# HIERARCHICAL STRUCTURE MODELLING OF FACTORS AFFECTING TECHNOLOGY ADOPTION BY MSMEs IN INDIA: AN ISM APPROACH

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## ABSTRACT

***Background****: Micro Small Medium Enterprises (MSMEs) has a pivotal role in industrial growth in Indian economy. The MSMEs have noteworthy contribution to national GDP, export shares, industrial output and employment. MSMEs have provided large scale employment opportunities ensuring regional balance alleviating social disparity with inclusive growth. MSMEs encountered major challenges post globalization and economic reforms with free flow of goods, capital and technology. The technology adoption by MSMEs is major constraint to competitiveness and growth of MSMEs.*

***Purpose:*** *This study investigates the factors affecting the technology adoption by MSMEs in India. The factors are identified through systematic literature review and opinion of experts to capture industry and academic perspective. The hierarchical structure and contextual relationship of factors is established through Interpretive Structure modelling (ISM) followed by classification of factors with Fuzzy-MICMAC analysis.*

***Findings:*** *The study has identified ten factors affecting technology adoption by MSMEs in India. Based on analysis, top management commitment, financial capability and human capital are significant factors with high driving power and require emphasis. The regulatory norms, adequacy of infrastructure and policy management have less driving power and factors are positioned at higher level in the model.*

***Conclusion:*** *The integrated ISM and MICMAC analysis illustrate the hierarchical structure and significance of factors based on driving and dependence power to assist in strategic decision making.*

***Practical Implication:*** *The policy makers and entrepreneurs can use the results of the study for operational and tactical planning for overall growth of respective enterprises depending upon the hierarchy and classification of factors.*

***Original Contribution****: This study presented extensive literature review and industrial and academic perspective of experts for factors affecting technology adoption by MSMEs in India. These findings were cemented with statistical approach with integrated ISM-MICMAC analysis.*

**Keywords:** MSMEs, Technology adoption, Interpretative Structural Modelling (ISM), Fuzzy-MICMAC.

## INTRODUCTION

Industrialization in developing and developed countries is an effective means to achieve socioeconomic growth across the world. Micro Small Medium Enterprises (MSMEs) act as catalyst for rural industrialization, containing regional imbalance and fostering equitable



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economic growth in all regions. The major obstacles for socio-economic growth of developing countries: poverty and unemployment (Ayyagari et al., 2011). MSMEs are second largest employment sector with low capital investment as compared to any other industrial sector and acting as economic growth engine for India (Singh et al., 2012).

The MSME sector has vast network of 6.3 Cr of units and contributes significantly to economic growth of India. MSMEs in India offer heterogeneous fabric with respect to size of unit, production volume, categories of products and services and technology applications. The enterprises are registered in MSME Act, 2006 are mainly involved in production, manufacturing, preservation and processing of goods and services. Around 50% of the total MSMEs in India operate in rural areas and provide 45% of total employment (Katyal and Xaviour, 2015). Interestingly, the micro enterprises account for 97% of total employment in MSME sector.

MSMEs in India accounts for 45% of complete manufacturing output and approximately 8% of GDP. The manufacture of more than 6000 products have come from this sector (Satpathy et al., 2017). In India, continuously increasing registered MSMEs in India also contribute over 40% of total nation's exports (Annual Report 2020-21). The flipside of the fact is that the globalization have impacted MSME sector adversely and affected the export share and growth rate of MSMEs (Scholar, 2021). The globalization invited the foreign direct investment (FDI) with upgraded technologies posing competitive threats for sustenance of MSMEs (Das, 2008a; Mukherjee, 2018). The continuously changing definition of MSMEs have hidden barriers for flow of credit, subject to institutional assessment of credit worthiness and profit oriented investment avenues (Das, 2017). This result in high cost of credit and poor cost competitiveness in addition to deficient basic infrastructure and quality human capital (C.B. Rathod, Darshan Ranpura, 2016).

MSMEs have faced challenges with respect to inadequate infrastructure, availability of capital and institutional credit facilities, inadequate access to market linkage, skilled manpower, raw material at affordable cost, lack of awareness, regulatory norms, completion with domestic and global firms and knowledge & access to new technology. Despite that, sector has shown phenomenon growth in terms of increasing registrations, quantum of investment, scale of production and overall contribution to national GDP. MSMEs in India continuously feed the domestic and the international value chain as manufacturer, supplier, distributor, retailers, contractors, and service providers by accounting for substantial segment of our industrial units. MSMSEs have demonstrated the economic resilience with inherent strength, flexibility, and adaptability. It has maintained consistent growth rate even during the economic downturn and worldwide recession.

Technology adoption by MSMEs has been major constrain for growth of sector. The government policies have been promoting tech adoption by MSMEs to provide the level play field with global and large domestic firms. Post Globalisation MSMEs having technological orientation and emphasising on process and product innovation can achieve competitiveness through cost reduction, increased productivity, quality improvement and meeting customer need. There are no tailor-made solutions for technology adoption by MSMEs. This varies with level of socio-economic development of region, education level, language and culture, awareness of entrepreneur and employees, focus of management, financial capability and credit worthiness of enterprises, availability of infrastructure / resources at affordable cost, skilled human resources, advertising, marketing, and payments methodology etc.



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These factors affecting the technology adoption by MSMEs have been studied by various researchers along with the suggestive measures. However, the analysis of these factors was based on the literature input and authors view, empirical study, and secondary data analysis. The factors affecting were required to be addressed as per the priority and its impact to other factors for strategic decision making. This study is an attempt to explore the identify the factor affecting the technological adoption by MSMEs considering the opinion of domain experts from industrial and academic perspective to establish the inter-relationship amongst the factors. The aim of the study is as follows:

(i) To identify the factor affecting the technological adoption by MSMEs in India.
(ii) To establish the interpretive structural relationship amongst the factors affecting technological adoption.

To achieve the first objective systematic literature review is carried out to identify the factors from academic perspective. The domain experts were selected from various industries and having core experience of decision making and policy implementation. The semi structure interviews have been conducted to capture the industrial perspective of factors affective technology adoption. To achieve the second objective the integrated data analysis is carried out by interpretive structure modelling (ISM) and MICMAC analysis to establish the structural hierarchical relationship amongst the factors.

The complexity of contextual relationship of these factors with consultation of respective domain experts would provide the holistic approach towards the technological adoption by MSMEs. The common solution may not be available, applicable, and possible for all factors by the entrepreneurs. Therefore, the hierarchical structure of factors is analysed through ISM. The driving and dependence power of the factors analysed based on the category of the clusters using Fuzzy-MICMAC analysis.

The paper is organized in five parts, the first it presents the literature review of the factors affecting the technology adoption by MSMEs and rationale for Interpretative Structural Modelling (ISM) is explained in the second section. The third part covers Methodology for systematic literature review, ISM and MICMAC analysis. Results of ISM analysed and discussed in the fourth segment along with the categorization of factors in four clusters (Driver, Linkage, Dependent and Autonomous) based on MICMAC analysis in this section and finally implications are discussed in the last segment.

