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A TISM Model for Structuring the Productivity Elements of Flexible Manufacturing System

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***Abstract*—**Flexible Manufacturing System (FMS) is seen as an option for industries which want to boost productivity as well as respond quickly to an increasingly changing marketplace. FMS produces in mid variety, mid volume range and can meet the changing market demands very quickly. But still the impact of adoption of FMS on the productivity of any industry is not very clear. In this paper an attempt has been made to model the various factors affecting the productivity of FMS installation using Total Interpretive Structural Modelling (TISM) Technique.

***Keywords*—**Flexible manufacturing system, productivity, total interpretive structural modelling.

I. Introduction

ADOPTION of FMS in any industry is a tough decision and although much literature is available on the benefits offered by a FMS, this technique needs much consideration before its large scale adoption because of its capital intensive nature. FMS is seen as an option for those industries which want to boost productivity as well as respond quickly to an increasingly fickle marketplace. Until recently, these two goals were seen as conflicting but with the introduction of FMS, which produces in mid variety mid volume range, the conflict between productivity and flexibility can be resolved.

An FMS is an integrated, computer-controlled complex system involving automated material handling devices and numerically controlled (NC) machine tools. It can simultaneously process medium sized volumes of a variety of part types [1]. This technology has the ability to achieve the efficiency of a well-balanced transfer line, while offering the flexibility of a job shop for machining multiple parts. FMS can produce quality products at a lower cost while maintaining a short lead time. Usually the system is designed in such a way that the manual intervention and changeover time are kept to a minimum [2]. A unique feature that distinguishes FMS from other factory automation techniques is the ability to achieve the flexible automation, i.e. the capacity to efficiently produce a great variety of part types in variable quantities [3]. So firms are adopting FMS as a means for meeting the mounting requirements of customised production [4]. An FMS is designed to produce a variety of products to combine the efficiency of amass production line and the flexibility of a job shop [5].

In this paper, an attempt has been made to list some of the factors affecting the productivity of FMS through literature survey and expert opinion. These factors are structured using TISM technique. A TISM model is an up-gradation of Interpretive Structural Model (ISM). The authors have previously worked on modelling the productivity elements using ISM and now in this paper an attempt has been made to further extend the same using TISM [6]. ISM is a technique for establishing relationship among specific factors which define a problem [7]. The ISM process transforms vague and weakly expressed mental models of systems into systematic and well defined models. In this technique, directly and indirectly related elements are arranged into a comprehensive logical model. The model shows the structure of a complex issue or problem in a well-defined pattern using graphics as well as words [8], [9]. However, the interpretation of links in terms of how it operates is comparatively weak in ISM. In case of a graphical model, the interpretation of the relation can be shown by the side of the link connecting the pair of elements having the relation. By interpreting both the nodes and links in the structural model, an ISM can be upgraded as a TISM, which may have higher applicability in real life situations [10].

The organisation of the rest of the paper starts with the listing of the various factors affecting the productivity of FMS as identified through literature survey and discussion with experts, in Section II. In Section III, an overview of TISM technique is given. Use of TISM approach in modelling the factors is discussed in Section IV. The results of this research are followed by discussion and conclusion in Sections V and VI respectively.

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II. Identification of the Main Factors Affecting the Productivity of FMS

On the basis of the literature review and experiences of manufacturing managers and academicians, it has been found that firms adopt FMS as a means for meeting the mounting requirements of customized production. FMS has the potential for productivity improvement in batch production of discrete parts. It can very easily adjust to changes in product variety as per the market demands. It can respond quickly and smoothly to unexpected market changes and has been hailed as the solution to the challenges being faced by the manufacturing industries worldwide [11]. To continue to meet the challenges of the market place, FMS has been accepted as the weapon for boosting productivity and competitiveness [12].

