A Method for Identifying Critical Success Factors of JIT Implementation in Different Circumstances (Case Study: Appliance Industry)

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Abstract

World Class Manufacturing is a management philosophy that emphasizes on meeting external and internal customers' needs and expectations and importance of doing things right for world market society. One of the most world class production techniques is Just in Time (JIT). JIT production system has some components that need to implement it. Researches show that implementation of this system isn't unique in all time, places and circumstances. Implementation of this system may be differed from one company to another and the components those are needed to a company may not be necessary in another company. The purpose of this study is to introduce a mathematical method for identifying elements and components that are critical for JIT success in different circumstances. The study recommends this method by using TOPSIS and Pareto techniques. We use TOPSIS and Pareto techniques for setting a priority and thereby selection of component and use entropy method for giving coefficient to TOPSIS matrix. In this process, the statistical population to answer these questions is 1500 of the company's managers and engineers as experts in appliance industry of Iran. In this case we have extracted 5 components from 11 possible components in this system to implement in these companies (in appliance industry).The components for JIT implementation are different in different industries and companies. In a scene, while JIT implementation flow the logical priorities as an algorithm, it can perform regarding to its circumstances, readiness and needs. Concerning these circumstances, readiness and needs, these components of JIT must be implemented with priority in these companies: JIT supplier management, Preventive maintenance, set up time reduction, Lot sizing, Pull production system.

Keywords: World Class Manufacturing, Just in Time, TOPSIS method, Pareto technique, Entropy method.

1. Introduction and Theoretical Development

Most of the organizations and companies which have improved rapidly during the recent years are facing special challenges. Changing environmental and social conditions like population is very important to consider. These changes create some chances and challenges at the same time. A successful company not only knows environmental challenges but also tries to identify and utilize environmental chances. More changes a company has, the faster it should adapt itself to the changes. So, awareness is needed in this condition. Companies which use the chances can only improve. However, managers try to protect themselves against the outside environmental distrust by the use of special manners. The difference between what a company does and what a company should do is increasing: in such conditions only top activated companies can work successfully. World class manufacturers use information as a strategic tool in order to reach the highest level of activation. So WCM wants to globalize international trade in order to have competitive products, high quality, reasonable price and top services to customers. JIT manufacturing systems were developed initially in the Japanese manufacturing industry. More precisely, they come from the improvement of Toyota's production system. These modifications were soon adopted by other Japanese companies in the automotive Industry and, as early as the 1980s, by American and European companies. Until then, companies were using mass production systems designed to protect them from market fluctuations. This system has somewhat become a catch phrase in recent times and has significant overlaps to concepts such as Total Quality Management (TQM), Continuous Improvement, Time based manufacturing and business process re-engineering (Lawrence and Lewis 1996 ;Cua et al. 2001). One outcome of a JIT framework would be identification and separation of components that were critical to JIT success and those components that were less critical. From this identification, managers would be able to focus on those components which were found to be more important to a JIT program (Spencer and Guide 1995). But a major constraint in JIT implementation is that there are no universally accepted JIT techniques, as they seem to vary from one culture to another and also from one industry to another (Sandanayake, et al. 2008). The case study approach applied aforementioned systematic and efficient methods to identify key JIT variables and components for the mixed model automotive component assembly line. This research study used the simulation modeling with ProModel software and linear mathematical modeling to identify the impact of key JIT drivers on performance (Sandanayake, et al. 2008). Therefore, before implementing this system, one of the most important questions is: *what are the components of JIT*?

Studying literature review of JIT shows that there aren't any consensuses about this component of JIT. Spencer and Guide (1995) have confirmed this disagreement. Also there remains a lack of a comprehensive mechanism to identify the most significant JIT drivers for the purpose of system process optimization (Sandanayake, et al. 2008).

For instance, Voss and Robinson (1987) stated that the UK has shown a high level of JIT awareness and understanding, but in their study only 10% of responses had 'major' JIT programs. They found that 57% of a sample of 123 companies were either implementing or intending to implement some aspects and components of JIT. They reported that core JIT techniques such as 'Kanban', 'Cellular manufacturing', 'Statistical Process Control' and 'Zero-Defects' had the lowest rating for actual and planned implementation in the UK. Further, they have observed that some manufacturing companies implementing JIT concentrate on a subset of JIT practices; thus suggesting that they only focus on easy-to-implement techniques rather than those giving the greatest benefits.