## LITERATURE REVIEW

### Top Management Commitment

The top management commitment, pro-innovation technology planning and user guided implementation strategy play a significant role in technology adoption by enterprises (Taherdoost, 2018). The management vision, capability assessment and decision with long term perspective (Sonar et al., 2020) ensure the availability of resources for technology implementation (Raut et al., 2017), knowledge management (Singh and Kant, 2008) and information sharing with employees towards the overall benefits of technology (Globerson et al., 1995). The human resource management with incremental innovation and training (Ringberg et al., 2019) and involvement of employee towards the change management is very important (Gupta et al., 2013). Top management decision making depends on the organizational capability



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and ensuring acquiring the maximum benefits through government policies (Venkataramanaiah and Suneetha, 2019; Wani et al., 2003). Top management need to negotiate the resistance towards the adoption of technology by reinforcing of vision and values, fostering the belief for overall growth and development to employees and continuous commitment of resources with balance cost benefit analysis (Dey, 2014; Zwick and Zwick, 2006).

## Adequacy of Infrastructure

The technology adoption has been facing major challenges in terms of adequacy of basic infrastructure like uninterrupted power supply, means of transport and road , rail and air connectivity, water supply etc. the stringent environmental norms, waste management system and maintenance of industrial hygiene(Christopher J. Green, 2006; Katyal and Xaviour, 2015). The telecom and internet connectivity are crucial for value change management and firm competitiveness (Buteau, 2021). The infrastructural deficiencies adversely affect the sector and increase the operational cost, poor market linkage, poor supply chain management and network issues render the competitiveness of MSMEs(Kumari, 2018; Thakkar *et al.*, 2008). In addition to generic infrastructure the economic infrastructure, well developed industrial estate, design, testing and quality check facility etc cited as constraints for growth of MSMEs (C.B. Rathod, Darshan Ranpura, 2016; Dwivedi *et al.*, 2017a).

## Human Capital

MSMEs in India have wide spectrum of demographic characteristic of their employees in terms of age, education, culture, sex and language which affect the attitude towards the technology (Chowdhury, 2020; Fatonah et al., 2018). The resistance to change is natural human response coupled with job insecurity, poor industrial relationship in term of growth, promotion and compensations (Fatonah et al., 2018). The higher technology requires the combination of visionary and skilled human resources, which is to be available as affordable cost and may be retained by the enterprise to maintain competitiveness. The technology adoption also driven by social influence, individual belief and attitude (Soto-Acosta *et al.*, 2017; Xena and Rahadi, 2019). The constantly upgrading labour laws require safeguarding the interest of employees and implementation of best industrial management practices (Ali and Husain, 2017; V, 2013).

## Competitiveness

MSMEs face competition from large scale global and domestic organised firm. The competitiveness has emerged larger barrier post globalization with changes in protection policies for MSMEs (Lahiri, 2012). The easy credit flow from financial institutions for medium and small industry has created divide amongst MSMEs specially for micro enterprises after recent change in definition of MSMEs (Bargotra *et al.*, 2014). The MSMEs act 2006 opened the opportunity for foreign direct investment in MSMEs in plant and machinery, which provide the technological edge for productivity and other services (Syal, 2015). Larger companies have network and well established supply chain and warehousing, which provide them dynamic distribution capabilities, whereas MSMEs have restricted infrastructure and networking, which increases the operational cost (Das, 2017; Singh and Daniel, 2017). The larger form have organised services and technical support service at competitive cost (Khurud, 2015; Syal, 2015) They have higher export potency which depends on productivity, quality and supply chain etc. The quality of human capital,



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technical capability and availability of skilled manpower at affordable cost also a major benchmark for competitive advantage (Christopher J. Green, 2006; Gulrajani, 2006).

## Technology Orientation

MSMEs geographical location and education level of entrepreneur and employees plays an important role regarding awareness of contemporary technology available and methods of acquisition of technology (Ramesh, 2019; Sahu, 2006). The major driving force for technological adoption of MSMEs is short life span of product(Kavilal *et al.*, 2018), continuous change in design of product as per demand of customer, global competitiveness in term of cost and quality of product (Singh *et al.*, 2007). The digital marketing, payment and advertising methods are major driving force for adoption of technology by the enterprises (Sivathanu, 2019). Majorly the MSMEs are practicing conventional technology due to gap between the financial capability of enterprise and cost of technology acquisition and implementation (Roy and Sinha, 2017). The government policies in India are inclined towards the vendor based technology acquisitions/ transfer rather promoting the in- house research and development of technology and innovation (Dwivedi *et al.*, 2017a; Nangia and Pramanik, 2011). The entrepreneur in absence of policy support is always at risk for technology failure especially during the initial phases. The rural areas lack the technical support in case technological restoration in case of breakdown (Goel *et al.*, 2022). The stake holders including suppliers, user and customers integration for technology adoption poses unique resistance at all levels (Chaturvedi *et al.*, 2015).

## Marketing

The MSMEs suffers a major challenge of access to market, information gaps and advertising and marketing strategy of their product and services (Garg and Agarwal, 2017). Maintenance of supply and demand requires knowledge sharing, data base, supply chain management and importantly the optimal exploitation of distribution channel for penetration into domestic and global market (Bala Kalyan Kumar and Gugloth, 2012). The information on export opportunity, trade tariff management, production and supply chain network building act as barrier for competitive marketing for MSMEs (Dhanaraj, 2013). The financial capability, innovative process and production flexibility plays significant role for continuously changing market demand, technology up-gradation by competitor etc (Xue *et al.*, 2021). The digital marketing have opened a new dimension of market competitiveness and influencing consumer opinion by penetrating through social media platform with app based and web based marketing strategies (Baswala, 2017; Soto-Acosta *et al.*, 2017). The technology adoption by MSMEs with low capital investment has to be compensated with high skill and multi-dimension approach with innovative ideas instead of conventional approach of distributor based channel (Sudha Venkatesh, 2012).

## Finance

The financial capability and flow of credit is backbone for industrial growth. MSMEs are largely dependent on self-finance then non institutional finance and few are benefited from institutional finance(Garg and Agarwal, 2017). Micro enterprises face more challenges than Medium and small enterprises (Tandon *et al.*, 2018). The financial literacy of entrepreneur, credit worthiness of enterprises and financial integrity of institutions for voluntary and



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involuntary exclusion in terms of flow of credit are major contributing factors(Das, 2008b; Klapper, 2017). The cost of credit, lengthy paper work, cost of small ticket transaction and historical performance and NPA in the sector also widen the gap of demand of credit and supply of finance by financial institutions (Ali and Husain, 2017; Garg and Agarwal, 2017).

## Technology Implementation

The technology implementation in MSMEs requires integration of various stakeholders' supplier, employee, management and consumers (Lee *et al.*, 2012). The front line barriers include technology management in terms of licencing, process innovation, product R&D with, technical support and reliability to prevent machine downtime etc (Minis *et al.*, 1992; Seethamraju and Diatha, 2019; Wani *et al.*, 2003). The demographic factors age , education level and social influence include employee level challenges where the managerial involvement is important for knowledge and information sharing for technology implementation (Globerson *et al.*, 1995; Hasan, 2017). The initial resistance for perceived usefulness against the conventional method require change management with adequate training and confidence building with common goal of overall growth of enterprises (Dwivedi *et al.*, 2017b; Zwick, 2005). The strategic decision of management involve the technology implementation schedule, training, productivity enhancement and rate of return of cost of technology (Chaudhary, 2017; Chowdhury, 2020; Gupta *et al.*, 2013).

