# Interpretive Structural Modeling of Challenges for Indian Machine Tool Small and Medium Enterprises

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**Abstract**

Machine tool small and medium enterprises (SMEs) in India have been a major contributor to the manufacturing sector from last many decades. It has ensured that the Indian machinery market is self-sufficed. In the globalized and modern market, Indian machine tool SMEs is facing competition not only from local players but also from global competitors. Timely delivery of good quality,low cost products is the main challenge for Indian machine tool SMEs. The study focuses and identifies the challenges for Indian machine tool SMEs by the critical review of the literature and tries to prioritize challenges and factors using Interpretive Structural Modeling (ISM) by taking guidance from experts both of academic & industry. The paper also segregates the challenging factors based on their driving/dependence power. It is observed that top management competency, government and regulatory compliance, financial stringency, fragile local/globalized market demand and modern innovation technology are main driving powers and weakly dependent on other factors. Competition from the global market, job precision and automation, Supply Chain disruption, logistics management, better marketing strategy and export policy are weak drivers but are strongly dependent on other factors.

**Keywords**: 1.SCM, 2.Interpretive Structural Modelling (ISM); 3.Small and Medium Enterprises (SMEs); 4.Machine tool

## Introduction

In the 21st century of fastmoving competitive world, with the rise of big corporations with humongous financial strength have taken over the whole market share, thus making it difficult for small machine tool enterprises to sustain with limited resources. SMEs are pressed by the external pressures such as changes in economic, governmental, political, socio-cultural and technological advancement (Hashim, 2007). Singh *et al*. (2012) observed that fluctuating prices of raw materials, sharing of sensitive information and seasonality of demand are the main risks which SMEs feel while working in the supply chain. As a result, small and medium enterprises are on the verge of extinction. But still, there are cases where SMEs have sustained time with small innovations which have made them robust in order for self-sustenance.

Machine tool SMEs are labour intensive but the capital intensity is much less than that of large-scale industry (Thamrin*et al*., 2017). Rising local manufacturing helps to achieve a higher employment rate

due to the creation of new jobs in local manufacturing (Matt*et al.,* 2015).Employment generation in SMEs is swifter, 5 lakhs jobs annually. SMEs is 33% more employment intensive than the whole of the economy taken together. Exports of SMEs are surging fast and its share is over 42%. Besides these the capital intensity is less as capital investment in the fixed asset in SMEs is just one-fourth of that of large-scale industries. On the other side, the labour absorbing capacity of large scale industries is limited and has been declining over a period of time due to the fact that it becoming more capital intensive (Kalpandee*t al.,* 2015).

**2. Literature review**

Kherbach and Mocan (2016) have observed that in Romania where 99.5% of developed companies are classified as small and medium-sized enterprises enhanced services of logistics have played a major role in the sustenance of Romanian small and medium-sized enterprises. Cost-effective and on-time delivery capability of SMEs is important factors of selection and evaluation of suppliers in Indian SMEs (Kumar *et al.*, 2015). Kaur*et al.* (2008) have observed that coordination among firms may help in managing interdependencies and reduce uncertainties. The geographical clustering of firms stimulates interactive learning and innovation, thus engendering sustained competitiveness of the clustered firms and the cluster as a whole (Rallet and Torre, 1999; Maskell, 2001; Pinch *et al.*, 2003; Tallman *et al.*, 2004). SMEs getslong term benefits by coordination and information up gradation with local and outside partners (Bathelt *et al.*, 2004; Chapman *et al.*, 2004; Caniels and Romijn, 2005; Zucchella, 2006; Menzel and Fornahl, 2009).