Product and process improvements are possible solutions to provide economic gains and also increase flexibility, but are difficult to implement. Most manufacturing firms worldwide have batch production and batch size plays an important role in productivity issue, with small batch sizes it is difficult to produce economically and hence firms show low productivity. With FMSs, set-up time and hence the related costs are reduced. So it becomes economical to produce parts in small lots as well [13]. FMS allows the optimum levels of both productivity and flexibility to be achieved. A FMS can simultaneously meet several goals: small batch sizes, high quality standards and efficiency of the production process. The advantages of flexible manufacturing technology are improved productivity, reduced work-in-process inventory and lead time, faster response to customer requests and so on [13], [14].

Range of direct cost reductions, based on [15], varies between 3% and 66%. This is because of direct cost savings due to less labor and materials components. This cost reduction forms a major attribute to economic justification of the system. Besides reduced direct labour, other impacts on labour requirements are also present. The skills of direct labour can be lower if the direct labour is only used for loading and unloading workpieces in FMS. But if the system is to be used for increased flexibility and quality, labour skills are still very demanding; skills which must be attained by continuous on job training [6]. The indirect costs in management, engineering, tooling, programming and labour training should also be assessed and then the total and indirect labour cost savings are evaluated in FMS installations for productivity calculations [16].

The system performance is usually measured by the number of completed parts and with FMS installation the throughput is increased. Researchers have been constantly improving performance of an FMS [17], [18]. With reduced human intervention of manufacturing operations in FMS, significant increases in output are very much expected. Because of reductions in set-up times and the significant increase in the spindle utilization rate in a FMS, the system achieves a higher output rate hence higher productivity [19].

In FMS, maximum utilization of equipments is made by making the use of same equipments for a variety of products or parts [20], [21]. It is done by using the principles of flexible automation. The main aim is to reduce the setup time and the requirement of different equipments for the same product [2].

The main reason for the flexible manufacturing to gain worldwide attention in recent years both in manufacturing industry and academic research is because of its capability to respond to customer demands quickly. According to changing demand patterns, quantities of production can be adjusted easily [22]. An FMS quickly responds to design changes, changes in production schedule, product mix, machine break downs, cutting tool failures and can introduce new parts quickly [13]. Adjustments can be made in the production schedule to respond to rush orders and special customer requests [23].

In the present decade, apart from cost, quality and other performance measures, the additional focus has been on time-based performance measures. These time-based performance measures play a key role in reducing the lead-time (in any form such as in set-up time, waiting time, make span, etc.) in the manufacturing system [24]. In today's manufacturing scenario of made to ordered products with shorter life cycles the flexibility of a FMS has made it one of the most suitable manufacturing systems [25]. In FMS not only the processing, but the set-up and change over time are also reduced. The ability of a manufacturing firm to deliver a product to the customer is referred to as manufacturing lead time [26] and in FMS this lead time is reduced [18]. This means faster customer deliveries.

There is reasonable support for the proposition that FMS results in reduction of work-in-process (WIP) inventories. In FMS, as different parts are processed together instead of separately in batches, WIP is less than in a batch production. The raw material and finished goods inventory can also be reduced. Inventory reductions of 60-80% are estimated [13]. But still, recognizing the Japanese experience in just-in-time (or Kanban) production systems, the FMS should have a great deal more potential for reducing WIP inventories.

Reference [13] has identified that production occurs as a sequence of operations. Each part may need many processing steps. By combining operations there is a reduction in the number of different workstations through which the part must be routed. This is done by performing more than one operation at a given machine. To fulfill the production requirements, a FMS is designed to provide an effective operation sequence by reasonably allocating the resources [18]. Since more number of setups is needed with more number of machines, setup time can be saved as a consequence of effective operation sequence and combined operations. Material handling effort and nonoperational time are also reduced [27].