## Policy Management

The policy makers have made constant endeavours for refining the MSMEs sector by redefining investment ceiling limits, reserve range of products for MSMEs diversification of sectors, cluster of industry and other financial support to the sector (Das, 2008b; Mesut Savrula, Ahmet Incekarab, 2014; Shiralashetti, 2012). During the past two decades globalization have opened the opportunities by diminishing artificial trade boundaries by free flow of knowledge, goods, services and capital (FDI) (Deveshwar, 2014; Syal, 2015). The globalization was beginning of the end of protective policy for MSMEs and raised a major challenge of competitiveness (Chandraiah and Vani, 2014). The employment, unit growth, output and export have come down constantly. The reclassifications of MSMEs have started cold war amongst micro, small, and medium industry. The banking sector considers the small enterprises as risky investment due to their low growth rate or poor credit worthiness (Chandra and Pareek, 2014). Also, the MSMEs faces extreme competition from large domestic and multinational firms due to lack of infrastructure, poor technology base, marketing and distribution system etc. The export share of MSMEs prone global fluctuation and high tariff wall and complex foreign trade policies (Khurud, 2015; Sethi, 2007). The policy intervention requires to provide the reserve categories for MSMEs trade, formulate tax rebate, credit policies for technology-oriented sector and ease of export duties and taxes for promoting MSMEs. The in-house R&D may be encouraged for innovations and less dependency on vendor based technology transfer (Nangia and Pramanik, 2011). The cost of credit and duration of payment to be regulated through policy measures (Rigol *et al.*, 2017).



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## Regulatory Norms

The technology comes with cost of implementation and protection. The technology adoption by MSMEs in the field of product R&D, process innovation, payment system, marketing and maintaining the supply chain etc mostly depends on outsourcing with local level organization and Networking. The online data safety and integrity of information sharing and security is a big question mark (Dwivedi *et al.*, 2017b; Kwabena *et al.*, 2019; Venkatesh and Kumari, 2018). The competitive world of industry where the technology, process and finance and marketing detail requires adequate regulations for protective measures for MSMEs. The traditional methods of productions are unique solution for the product development and required to be covered under patent art and IPR while competing with local and global organised players (Bala Kalyan Kumar and Gugloth, 2012; Katyal and Xaviour, 2015). The complicated process of regulations and contracts require simplification and standardization for implementation and smooth technology adoption (Sivathanu, 2019). The cost of credit for MSMEs are high especially when they are trading based on self-finance and non-institutional financial organizations (Pandya, 2017). The delayed payment in the business environment act as additional penalty and create financial imbalance by increasing the cost of credit for larger tenure, therefore the regulatory norms for delayed payment (Sahu, 2006). The focus of policy on infrastructure building, strengthening financial institutional support, assured market share , training and development of human resources and technological adoption will enable the MSMEs to face global competitiveness and generate employment opportunities (Bargotra *et al.*, 2014).



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**Table 1**
**FACTORS AFFECTING TECHNOLOGY ADOPTION**

| Factors | Authors | Dimensions of Factor |
|---|---|---|
| **Top Management Commitment** | (Bang Nguyen Dilip S. Mutum, 2015), (Barve and Muduli, 2013), (Dewangan *et al.*, 2015), (Govindan *et al.*, 2010), (Rodríguez *et al.*, 2008), (Govindan *et al.*, 2010), (Taherdoost, 2018), (Raut *et al.*, 2017), (Singh and Kant, 2008), (Ringberg *et al.*, 2019), (Zwick and Zwick, 2006)(Wani *et al.*, 2003), (Gupta *et al.*, 2013) | Focus of management; Vision, forecasting and decision making; Organization capability; Working environment, trust & encouragement; Risk Aptitude and Scientific approach; Appropriate resource allocation; Tapping of potential benefits of government policies and global opportunities; Strategy for technology implementation and cost benefit analysis |
| **Adequacy of Infrastructure** | (Christopher J. Green, 2006), (Katyal and Xaviour, 2015), (Buteau, 2021), (Venkatesh and Kumari, 2018), (Thakkar *et al.*, 2008), (C.B. Rathod, Darshan Ranpura, 2016), (Dwivedi *et al.*, 2017b), (Das, 2008a), (Mukherjee, 2018), (Garg and Agarwal, 2017) | Cost effective production and distribution system; Cost of infrastructure and services; Technological support and services; Supply chain management; Operational cost & market competitiveness. |
| **Human Capital** | (Fatonah et al., 2018), (Chowdhury, 2020), (Xena and Rahadi, 2019), (Ali and Husain, 2017), (V, 2013), (Soto-Acosta *et al.*, 2017), (Gaurav Goyal, Harsh Vardhan Samalia, 2017), (Gupta *et al.*, 2013), (Sommer, 2015) | Demographic and cultural factors; Individual belief, attitude, and social influence; Level of education, training & skill; Retention and affordable cost of skilled manpower; Resistance for technology adoption; Industrial regulations and employee management |
| **Competitiveness of Enterprises** | (Lahiri, 2012), (Bargotra *et al.*, 2014), (Gulrajani, 2006), (Syal, 2015), (Das, 2017), (Singh and Daniel, 2017), (Khurud, 2015), (Sardar, 2019), (Chandraiah and Vani, 2014), (Suman, 2015) | Larger umbrella of MSMEs definition; Cost of credit; Supply chain management and warehousing; marketing strategy; Manufacturing flexibility & process innovation; Foreign investment and technology; Export propensity; Availability of data for decision making; Government policies; Global influence. |
| **Technological Orientation** | (Ramesh, 2019), (Nangia and Pramanik, 2011), (Roy and Sinha, 2017), (Goel *et al.*, 2022), (Chaturvedi *et al.*, 2015), (Kavilal *et al.*, 2018), (Sahu, 2006), (Singh *et al.*, 2007), (Dwivedi *et al.*, 2017b), (Sivathanu, 2019), | Driving force for technology innovation – short life of product, social influence; Global competitiveness; Customer demand; Cost effectiveness; Quality; Technological Awareness / Access to Technology; Financial capability; Cost of Technology |
| **Marketing** | (Garg and Agarwal, 2017), (Bala Kalyan Kumar and Gugloth, 2012), (Dhanaraj, 2013)(Xue *et al.*, 2021), (Baswala, 2017), (Sudha Venkatesh, 2012), (Soto-Acosta *et al.*, 2017), (Singh *et al.*, 2007), (Vasanthakumar *et al.*, 2016) | Market support – Continuity of demand; Digital marketing interface/ e commerce; Customer -Supplier integration; Marketing & advertising facility/ social web platform marketing channels; Development of B2B interface; Collaboration & networking with service providers |



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| | | |
|---|---|---|
| **Finance** | (Garg and Agarwal, 2017), (Tandon *et al.*, 2018), (Das, 2008a), (Klapper, 2017), (Ali and Husain, 2017), (Chandraiah and Vani, 2014), (Lahiri, 2012), (Sardar, 2019), (Pandya, 2017), | Financial literacy; Sources of finance; Cost of credit; Credit worthiness of enterprises; Subsidies and rebate policies; Transparency and tax implications; Payment recovery mechanism; Foreign direct investments, Digital payment system and technology orientation of stakeholders |
| **Technology Implementation** | (Lee *et al.*, 2012), (Goel *et al.*, 2022), (Chowdhury, 2020), (Minis *et al.*, 1992), (Seethamraju and Diatha, 2019), (Wani *et al.*, 2003), (Globerson *et al.*, 1995), (Hasan, 2017), (Dwivedi *et al.*, 2017b), (Zwick and Zwick, 2006), (Chaudhary, 2017), (Gupta *et al.*, 2013) | Productivity & quality of production; Licencing of technology; R & D versus Technology transfer; Cost and capability of technology implementation; Implementation strategy; Rate of return of technology implementation; information sharing; Training for technology adoption |
| **Policy Management** | (Rigol *et al.*, 2017), (Das, 2008a), (Mesut Savrula, Ahmet Incekarab, 2014), (Shiralashetti, 2012), (Deveshwar, 2014), (Syal, 2015), (Chandraiah and Vani, 2014), (Khurud, 2015), (Sethi, 2007), (Nangia and Pramanik, 2011), (Chandra and Pareek, 2014) | Duties and tariff of trades and export; Rebate for technology-oriented enterprises; Facilities of training centre for industrial clusters; Accessibility for Government e portal; Design clinics for R&D support; Availability of credit for tech acquisition; Assured market share; Development of industrial infrastructure; |
| **Regulatory Norms** | (Bala Kalyan Kumar and Gugloth, 2012), (Sivathanu, 2019), (Bargotra *et al.*, 2014), (Sahu, 2006), (Venkatesh and Kumari, 2018), (Pandya, 2017), (Bargotra *et al.*, 2014), (Sahu, 2006),(Kwabena *et al.*, 2019) | Privacy and protection laws for data safety; Standardization of contracts; IPR protection for technology innovation; Payment protection regulations |