Trust is important for information exchange between all members of the supply chain (Kumar *et al.*, 2015). (Cachon and Lariviere, 2005) observed that if each member of supply chain works for individual profit then the overall profit of supply chain get affected. Kaur et al. (2006) have observed that in the absence of clarity of benefit sharing result in the individual's profit maximization rather than profit maximization of the supply chain. The uncertainty of demand, inefficient management of supply chain and involvement of middle-man in supply chains are some of the key factors affecting supply chain coordination of SMEs (Kumar *et al.*, 2014). Modern manufacturing systems connect devices using Industrial internet of things and make rapid interchange, reconfiguration for production machines and equipment easier (Mcfarlane, 1998; Bachula and Zajac, 2013). Ferreira *et al.* (2011) observed that collaboration will help partners to build valuable trust, cooperation and coordination. Moreover, use of information technology such as an internet, intranet, software applications packages and decision support systems can be applied to facilitate the information flow within the supply chain, between the members. SMEs will be more productive if they use modern technologies (Lancioni *et al.*, 2000). Ngai *et al.* (2004) have observed that the successful implementation of web-based SCM system often requires a substantial amount of investment and intensive research. Tsuji (2003) observed that though from the 1960s onward, 50% of the advanced technology used was from the US as the US had most advanced technology in the field of the machine tool, the Japanese machine tool industry saw numerically controlled (NC) machines as machine tools of future.

Centre for Product Development (CPD) should be established which would be similar to Fraunhofer Institutions in Germany, where each CPD has a specific technologycompetencewhich could help industries across manufacturing sectors. It would service technology and product development requirements of industries which deploy technologies and strengths which are core competencies of the particular CPD, thus enhancing the indigenous technological advancement of machine tool industry (Singh and Chavre, 2016). In SMEs top management play important role in major decision making such as partner selection, performance issues and SCM issues (Thakkar *et al.,* 2009). For SMEs mutual collaboration with all members of the supply chain is a challenging task (Soh and Roberts, 2005; Bennett and O' Kane, 2006).Kumar and Singh (2017) stated that coordination can

improve common problems such as quality, delay in delivery and over costing. Hsu *et al.*(2011) observed that top management pro-activeness ensures a firm's ability to integrate supply chain feedback and shape its business by introducing new products, technologies, and administrative techniques so as to seize new opportunities and take pre-emptive action against any challenges or situations. Lack of financing, market challenges and regulatory issues are perceived as barriers to small business growth in Canada (Gill and Biger, 2012). SMEs of machine tools sectors have more severe effects on financial issues as compared to large organizations of the same sector (Sener*et al.*, 2014). Singh and Chavre (2016) stated that higher interest rate, high capital investment and long gestation period makes setting up units in machine tool sectors difficult.There must be a well-defined documented export policy which will drive the growth of the Indian machine tool industry in terms of revenue and market share as the area of operation increases. Kalafsky (2016) observed that in the machine tool industry, high export demand could be a sign of competitive advantages such as precision, speed and technological sophistication. The high cost of distribution in foreign markets and non-tariff barriers along-with adverse FTAs has restricted Indian machine tool industry enterprises to increase their market share in foreign markets (Singh and Chavre, 2016).Japanese, machine tool makers have used exports as a means of growth during periods of stagnant economic activity (Kalafsky, 2016).

Job accuracy followed by the level of precision by machine tool industry affects the market demand and stability of demand in all-weather condition. Modern methods of Computer Integrated Manufacturing (CIM) systems which enables the higher degree of automation enhances the standard of the manufacturing process. Copani and Rosa (2015) observed that ''Technology Development Fund'' required being set up for modernization, expansion and upgradation of the SMEs and other companies. The fund can also be used for design development, product development, energy efficiency, green technology development, product development, training and such other knowledge development activities (Singh and Chavre, 2016). In the last few years, the import of finished machine tools is about 55–60 percent of the total demand (Singh and Chavre, 2016). Measures such as anti-dumping duty should be imposed on machine tool enterprises who try to price their product below fair market value. The rise of 'Regional' distributors selling on 'Stock and Sale' basis, on behalf of foreign manufacturers and some foreign machine tool industry enterprises incorporating 'Direct' marketing in India through their own selling setups are posing greater risks for Indian domestic market (Singh and Chavre, 2016).

