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THE SIGNIFICANCE OF WAREHOUSE MANAGEMENT IN SUPPLY CHAIN: AN ISM APPROACH

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Abstract: *Warehouse management is the key aspect for an uninterrupted flow of products within a supply chain. This paper deals with the critical factors that are responsible for creating an impactful influence on the working of warehouse management. The analysis involves the selection of critical factors then applying Interpretive Structural Modelling (ISM) methodology to them in order to get the level partition and final ISM model. This research also involves the MICMAC analysis on the factors which classifies all the selected factors into four groups namely, autonomous variables, dependent variables, linkage variables and driver variables. This research will help the supply chain architects to establish a better and reliable warehouse system. As this research involves analysis of multiple domains that is why a variety of users can refer to this work for their businesses, also the ISM approach gives a good accuracy of the hierarchy of the factors which helps in deciding the most effective chronology of the implementation of various warehousing operations. Researchers can also refer to this work to get insights of the significance of warehouse management in the supply chain and also the complete working of the ISM methodology.*

Key words: *Warehouse, Supply Chain Management, Critical Factors, ISM.*

1. Introduction

One of the most critical parts of any supply chain is the warehouse. The success or failure of a business significantly depends on its supply chain structure. The supply chain consists of multiple stages that contain multiple nodes, each having different functionalities and objectives (Handfield & Nicholas Jr., 1999). Similarly, warehouses occupy their places in the supply chain at multiple levels. There is a need for warehouses at the supplier side, at the manufacture as well as the retailer end. The main function of a warehouse is to provide buffer storage to maintain the uninterrupted flow of the supply chain. Warehouses stores goods on a temporary basis in order to deal with the variability in the market, interruption in the flow of products,

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the delivery criterion of the customers, value addition processes, customization of products, etc..

Markets are experiencing rapid variations in customer demands. Products get updated frequently, new products are also being introduced very rapidly and due to large competition, there is also a need for quick delivery of the demanded products. To cope up with the changing market structure, businesses are also adapting to the new production methods like the Just In Time (JIT) method or Lean Production methods (Gu et al., 2007). To achieve these production levels, a well-equipped supply chain is needed and for a good supply chain, there is a necessary requirement of highly efficient and effective warehouses. These warehouses must include a better storage facility, faster input and output processes, technologically advanced infrastructure, an efficient warehouse management system, skilled human resources and all other required elements. Along with this, automation is also playing an important role in the success of warehouses, it ensures better resource utilization with improved reliability. The main constraint to this increasing influence of IT in supply chain management is the lack of adaptability of the old conventional system into a new dynamic system. In this way, there are multiple factors that are responsible for the success of the warehouse system (Baker & Canessa, 2009).

This paper deals with the identification of the critical factors that influences the establishment and working of a warehouse. A number of literature reviews have been explored for a better understanding of the topic. In this work, one Multiple Criterion Decision Making (MCDM) approach is used to define a model that can be referred to while building a warehouse system. The MCDM technique which has been used here is Interpretive Structural Modelling (ISM) methodology. ISM focuses on the complex interrelationships between the selected factors and gives out the best and analytically correct model for implementation.

2. Literature Review

The most critical phase of any MCDM technique is the determination of factors that influence the functioning as well as the growth of the selected domain. In this research, we have considered a domain comprising of advanced warehouse activities. After a thorough review of the earlier literature, we have enlisted all the important factors that are most influential during the functioning as well as determining the growth of a modern warehouse, in Table 1.

Table 1. Critical factors affecting the modern warehouse identified by previous studies.

Important Factors	Research Articles
Optimal Warehouse Storage	Leng, J., Yan, D., Liu, Q., Zhang, H., Zhao, G., Wei, L., ... & Chen, X. (2021). Digital twin-driven joint optimisation of packing and storage assignment in large-scale automated high-rise warehouse product-service system. International Journal of Computer Integrated Manufacturing, 34(7-8), 783-800.
Inventory Management	Au, Y. H. N. (2009). Warehouse management system and business performance: Case study of a regional distribution centre.