## RATIONALE FOR ISM

MSMEs have been vibrant topic for global researchers for the challenges and opportunity poses by the sector. Researchers and entrepreneurs have identified various factors which are responsible for growth and sustenance of MSMEs, where technology adoption emerged as one of the major areas of concern. The literature has identified the factors affecting the technology adoption by MSMEs gives insight of problem statement. These factors are inter-related and directly and indirectly contribute for each other as their impact interaction may not change. Therefore, it is pertinent to understand the importance and contextual relationship of these factors with unbiased approach, which is beyond the individual perception.

ISM methodology developed by Warfield, (1974) which help to manage the complexity of problems by explaining interrelationship of its elements and organize them in an order to facilitate the strategic decision making. ISM technique is called interpretive as it involves the interpretation of opinion of experts regarding interrelationship of factors of complex issue. These domain expert opinion formulate the structure of factors based on their direct and indirect interactions (Gupta *et al.*, 2013). The is important tool which is unbiased to individual opinion and extract the structure by developing computer assisted model based on inputs provide by the domain experts (Sushil, 2012). ISM is deployed by various researchers to clearly identify the factors for strategic decision making that which factors to be controlled to achieve long term objectives (Mohammed *et al.*, 2008). ISM used to develop the hierarchical model based on the



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contextual relationship of the factors and provide other indicators for decision making (Saxena *et al.*, 1992).

Interpretative Structural Modelling (ISM) is well established method used by researcher to deal a system with the complex issue, which has multiple factors having their direct and indirect interactions. The ISM involves the identification of factors for any complex issues by rather addressing the factor in isolation, the direct and indirect relationships between the factors are defined. The inputs from group of people will establish the contextual relationship amongst the factors. ISM transforms the poorly articulated complex issue into well structured, organized, and systematic model alongwith graphical representation. ISM is computer aided method to develop the structured representation of system. This model has theoretical, conceptual, and computational mechanism to link the scientific analysis of perceptions of experts. The other techniques ANP, AHP, and TOPSIS, etc. require the assessment of dominance level of the factors to establish the interrelationship. ISM methodology does not necessitate computation of dominance level of any factors to establish association between them and therefore, it helps to reduce the biases of expert's opinions while establishing interrelationship.

## METHODOLOGY

The factors affecting the technology adoption in MSMEs have been identified through extensive literature review provided the academic perspective. These factors also have been validated for industrial perspective by domain experts during interactions and semi-structured interview. A set of ten factors have been identified affecting technology adoption by MSMEs. We have identified the domain experts from variety of field of entrepreneurs, academicians and government officials from various echelons. The industry entrepreneurs were selected based on the technology orientation of the enterprises, years of experience, age and performance profile of the enterprises and position held in the enterprises. The government official selected from various echelons of ministry offices involved in the field jobs to decision making and policy implementations and years of experience. The academicians are selected based on their area of research in the field of MSMEs and years of experience.

The heterogeneity of panel of domain experts have been maintained to reduce the biases and ensure robustness of model and achieve the generality of the findings (Sonar *et al.*, 2020). The selected domain experts were from various areas of industry, academia, and policy makers with minimum of 10 years of experience having witness the transformation of MSMEs in terms of technology implementation. Some experts turned down our request for participation in the study citing privacy of data and information and shortage of time for session for unwillingness. Finally, 11 domain experts have agreed to voluntarily participate in the study. The profiles of domain experts are summarized in Table 2.

The domain experts were from various fields and having vast experience in MSMEs sector. These sample size of domain experts for their inputs to develop the model have been examined. The sample sizes for heterogeneous group of experts have been recommended to be between 5 and 15 for adequacy of data analysis (Murry and Hammons, 1995; Novakowski and Wellar, 2008).

**Table 2**
**SUMMARY OF DOMAIN EXPERTS**

| S No | Field of Domain Expert | Area of Expertise | Expert Profile | Experience in Years |
|---|---|---|---|---|



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| | | | | |
|---|---|---|---|---|
| 1 | Academia | Supply Chain Management Industrial Engineering | Professor | 19 |
| 2 | Academia | Additive Manufacturing Technology | Professor | 23 |
| 3 | Academia | Marketing Strategy and Business Development | Associate Professor | 18 |
| 4 | Academia | Organization Culture and Human Resource Management | Professor | 17 |
| 5 | Industry | Waste Management Technology | Director | 18 |
| 6 | Industry | Security System and Networking Technology | CEO | 19 |
| 7 | Industry | Food Processing and Preservation Technology | Export Manager | 17 |
| 8 | Industry | Technological Solution and Networking | Consultant | 17 |
| 9 | Government Institution | Rural Banking and Micro Financing | Divisional Manager | 14 |
| 10 | Government Institution | Cooperative Society and Business Development | Manager | 11 |
| 11 | Government Institution | Warehousing and Cold Storage Management | Marketing Manager | 14 |

The selected domain experts were approached to discuss the factors affecting technology adoption by MSMEs, identified from literature review. These factors were discussed and analysed for their relevance and validity. The similar methods have been adopted by other researchers to identify the factor affecting implementation of additive manufacturing in automobile industry (Dwivedi *et al.*, 2017a) and implementation of information technology in SMEs (Thakkar *et al.*, 2008) and identification of challenges for implementation of Industry 4.0 in SMEs (Goel *et al.*, 2022). During the discussion and analysis all the factors were found to be relevant therefore ten factors are considered for the study. The pairwise comparison of all the identified factors affecting technological adoption by MSMEs were carried out by the domain experts. In the pairwise comparison the domain experts have given out the direct and indirect interrelation of factors. Secondly, during the interview session domain experts have provided the inputs for structural self-interaction matrix (SSIM). The SSIM is prepared based on input received from each expert.