The purpose of this study is to identify elements and components that are critical for JIT success. There have been only a few attempts for defining the components of JIT programs. Most researches have provided only general principles or guidelines. For example, Schonberger (1982) provided a list of 17 principles of operations management based on his examination of JIT, particularly the Kawasaki Motorcycle factory in Lincoln, Nebraska. Hall (1983) also developed an early set of JIT principles but grouped his findings into only six generalizations.

The first proposed model of JIT components was developed by Giunipero (1990) but it focused on managerial support for JIT implementation issues rather than operational components. In 1992, Mehra and Inman (1992) proposed a model based on their review of existing literature that identified 19 elements they found to be critical for JIT success, and grouped them into four key factors: management commitment, JIT production strategy, JIT vendor strategy, and JIT education strategy. Mehra and Inman (1992) then tested hypotheses based on their classification by conducting a survey of 550 manufacturers. Based on the 114 usable responses Mehra and Inman (1992) concluded that:

- No significant relationship was found between management commitment and JIT educational strategy and the level of successful JIT implementation.
- There was a significant relationship between JIT production strategy and JIT vendor strategy and JIT success.

These findings appear counter-intuitive and do not support findings or generalizations made by other researchers discussed previously. Findings from this study are used to help resolve these differences.

In addition, in consideration of related books and article this reality is manifested that every reference has been referenced different component from others.

For instance, James (1997) has listed this component in his book as:

(A) Shop floor management: Set up time reduction, Preventive maintenance and Pull system production

(B) Scheduling

(C) Process designing and production: Equipment layout, Small solving group and Staff training

(D) Supply management: JIT delivery and Supplier's quality

(E) Accounting-information systems

Whereas Russel and Taylor (1995) have introduced this component as: Flexible resourcing, Cellular layout, Pull production system, Kanban, production control, Lot sizing, Fast Set up, Production smoothing, Quality in resources, Productive and total maintenance and Supplier grids.

Eventually Melnyk and Denzler (1996) have introduced this component as: Kanban or Pull production planning, Set up time reduction, Zero defects, Quality in resources, Multi skill and flexible workers, Group technology, Centered factory, Statistical quality control, Supplier partnership and Continuous improvement.

As understood, the introduced component by this references are same in some cases and aren't in other cases. Then if more references added to this paper, these disagreements expand and confirm the Spencer and Guide (1995) research.

The second question that should be kept in mind for preparing a company to implement JIT production system is: *How is this component priority for different company with different circumstances and ability? Have they same priorities*?

With more review and analysis, these similarities can be rejected. Mould and King (1995) showed that this system has been established successfully in many companies with different methods and components. They have shown that the priorities of this different components are different in different companies with different circumstances and abilities. However, it is understood that JIT components aren't not implemented with same method and priority in every company (Mould and King 1995). In additions, the inspection of organizational contingency theories confirms this matter too. Because according to these theories, presenting a solution for all situations has rejected. While Salaheldin (2005) has introduced human resource fitness as factor that induces success or failure in JIT implementation. In other company, technological and supplier problem may had the most related effect. He find in his survey that JIT implementation is more likely to be in the food, chemicals, engineering and electronic industries; while less likely to be found in other industries. Moreover, the need for implementing the JIT philosophy is likely to be greater when companies are larger and older (Salaheldin 2005). Also it is certain that companies' emphasis on different problem base on their needs, situation and abilities. When a company doesn't have any problem in staff training, it will not spend any time and money to that matter. When a company has a little set up time, it will not give notice to the component of JIT in terms of time, energy and money. When a company has quality problems, then it must be working about quality control group and ANDON light and focusing more time, expenditure and creativity on these kinds of matters.

For example, companies like UKAN has implemented JIT system because of their overfull production cost and disorder that was created by overfull inventory and late delivery; but companies like Harley Davidson and TI has introduced JIT system to enhance the level of quality (Noori and Radford 1995). Furthermore Lawrence and Lewis (1996) concluded that JIT can be used successfully in some Mexican manufacturing firms. Moreover, they found that there are three groups of obstacles that hinder the implementation of JIT in Mexican operations:

1. Employee participation obstacles.
2. Supplier participation obstacles.
3. Obstacles to the managerial integration of the JIT companies (Lawrence and Lewis 1996).