In FMS a set of machine tools and material handling system (MHS) are linked by a network of computers which control and interface with them. In traditional MHS, where people are involved in the movement of materials between various locations, human intervention is almost non-existent in FMS [28]. This is because of the developments in guided-vehicle technology and computer controlled MHSs. Automated guided vehicles are the most popular choice as material handling equipments in FMS. An automated guided vehicle system features battery powered, driverless vehicle moving on a guided path layout [29]. Thus adoption of FMS is not only a strategic but a tactile decision. Based on the above discussion the factors affecting the productivity of FMS are identified as given in Table I. These factors are further modeled using TISM.

TABLE I
VARIOUS FACTORS AFFECTING THE PRODUCTIVITY OF FMS

S.No.	Factor	Reference Source
1	Reduced labour cost	[15], [16] and [6].
2	Increased output	[17]-[19].
3	Reduced set-ups	[20], [2] and [21].
4	Fast response to customers	[13], [22] and [23].
5	Reduced lead time	[26], [18], [24] and [25].
6	Effective inventory control	[13].
7	Better workpiece processes	[18], [13] and [27].
8	Minimum material handling	[28], [[29].

III. An Overview of TISM

Many times we encounter the situations where a large number of elements or factors influence any system. There is usually direct or indirect interaction between these elements which makes the system complex. For instance, there are a number of factors which affect the productivity of FMS and these factors are mutually linked. So it becomes difficult to visualise any structure among these factors.

ISM is a technique which aids in identifying a structure within a system. ISM is a computer assisted interactive learning process whereby structural models are produced and studied. It shows the structure of a complex issue in a designed pattern employing graphics and words. ISM helps to impose order and direction on the complexity of relationships among various elements of a system [7], [30].

In ISM the interpretation of the diagraph can be done at the nodes and the links. In ISM the nodes define the different elements influencing the system. But the interpretation of links is comparatively weak in ISM. This is limited to interpreting the contextual relationship between the elements and the direction of relationship in a paired comparison [10]. The interpretation of the directed link in terms of how it operates is missing in ISM. The addition of the interpretation of all the links of an ISM model leads it to TISM. The TISM takes its predecessor to the next level by incorporating the interpretation of each observed relationship. The new approach improves upon the interpretive aspects of ISM by building a knowledge base of logical interpretations of each observable relationship. This repository of knowledge serves to bolster the interpretive aspects of ISM and makes the logic that drives the model more transparent and less likely to being interpreted incorrectly.

The basic steps for TISM are outlined below:

Step1. Identify and the define factors: The first step is to identify and define the elements whose relationships are to be modeled.

Step2. Defining the contextual relationship between these factors: After identifying the various factors, a contextual relationship is developed between them. This contextual relationship is developed based on how one factor influences the other.

Step3. Giving interpretation of contextual relationships: In traditional ISM, the relationship between the various factors is developed without any interpretation being added to that but in TISM, the interpretation of the relationship is also clarified. In fact, it is at the commencement of this step that the study moves forward from the scope of traditional ISM to TISM.

Step4. Interpretive logic of pair-wise comparison: In ISM, individual factors are compared. The only interpretation at this stage relates to the direction of the relationship. In order to upgrade ISM to TISM, interpretive matrices were used so as to fully interpret each paired comparison in terms of how that directional relationship operates in the system under consideration [10].

Step5. Reachability matrix and transitivity check: A reachability matrix is created by the paired comparisons.

Step6. Level partition on reachability matrix: The level partition is carried out similar to ISM to know the placement of factors level-wise [31], [32]. It is done by determining the reachability and antecedent sets for all the factors. The factors in the top level of the hierarchy will not reach any factors above their own level. As a result, the reachability set for a top level factor will consist of the factor itself and any other factors within the same level which the factor may reach, such as components of a strongly connected sub-set. The antecedent set for a top level factor will consist:

- factor itself,
- factors which reach it from lower levels and
- any factor of a strongly connected sub set involving the top level.