Important Factors	Research Articles
Order Picking System	Yerpude, S., & Singhal, T. K. (2018). Smart warehouse with internet of things supported inventory management system. International Journal of Pure and Applied Mathematics, 118(24), 1-15. Custodio, L., & Machado, R. (2020). Flexible automated warehouse: a literature review and an innovative framework. The International Journal of Advanced Manufacturing Technology, 106(1), 533-558. Lee, C. K., Lv, Y., Ng, K. K. H., Ho, W., & Choy, K. L. (2018). Design and application of Internet of things-based warehouse management system for smart logistics. International Journal of Production Research, 56(8), 2753-2768.
Warehouse Management System	Ramaa, A., Subramanya, K. N., & Rangaswamy, T. M. (2012). Impact of warehouse management system in a supply chain. International Journal of Computer Applications, 54(1).
Transportation	Kondratjev, J. (2015). Logistics. Transportation and warehouse in supply chain.
Manpower	Tonape, S., Patil, K., & Karandikar, V. (2016). Manpower Optimization and Method Improvement for a Warehouse.
Safety Measures	Glickman, T. S., & White, S. C. (2007). Safety at the source: green chemistry's impact on supply chain management and risk. International Journal of Procurement Management, 1(1-2), 227-237. Rajaprasad, S. V. S., & Chalapathi, P. V. (2015). Factors influencing implementation of OHSAS 18001 in Indian construction organizations: interpretive structural modeling approach. Safety and health at work, 6(3), 200-205.
Overall Running Cost	Varila, M., Seppänen, M., & Suomala, P. (2007). Detailed cost modelling: a case study in warehouse logistics. International Journal of Physical Distribution & Logistics Management. Speh, T. W. (2009, June). Understanding warehouse costs and risks. In Ackerman Warehousing Forum (Vol. 24, No. 7, pp. 1-6).
Warehouse Productivity	Staudt, F. H., Alpan, G., Di Mascolo, M., & Rodriguez, C. M. T. (2015). Warehouse performance measurement: a literature review. International Journal of Production Research, 53(18), 5524-5544.
Location	Jha, M. K., Raut, R. D., Gardas, B. B., & Raut, V. (2018). A sustainable warehouse selection: an interpretive structural modelling approach. International Journal of Procurement Management, 11(2), 201-232.
Green Initiatives	Bartolini, M., Bottani, E., & Grosse, E. H. (2019). Green warehousing: Systematic literature review and bibliometric analysis. Journal of Cleaner Production, 226, 242-258.

Important Factors	Research Articles
Use of Right Storage Solution	Lee*, M. K., & Elsayed, E. A. (2005). Optimization of warehouse storage capacity under a dedicated storage policy. International Journal of Production Research, 43(9), 1785-1805.
Order Fulfilment	Reaidy, P. J., Gunasekaran, A., & Spalanzani, A. (2015). Bottom-up approach based on Internet of Things for order fulfillment in a collaborative warehousing environment. International Journal of Production Economics, 159, 29-40.
Automation	Atieh, A. M., Kaylani, H., Al-Abdallat, Y., Qaderi, A., Ghoul, L., Jaradat, L., & Hdairis, I. (2016). Performance improvement of inventory management system processes by an automated warehouse management system. Procedia Cirp, 41, 568-572.
	van Geest, M., Tekinerdogan, B., & Catal, C. (2021). Design of a reference architecture for developing smart warehouses in industry 4.0. Computers in industry, 124, 103343.
Forecasting	Mohsen, & Hassan, M. D. (2002). A framework for the design of warehouse layout. Facilities, 20(13/14), 432-440.
	Suesut, T., Gulphanich, S., Nilas, P., Roengruen, P., & Tirasesth, K. (2004, November). Demand forecasting approach inventory control for warehouse automation. In 2004 IEEE Region 10 Conference TENCON 2004. (pp. 438-441). IEEE.

3. Identified Critical Factors

There were multiple factors that are affecting the warehousing operations. As mentioned in the preceding section, 15 of the most important factors have been chosen for further investigation. The significance of all these factors is discussed in detail below.

3.1. Optimal Warehouse Storage

The storage capacity of a warehouse is critical to the overall operation of warehousing. Someone can think that the whole available storage must be used for storage purposes, but in reality, this is one of the blunder mistakes that leads to the failure of many supply chains.

The proper approach is we should focus on utilizing the available space in such a way that smooth conduct of other warehousing activities apart from storage, like the ease of movement of workforce and machinery, proper accounting units, can be assured (Leng et al., 2021).

Some key features of optimal warehouse storage are

1. Optimal storage utilization for maximum efficiency.
2. Storage occupancy within 22% to 27% of the total usable space is maintained.
3. It can handle seasonal growth in demands.
4. It ensures optimal clearance height.

5. Ease in the movement of employees and robots.
6. Can provide high flexibility and agility to the warehouse depending upon the change in product.

3.2. Inventory management

Every organization requires inventories to ensure the efficient and de-stressed flow of supply chains. Inventory accounts for safeguarding the organizations from demand fluctuations, the unreliability of supply, price variations, lead time variations, etc. (Au, 2009).