Such classification shows that before implementation of JIT production system, every company must prepare for that and then should be answering these questions:

1. What are the possible components of the JIT production system?
2. What are the priorities of these components?
3. What are the components that this company must use for JIT implementation?

First questions answer recognize from related literature review so that components that every source have introduced them are selected, and then eliminate the repetitive components to recognize all no repetitive component that has introduced in these references, this component are:

1. Preventive Maintenance

2. Lot sizing
3. Cellular Layout
4. Accounting-Information Systems
5. JIT Supplier Management
6. Production Smoothing
7. Set Up Time Reduction
8. Pull Production System
9. Centered Factory
10. Quality in Resource
11. Multi Skill and Flexible Workers

2. Methodology

As mentioned, literature review of world class manufacturing offers a consistent and rigorous problem-solving framework for identifying the scope of the problem. Reliability, Quality and Cost are inter-linked, higher quality being associated with higher reliability. The reliability of items, products and facilities is an important consideration of design by world class manufacturing techniques. Techniques have an important role to play in dynamic world market society. World class manufacturing techniques are a competitive strategy involving continuous improvement of products, processes and services to improve quality, reduce costs, increase productivity and increase total customer satisfaction. In these process, 11 components was introduced as JIT possible components that can be used in JIT implementation. To answer the second question, TOPSIS method was used, so that criteria are JIT benefits. In this way, JIT benefits have been recognized in past researches. Research has shown that the successful implementation of JIT philosophy can produce significant benefits for manufacturing firms; such as, improving quality that consistently and continually meets customers requirements; minimizing levels of inventory and improving relationship with suppliers (Aghazadeh 2003); reducing the labour turn over rate; reducing manufacturing lead times; reducing set-up time (Wafa and Yasin 1998); reducing operations and materials handling costs; and maximizing the use of space (Petersen 2002).

JIT can also improve the on-time receipt of material from suppliers (Yasin et al. 2001); improving purchasing function; improving preventive maintenance; increasing worker participation; improving the quality and timing of received material; full utilization of people, equipment, materials and parts (Alternburg et al. 1999)

Finally, cost reduction (Brox and Fader 1997; Fullerton and McMasteres 1999), Quality increase, lead-time reduction (Flynn et al. 1995), inventory reduction (Balakrishnan et al. 1996; Billesbach and Hayen 1994; Ockree, 1993; Norris et al. 1994), and labour productivity (White and Prybutok 2001) that are the main JIT benefits that every company seek them to use as priority indicator has been selected. For answering the second question, TOPSIS method as a Multi Criteria Decision Making (MCDM) method has been used. The well-known MCDM method provides an effective framework for comparison based on the evaluation of multiple conflict criteria. MCDM method has been one of the fastest growing areas of operational research, as it is often realized that many concrete problems can be represented by several (conflicting) criteria. It was described as the most well-known branch of decision making. MCDM methods include Total Sum (TS), Simple Additive Weighting (SAW) method, AHP, Data Envelopment Analysis (DEA), Outranking approaches (ELECTRE and PROMETHEE), and TOPSIS method (Hwang and Yoon, 1981).

TOPSIS method is based on this concept that chosen alternative should have the shortest distance from the positive-ideal solution and the longest distance from the negative-ideal solution. TOPSIS defines an index called similarity to the positive-ideal solution and the remoteness from the negative-ideal solution. Then the method chooses an alternative with the maximum similarity to the positive-ideal solution. In this process, the statistical population to answer these questions is 1500 of the company's managers and engineers as experts in appliance industry of Iran. In this part, for each extracted component, questions have been put forward that in every question the impact of this component on any one of the criteria has designed. For example such question has been asked: in your company, how is the set up time reduction effect on employee participation increase? In this question, effect of set up time reduction as a component on employee participation increase as a criterion has measured with this commentaries on the scale:

Extreme: 9; High: 7; Moderate: 5; Low: 3; Seldom: 1

Also to accounting the coefficient related to criteria, entropy method has been used. To answer the third question, Pareto analysis has been used. in this process the cumulative effect of coefficient for all component has been accounted and then component that their effect are more than 80 per cent of all effect, has been selected as JIT component that must be implementing in these companies.

3. Data Analysis

Date in Table 1 show the geometric mean of every question. For example, geometric mean of persons' answer related to effect of preventive maintenance to inventory reduction is 8.45; this data show relatively extreme effect of this component on inventory reduction as a criterion in JIT implementing.