As a result, the intersection of the reachability set and the antecedent set will be the same as the reachability set if the factor is in the top level. The top level factors satisfying the above condition should be removed from the factor set and the exercise is to be repeated iteratively till all the levels are determined.

Step7. Developing the digraph: A digraph is developed which is the graphical representation of the factors arranged in levels with the directed links drawn as per the relationships shown in the reachability matrix. The digraph is simplified by eliminating the transitive relationships step-by-step by examining their interpretation from the knowledge base. Only those transitive relationships are taken whose interpretation is important.

Step8. Developing interaction matrix and converting to interpretive matrix: The final diagraph is translated into a binary interaction matrix form and is interpreted by picking the relevant interpretation from the knowledge base in the form of interpretive matrix [33].

Step9. Prepare TISM: The connective and interpretive information contained in the interpretive direct interaction matrix and diagraph is used to derive the TISM. The nodes in the diagraph are replaced by the interpretation of factors placed in boxes. The interpretation in the cells of interpretive direct interaction matrix is shown along the side of the particular links in the structural model. This results in the total interpretation of the structural model with the interpretation of its nodes as well as links.

It is widely believed that TISM may have a higher applicability in real life situations, which is why it was used for the purpose of this study.

IV. TISM Approach for Modeling the Productivity Factors

The various steps leading to the TISM model are:

Step1. Identify and the define factors: The various factors are identified are identified by literature survey and discussion with experts as given in Section II. A total of 8 important factors are identified and tabulated in Table I.