The supervision and controlling of this inventory with proper management techniques are termed inventory management. Inventory management is a vital aspect that heavily contributes to the success of the industry (Yerpude & Singhal, 2018).

Some key features of inventory management are

1. Control over inventory for achieving optimal storage and capital utilization.
2. Fulfilment of volatile customer demands.
3. Tackles the problem of erratic supplies.
4. Safeguarding organizations from price fluctuations.
5. Ensures real-time storage usage.

3.3. Order Picking System

Order Picking is *the process of retrieving products from storage in response to specific customer demand* (Custodio & Machado, 2020). It is one of the most labour intensive and capital consuming activities in the whole warehousing operations. It has been found from the earlier studies that order picking activities almost constitutes 55% of the total warehousing costs. Any shortcoming in the order picking process results in unsatisfactory customer reviews and an increase in the cost of maintaining operations activities (Lee et al., 2018). During the design of the order picking system, special attention should be paid to the fact that it must be both sturdy and efficient in operation.

Some key features of the order picking system are

1. Reduces the lead time.
2. Supports the just in time approach of the supply chain.
3. Helps in handling the changing market conditions.
4. Ease in accumulation of items in the storage as well as their proper labelling can be assured (De Koster et al., 2007).
5. Ease in the accessibility of all the items with optimal storage utilization.

3.4. Warehouse Management System

Warehouse management system is used to manage processes, resources, people and equipment on the operational level within a warehouse.

There are basically three types of warehouse management systems (Mao et al., 2018). First is the basic WMS, it supports the stock and location controls of the product. Its main functions are registering, storing and picking information about the products. The second is the advanced WMS, which has some added advantages over the basic WMS like it can do resource planning activities to synchronize the flow of items. Basically, it focuses on the throughput, stocks and capacity analysis within a warehouse. The third is the complex WMS, it can organize and optimize a group of warehouses simultaneously (Ramaa et al., 2012). Its advanced additional functionalities include transportation planning, value-added logistics planning and most importantly helps in smooth communication between the different units of the supply chain.

Some key features of the warehouse management system are

1. Tracking of the flow of items within the supply chain.
2. Sharing of the information at different workstations.
3. Synchronization of all the logistics processes.
4. Improving the efficiency of resource planning.
5. Ensuring proper connectivity at all the nodes within the supply chain.

3.5. Transportation

Transportation is one of the basic parts of any economic activity, which is associated with an improvement in the satisfaction level of people and businesses by altering the location of goods and services (Kondratjev, 2015). Moving products for fulfilling customer requirements is the key aspect of transportation in logistics. There are various means of transportation such as roadways, railways, waterways, airways, etc. are involved in supply chain management (Žunić et al., 2018).

Some key features of transportation are

1. Forwarding, cargo handling and transfer of products.
2. Sequencing of the utilization of different modes of transport.
3. Ensuring risk-free maneuver of products.
4. Proper scheduling of delivery for reducing time consumption within the supply chain.

3.6. Manpower

For all firms, trained staff is a requirement of the day. The efficiency and effectiveness of the human resource involved in a warehouse are critical to its growth and development. Manpower is the key requirement for every workstation, especially at the loading, unloading and packaging units (Tonape et al., 2016). A good working environment gives better output in comparison to the overcrowded and overloaded facilities. And finally, all the critical decision-making lies with the skilled and experienced personnel working in the supply chain.

Some features of manpower activities are

1. Responsible for unpacking and arranging goods when they arrive at the storage facility.
2. Labelling and packing are also carried out by the employees with the help of some tools and technologies.
3. Customization of special orders is mostly handled by the manpower working there.
4. A good set of technically skilled employees can give a lot of flexibility to the warehouse.
5. All the final stage inspections are carried out by the employees themselves.

3.7. Safety Measures

The goal of putting in place safety measures in a company is to protect the employees' health, safety, and well-being, as well as the valuable commodities that are kept there. In the event of an emergency, safety precautions are critical (Glickman & White, 2007). Mis happenings are a part of the working environment but by applying safety measures we can reduce it drastically.

Some of the key safety measures are

1. Fireproofing of the whole warehousing facility.
2. Strictly following checkboxes that are related to the safety measures (Rajaprasad & Chalapathi, 2015).
3. Installation of advanced and reliable alarming system.
4. Proper arrangement of security personnel for the safeguarding of the warehouse.
5. Availability of first aid kits and fire extinguishers at every possible location.

3.8. Overall Running Cost

Running cost calculation is the activity that assists the decision making, planning and control strategies. This task needs to be done very accurately because almost all the major decisions are taken based on the overall cost (Varila et al., 2007). The location and size of the project play a vital role in the determination of overall running cost. It incorporates almost all the expenditures such as power bills, the salary of employees, transportation costs, maintenance costs, etc. (Speh, 2009).

