1*	*0*	*0*	*1*	*1*	*1*	*0*	*0*	*0*
3	Training Challenges	*1*	*1*	*1*	*1*	*0*	*1*	*1*	*0*	*0*	*0*
4	Workplace Communication	*0*	*1*	*0*	*1*	*0*	*1*	*1*	*0*	*0*	*0*
5	Financial Constraints	*0*	*0*	*1*	*0*	*1*	*1*	*0*	*0*	*0*	*0*
6	Supply Chain Risk Management	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*
7	Coordination Risks	*0*	*0*	*0*	*0*	*0*	*1*	*1*	*0*	*0*	*0*
8	Disruption Risks	*1*	*1*	*0*	*0*	*1*	*1*	*1*	*1*	*0*	*0*
9	Cultural Resistance	*1*	*0*	*0*	*1*	*1*	*1*	*1*	*0*	*1*	*1*
10	Political Risks	*1*	*0*	*0*	*1*	*1*	*1*	*1*	*0*	*0*	*1*

3.1.3 Development of the FRM

The IRM is converted to the final reachability(accessibility) matrix (FRM) which is shown in Table 4. It takes into account the idea of reachability of the ISM method, i.e., when the 'A' of the risk factor influences the 'B' of the risk factor and -B risk factor influences the 'C' element, and then the 'A' risk factor also influences the 'C' factor and is displayed in the table with an asterisk (*). Table 5 shows the FRM's driving force and reliance on all eight risk factors for generating foreign trade.

Table 4. Final reachability matrix

S.no	*Risk Factors*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1	Management Challenges	1	1	1*	1	1	1	1	0	0	0
2	Employee Performance	0	1	0	0	1	1	1	0	0	0
3	Training Challenges	1	1	1	1	1*	1	1	0	0	0
4	Workplace Communication	0	1	0	1	1*	1	1	0	0	0
5	Financial Constraints	0	0	1	1*	1	1	1*	0	0	0
6	Supply Chain Risk Management	0	0	0	0	0	1	0	0	0	0
7	Coordination Risks	0	0	0	0	0	1	1	0	0	0
8	Disruption Risks	1	1	1*	1*	1	1	1	1	0	0
9	Cultural Resistance	1	1*	1*	1	1	1	1	0	1	1
10	Political Risks	1	1*	1*	1	1	1	1	0	1	1

Table 5. FRM with driving power and dependency

S. no	*Risk Factors*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*Driving power*
1	Management Challenges	1	1	1*	1	1	1	1	0	0	0	7
2	Employee Performance	0	1	0	0	1	1	1	0	0	0	4
3	Training Challenges	1	1	1	1	1*	1	1	0	0	0	7
4	Workplace Communication	0	1	0	1	1*	1	1	0	0	0	5
5	Financial Constraints	0	0	1	1*	1	1	1*	0	0	0	5
6	Supply Chain Risk Management	0	0	0	0	0	1	0	0	0	0	1
7	Coordination Risks	0	0	0	0	0	1	1	0	0	0	2
8	Disruption Risks	1	1	1*	1*	1	1	1	1	0	0	8
9	Cultural Resistance	1	1*	1*	1	1	1	1	0	1	1	9

10	Political Risks	1	1*	1*	1	1	1	1	0	0	1	8
	Dependence Power	5	7	6	7	8	10	9	1	1	2	

3.1.4 Partitioning the FRM

The construction model is the next step after the FRM construction of hazardous materials. The accessibility set includes a risk factor and other risk factors influenced by that risk factor. A limited risk line's columns with a value of 1 denote risk factors that are part of the accessibility set. In the same manner, the previous set contains hypothetical factors and other risk factors that may contribute to a particular risk factor. Every row containing column 1 of the estimated risk factor indicates that the risk factor for that line is contained in the previous set. All risk components are found to have inconsistencies after accessing the prior sets of each risk factor. Dangerous substances where accessibility and their incompatibility are given a high standard in the ISM system. This process continues until all building levels are identified and, in this case, five levels are identified five times as shown in Table 6. These identified levels assist in model development.