TABLE II
INTERPRETIVE LOGIC – KNOWLEDGE BASE

S. No	Factor Number	Paired comparison of Factors	Y/ N	In what way one factor will influence/enhance the other? With reason if 'Yes'
F1- Reduced labour cost				
1.	F1-F2	Reduced labour cost will influence or enhance output	N	
2.	F2-F1	Increased output will influence or enhance reduced labour cost	N	
3.	F1-F3	Reduced labour cost will influence or enhance reduced set ups	N	
4.	**F3-F1**	**Reduced set ups will influence or enhance reduced labour cost**	**Y**	**Less manpower required**
5.	F1-F4	Reduced labour cost will influence or enhance fast response to customers	N	
6.	F4-F1	Fast response to customers will influence or enhance reduced labour cost	N	
7.	F1-F5	Reduced labour cost will influence or enhance reduced lead time	N	
8.	F5-F1	Reduced lead time will influence or enhance reduced labour cost	N	
9.	F1-F6	Reduced labour cost will influence or enhance effective inventory control	N	
10.	F6-F1	Effective inventory control will influence or enhance reduced labour cost	N	
11.	F1-F7	Reduced labour cost will influence or enhance better workpiece processes	N	
12.	**F7-F1**	**Better workpiece processes will influence or enhance reduced labour cost**	**Y**	**Number of separate workstations reduces**
13.	F1-F8	Reduced labour cost will influence or enhance minimum material handling	N	
14.	**F8-F1**	**Minimum material handling will influence or enhance reduced labour cost**	**Y**	**Automated material handling devices reduces labour cost**
F2 – Increased Output				
15.	F2-F3	Increased Output will influence or enhance reduced set ups	N	
16.	**F3-F2**	**Reduced set ups will influence or enhance increased output**	**Y**	**Less unproductive time**
17.	**F2-F4**	**Increased Output will influence or enhance fast response to customers**	**Y**	**More production to meet more demands**
18.	F4-F2	Fast response to customers will influence or enhance increased output	N	
19.	F2-F5	Increased Output will influence or enhance reduced lead time	N	
20.	**F5-F2**	**Reduced lead time will influence or enhance increased output**	**Y**	**Per unit time reduction hence more output**
21.	F2-F6	Increased Output will influence or enhance effective inventory control	N	
22.	F6-F2	Effective inventory control will influence or enhance increased output	N	
23.	F2-F7	Increased Output will influence or enhance better workpiece processes	N	
24.	**F7-F2**	**Better workpiece processes will influence or enhance increased out put**	**Y**	**Reduces wastages hence more productivity**
25.	F2-F8	Increased Output will influence or enhance minimum material handling	N	
26.	F8-F2	Minimum material handling will influence or enhance increased output	Y	Transitive
F3- Reduced set ups				
27.	**F3-F4**	**Reduced set ups will influence or enhance fast response to customers**	**Y**	**Saves time and hence fast response**
28.	F4-F3	Fast response to customers will influence or enhance reduced set ups	N	
29.	**F3-F5**	**Reduced set ups will influence or enhance reduced lead time**	**Y**	**Unproductive time reduces**
30.	F5-F3	Reduced lead time will influence or enhance reduced set ups	N	
31.	**F3-F6**	**Reduced set ups will influence or enhance effective inventory control**	**Y**	**Less** WIP **inventory**
32.	F6-F3	Effective inventory control will influence or enhance reduced set ups time	N	
33.	F3-F7	Reduced set ups will influence or enhance better workpiece processes	N	
34.	**F7-F3**	**Better workpiece processes will influence or enhance reduced set ups**	**Y**	**More operations on a single workstation**
35.	**F3-F8**	**Reduced set ups will influence or enhance minimum material handling**	**Y**	**Movement between workstations reduces**
36.	F8-F3	Minimum material handling will influence or enhance reduced set ups	N	
F4 – Fast response to the customers				
37.	F4-F5	Fast response to the customers will influence or enhance reduced lead time	N	
38.	**F5-F4**	**Reduced lead time will influence or enhance fast response to the customers**	**Y**	**Less time means fast delivery to customers**
39.	F4-F6	Fast response to the customers will influence or enhance effective inventory control	N	
40.	F6-F4	Effective inventory control will influence or enhance fast response to the customers	N	
41.	F4-F7	Fast response to the customers will influence or enhance better workpiece processes	N	
42.	**F7-F4**	**Better workpiece processes will influence or enhance fast response to the customers**	**Y**	**Better productivity**
43.	F4-F8	Fast response to the customers will influence or enhance minimum material handling	N	
44.	F8-F4	Minimum material handling will influence or enhance fast response to the customers	Y	Transitive
F5 – Reduced lead time				
45.	F5-F6	Reduced lead time will influence or enhance effective inventory control	N	
46.	F6-F5	Effective inventory control will influence or enhance reduced lead time	N	
47.	F5-F7	Reduced lead time will influence or enhance better workpiece processes	N	
48.	**F7-F5**	**Better workpiece processes will influence or enhance reduced lead time**	**Y**	**Less unproductive time**
49.	F5-F8	Reduced lead time will influence or enhance minimum material handling	N	
50.	**F8-F5**	**Minimum material handling will influence or enhance reduced lead time**	**Y**	**Less unproductive time**
F6 – Effective inventory control				
51.	F6-F7	Effective inventory control will influence or enhance better workpiece processes	N	
52.	F7-F6	Better workpiece processes will influence or enhance effective inventory control	Y	Transitive
53.	F6-F8	Effective inventory control will influence or enhance minimum material handling	N	
54.	F8-F6	Minimum material handling will influence or enhance effective inventory control	N	
F7- Better workpiece processes				
55.	**F7-F8**	**Better workpiece processes will influence or enhance minimum material handling**	**Y**	**Combining of operations**
56.	F8-F7	Minimum material handling will influence or enhance better workpiece processes	N	

TABLE III
REACHABILITY MATRIX

	F1	F2	F3	F4	F5	F6	F7	F8
F1	1	0	0	0	0	0	0	0
F2	0	1	0	1	0	0	0	0
F3	1	1	1	1	1	1	0	1
F4	0	0	0	1	0	0	0	0
F5	0	1	0	1	1	0	0	0
F6	0	0	0	0	0	1	0	0
F7	1	1	1	1	1	1*	1	1
F8	1	1*	0	1*	1	0	0	1