Some key characteristics of the overall running cost are

1. It helps in finding the cost per order.
2. Important operational expenditures like the cost of equipment and maintenance costs can be determined.
3. Maximum attempts are made in the direction of reducing the running costs.
4. Lastly, it helps the organization to compare the total cost incurred during the running of the warehouse in comparison with the total revenue generated by the warehouse.

3.9. Warehouse Productivity

Metric analysis of the warehouses is required for determining the overall throughput and productivity. Due to the increasing complexities in the warehousing operations, it becomes very difficult to quantify all the aspects for easy understanding (Staudt et al., 2015). The performance analysis helps the managers to get a clear view of the productivity of a warehouse.

Warehouse productivity includes

1. Analysis of orders dispatched per hour.
2. Analysis of lines cleared per hour.
3. Analysis of items handled per hour.
4. Calculates the total throughput of the warehouse.
5. Helps in determining the working layout (for e.g., shifting from multichannel distribution to omnichannel distribution).

3.10. Location

Selection of the location for a warehouse is a very critical decision. As it is a one-time decision to be made so a lot of other factors are considered while selecting a strategic location. Some of these factors are good accessibility to the required modes of transport (roadways, railways, waterways, airways, etc.), land acquired must be free from any legal conflicts, the location should be isolated from the people-centric city areas, there should be a continuous supply of water and electricity, favorable legal policies for the uninterrupted working of the warehouse, it must be a properly planned node point on the supply chain, must be at a product and employee-friendly climatic conditions, etc. (Jha et al., 2018).

Some additional features of the strategic location are

1. It accounts for the quick responsiveness towards the customer demands.
2. It must avoid choking up the supply chain.
3. It should ensure an optimal supply chain path.
4. It must satisfy the basic needs of transportation, power and water supply.
5. It should work in accordance with government policies and regulations.

3.11. Green Initiatives

Unfortunately, warehouses are the major contributors to the emission of greenhouse gases. Also, a large portion of the human resource working in the supply chain is involved in various warehousing activities. That is why it becomes very essential to provide a sustainable working environment within the warehouses (Bartolini et al., 2019). Accordingly, implementation of green initiatives becomes an integral part of the warehousing operations. Green initiatives basically are the activities that an organization undertakes in order to reduce its carbon footprint and to improve the work environment for the employees.

Some of the key green initiatives are

1. Establish a green environment around the workplace.
2. Reduce fossil fuel consumption from the various warehousing operations.
3. Promote utilization of recyclable and biodegradable resources.
4. Take account of the moral and social responsibilities.
5. Develop a feel-good factor within the workplace.

3.12. Use of Right Storage Solution

Warehouses are large volumes of spaces that are used for storage purposes for a supply chain. If the internal space within the warehouse is not managed properly then it would lead to major setbacks for the whole supply chain. To ensure the optimal utilization of the available space, the use of the right storage solution is required (Lee* & Elsayed, 2005).

Some of the right storage solution practices are

1. Use of pallet racks for storage.
2. Flexible and situation-specific implementation of LIFO and FIFO arrangements.
3. Use of mobile racks, conveyors and forklifts for the movement of products within the warehouse
4. Ensuring proper management of all the stock-keeping units (SKUs).

3.13. Order Fulfilment

Order fulfilment is one of the parameters that give a direct insight into customer satisfaction for an organization. Competition in the market is increasing day by day, firms that are able to fulfil the needs of their clients at a satisfactory rate can only sustain in the business for a longer period of time (Reaidy et al., 2015). Order fulfillment at a rapid rate gives the organizations a push towards expanding the number of customers for their products.

Some of the key features of order fulfilment are

1. Orders were delivered on time according to the client's requested date.
2. Optimum utilization of the shipment facility.
3. Proper handling of orders while picking, packaging and shipping operations.
4. Lead time monitoring of all the orders.

3.14. Automation

When compared to a manual system, a well-automated warehousing facility requires fewer efforts, is more efficient and produces more consistent results. There are a lot of repetitive tasks that are involved in warehousing activities. Now, with the help of advanced technologies, one can easily automate these tasks in order to get very high efficiency with very little effort (Atieh et al., 2016). Another reason to automate the warehouse is that manual activities might result in inadvertent human errors, lowering warehouse productivity.

The basic steps towards automating a warehouse are the identification and reengineering of the processes which are best suited to get automated. Followed by detailed modelling of the activity, then building the framework, integration of the software to it and finally implementing it in the warehouse.