Table 1 Data Results

Component / Criteria	Cost reduction	Quality increase	Product diversity increase	Inventory reduction	Employee participation increase
Preventive maintenance	8.19	5.61	2.97	8.45	4.89
Lot sizing	3.87	4.4	4.69	5.32	2.9
cellular layout	1	1.14	4.12	4.17	1.31
Accounting-information	1.14	1.31	3.4	4.69	1
JIT supplier management	8.72	8.45	4.58	4.58	2.97
Production smoothing	1	1.14	6.23	4.69	1
Set up time reduction	3.4	2.97	8.45	7.45	5.26
Pull production system	1.98	2.78	5.43	3.58	4.12
Centered factory	1.14	1.14	1.4	4.58	1.14
Quality in resource	1.22	1.84	1.22	1.22	1
Multi skill and flexible	1.14	1	6.5	1.14	2.61
Column sum	32.8	31.78	48.99	50.12	28.21
$\sqrt[2]{\sum_{j=1}^{11} r_{ij}^2}$	13.45	12.19	16.3	16.61	21

Table 2 shows the weight recognition matrix for asked criteria in TOPSIS method. This Table shows that this criteria's weight extracted from answer matrix (Table 1) by entropy method where E_j, d_j and W_j are:

$$E_j = -k\sum_{i=1}^{m}[\ p_{ij}.Lnp_{ij}\ ]$$

$k = \frac{1}{Lnm}$, is number of components and is Table 2 values

$$d_j = 1 - E_j$$

$$W_j = \frac{d_j}{\sum d_j}$$

As depicted in table 3, this weight has been converted to an N dimension. In this matrix, the Table 5 has been established by product of normalization of Table 1's data (Table 4) and Table 3's data.

After obtaining the V matrix, all of criteria conceptually are in this manner that it is better for them that they are more and more, thus the positive and negative ideal solution perform as:

$$A^+ = \{\max V_{i1}, \max V_{i2}, \max V_{i3}, \max V_{i4}, \max V_{i5}\}$$
$$= \{.178, .191, .058, .062, .101$$
$$A^- = \{\min x V_{i1}, \min V_{i2}, \min V_{i3}, \min V_{i4}, \min V_{i5}\}$$
$$= \{.02, .022, .023, .007, .119$$

A^+ is positive ideal alternative and A^- is negative ideal alternative.

Table 2 Weight Recognition Matrix for asked Criteria

Preventive maintenance	.249	.176	.06	.168	.173
Lot sizing	.117	.138	.095	.106	.102
cellular layout	.03	.035	.084	.083	.046
Accounting-information systems	.034	.041	.069	.093	.035
JIT supplier management	.265	.265	.093	.091	.105
Production smoothing	.03	.035	.127	.093	.035
Set up time reduction	.1	.093	.172	.148	.186
Pull production system	.06	.087	.11	.076	.146
Centered factory	.034	.035	.028	.091	.4
Quality in resource	.037	.057	.024	.024	.035
Multi skill and flexible workers	.034	.031	.132	.022	.09
E_j	.884	.883	.946	.948	.919
$d_j = 1 - E_j$	.116	.117	.054	.052	.081
W_j	.276	.227	.128	.123	.192

Then in next phase:

$$d_{i^-} = \left[\sum_{j=1}^{n}(V_{ij} - V_j^-)^2\right]^{\frac{1}{2}} ; i = 1,2,3,.......,m$$

$$d_{i^+} = \left[\sum_{j=1}^{n}(V_{ij} - V_j^+)^2\right]^{\frac{1}{2}} ; i = 1,2,3,.......,m$$

$$CL_{i^+} = \frac{d_{i^-}}{d_{i^+} + d_{i^-}} ; 0 \le CL_{i^+} \le 1; i = 1,2,3,......,m$$