TABLE IV
PARTITIONING THE REACHABILITY MATRIX INTO DIFFERENT LEVELS

Factors	Reachability set	Antecedent set	Intersection set	Level
		(a) Iteration 1		
F1	**1**	**1,3,7,8**	**1**	**I**
F2	2,4	2,3,5,7,8	2	
F3	1,2,3,4,5,6,8	3,7	3	
F4	**4**	**2,3,4,5,7,8**	**4**	**I**
F5	2,4,5	3,5,7,8	5	
F6	**6**	**3,6,7**	**6**	**I**
F7	1,2,3,4,5,6,7,8	7	7	
F8	1,2,4,5,8	3,7,8	8	
		(b) Iteration 2		
F2	**2**	**2,3,5,7,8**	**2**	**II**
F3	2,3,5,8	3,7	3	
F5	2,5	3,5,7,8	5	
F7	2,3,5,7,8	7	7	
F8	2,5,8	3,7,8	8	
		(c) Iteration 3		
F3	3,5,8	3,7	3	
F5	**5**	**3,5,7,8**	**5**	**III**
F7	3,5,7,8	7	7	
F8	5,8	3,7,8	8	
		(d) Iteration 4		
F3	3,8	3,7	3	
F7	3,7,8	7	7	
F8	**8**	**3,7,8**	**8**	**IV**
		(e) Iteration 5		
F3	**3**	**3,7**	**3**	**V**
F7	3,7	7	7	
		(f) Iteration 6		
F7	**7**	**7**	**7**	**VI**

TABLE V
LIST OF FACTORS AND THEIR LEVELS IN TISM

S.No.	Factor Code	Factor	Level in TISM
1.	F I	Reduced labour cost	I
2.	F4	Fast response to customers	I
3.	F6	Effective inventory control	I
4.	F2	Increased output	II
5.	F5	Reduced lead time	III
6.	F8	Minimum material handling	IV
7.	F3	Reduced set-ups	V
8.	F7	Better workpiece processes	VI

Step2. Defining the contextual relationship between these factors: After exhaustive discussions with both experts from industry and academia a contextual relationship is developed between these factors.

Step3. Giving interpretation of contextual relationships: The interpretations are added to the SSIM and it is converted into interpretive logic.

Step4. Interpretive logic of pair-wise comparison: In order to develop the knowledge base of interpretive logic the relationship between the factors affecting the productivity are compared pair wise by writing 'Y' for Yes and 'N' for No. Also the reasons are cited for each 'Yes' as given in Table II.

Step5. Reachability matrix and transitivity check: The paired comparisons in the interpretive logic – knowledge base are then converted to a reachability matrix. The reachability matrix is tested for the transitivity rule and updated iteratively. The final reachability matrix satisfying the transitivity rule is shown in Table III.

Step6. Level partition on reachability matrix: The level partition is done as mentioned in Section III. The partitioning is shown in Table IV. The different iterations are given in Table IV a, b, c, d, e and f respectively for the six levels of partitioning. The various factors with their levels in TISM are given in Table V.

Step7. Developing the diagraph: A diagraph is obtained by arranging the factors as per the levels and the links are mapped from the reachability matrix. Only significant transitive links are included and other are removed as shown in Fig. 1.