Some of the key features of automation are

1. Data collection of the products as soon as they arrive at the warehouse.
2. Implementing robots in the warehouse to ease up the tasks for the employees.
3. Implementation of Automated Guided Vehicles (AGVs) for the automated flow of products.
4. Implementation of IoT, AR, and RFID technologies for various activities (Van Geest et al., 2021).

3.15. Forecasting

Forecasting is used for preparing the capacity of the warehouse and collecting the necessary information which would be utilized for determining the inventory capacity, equipment requirements and proper allotment of storage locations (Hassan, 2002). Without forecasting the organizations are not able to keep a track of the future demand trends which can lead them towards catastrophic failures.

Some of the key aspects of forecasting are

1. Tracking the trends of future demands.
2. Determining the order limit according to the warehouse capacity.
3. Segregation of business demands according to the local and global market (Suesut et al., 2004).
4. Identification of the seasonal market along with their demand pattern
5. Helps in stock planning activities.

4. The proposed ISM methodology

Determination of the appropriate relationships between the selected factors and their impact on the whole project leads to better decision making and project planning. Interpretive Structural Modelling (ISM) is a tool (an algorithm) that creates solutions for complicated issues by establishing the contextual relationships between the elements, and when combined with the MICMAC analysis it also gives the classification and ranking of the components in terms of their driving force.

The requirements for ISM analysis are the identified elements according to the problem statement and defining a proper contextual relationship between them. These elements can either be qualitative or quantitative. The scope of the analysis doesn't get bounded by the measurable entities only and because of this ISM possesses a lot of flexibility than other methods which are only based on quantitative analysis (Singh & Kant, 2008). After selection of the factors, the maximum efforts are required in determining the complex relationships between these factors and this task is carried out by a set of professionals who have the expertise in the designated sectors. In this study, 15 factors have been identified after thorough literature reviews. Now the task is to implement ISM methodology on these selected factors and further discuss the results obtained.

The steps involved in ISM methodology are,

a. Creation of structural self-interaction matrix (SSIM).
b. Development of the reachability matrix.
c. Execution of the level partitions.
d. Classification of the selected factors.
e. Development of the ISM model.

4.1. Creation of structural self-interaction matrix (SSIM)

The most complex and demanding phase of ISM is the structural self-interaction matrix. A variety of specialists from various sectors and academies were consulted during this step to construct the intricate contextual relationship between the specified elements (Pfohl et al., 2011). The following four symbols are used to determine the direction of a relationship between two elements (*i* and *j*).

V: factor *i* will help to achieve factor *j*
A: factor *j* will help to achieve factor *i*
X: factor *i* and *j* will help each other, and
O: both factors *i* and *j* are unrelated

For the sake of clarity, each factor has been allocated a notation. Table 2 contains a list of all the notations.

Table 2. Factors with their notations.

Sl. No.	Selected Factors	Notations
1.	Optimal Warehouse Storage	OWS
2.	Inventory Management	IM
3.	Order Picking System	OPS
4.	Warehouse Management System	WMS
5.	Transportation	TR
6.	Manpower	MAN
7.	Safety Measures	SM
8.	Overall Running Cost	ORC
9.	Warehouse Productivity	WPR
10.	Location	LOC
11.	Green Initiatives	GI
12.	Use of Right Storage Solution	URS
13.	Order Fulfillment	OF
14.	Automation	AUT
15.	Forecasting	FR

The structural self-interaction matrix (SSIM) is generated in Table 3 based on the determined associations.

Table 3. Structural Self-Interaction Matrix (SSIM)

Factors	OWS	IM	OPS	WMS	TR	MAN	SM	ORC	WPR	LOC	GI	URS	OF	AUT	FR
OWS		A	V	A	A	A	A	V	V	A	A	A	V	A	A
IM			V	A	A	A	A	V	V	A	O	X	V	A	A
OPS				A	A	A	A	O	V	A	A	A	V	A	A
WMS					A	A	V	V	V	A	V	V	V	X	A
TR						O	V	V	V	O	V	V	V	V	O
MAN							V	V	V	O	V	V	V	V	O
SM								V	V	A	V	V	V	O	A
ORC									V	A	A	A	V	A	A
WPR										A	A	A	A	A	A
LOC											V	V	V	V	O
GI												X	V	A	A
URS													V	A	A
OF														A	A
AUT															A
FR															

4.2. Development of the reachability matrix

The SSIM has been turned into a binary matrix, known as the initial reachability matrix, at this phase (Aich & Tripathy, 2014). The reachability matrix is created by replacing V, A, X, and O with 1 and 0. The substitution of 1s and 0s is accomplished using the rules below:

1. If the SSIM entry I j) is V, the reachability matrix I j) entry becomes 1 and the (j, I entry becomes 0.
2. If the SSIM entry I j) is A, the reachability matrix I j) entry becomes 0 and the (j, I entry becomes 1.
3. If the SSIM's I j) entry is X, then the reachability matrix's I j) and (j, I entries are both 1.
4. If the SSIM's I j) entry is O, then the reachability matrix's I j) and (j, I entries become 0 as well.