Marketing is a key aspect for the sustenance of enterprises as these days with the growth of large corporations managing competition and giving a better option to the customer is one of the humongous tasks for small enterprises. Market development can be a better choice as compared to market creation as stated by Wieandt (1994) as market creation involves huge funding. Machine tool industry in India faces unusual pattern of demand thus prohibiting the enterprise from greater investments and acquisition of modern advanced technology. Uncertain market demand and unavailability of well-defined export policy have wrecked foreign market demand as well. Moreover, low quality of the domestic product as compared to global product standard has restricted the foreign market demand for export. Following are the some of the primary factors identified from the Literature Review critical to the growth and sustenance of Indian machine tool Industry on which Interpretive Structural Modelling (ISM) is done.

**Table 1. Variable identified for ISM based model**

| | | | |
|---|---|---|---|
| 1 | Top management commitment | 2 | Govt. & regulatory compliance |
| 3 | Competition from global market | 4 | Fragile local/globalized market demand |
| 5 | SC disruptions | 6 | Logistics management |

| | | | |
|---|---|---|---|
| 7 | Financial limit stringency | 8 | Export policy |
| 9 | Affordable skilled labour | 10 | Modern innovative technology |
| 11 | Job precision & automation | 12 | Better marketing strategy |

**3. ISM methodology**

Interpretive Structural Modellingmethodology (ISM) can be applied to find relations among different variables, which are critical for a problem. Mandal and Deshmukh (1994) stated that ISM makes difficult problem well defined and simple. It is a well-known methodology for identifying and summarizing relationships among specific elements, which define an issue or a problem and provide a means by which order can be imposed on the complexity of such elements. In this paper, we came across different challenges that the textile SMEs are facing. Implementing or working on these factors at once is not possible. So, with the help of ISM, we are prioritizing the factors on the basis of driver power and dependence power.

***3.1 Structural Self-Interaction Matrix (SSIM)***

By expert opinion, the contextual relation between different variables is developed. Different techniques such as brainstorming, nominal group technique, idea engineering are used by experts while giving an opinion. In this exercise, five experts, three from the industry and two from academia were consulted. To express the relationship between different critical factors of the textile industry, four symbols have been used to denote the direction of the relationship between the parameters *i* and *j*:

- V – Parameter *i* will lead to parameter *j*
- A – Parameter *j* will lead to parameter *i.*
- X – Parameters *i* and *j* will lead to each other
- O – Parameters *i* and *j* are unrelated.

Based on contextual relationships, the SSIM is developed (Table 2)

Table 2. Structural Self-Interaction Matrix (SSIM).

| | *Challenging factors* | *12* | *11* | *10* | *9* | *8* | *7* | *6* | *5* | *4* | *3* | *2* | *1* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Top Management Competent | V | V | V | V | V | V | V | V | V | V | V | |
| 2 | Govt. and Regulatory compliance | V | V | V | V | V | V | V | V | V | V | | |
| 3 | Financial Stringency | V | V | V | V | V | V | V | V | A | | | |
| 4 | Fragile Local/Globalised Market demand | O | V | V | V | V | V | V | V | | | | |
| 5 | Modern innovation technology | V | V | V | A | V | X | V | | | | | |
| 6 | Competition from Global Market | V | X | X | O | A | X | | | | | | |
| 7 | Job Precision and Automation | X | O | V | A | X | | | | | | | |
| 8 | SC Disruptions | V | X | X | A | | | | | | | | |
| 9 | Affordable Skilled Labour | O | V | O | | | | | | | | | |
| 10 | Logistics Management | V | V | | | | | | | | | | |
| 11 | Better Marketing Strategy | V | | | | | | | | | | | |
| 12 | Export Policy | | | | | | | | | | | | |