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## Interpretative Structural Modelling Techniques

Step 1: Structural Self –Interaction Matrix

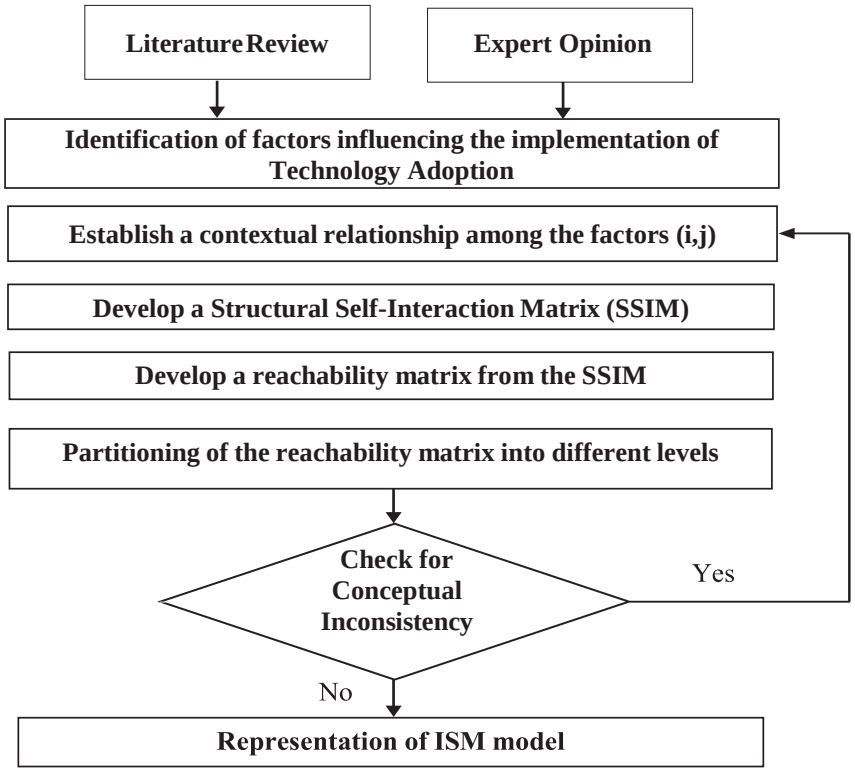


**FIGURE 1**
**FLOW CHART FOR DEVELOPMENT OF ISM**

Source : (Mishra et al., 2017).

The brief description was prepared consisting of factors affecting technological adoption by MSMEs, identified from the literature. The experts of selected from various domain were approached for their feedback after a brainstorming session. A set of 11 domain experts from industry, academia and government agencies were approached for their inputs, whose experience was ranging from 10-23 years. The feedback was collected in the form of structural self-interaction matrix and compiled as per the instructions of the technique. The feedback of the domain experts was based on most preferred interrelation among the factors and following symbols were used for denotation of relationships.

V: Factor i will help to attain factor $j_i$
A: Factor j will help to attain facto $i_i$
O: No relationship between factor i and j and
X: Factor i and j will help to attain each other.

The feedback was collected and correlated from all 11 domain experts of their individual opinion of contextual relationship. There were some variations in the feedback and opinion of



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experts for any contextual relationship of factors. The consensus method is used for correlating the responses and analysing the inter-relationship of factors (Dwivedi *et al.*, 2017a; Kavilal *et al.*, 2018). These experts provided the feedback regarding the relationship of factors based on their domain knowledge and field expertise. Therefore, these factors have been practically validated for the study. All the feedback were collected and based on the maximum frequency of responses assigned by the experts for V, A, X and O, final SSIM is developed for the study Table 3. These factors relations are denoted with symbols for examples if the Finance factor (TAF) 1 lead to competitiveness of enterprises factor (TAF) 9, the relationship between the TAF 1 and TAF 9 is represented by 'V', similarly if TAF 10 leads to attain TAF 2, then it is represented by 'A', similarly if TAF 8 and TAF 2 are interrelated and help to attain each other, then it is represented by symbol 'X' and TAF 10 and TAF 6 have no relationship then it is represented by O.

**Table 3**
**STRUCTURAL SELF –INTERACTION MATRIX (SSIM)**

| | **TAF** | **10** | **09** | **08** | **07** | **06** | **05** | **04** | **03** | **02** | **01** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | Finance | A | V | V | O | O | V | X | O | V | - |
| 02 | Policy Management | A | A | O | A | V | A | A | A | - | |
| 03 | Marketing | A | O | A | X | V | A | A | - | | |
| 04 | Human Capital | A | V | V | V | V | V | - | | | |
| 05 | Technology Implementation | A | A | A | V | V | - | | | | |
| 06 | Regulatory Norms | O | O | O | A | - | | | | | |
| 07 | Adequacy of Infrastructure | A | A | A | - | | | | | | |
| 08 | Technological Orientation | X | X | - | | | | | | | |
| 09 | Competitiveness of Enterprises | X | - | | | | | | | | |
| 10 | Top Management Commitment | - | | | | | | | | | |

Step 2: Reachability Matrix

The reachability matrix is developed by transforming the structural self-interaction matrix Table 4. This is developed by substituting the V, A, X, O with 0 and 1 as per the instructions of techniques given below (Singh and Kant, 2008) .

(i) If the SSIM entry in the (i, j) is V, then initial reachability matrix entry for (i, j) becomes 1, and the (j, i) entry becomes 0.
(ii) If the SSIM entry in the (i, j) is A, then initial reachability matrix entry for (i, j) becomes 0, and the (j, i) entry becomes 1.
(iii) If the SSIM entry in the (i, j) is X, then initial reachability matrix entry for (i, j) becomes 1, and the (j, i) entry becomes 1.
(iv) If the SSIM entry in the (i, j) is O, then initial reachability matrix entry for (i,j) becomes 0, and the (j,i) entry becomes 0.



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**Table 4**
**INITIAL REACHABILITY MATRIX**

| | TAF | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | Finance | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 |
| 02 | Policy Management | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 03 | Marketing | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 04 | Human Capital | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 05 | Technology Implementation | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| 06 | Regulatory Norms | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 07 | Adequacy of Infrastructure | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 08 | Technological Orientation | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 |
| 09 | Competitiveness of Enterprises | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 |
| 10 | Top Management Commitment | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |

Step 3: Transitivity Matrix

The transitivity matrix also known as final reachability matrix, is developed by using the transitivity concept. The concept of transitivity is described as an example : if the factor ‘i’ relates to factor ‘j’ and factor ‘j’ relates to factor ‘k’ then transitivity implies and factor ‘i’ related to factor ‘k’(Singh *et al.*, 2007). The transitivity is incorporated to maintain the consistency of conceptual relationship. The transitivity analysis is computer assisted process and performed using the MATLAB program Table 5.

**Table 5**
**TRANSITIVITY MATRIX**

| | TAF | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | Finance | 1 | 1 | 1* | 1 | 1 | 1* | 1* | 1 | 1 | 0 |
| 02 | Policy Management | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 03 | Marketing | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 04 | Human Capital | 1* | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 05 | Technology Implementation | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| 06 | Regulatory Norms | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 07 | Adequacy of Infrastructure | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 08 | Technological Orientation | 0 | 1* | 1 | 0 | 1 | 1* | 1 | 1 | 1 | 1 |
| 09 | Competitiveness of Enterprises | 0 | 1 | 1* | 0 | 1 | 1* | 1 | 1 | 1 | 1 |
| 10 | Top Management Commitment | 1 | 1 | 1 | 1 | 1 | 1* | 1 | 1 | 1 | 1 |

Step 4: Level Partitioning

To achieve the hierarchical structure through level partitioning of factors, the antecedent set and reachability sets are prepared for each factor. The reachability set for any factor entail the factor itself and other factors which it may help to achieve it. Similarly, antecedent set for any factor entail the factor itself and other factors which may assist in achieving it. Once the reachability and antecedent sets are prepared for the matrix the intersection points are derived from the sets. Based on these intersections the ISM hierarchical model is prepared. The intersection points for factors are same then those factors are taken at same level. The level portioning is summarized in Table 6 and Table 7. For example, in Table 6 the factor 6 has same reachability and antecedent set, then factor is considered as level 1 for ISM model. Once the



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level 1 factor is identified then it is separated from other factors. The similar step is repeated for identification of factors at other level and continued till we achieve the level for each factor. The final ISM model is prepared based on the analysis Figure 2.