By applying the above-mentioned rules, the reachability matrix has been developed and shown in Table 4.

Table 4. Reachability Matrix (matrix M)

Factors	OWS	IM	OPS	WMS	TR	MAN	SM	ORC	WPR	LOC	GI	URS	OF	AUT	FR	Driving Power
OWS	1	0	1	0	0	0	0	1	1	0	0	0	1	0	0	5
IM	1	1	1	0	0	0	0	1	1	0	0	1	1	0	0	7
OPS	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	3
WMS	1	1	1	1	0	0	1	1	1	0	1	1	1	1	0	11
TR	1	1	1	1	1	0	1	1	1	0	1	1	1	1	0	12
MAN	1	1	1	1	0	1	1	1	1	0	1	1	1	1	0	12
SM	1	1	1	0	0	0	1	1	1	0	1	1	1	0	0	9
ORC	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	3
WPR	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
LOC	1	1	1	1	0	0	1	1	1	1	1	1	1	1	0	12
GI	1	0	1	0	0	0	0	1	1	0	1	1	1	0	0	7
URS	1	1	1	0	0	0	0	1	1	0	1	1	1	0	0	8
OF	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	2
AUT	1	1	1	1	0	0	0	1	1	0	1	1	1	1	0	10
FR	1	1	1	1	0	0	1	1	1	0	1	1	1	1	1	12
Dependence Power	11	9	12	6	1	1	6	12	15	1	9	10	14	6	1	

Table 4 also displays the driving and dependence powers of each element. The driving power of a selected factor refers to the number of variables it assists in achieving or making them fulfil the aim, whereas the dependence power of a selected factor refers to the number of elements it relies on to accomplish its goal. With the use of MICMAC analysis, these driving and dependence powers will be used to classify all of the components.

4.3. Execution of the level partitions

The level division is carried out after the production of the final reachability matrix (M). To begin, each factor's reachability set, antecedent set, and intersection set are determined. Furthermore, the component with the same reachability set and intersection set gains the topmost level in the level partition (Singhal et al., 2018). After the top-level factor is established, it is removed from the list of other factors, and the next level of factors is determined using the same procedures.

After all of the components' levels have been determined, they are grouped in a digraph according to their levels. This digraph showcases the structure of the final ISM model that is desired to be achieved.

Table 5 shows the final level partition of all the selected critical factors.

Table 5. Final Level Partition

Factor	Notation	Reachability Set	Antecedent Set	Intersection Set	Level
1.	OWS	1, 3, 8, 9, 13	1, 2, 4, 5, 6, 7, 10, 11, 12, 14, 15	1	4
2.	IM	1, 2, 3, 8, 9, 12, 13	2, 4, 5, 6, 7, 10, 12, 14, 15	2, 12	5
3.	OPS	3, 9, 13	1, 2, 3, 4, 5, 6, 7, 10, 11, 12, 14, 15	3	3
4.	WMS	1, 2, 3, 4, 7, 8, 9, 11, 12, 13, 14	4, 5, 6, 10, 14, 15	4, 14	6
5.	TR	1, 2, 3, 4, 5, 7, 8, 9, 11, 12, 13, 14	5	5	7
6.	MAN	1, 2, 3, 4, 6, 7, 8, 9, 11, 12, 13, 14	6	6	7
7.	SM	1, 2, 3, 7, 8, 9, 11, 12, 13	4, 5, 6, 7, 10, 15,	7	6
8.	ORC	8, 9, 13	1, 2, 4, 5, 6, 7, 8, 10, 11, 12, 14, 15	8	3
9.	WPR	9	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15	9	1
10.	LOC	1, 2, 3, 4, 7, 8, 9, 10, 11, 12, 13, 14	10	10	7
11.	GI	1, 3, 8, 9, 11, 12, 13	4, 5, 6, 7, 10, 11, 12, 14, 15	11, 12	5
12.	URS	1, 2, 3, 8, 9, 11, 12, 13	2, 4, 5, 6, 7, 10, 11, 12, 14, 15	2, 11, 12	5

Factor	Notation	Reachability Set	Antecedent Set	Intersection Set	Level
13.	OF	9, 13	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15	13	2
14.	AUT	1, 2, 3, 4, 8, 9, 11, 12, 13, 14	4, 5, 6, 10, 14, 15	4, 14	6
15.	FR	1, 2, 3, 4, 7, 8, 9, 11, 12, 13, 14, 15	15	15	7

4.4. Classification of the selected factors

In this phase, all the 15 selected factors will get classified into four groups namely, driver variable, dependent variable, autonomous variable and linkage variable. The classification is shown in Figure 1.