*3.2 Reachability matrix*

The SSIM (Table 2) is converted into a binary matrix, known as the initial reachability matrix by replacing V, A, X and O by 1 and 0 as per the case. The rules for the replacing of 1s and 0s are as follows: as described below with variables and their following binary output based on the relationship:

| Variable in reachability matrix | (i, j) entry in reachability matrix | (j, i) entry in reachability matrix |
|---|---|---|
| V | 1 | 0 |
| A | 0 | 1 |
| X | 1 | 1 |
| O | 0 | 0 |

After incorporating all the above rules, the initial reachability matrix is shown in Table 3. Then the final reachability matrix is prepared which is shown in Table 4 after incorporating the transitivities. Transitivity implies that if A is related to B and B is related to C then A must be related to C.

Table 3. Initial reachability matrix.

| | *Challenging factors* | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* | *11* | *12* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Top Management Competent | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | Govt. and Regulatory compliance | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3 | Financial Stringency | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 4 | Fragile Local/Globalised Market demand | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 5 | Modern innovation technology | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 6 | Competition from Global Market | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| 7 | Job Precision and Automation | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 |
| 8 | SC Disruptions | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 9 | Affordable Skilled Labour | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 |
| 10 | Logistics Management | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 |
| 11 | Better Marketing Strategy | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 |
| 12 | Export Policy | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 |

Table 4. Final reachability matrix.

| | *Challenging factors* | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* | *11* | *12* | *Driver power* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Top Management Competent | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 |
| 2 | Govt. and Regulatory compliance | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 11 |
| 3 | Financial Stringency | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| 4 | Fragile Local/Globalized Market demand | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1* | 9 |
| 5 | Modern innovation technology | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 7 |
| 6 | Competition from Global Market | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1* | 0 | 1 | 1 | 1 | 5 |
| 7 | Job Precision and Automation | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1* | 1 | 5 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | SC Disruptions | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 6 |
| 9 | Affordable Skilled Labour | 0 | 0 | 0 | 0 | 1 | 1* | 1 | 1 | 1 | 1* | 1 | 1* | 5 |
| 10 | Logistics Management | 0 | 0 | 0 | 0 | 0 | 1 | 1* | 1 | 0 | 1 | 1 | 1* | 4 |
| 11 | Better Marketing Strategy | 0 | 0 | 0 | 0 | 0 | 1 | 1* | 1 | 0 | 1* | 1 | 1 | 4 |
| 12 | Export Policy | 0 | 0 | 0 | 0 | 0 | 1* | 1 | 1* | 0 | 1 | 1* | 1 | 3 |
| *Dependency* | | 1 | 2 | 4 | 3 | 6 | 10 | 10 | 10 | 5 | 10 | 10 | 9 | **80** |

*3.3 Level partitions*

For each factor reachability and antecedent set is derived from final reachability matrix. Factor itself and the other factors influenced by it form reachability set. Factor itself and other factors influencing it to form antecedent set. Top level in ISM hierarchy is taken by factors having same reachability and intersection. These factors are not going to help in achieving other factors. These factors are eliminated and help in finding levels of other factors in the similar fashion. Final ISM model and diagraph are developed by these identified levels.

Table 5. Level partition table.