**Table 6**
**LEVEL PARTITION – ITERATION 1**

| | TAF | Reachability set | Antecedent set | Intersection set | Level |
|---|---|---|---|---|---|
| 01 | Finance | 1,2,3,4,5,6,7,8,9 | 1,4,10 | 1,4 | |
| 02 | Policy Management | 2,6 | 1,2,3,4,5,7,8,9,10 | 2 | |
| 03 | Marketing | 2,3,6,7 | 1,3,4,5,7,8,9,10 | 3,7 | |
| 04 | Human Capital | 1,2,3,4,5,6,7,8,9 | 1,4,10 | 1,4 | |
| 05 | Technology Implementation | 2,3,5,6,7 | 1,4,5,8,9,10 | 5 | |
| 06 | Regulatory Norms | 6 | 1,2,3,4,5,6,7,8,9,10 | 6 | 1 |
| 07 | Adequacy of Infrastructure | 2,3,6,7 | 1,3,4,5,7,8,9,10 | 3,7 | |
| 08 | Technological Orientation | 2,3,5,6,7,8,9,10 | 1,4,8,9,10 | 8,9,10 | |
| 09 | Competitiveness of Enterprises | 2,3,5,6,7,8,9,10 | 1,4,8,9,10 | 8,9,10 | |
| 10 | Top Management Commitment | 1,2,3,4,5,6,7,8,9,10 | 8,9,10 | 1,4 | |

**Table 7**
**IDENTIFIED LEVELS OF TAF**

| | TAF | Reachability set | Antecedent set | Intersection set | Level |
|---|---|---|---|---|---|
| 01 | Finance | 1,4 | 1,4,10 | 1,4 | 6 |
| 02 | Policy Management | 2 | 1,2,3,4,5,7,8,9,10 | 2 | 2 |
| 03 | Marketing | 3,7 | 1,3,4,5,7,8,9,10 | 3,7 | 3 |
| 04 | Human Capital | 1,4 | 1,4,10 | 1,4 | 6 |
| 05 | Technology Implementation | 5 | 1,4,5,8,9,10 | 5 | 4 |
| 06 | Regulatory Norms | 6 | 1,2,3,4,5,6,7,8,9,10 | 6 | 1 |
| 07 | Adequacy of Infrastructure | 2,3,6,7 | 1,3,4,5,7,8,9,10 | 3,7 | 3 |
| 08 | Technological Orientation | 8,9,10 | 1,4,8,9,10 | 8,9,10 | 5 |
| 09 | Competitiveness of Enterprises | 8,9,10 | 1,4,8,9,10 | 8,9,10 | 5 |
| 10 | Top Management Commitment | 1,4 | 8,9,10 | 1,4 | 6 |



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**ISM-BASED MODEL**

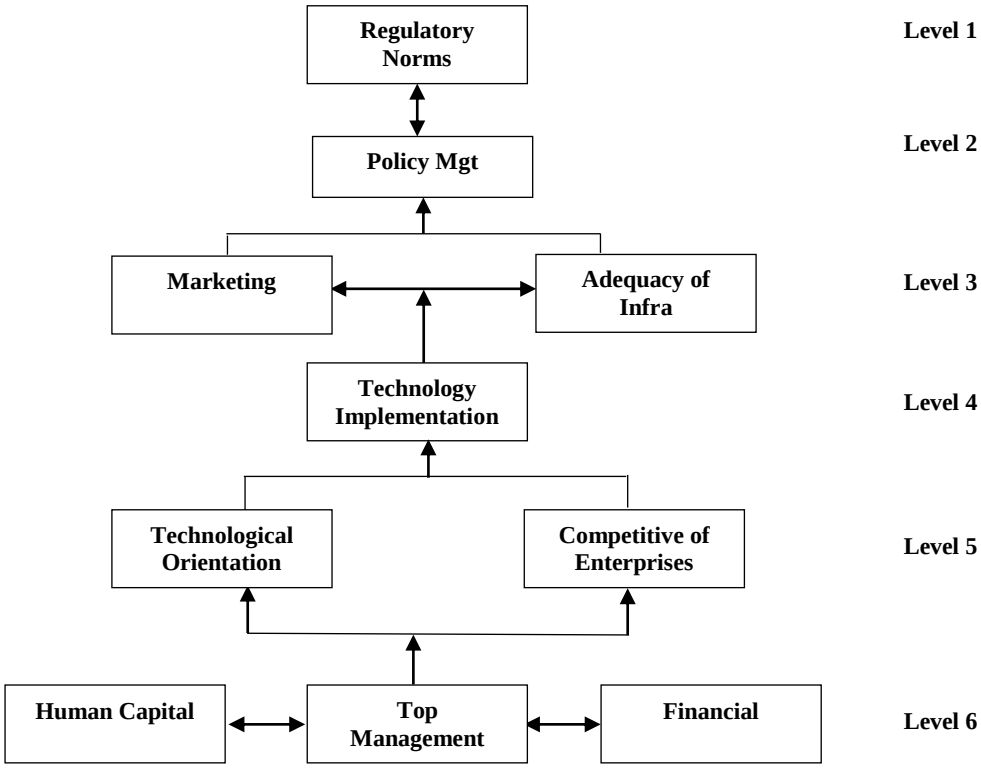


**FIGURE 2**
**LEVEL PARTITION OF TAF**

## Fuzzy MICMAC Analysis

Generally, the MICMAC analysis is conducted based on the binary relationship of factors. This conventional approach of MICMAC analysis is incorporated with fuzzy set theory to complement the feedback of domain experts as part of human judgement to have deeper insight of interrelationship of factors. The similar approach have been followed by the researcher for factor affecting additive manufacturing (Sonar *et al.*, 2020), electrical power system interdependencies (Al-Zarooni and Bashir, 2020), factor affecting supply chain of vaccines in developing countries (Chandra and Kumar, 2018). The possibility of interrelationship has been quantified by the researchers and used at various scale applicable to their research areas. The quantification of interrelationship of the factors are ranging from no relationship (0) to very high relationship (0.9) and the intermediate possible values of relationship are captured as ; very low (0.1), low (0.3), medium (0.5) and high (0.7) , the same have been illustrate on other studies also (Gorane and Kant, 2013; Mishra *et al.*, 2017).

The researchers have developed the ISM based model for understanding the contextual and hierarchal relations of the factors. However, the factors are variable and therefore their interrelationship is also variable in nature. The limitation of ISM modelling techniques is that the feedback captured from domain experts is only binary in nature. The interrelationship is denoted as 0 and 1 for each factor. It is pertinent to note that the relationship may not be always equal



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between different factors and the intensity of interrelationship may vary from very weak, weak, strong, and very strong and there may be absolutely no relationship.

The strategic decision based on the ISM model require further understanding of factors and mitigate the gap of ISM technique. To establish the better understanding of interaction of factors and their contextual relationship, the Fuzzy-MICMAC analysis is carried out.

MICMAC analysis was developed by Dupperrin & Godet (1973) to analyse the driving and dependence power of factors in the system. The working of MICMAC analysis is based on the principal of matrix multiplication properties. The detailed technique followed for Fuzzy-MICMAC analysis is as follows:

## Binary Direct Relationship Matrix

To develop the binary direct relationship matrix the diagonal entries are converted to zero. During the process the transitivity is ignored to develop binary direct relationship matrix from the initial reachability matrix Table 8.