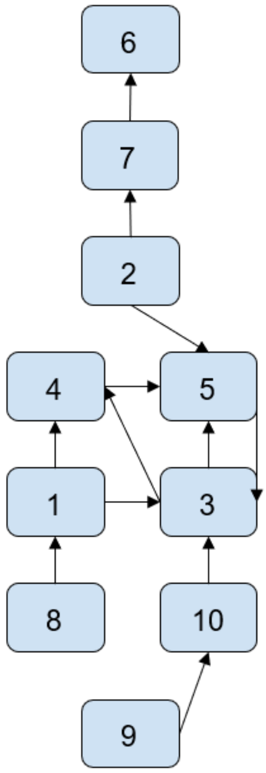
Table 6. Result of iterations

Risk factors	*Reachability*	*Antecedent*	*Intersection*	*Level*
1	1,2,3,4,5,6,7	1,3,8,9,10	1,3	VI
2	2,5,6,7	1,2,3,4,8,9,10	2	IV
3	1,2,3,4,5,6,7	1,3,5,8,9,10	1,3,5	V
4	2,4,5,6,7	1,3,4,5,8,9,10	4,5	IV
5	3,4,5,6,7	1,2,3,4,5,8,9,10	3,4,5	III
6	6	1,2,3,4,5,6,7,8,9,10	6	I
7	6,7	1,2,3,4,5,7,8,9,10	7	II
8	1,2,3,4,5,6,7,8	8	8	VII
9	1,2,3,4,5,6,7,9,10	9	9	VIII
10	1,2,3,4,5,6,7,10	9,10	10	VII

3.1.5 Development of Digraph

After removing the transitivity, the diagraph is developed according to Table 6 the levels which are given in the table show the exit stage of the risk in the digraph. The arrow represents the direction in which the one risks affects the other (The tail end affects the head end).

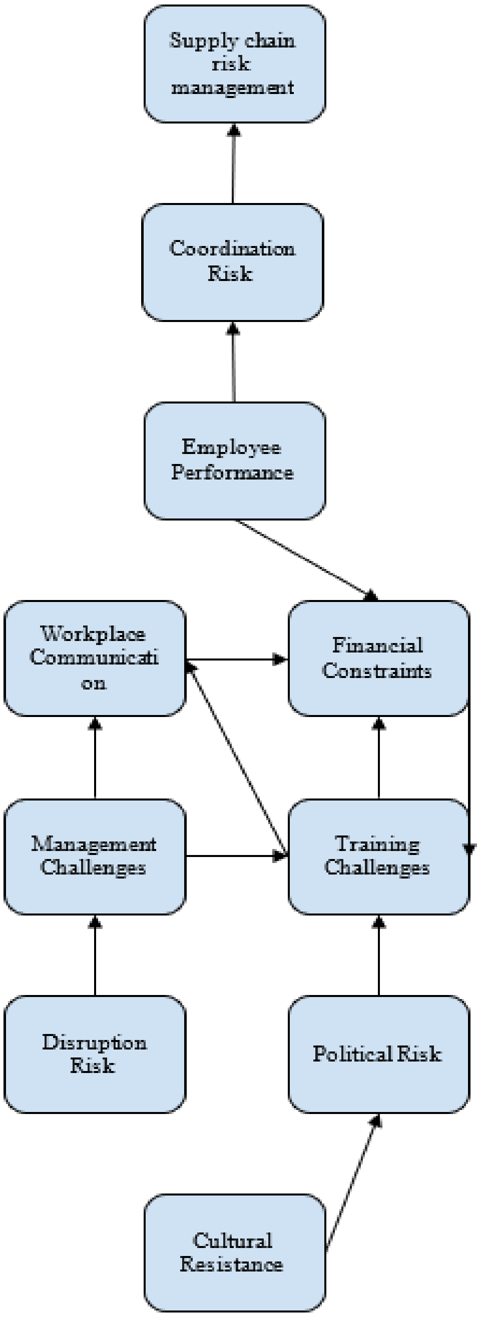
Figure 1. Diagraph showing the level of risk factors



3.1.6 Development of ISM model

By substituting the nodes with the names of risk variables that have an impact on the manufacturing system's transition, the diagraph is transformed into an ISM model.

Figure 2. ISM model showing the level of risk factors of manufacturing outsourcing.



3.1.7 Cross Impact Matrix

Cross impact matrix approach is followed to determine the key risk factors and divide them according to their driving and dependency powers to get a clear picture of the factors that affect the transition from traditional to flexible manufacturing system. This approach is also known as MICMAC analysis. Based on their driving power and dependency the challenges in the present case have been classified as shown in figure 3. It is observed that the factor with the most driving power lies in the quadrant of independent variables.