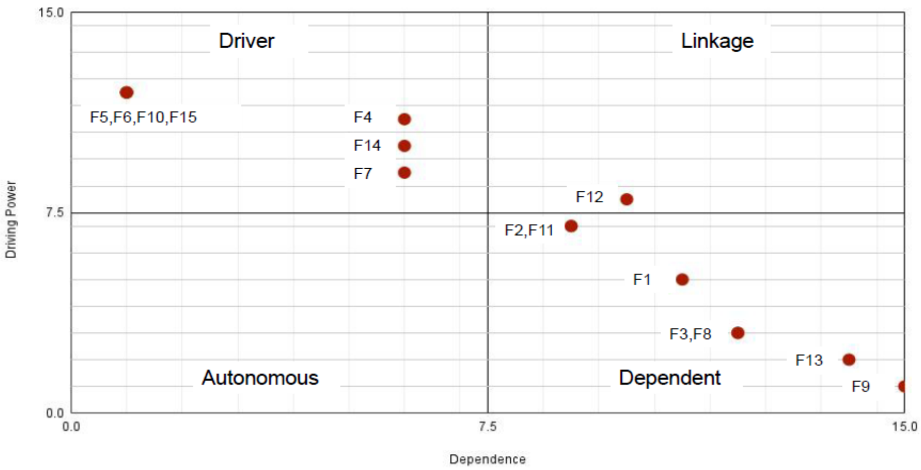

Figure 1. Classification of factors (Driver-Dependence Graph)

The first quadrant, 'Autonomous Variable' refers to the group of elements that nave the least driving as well as dependence power. Autonomous variables usually don't have a significant impact on the working domain. The second quadrant, 'Dependent Variable' refers to the group of elements that have a high dependence on other factors. The third quadrant, referred to as 'Linkage Variable,' refers to elements with a strong driving and dependence power. These are the most insecure and problematic characteristics in any working environment. The fourth quadrant, 'Driver Variable' refers to the elements that have a very high driving influence on the other factors (Aich & Tripathy, 2014).

Figure 1 shows that there are no factors that come under the autonomous variable category, implying that no insignificant factors were chosen for our investigation. In the dependent variable region, there are 7 factors among which 'Warehouse Productivity' has the highest dependence. In the linkage region, the only factor is there, that is 'Use of Right Storage Solution'. This factor needs to be optimized in order to make the supply chain stable. In the driving variable region, there are 7 factors among which 'Transportation', 'Manpower', 'Location' and 'Forecasting' have the highest driving power.

4.5. Development of the ISM model

The construction of the ISM model is the final stage of the ISM study. The final reachability matrix (Table 4) and the level partition of the entire model can be used to create this model. If there is a link between factors I and j, arrows and points will be used to depict that relationship (Singhal et al., 2018). The initial digraph is also known as the initially directed graph. The final ISM model is created after deleting all transitivities among the variables, as shown in figure 2.

5. Results and Discussions

The warehouse is well-known for playing a critical role in the entire supply chain. Establishing an efficient warehousing facility for the supply chain's profitable output is one of the most important jobs.

From the earlier studies of the analysis, 15 factors have been found out which influences the establishment and working of a warehouse. After the identification of the critical factors, ISM analysis was carried out and the corresponding results were obtained. From the gathered outcomes, it can be deduced that,

1. There is no autonomous variables or factors. Autonomous variables are usually those elements that have a very weak influence over the selected domain. In this case, there are no factors that have an insignificant effect on the warehousing activities or supply chain. Also because of the less driving as well as less dependence power, the autonomous factors doesn't participate in the decision-making activities.

2. Seven factors fall under the dependent variable region. These factors are namely Inventory Management, Green Initiatives, Optimal Warehouse Storage, Order Picking System, Overall Running Cost, Order Fulfilment and Warehouse Productivity. Those elements with a high dependence power but low driving power are known as dependent variables. Usually, these elements occupy the topmost levels of the ISM model and are hence also known as the long-term objectives. These are basically the desired outcomes of the warehousing activities. Warehouse Productivity has the largest dependence power among all the other factors.