**Table 8**
**BINARY DIRECT RELATIONSHIP MATRIX**

| | TAF | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | Finance | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 |
| 02 | Policy Management | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 03 | Marketing | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 04 | Human Capital | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 |
| 05 | Technology Implementation | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 06 | Regulatory Norms | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 07 | Adequacy of Infrastructure | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 08 | Technological Orientation | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 |
| 09 | Competitiveness of Enterprises | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 |
| 10 | Top Management Commitment | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 |

## Development of Fuzzy Direct Relationship Matrix

The feedbacks from the domain experts for Fuzzy-MICMAC analysis was collected again to rate the interrelationship of the factors affecting technology adoption by MSMEs. This qualified feedback is correlated based on the consensus of highest frequency of responses assigned to the factors Table 9.



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**Table 9**
**FUZZY DIRECT RELATIONSHIP MATRIX**

| | TAF | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | Finance | 0 | 0.3 | 0 | 0.5 | 0.7 | 0 | 0 | 0.5 | 0.9 | 0 |
| 02 | Policy Management | 0 | 0 | 0 | 0 | 0 | 0.3 | 0 | 0 | 0 | 0 |
| 03 | Marketing | 0 | 0.3 | 0 | 0 | 0 | 0.7 | 0.3 | 0 | 0 | 0 |
| 04 | Human Capital | 0 | 0.1 | 0.1 | 0 | 0.5 | 0.5 | 0.3 | 0.5 | 0.7 | 0 |
| 05 | Technology Implementation | 0 | 0.3 | 0.5 | 0 | 0 | 0.1 | 0.7 | 0 | 0 | 0 |
| 06 | Regulatory Norms | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 07 | Adequacy of Infrastructure | 0 | 0.5 | 0.7 | 0 | 0 | 0.1 | 0 | 0 | 0 | 0 |
| 08 | Technological Orientation | 0 | 0 | 0.3 | 0 | 0.3 | 0 | 0.3 | 0 | 0.5 | 0.5 |
| 09 | Competitiveness of Enterprises | 0 | 0.5 | 0 | 0 | 0.7 | 0 | 0.3 | 0.5 | 0 | 0.1 |
| 10 | Top Management Commitment | 0.5 | 0.3 | 0.3 | 0.5 | 0.7 | 0 | 0.7 | 0.7 | 0.5 | 0 |

## Fuzzy-MICMAC Stabilized Matrix

The fuzzy direct relationship matrix is multiplied as following the fuzzy matrix multiplication principles (Kandasamy *et al.*, 2007). The matrix is multiplied repetitively to achieve the stabilized matrix considering the fuzzy direct relationship matrix as base (Table 10). Fuzzy matrix multiplication is the generalized form of multiplication of Boolean matrix, where two fuzzy matrices are multiplied to achieve the product matrix is also fuzzy matrix. The driving and dependence power of the factors are derived from fuzzy MICMAC analysis. The driving power for the factors is summation of the entries of interaction of the factor in each column. Similarly, the dependence power for any factor is summation of the entries in the row.

**Table 10**
**FUZZY-MICMAC STABILIZED MATRIX**

| | TAF | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | Driving Power |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | Finance | 0 | 0.5 | 0 | 0.7 | 0.9 | 0 | 0 | 0.9 | 0.7 | 0 | 3.7 |
| 02 | Policy Mgt | 0 | 0 | 0 | 0 | 0 | 0.7 | 0 | 0 | 0 | 0 | 0.7 |
| 03 | Marketing | 0 | 0.3 | 0 | 0 | 0 | 0.5 | 0.9 | 0 | 0 | 0 | 1.7 |
| 04 | Human Capital | 0 | 0.1 | 0.9 | 0 | 0.7 | 0.5 | 0.7 | 0.9 | 0.9 | 0 | 4.7 |
| 05 | Technology Implementation | 0 | 0.9 | 0.9 | 0 | 0 | 0.9 | 0.7 | 0 | 0 | 0 | 3.4 |
| 06 | Regulatory Norms | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 07 | Adequacy of Infra | 0 | 0.5 | 0.7 | 0 | 0 | 0.1 | 0 | 0 | 0 | 0 | 1.3 |
| 08 | Technological Orientation | 0 | 0 | 0.9 | 0 | 0.9 | 0 | 0.7 | 0 | 0.9 | 0.9 | 3.7 |
| 09 | Competitiveness of Enterprises | 0 | 0.5 | 0 | 0 | 0.5 | 0 | 0.3 | 0.7 | 0 | 0.9 | 2.9 |
| 10 | Top Mgt Commitment | 0.9 | 0.7 | 0.5 | 0.9 | 0.5 | 0 | 0.7 | 0.7 | 0.7 | 0 | 5.6 |
| | Dependence Power | 0.9 | 3.5 | 3.9 | 1.6 | 3.5 | 2.7 | 4 | 3.2 | 3.2 | 1.8 | |

## Classification of Factors

The factors affecting technology adoption by MSMEs have been analysed with the hierarchical ISM model. These factors are further analysed with fuzzy MICMAC, based on their dependence, and driving powers. The driving and dependence powers are taken on x and y axis respectively to plot the factors as Figure 3 for instances the technology adoption factor (TAF) 4 has driving power and dependence power 3.8, thus TAF 4 is plotted as per its value. Based on



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the outcome of fuzzy MICMAC analysis the technology adoption factors (TAF) are categorized in four clusters – autonomous, driver, linkage, and dependent clusters.

**CLUSTER OF TAF**

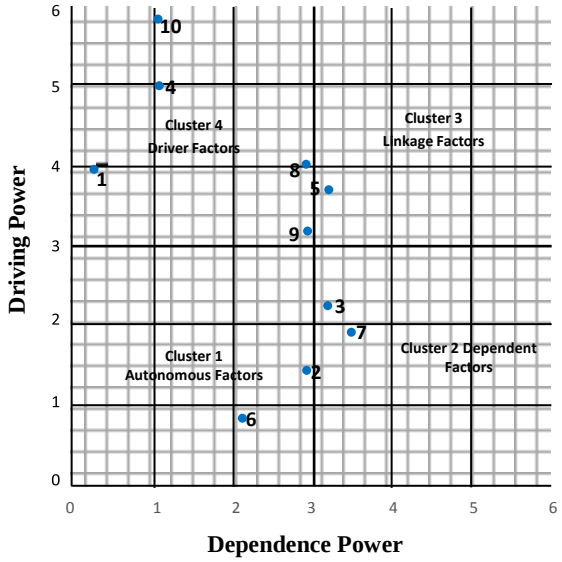


**FIGURE 3**
**CLASSIFICATION OF TAF**

In order to establish the interrelationship amongst the factors affecting technology adoption the factors are classified based on their driving and dependence power. These factors have been classified into four clusters through MICMAC analysis.

## Autonomous Cluster

The factors having weak driving and weak dependence power are classified as autonomous factor. These factors generally do not have much influence on the technology adoption process. In this study the regulatory norms are classified as autonomous factor, which is disconnected from the technology adoption by MSMEs. The regulatory norms are essential as protective measures for technology adoption rather influencing implementation.

## Driver Cluster

This cluster constitutes most important factors having strong driving and weak dependence power. The top management commitment, Human capital and financial capability are regarded as driving factors. These factors are the variables which controls the other factors. The top management commitment is important for allocation of resources and focus to provide impetus for technology adoption by MSMEs. The top management endeavour for acquisition of technology, infrastructure development and training and development of human resources. The quality of human resources at affordable cost and their cultural belief and attitude toward technology adoption play a significant role. The strategic decisions of top management also



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depend upon financial capability of enterprises with optimum utilization of trading aids and grants provided by government policies.