Figure 3. The MICMAC graph

INDEPENDENT LINKAGE

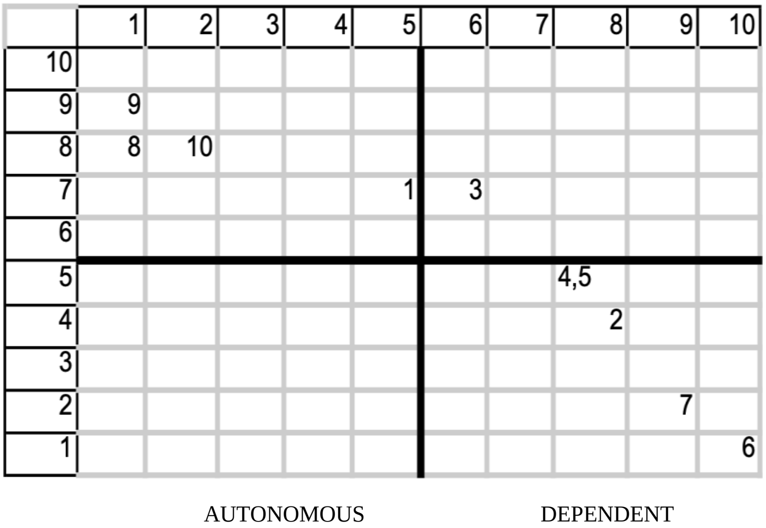


Table 7. Categories of risk factors

S. no.	*Categories*	*Definition*	*Risk factors (driver power index, dependency index)*
1	Independent risk factors	These have strong driver strength, but dependency strength is weak.	Cultural resistance (9, 1), Disruption risk (8, 1), Political risk (8,2), Management Challenges (7,5)
2	Linkage risk factors	These have strong driver strength and strong reliability. These are also unstable. Any action to them has an impact on others and has a positive impact on them.	Training challenges (7,6)
3	Dependent risk factors	This category includes those risk factors that have a strong reliability, but the driver's strength is weak.	Workplace communication (5,7), Financial constraints (5,8), Employee performance (4,7), Coordination risk (2,9), Supply chain management (1,10)
4	Autonomous risk factors	These risk factors have weak driver strength and are unreliable. They are fragmented compared to a system with fewer solid links.	

4. RESULTS & DISCUSSIONS

The sole purpose of this work was to identify and study the factors that hinder in a smooth transition from traditional manufacturing system to flexible manufacturing system so that the top executives can effectively minimize or eliminate these factors so that a better and more efficient manufacturing system can be evolved. In this study an ISM model was established and interrelationships among these factors were studied and analyzed. It is advantageous for top level authorities of relevant industries to study and understand these risk factors or challenges so that they can be enlightened and informed for a better and more efficient transition from traditional manufacturing system to flexible manufacturing system. Some of the findings of this study are discussed below.

It was noticed from the dependence power and driving power diagram that three factors “Disruption risk, Cultural resistance and Political risk” have high driving power and low dependence power. Meaning they are less dependent on other factors. They are strong drivers and any change in these factors will affect the whole manufacturing system because of their high driving power. These factors are the main root cause that influence all other factors hence they are considered a priority for decision makers to minimize and eliminate their cause and influence on the manufacturing system for a smooth transition from traditional manufacturing system to flexible manufacturing system.

Risks that result from unplanned and unpredictable circumstances, such as natural or man-made calamities like flood, fire, economic crisis, etc., are known as disruption risks. There are certain things that can be done in advance to lessen their impact on the production system, but it is hard to completely eliminate them in the long term. The decision is mostly based on EPFs and the non-stationary demand is approximated by an exponential characteristic of the wholesale price raised by the largest marketplace size. The disruption risk is indicated by probability. This study offers closed-form remedies and crucial values to help managers and decision-makers choose the most advantageous sourcing strategies in the face of concerns related to disruptions to supply chains. The findings are particularly relevant to situations where the client's need is responsive to the supplier's bulk pricing, the market will probably alter as a result of a delivery delay, providers are readily available but differ in terms of cost and dependability, and each supplier is unhindered by any barriers. The conclusions given in this research may have relevance in circumstances where a domestic vendor and a worldwide supplier are employed to buy commodities or non-strategic products. (Yu, Single or dual sourcing: decision-making in the presence of supply chain disruption risks, 2009).