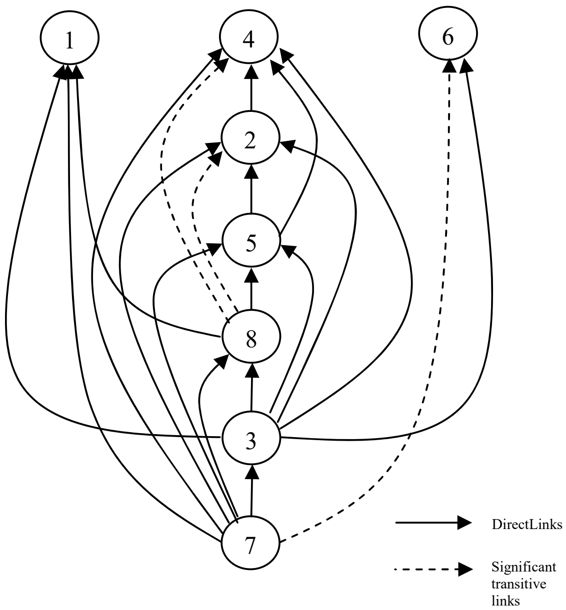

Fig. 1 Diagraph with Significant Transitive Links

Step8. Developing interaction matrix and converting to interpretive matrix: The final diagraph is translated into a binary interaction matrix form and is interpreted by picking the relevant interpretation from the knowledge base in the form of interpretive matrix as shown in

Tables VI (a) and (b).

TABLE VI
INTERACTION MATRIX

	F1	F2	F3	F4	F5	F6	F7	F8
				(a) Binary Matrix				
F1	-	0	0	0	0	0	0	0
F2	0	-	0	**1**	0	0	0	0
F3	**1**	**1**	-	**1**	**1**	**1**	0	**1**
F4	0	0	0	-	0	0	0	0
F5	0	**1**	0	**1**	-	0	0	0
F6	0	0	0	0	0	-	0	0
F7	**1**	**1**	**1**	**1**	**1**	*1*	-	**1**
F8	**1**	*1*	0	*1*	**1**	0	0	-
				(b) Interpretive Matrix				
F1	-	-	-	-	-	-	-	-
F2	-	-	-	More production to meet more demands	-	-	-	-
F3	Less manpower required	Less unproductive time	-	Saves time and hence fast response	Unproductive time reduces	Less WIP inventory	-	Movement between workstations reduces
F4	-	-	-	-	-	-	-	-
F5	-	Per unit time reduction hence more output	-	Less time means fast delivery to customers	-	-	-	-
F6	-	-	-	-	-	-	-	-
F7	Number of separate workstations reduces	Reduces wastages hence more productivity	More operations on a single workstation	Better productivity	Less unproductive time	T	-	Combining of operations
F8	Automated material handling devices reduces labour cost	T	-	T	Less unproductive time	-	-	-

Step9. Prepare TISM*:* The nodes in the diagraph are replaced by the interpretation of factors placed in boxes. The interpretation in the cells of interpretive direct interaction matrix is shown along the side of the particular links in the structural model. This gives the TISM for productivity factors of FMS, Fig. 2.

V. DISCUSSIONS

Main objective of this research is to analyse the various factors affecting the productivity of FMS. A structure is developed among these various factors by establishing their relative importance and influence on each other. The TISM model developed shows that better workpiece process is the basic factor which influences all the other factors for achieving better productivity. With improved workpiece processes, the set ups are reduced and as such more and more operations are either combined or are done at a single workstation thus leading to minimum material handling. This leads to lead time reduction and more outputs. Finally the factors like reduced labour cost, fast response to the customers and the effective inventory control are dependent factors which are influenced by the others.

VI. CONCLUSION

The results of this study can help in the strategic and tactical decisions for a firm wanting to boost its productivity. By using TISM the interpretation of each relation is also incorporated. So a practising engineer or the manager has a clear picture as to how each factor is related to the other factors influencing the productivity of the firm. The factors which influence the other factors more such as the workpiece processes, set ups and material handling, are of strategic orientation. On the other hand, the dependent factors, which are affected by the others like labour cost, response to customers, inventory control, are of operation and performance orientation. Hence superior performance of FMS can be achieved by continuously improving the strategic factors.

Finally this model can be analysed for the driver power and dependence power of various elements in the model or the elements or the paths in TISM can be ranked using Interpretive Ranking Process.