### Linkage Cluster

The factors have strong driving and strong dependence power constitutes this cluster. These factors act as facilitators for technology adoption by MSMEs and also being driven by deriving factors and also assist the dependent factors. The basic technical orientation of enterprises and technology implementation by enterprises are depends constituent of linkage cluster. The technology orientation and adoption would require top management focus, strategy of implementation, knowledge and education level of human resources and their acceptance level. The technology adoption by enterprises depends on dedicated allocation of finance and resources.

### Dependent Cluster

The dependent cluster has factors having weak driving power and strong dependence power. These factors act as indicator of technology adoption by MSMEs. This cluster includes adequacy of infrastructure, Marketing and policy management and competitiveness of enterprises. The top management would exercise the industrial management policies and human resource management to enhance the productivity and improve competitiveness of enterprises. The technology implementation would provide new avenues for digital marketing and utilization of e-commerce and build up infrastructure and networking. The development of designing, testing, and training infrastructure alongwith physical infrastructure would strengthen marketing and overall competitiveness of the enterprises.

## DISCUSSION

The integrated approach of ISM and MICMAC analysis illustrated the factors affecting technology adoption by MSMEs. In the level partitioning factor at higher level denotes the hierarchy and higher driving power which drives the factors present at lower hierarchical levels (Gupta *et al.*, 2013). The top management commitment is important for resource allocation to focus areas, delegation of authorities, maintaining organizational culture, strategic planning, and interpersonal communication. This ensures the participation and motivation of employee towards the organizational aim with mutual benefits of promotion, remuneration and quality of life (Globerson *et al.*, 1995; Rodríguez *et al.*, 2008). Technology adoption and effective utilization largely depends upon the user readiness and attitude which is driven by the social influence, organizational culture, and manager -employee communication and employee participation in change management (Zwick, 2005). The quality of human capital; knowledge, education, training and motivation are the key enabler for technology adoption (Chaturvedi et al., 2015). The human resource management require emphasis on employee welfare, reward system, skill development, and delegation of authority and accountability for desired performance (Ali and Husain, 2017). Most of MSMEs in India located in rural areas where the availability of human capital with optimum balance of vision and skill at affordable cost is major challenge. The regional issues social equations, cultural belief at time language, job insecurity etc act as barrier for acceptance for change and adoption of technology (Chowdhury, 2020). The financial capability of enterprises to retain the skilled workforce throughout the business cycle poses



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restriction due to uncertainty stable profit margins in competitive market. The MSMEs are individual driven enterprises with compromised long term vision, consolidated business plan, financial literacy and aptitude (Klapper, 2017). These MSMEs are marginally utilize the institutional finance with voluntary and involuntary exclusion by financial institute. The cost of credit is high for required duration to maintain the cash flow the enterprises either depend on self-finance or non-institutional finance (Sahu, 2006). The additional burden of cost of basic facilities (power & water), transportation, losses due to poor quality and maintaining supply chain adds to overhead cost, denting the competitiveness of enterprises. The financial support to MSMEs are principally denied based on creditworthiness of enterprises, where financial institutes evaluate the past performance and financial health of enterprises for sanctioning credit for trades (Rigol et al., 2017).

The entrepreneur's knowledge, awareness and managerial capability is major constraints for technology adoption by MSMEs. The labour-intensive traditional methods of production, low productivity, poor quality and imbalanced demand-supply ratio with limited shelf life of product demand derails the market competitiveness. Whereas, globally the MSME sector is major contributor for innovative process and product, owing to inherent flexibility to adopt the changes to meet the customer demands. Indian MSMEs lacks technological orientation to compete on productivity, quality, and demand supply perspectives. These require acquiring new skills, technology, materials, and methods at affordable cost for long term sustenance. The reliance on promoting R&D than vendor-based technology transfer prevents adverse effects of cost of licensing, royalty, and contractual obligations. The technological orientation requires integrated approach and ecosystem management of all stake holders in terms of raw material, credit and finance, warehousing, marketing, payment digitization, production and marketing etc. The foot print of digital marketing of MSMEs have increased, 47 % of micro and 53% of SMEs have adopted digital platform for sales and marketing (Buteau, 2021). The rapid penetration of internet invites attention of MSMEs to develop their digital capabilities for tapping the growth utilizing e commerce potential by increasing customer bases and geographical reach with efficient accounting and backend management. This would include enhancing the product portfolio, documentation, packaging, and online vendor management.

The government of India is providing hand holding support with initiative like Digital MSMEs to develop awareness and digital integration with platform like Government e marketing (GeM). As per the GeM portal approximately one fourth of seller are MSMEs with 55% of order value on the portal in Nov 2021(Buteau, 2021). The National payment Corporation of India (NPCI) introduced Unified Payment Interface (UPI) with record transaction of 21000 Cr in year 2020. The digital on-board micro enterprises are not been charged Merchant Discount Rate (MDR) in UPI payments. The major concern of entrepreneurs in adopting digitization is experienced as loss of control, cost of small ticket transactions (Garg and Agarwal, 2017), privacy and online data safety mechanism with increasing cyber insecurity. The MSMEs entrepreneurs must utilize the incentives provided by government digital platforms like Udyam registration, MAME Sampark for skilled workforce, MSME Samadhan for timely payment mechanism etc. Although in view of economic reforms the globalization have posed major competitive challenges for MSMEs with free flow of capital goods and technologies, moreover MSMEs still face tall wall of trade tariff, networking for supply chain, complicated contracts and complicated documentation for export market (Mishra, 2012). The government initiative of ZED (Zero Defect Zero Effect) certification (Ministry of MSME Report, 2018) improved the quality measures of products. The regulatory norms would require further emphasis in the era of



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digitization for data safety with respect to product design process and quality testing results etc where common service provider need to be regulated. The Intellectual property Rights (IPR) and other contractual process required to be simplified for MSMEs to protect their industrial interest (Burrone, 2005).

## CONCLUSION

This study has explored the multidimensional perspective of experts from industry, academia and policy making and implementing institutions alongwith extensive literature review ISM methodology integrated with MICMAC analysis is proposed to establish the contextual and hierarchical structural relationship of factors. The study contributes to existing body of knowledge by identifying ten factors affecting technology adoption by MSMEs in India. Top management commitment, financial capability and human capital remains the root factors significantly affecting the technology orientation, infrastructure development and technology implementation by the enterprises. This would lead to improved marketing and distribution channels and enhance the overall competitiveness of the enterprises. Top management would utilized the opportunities provided by the policy measures and improve industrial management with contemporary regulatory norms.

### Limitations of Study

In the present study, ten technology adoption factors have been analysed. These factors have been derived from literature review. There may be other important factors, which could not be considered. The current study was limited to expert opinion, which also includes individual biases and judgement. The ISM methodology used with MICMAC analysis, where the hybrid approach comparing other techniques ANP, AHP, DEMATEL etc may provide better insight. The study has covered the MSMEs in Indian scenario as developing country without differentiating between manufacturing and service sector.

### Future Scope of Study

The future research may include the employee perspective and expert having international exposure. The changing definition of MSMEs have larger umbrella of enterprises, where the manufacturing and services sector can be analyses as a different segment.

### Implication of Study

These studies have significant implication for entrepreneurs and policy makers to objectively analyse the factors affecting technology adoption by MSMEs. This would assist in strategic decision making for management to identify the focus areas and priority of approach for overall growth. The combination of qualitative and quantitative approach has given out interrelationship among the various factors to formulate effective management strategies and policies.



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