3. One factor falls under the linkage variable region. Linkage variables are the most unstable entities within the selected domain. They need to be stabilized in order to establish an efficient and effective warehouse. From the study, Use of Right Storage Solution is the only factor that is unstable. If any change occurs in this factor, then it will cause an effect on the whole supply chain, as it has a high driving power as well as high dependence power.

4. Seven Factors fall under the driver variable region. These factors are namely Transportation, Manpower, Location, Forecasting, Warehouse Management System, Automation and Safety Measures (Wang et al., 2017). The elements with a high driving power and a low dependence power are known as driver variables. As the warehouse's key driving forces, these factors are accountable for accomplishing the necessary long-term objectives. These factors occupy the bottom-most levels of the ISM model because of their high driving influence and hence also known as the short-term objectives.

Transportation, Manpower, Location and Forecasting are the largest driving factors among all the other factors.

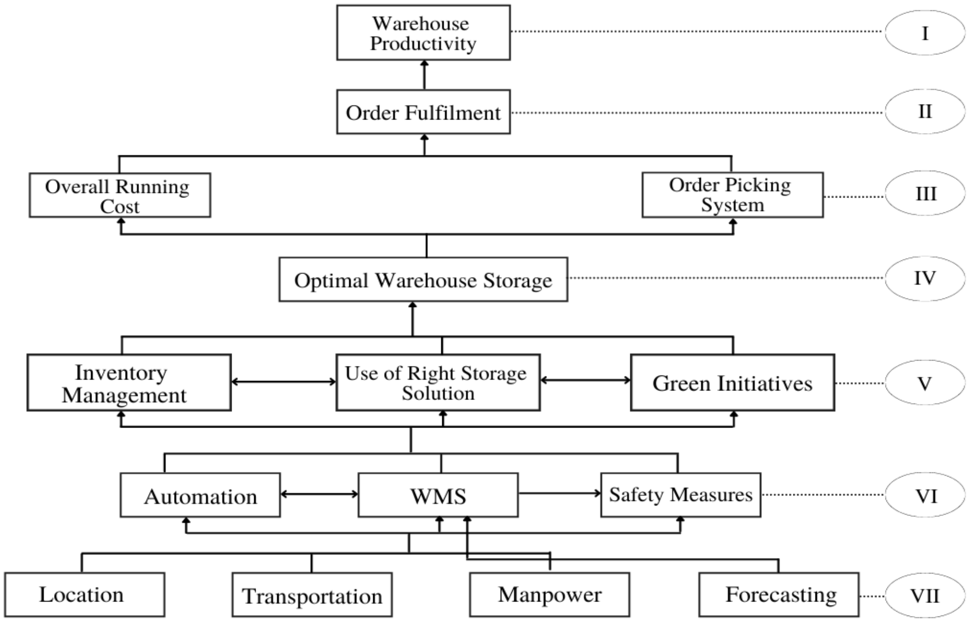

Figure 2. Classification of factors (Driver-Dependence Graph)

According to the ISM analysis, optimal warehouse storage is a major bottleneck that has a direct influence on long-term objectives. According to studies, a lack of planning when determining actual utilizable space causes major setbacks in the warehouse's economic stability (Rebelo et al., 2021). Along with this, a stable workforce schedule increases the overall effectiveness of all warehouse activities (Popović et al., 2021). The 5M (Man, Method, Material, Machine, and Measurement) are the most common sources of errors, and they require continuous maintenance (Hajej et al., 2021). Following the implementation of all remedies, performance metrics such as throughput and turnover should be monitored (Karim et al., 2020). It must have a long-term favourable trend, if not, then there must be some variables causing problems with the warehouse's operation.

6. Conclusions

The architects of the supply chain are well aware of the challenges that are encountered during the establishment and working of a warehouse within the system. To give a clear and more specific insight into the factors that influence the warehousing activities, this MCDM technique, i.e., ISM analysis was carried out. 15 critical factors have been identified that have a significant impact on the supply chain. The most crucial task is to figure out how these factors interact in complex ways, and that is why this task was carried out by a set of experts after which the rest of the ISM analysis was carried out. The outcomes show that there is a need to stabilize the instability of the Use of Right Storage Solution. Factors like Warehouse Productivity and Order Fulfilment are the long-term objectives of the warehouse whereas factors like Transportation, Manpower, Location and Forecasting are the primary drivers for the working of warehouses. This work will help the supply chain architects to properly plan an effective and efficient warehousing facility by following the ISM model. In order to attain long-term goals, more emphasis should be placed on the bottom-level driver variables.

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