$d_{1^+} = .074$	$d_{1^-} = .203$	$CL_{1^+} = .7328$
$d_{2^+} = .144$	$d_{1^-} = .109$	$CL_{1^+} = .4308$
$d_{3^+} = .243$	$d_{1^-} = .05$	$CL_{1^+} = .1706$
$d_{4^+} = .244$	$d_{1^-} = .035$	$CL_{1^+} = .1254$
$d_{5^+} = .05$	$d_{1^-} = .236$	$CL_{1^+} = .8251$
$d_{6^+} = .245$	$d_{1^-} = .042$	$CL_{1^+} = .146$
$d_{7^+} = .165$	$d_{1^-} = .121$	$CL_{1^+} = .5769$
$d_{8^+} = .194$	$d_{1^-} = .08$	$CL_{1^+} = .2919$
$d_{9^+} = .243$	$d_{1^-} = .029$	$CL_{1^+} = .1066$
$d_{10^+} = .248$	$d_{1^-} = .023$	$CL_{1^+} = .0848$
$d_{11^+} = .246$	$d_{1^-} = .034$	$CL_{1^+} = .1214$

Table 3 N dimension Matrix

276.	0	0	0	0
0	.277	0	0	0
0	0	.128	0	0
0	0	0	.123	0
0	0	0	0	.192

Table 4 ND Matrix or Table 1 Normalized Data

Preventive maintenance	.608	.46	.182	.508	.492
Lot sizing	.287	.36	.287	.32	.292
Cellular layout	.074	.093	.252	.151	.131
Accounting-information systems	.084	.107	.208	.251	.1
JIT supplier management	.648	.693	.28	.275	.299
Production smoothing	.074	.093	.287	.282	.1
Set up time reduction	.252	.243	.457	.448	.529
Pull production system	.147	.228	.234	.23	.414
Centered factory	.084	.093	.28	.275	.114
Quality in resource	.09	.15	.074	.073	.1
Multi skill and flexible workers	.084	.082	.069	.063	.262

Table 5 V Matrix

Preventive maintenance	167	127	023	062	094
Lot sizing	079	099	036	039	056
cellular layout	02	025	036	039	025
Accounting-information systems	023	029	032	03	019
JIT supplier management	178	191	035	033	057
Production smoothing	02	025	036	034	019
Set up time reduction	069	067	058	055	101
Pull production system	04	063	029	028	079
Centered factory	023	025	035	033	021
Quality in resource	024	041	009	007	019
Multi skill and flexible workers	023	022	008	007	05

Also Table 6 shows the amount of component priorities in these companies and Table 7 shows the priority information about JIT component for these companies. As this table shows, the first five components show about 80 per cent of priorities in these companies and other components that they are 6 components, show 20 per cent of priorities variation. Thus same as factor analysis Pareto principle has been used to select more important component to implementation regarding to our constraints. Thus it is better for these companies that implement these 5 components as first stage. This procedure used in factor analysis to select factors. In fact, the first five components are the selected components for these companies. Chart 1 (linear diagram) and Chart 2 (Pareto chart) show and confirm this fact.

Table 6

Component	Rank	Distance	Distance
Preventive maintenance	2	.7328	CL1
Lot sizing	4	.4308	CL2
Cellular layout	6	.1706	CL3
Accounting-information systems	8	.1254	CL4
JIT supplier management	1	.8251	CL5
Production smoothing	7	.1460	CL6
Set up time reduction	3	.5769	CL7
Pull production system	5	.2919	CL8
Centered factory	10	.1066	CL9
Centered factory	11	.0848	CL10
Centered factory	9	.1214	CL11

Table 7 Priority Information about JIT Component

Priority	Components	Distance	Cumulative distance	Cumulative distance per cent
1	JIT supplier management	0.8251	0.8251	0.228414
2	Preventive maintenance	0.7328	1.5579	0.4312765
3	Set up time reduction	0.5769	2.1348	0.5909808
4	Lot sizing	0.4308	2.5656	0.71024
5	Pull production system	0.2919	2.8575	0.7910473
6	cellular layout	0.1706	3.0281	0.8382748
7	Production smoothing	0.146	3.1741	0.8786922
8	Accounting-information systems	0.1254	3.2995	0.913407
9	Multi skill and flexible workers	0.1214	3.4209	0.9470144
10	centered factory	0.1066	3.5275	0.9765247
11	Quality in resource	0.0848	3.6123	1