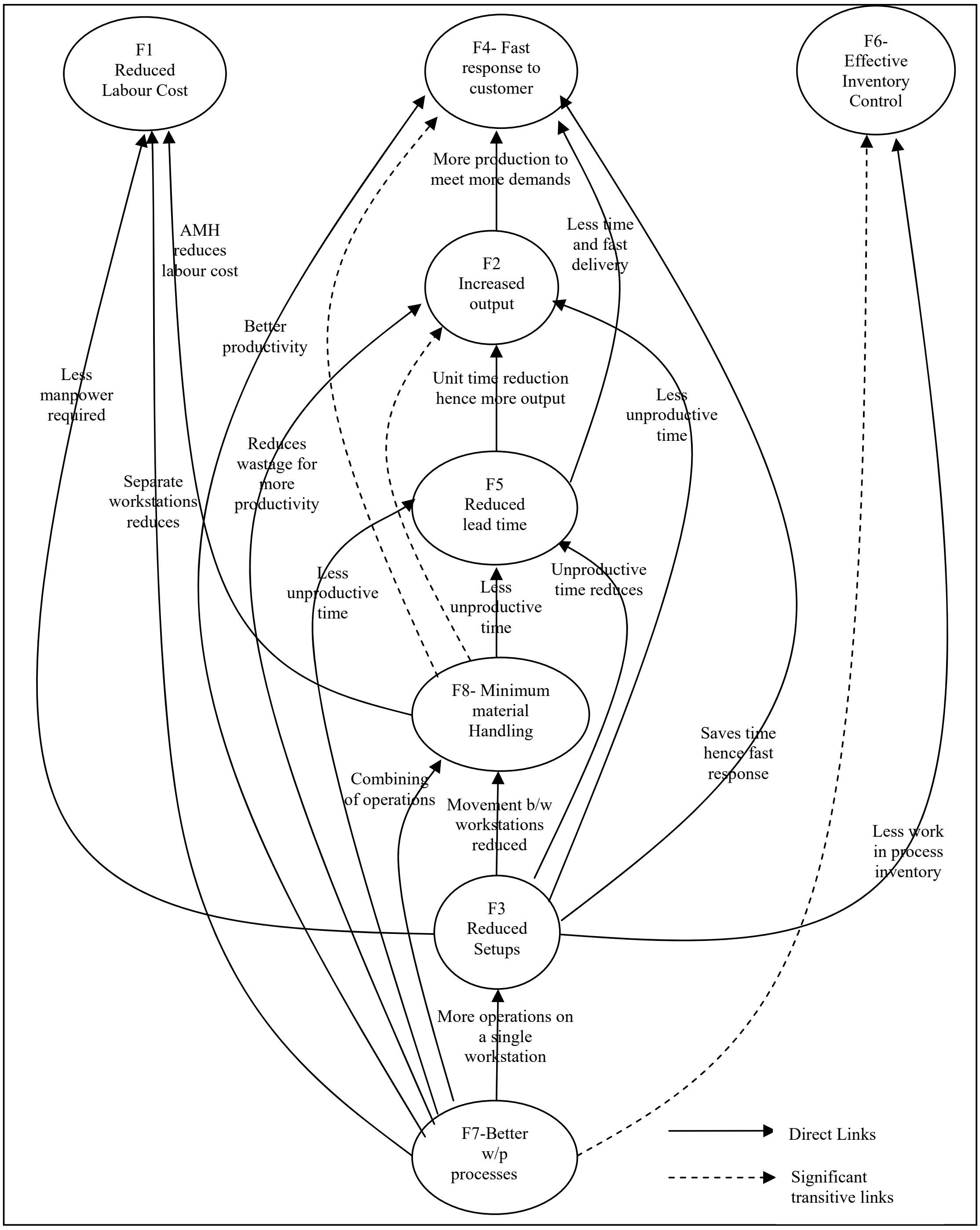

Fig. 2 TISM for Productivity Factors of FMS

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