| *Parameter* | *Reachability set* | *Antecedent set* | *Intersection set* | *Level* |
|---|---|---|---|---|
| 1 | 1,2,3,4,5,6,7,8,9,10,11,12 | 1 | 1 | 6 |
| 2 | 2,3,4,5,6,7,8,9,10,11,12 | 1,2 | 2 | 5 |
| 3 | 3,5,6,7,8,9,10,11,12 | 1,2,3,4 | 3 | 4 |
| 4 | 3,4,5,6,7,8,9,10,11,12 | 1,2,4 | 4 | 5 |
| 5 | 5,6,7,8,10,11,12 | 1,2,3,4,5,9 | 5 | 2 |
| 6 | 6,7,8,10,11,12 | 1,2,3,4,5,6,7,8,9,10,11,12 | 6,7,8,10,11,12 | 1 |
| 7 | 6,7,8,10,11,12 | 1,2,3,4,5,6,7,8,9,10,11,12 | 6,7,8,10,11,12 | 1 |
| 8 | 6,7,8,10,11,12 | 1,2,3,4,5,6,7,8,9,10,11,12 | 6,7,8,10,11,12 | 1 |
| 9 | 5,6,7,8,9,10,11,12 | 1,2,3,4,9 | 9 | 3 |
| 10 | 6,7,8,10,11,12 | 1,2,3,4,5,6,7,8,9,10,11,12 | 6,7,8,10,11,12 | 1 |
| 11 | 6,7,8,10,11,12 | 1,2,3,4,5,6,7,8,9,10,11,12 | 6,7,8,10,11,12 | 1 |
| 12 | 6,7,8,10,11,12 | 1,2,3,4,5,6,7,8,9,10,11,12 | 6,7,8,10,11,12 | 1 |

*3.4 Classification of critical factors (MICMAC analysis)*

The objective of MICMAC is to analyze and group the factors based on its driving and dependence powers. A graph is plotted with driving power along X-axis and dependence power along Y-axis. Factors are classified as follows:

1. Autonomous enablers: These factors have weak driving and weak dependence power. They are represented in Quadrant III. They are relatively disconnected from the system.
2. Dependent enablers: These factors have weak driving power but strong dependence power. They are represented in Quadrant IV. They are greatly affected by many factors.
3. Linkage enablers: These factors have strong driving as well as strong dependence power. They have represented in Quadrant I. These factors are unstable as their action affects others and also possesses back effect on themselves.
4. Driving variables: They have strong driving power but weak dependence power. They are represented in Quadrant II. They have greater driving power over many factors.

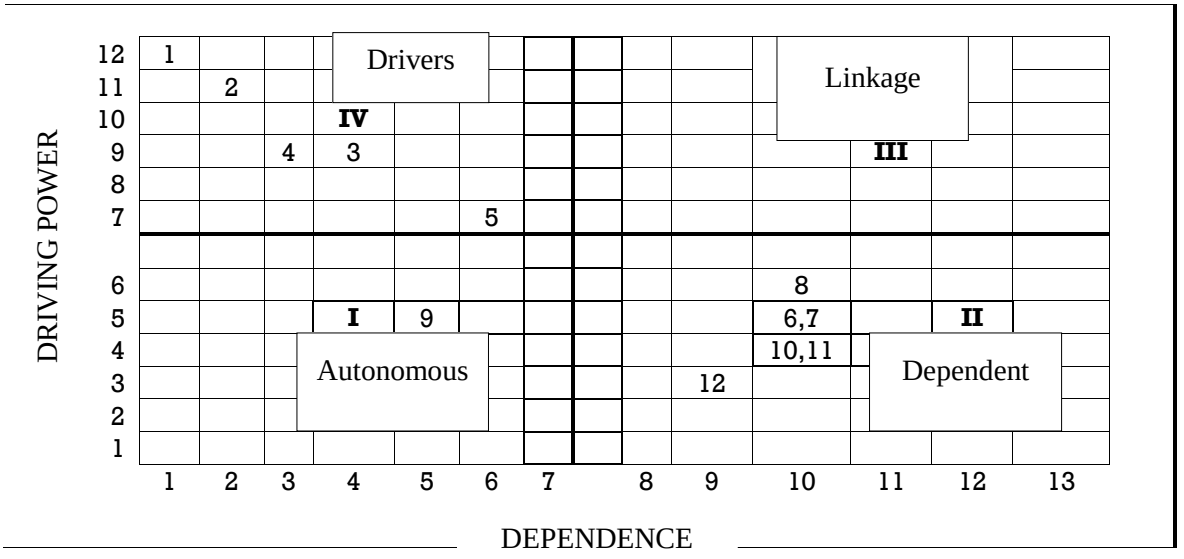


Figure 1. Driving power and dependence diagram.