Chart 1 Linear Diagram for Priority of 11 Surveyed Components in These Companies

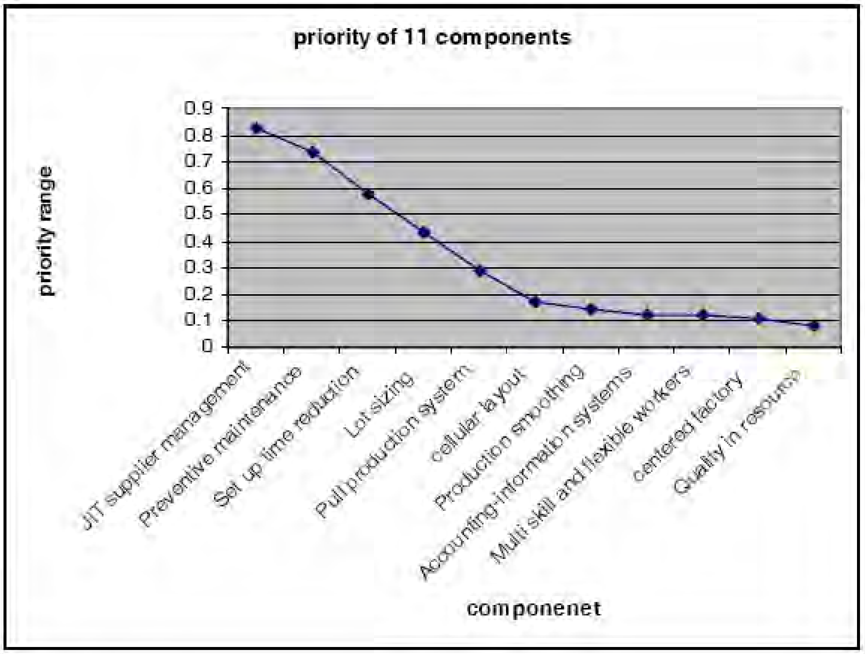
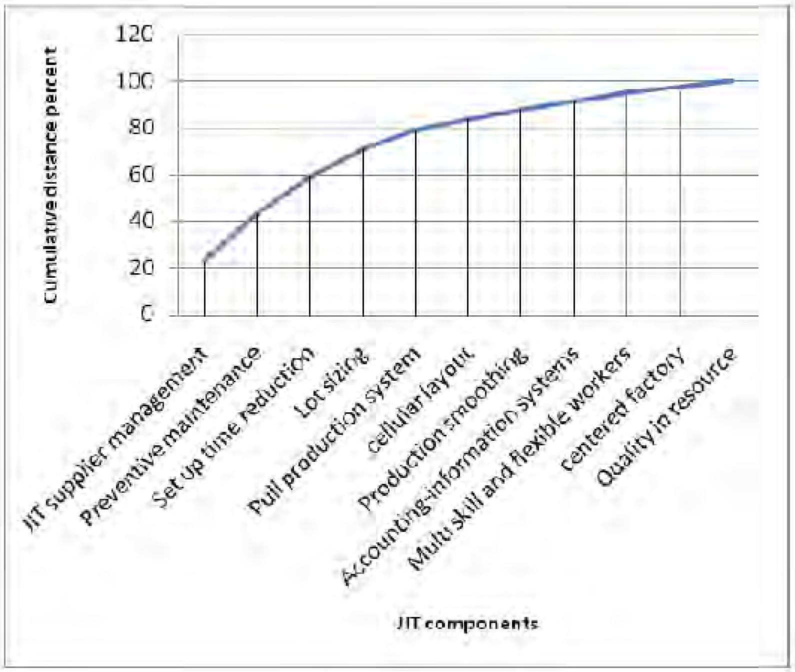


Chart 2 Pareto Chart for Priority of 11 Surveyed Components in these Companies



Research Constraints

This priority will be confirmed only if the logical priorities that JIT implantation as a project substantially need to does not decompose. This constraint pointing to this reality that JIT implementation is defined as a project that has itself logical priorities must be implemented systematically. For example, if a company need to implement pull system production to reach JIT benefits, it must implement set up time reduction before this decision, but if there is no problem in this areas it can perform any activity for set up time reduction. Researches that perform in JIT project priorities show that these priorities in these companies will not decompose any algorithm proposed.

Conclusion

(a) The components that companies need JIT implementation are different in different industries and companies. In a sense, while JIT implementation flow the logical priorities as an algorithm, it can perform in accordance to its circumstances, readiness and needs.

(b) Regarding circumstances, readiness and needs, these components of JIT must be implemented in the following order:

1. JIT supplier management
2. Preventive maintenance
3. Set up time reduction
4. Lot sizing
5. Pull production system

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