The term "cultural resistance" in this context refers to the cultural variances between customers and suppliers, employers and employees, etc. that may impede a company's ability to produce or manufacture goods. It is without a doubt one of the most crucial factors that should be handled with the help of the best decision-makers in order to carry out the simple transition from traditional production tool to flexible manufacturing tool. It may be discovered that over half of the enablers statistically distinguish themselves significantly from each organization. Researchers' organizations are more affected by "government promotions and rules," "economic advantages," and "attracting overseas direct investment" than are industry specialists, while business professionals are more affected by "improving excellent" and "education and schooling system." Additionally, in cases of constraints, researchers' institutions do better than business specialists due to the effects of "lack of knowledge of nearby clients in inexperienced products" and "lack of standardized metrics or overall performance benchmarks." Identifying causal linkages in each of the enablers and barriers will be helpful in identifying and focusing on essential enablers and barriers, even though it is not preferable to provide equal attention to all of them at once. (Bhanot, 2015).

Political danger factors refer to troubles or demanding situations that arrive in or come in the way of production due to special political viewpoints and guidelines among the supplier and client, organizations and employees, and many others. It was found to be one of the primary danger elements with excessive riding power and occasional dependence on electricity. top authorities are cautioned to cope with this issue quickly to attain clean transition from traditional production device to flexible manufacturing gadget. The results also suggest a positive relationship between captive offshore flows and IP safety, as well as first-class bureaucracy, which includes degrees of corruption. The model predicts a conflict between judicial independence, staff safety, the burden of customs tactics, and geopolitical risks. The results suggest a consistent overlap of important fantastic factors, such as IP protection, ease of paperwork, and difficulty of customs processes - all great for both outsourced and captive offshoring. This is in contrast to the findings from the offshore outsourcing sports. This broad finding highlights the significance of institutional and regulatory components found in the host country for both offshore operations. Companies will be better able to manage and keep an eye on the political context in which they must operate thanks to the insight on industry-specific risk exposure. Similarly, by comprehending the industry's fundamental concerns and the possible pull effects of various policy interventions, the study findings offer guidance to governments on how to encourage offshore operations. (Hansen, 2019).

It was additionally located from the graph (desk eight) that elements “supply chain control, coordination risk, employee performance, administrative center verbal exchange and economic constraints “have high dependence strength and low riding energy. These factors had been considered as structured and any exchange on other factors will influence these elements and change on those factors will hardly influence the entire gadget. pinnacle authorities are cautioned to deal consequently with those factors to obtain a successful transition and development of the manufacturing gadget.
It became observed that “education demanding situations” issue from the determine (table) to be a linkage thing because it has each high using energy and dependence energy. Any exchange on this aspect can have a big effect on the producing version and any trade on other factors will also quite impact this factor. Its miles cautioned to pinnacle government to deal with this thing, therefore.

5. Conclusions

This work intends to find the inter relationship among the factors that affect the transition from traditional to flexible manufacturing systems with the help of Interpretive Structural modelling and cross impact matrix approach. There are 10 risks that affect the transition, namely.

1. Management Challenges
2. Employee Performance
3. Training Challenges
4. Workplace Communication Problems
5. Financial Constraints
6. Supply Chain Risk Management
7. Coordination Risk
8. Disruption Risk
9. Cultural Resistance
10. Political Risk

From the above-listed factors, Disruption Risk, Cultural Risk & Political Risk exhibit strong driving power & low dependence power for affecting the rest of the risk factors. Disruption risk is the risk that arises from natural disasters, such as weather disruption, or man-made ones such as economic crises. Disruption is a natural risk that is unaffected by any other factors. Cultural Risk refers to the attitude of the people of the locality that work in a corporation as well as the consumer market towards the operations and functionality of a production system, it depends upon the beliefs, knowledge and the lifestyle of people. It should be properly addressed by the decision-making authorities to make the transition as smooth as possible. Political Risk Factors are those that the corporations, workers, and the consumer face due to change in political scenario or other important political events. Detailed planning of the management of these risks should be done in the beginning to minimize the disagreements in the decisions & action and the perception of reality in the decision making is reduced for the smooth transition of the manufacturing process.

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