### *3.5 Formation of ISM*

The structural model (Figure 2) is generated from the final reachability matrix and the digraph is drawn. If there is a relationship between the challenging factors i and j, this is shown by an arrow that points from i to j. This graph is called a directed graph or digraph. Removing the transitivities as described in the ISM methodology, the digraph is finally converted into the ISM.

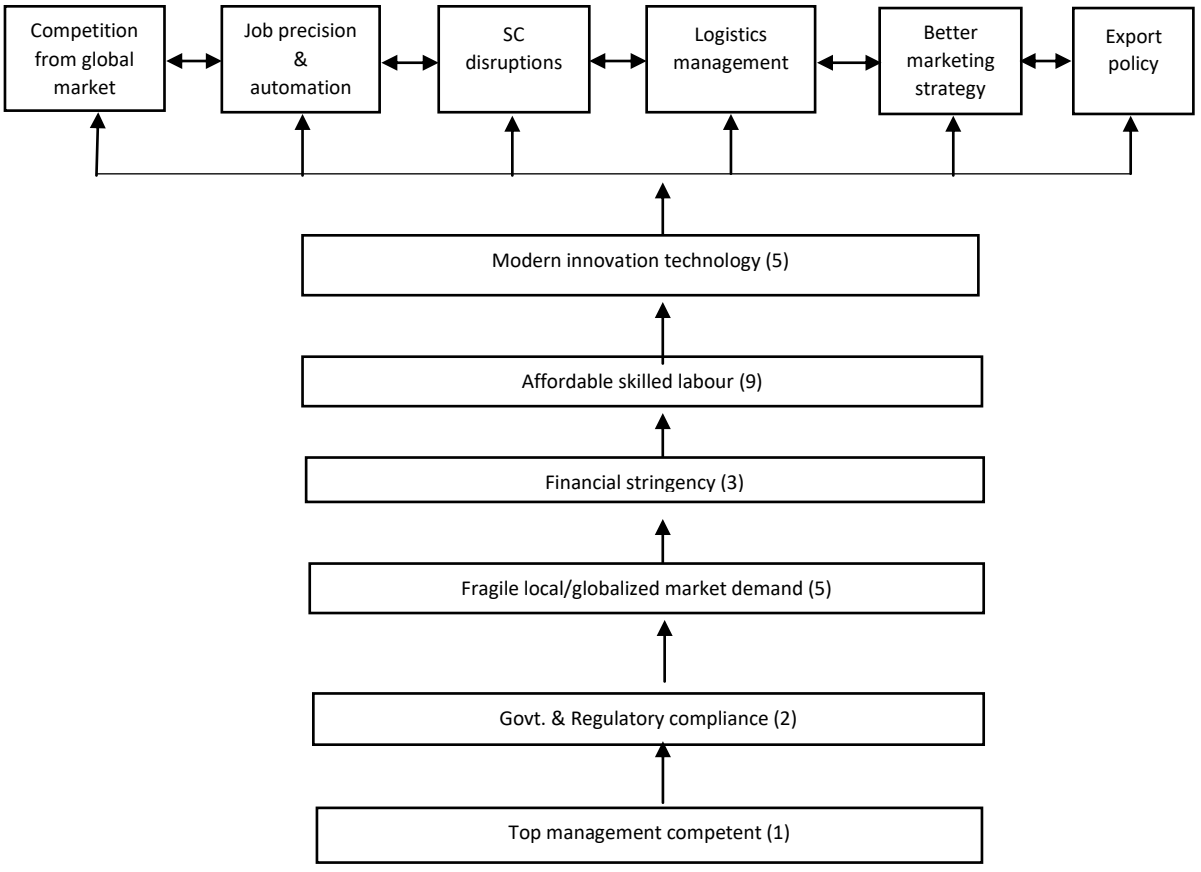


Figure 2. ISM based model of challenges faced by Machine tool SMEs

## 4 Result and discussion

Machine tool SMEs in India are facing challenges on different fronts. Competition from global players, financial limitation, government regulation compliance, modern innovative technology and high job precision and automation are few challenges observed by authors in the current research paper. ISM is applied to study the interaction among challenging factors. The major observations of this study are as follows:

- The driver-dependence matrix (Figure 1) gives an indication and helps to segregate factors or attributes into four different groups which gives clear view of inter-relationship among attributes or factors on the basis of which they act as independent factor as well as they vary when other factors change thus terming themselves as dependent, hence showing the key drivers(factors) who drive the growth of enterprise enabling to draw the digraph that segregates and prioritizes the factors.
- From the driving power and dependence diagram, there is no linkage variable that has a strong driving power as well as strong dependence. So, it can be concluded that among all the 12 challenging factorscritical none of the factor is unstable.
- From the driving power and dependence diagram Affordable Skilled Labor is an autonomous factor. Autonomous attributes/factors are weak drivers and are weakly dependent which are

relatively disconnected from the system. This variable (Affordable Skilled Labor) does not impact any other variables of the system and is highly independent.

- From the driving power and dependence diagram; Competition from the global market, Job Precision and Automation, SC disruption, Logistics Management, Better Marketing Strategy and Export Policy are weak drivers but are strongly dependent on other variables. They are put at the highest level of the ISM hierarchy (Figure 2). These variables represent most desired objective for any enterprise and are affected by many factors. Thus, these factors are classified as dependent variables which are driven by driver (independent) variables.
- The driver power-dependence diagram indicates that variables (factors) such as Top Management Competency, Government and Regulatory Compliance, Financial Stringency, Fragile Local/Globalized Market Demand and Modern Innovation Technology are at the bottom or lowest level of the ISM hierarchy having strong driving power and weak dependence power. These variables will help enterprises to achieve their most desired objectives and are classified as independent variables (factors) or drivers.
- Top management competency is at the bottom-most level with the highest driving power which shows it is the variable (factor) that drives other variables to achieve their most desired objective. In Indian machine tool SMEs, it is the competency of the top management results in better management and application of all the resources available in the most optimum manner thus driving the growth of the organization and sustaining throughout all situations.

Factors identified as having high driving power are important in strategic decision making. Management of machine tool SMEs should focus on these variables for effective & long term strategy formation. SMEs in India majorly work with short-term planning and profits. So critical implications taken from current study can help machine tool SMEs in facing global competition & other challenges.

## 5. Conclusion

In this research paper authors have identified various factors that affect growth and sustenance of SMEs of machine tool sector from the literature review. An opinion of experts from academic & industry was taken to validate ISM process. With help of ISM, factors were prioritized that ensures long-term growth of the machine tool industry along-with smooth management of the sector. The finding shows that the competency of top management is the main factors that challenge the SMEs of machine tool sector. Similarly along with top management competency there is the need of responsible governmental administration which formulates a long-term industrial policy which caters to the needs of the machine tool SMEs and make ample space for fair competition by maintaining consistency in market demand and shielding Indian enterprises from large global players through various policy decisions which will ensure the continual and comprehensive growth and sustenance of the machine tool SMEs in India.

Moreover, it is the need of the hour that Indian manufacturing sector especially machine tool industry innovate itself in terms of process and modernize its plant & equipment and incorporate higher degree of automation to augment the problem of affordable skilled labor and to ensure higher standards of quality of the product in terms of accuracy and precision in order to compete in global scenario.

Finding of this research paper will help the experts from industries to formulate their future strategies in global competition. In spite of the contribution from current paper, it has some limitation. The current study has considered only factors from machine tool sector. This study can be further extended in the context of other sectors.

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