Key Components Identification in Vendor Managed Inventory (VMI) and their Evaluation Using ANOVA for Automobile Industry in Indian Context

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Abstract. The latest market trend shows that generation of dissimilarity in demand is because of variation is required by market in goods. Lot of complexities like planning, forecasting is generated due to this demand. Market always have uncertainty in demand starting from raw material to the final product delivered to the customer. To reduce this uncertainty, the entire approach must be changed to some new techniques. This can be achieved by managing the company supply chain in a very efficient manner and by doing so they can have competitive advantage over others. Few components of Vendor Managed Inventory (VMI) vital for both vendors and clients are discussed in this paper. A comparison of degree of difficulty and importance is also done in this paper.

Keywords: Vendor Managed Inventory (VMI)

1. Introduction
VMI abbreviated as Vendor Managed Inventory, is a streamlined approach to inventory management and order fulfillment. It encompasses association of providers and their buyers (e.g., supplier, dealer, or users) that alters the conventional procedure of placing order.[1] This approach is useful in many other applications like materials used in solar energy [2-5] composite materials [6, 7] which are used in manufacturing of chassis in automobile industries widely these days.

Vendor Managed Inventory aims both suppliers and their customers by aligning business objectives and streamline chain operations. Increased information flow results in the direct outcome in the form of business value: Upgraded Inventory Turns, Enhanced Service, and Improved Sales.[8-10]

The following steps briefly describe the VMI process: Data communication, Calculation, Monitoring and Reporting. The recommended replenishment order is created by VMI software after analyzing the data. Recommendations are generally based on algorithms using factors for example predictions, occurrence of sale, and enhanced sales. [11, 12]

On ideal front, these processes encompass the following:

- Fixed interval review and estimation of time of placing of order and quantities associated with it, on the basis of movement data and unique information like promotions etc. [13]
- The recommended orders, any exemptions are thoroughly review by supplier's planner prior to the approval of appropriate orders. After which VMI system directs supplier and customer with a purchase order. [14]

Following below mentioned objectives must be fulfill for trading partners to begin with VMI:

- Inventory turns and Cost of transaction.
- The definite measured activity against the above described goal is strictly monitored by the system.
- To maintain the transparency in the process the information is reported to the supplier as well as the...
customer. On demand, information should be accessible to both supplier as well as customer. In the case, when measurements get disturb for example do not follow an acceptable range or difficulty in the fact comes, then VMI system should provide an immunity signal to both customer and supplier. [15-18]

2. Methodology

2.1 Introduction

Few factors are highlighted in the study that are related to VMI system:

Elements that are needed for VMI
Elements that are challenging to implement but important.
Elements that can be executed easily.
Elements that are more advantageous in Industries.

First step included the assessing of various key elements of VMI through literature survey, industry professionals and academic professionals to serve the aim of assessment. Study involves the following protocol:

Designing of Research
Tools/Technique
Applicants involved in the survey and Collection of Data

2.2 Designing of Research

It includes non-experimental quantitative research, more precisely, an online mail survey method. It entails responses of industry personnel and extensive analysis of quantitative data.

2.3 Tools/Techniques

To serve the purpose of finding the highly essential components of VMI that are easily implementable at industry level a investigatory survey was designed. The survey comprises the evaluation based on some of the highly usable parameters that are- Monitoring and Reporting, Communication and Information sharing between supplier and customer, Advance Product Quality Planning, Employee feedback and suggestion, Total Productive Maintenance (TPM) and Statistical Process Control, Team work, Communication and calculations of data, Use of Software, Quality Circle etc. [19-21]

2.4 Applicants Involved in The Survey

An online questionnaire was framed which included the pros and cons of VMI elements and this questionnaire then mailed to several industries. To distribute and gather the data, this study finds the use of a mail survey. It is the best way to obtain relevant and highly enriched information from huge number of industries.

2.5 Collection of Data

From the self-administered mail survey method, data was collected. Economical approach and easily accessible to widely discrete samples represent positive aspect of the self-administered mail survey. Common features of the automobile industries assumed to be the familiarized for the participants involved in the study.
The survey sends with the below mentioned features during mail:
Instructions to fill the form
VMI components details selected for the study
Following the questionnaire, thanks is mailed to individuals involved in the study, after their successful reply, for their valuable co-operation during the study.

3. Results

A comprehensive list of 25 components [22-26] of VMI structure which are fit for automobile industries. The questionnaire was sent to 60 professionals who belongs to automobile sector. The replies were composed from all the professionals efficaciously. The mean score for individual components was calculated. The mean score of VMI components is given by table1 and table 2 for difficulties and importance in perspective of automobile sector.

Table 1 shows that Technical Skills and capability of Vendor and Workforce received the greatest value (i.e. 139), therefore it is the most significant components of VMI for automobile Industries whereas, the mean for Performance of Non-Participating Members is 84, which is the smallest, therefore it is the least important component of VMI in industries

| S.N. | VMI COMPONENTS                                      | REPLIES | Mean Score (0-240) |
|------|-----------------------------------------------------|---------|-------------------|
| 1    | Implementation of 4Ps                               | 9 12 13 17 9 | 115               |
| 2    | Technical Skills and capability of Vendor and Workforce | 14 15 14 10 7 | 139               |
| 3    | Sole Sourcing                                       | 5 9 13 21 12 | 94                |
| 4    | Kanban                                              | 7 6 16 24 7 | 102               |
| 5    | Highly Effective Computer Information System         | 13 13 11 12 11 | 125               |
Table 2 shows that Failure Mode and Effect Analysis received the greatest value (i.e. 133), therefore it is the most difficult components of VMI for Industries whereas, the mean for Location of Inventory/Vendors is 86, which is the smallest, therefore it is the least difficult component of VMI in industries.

**TABLE 2. DEGREE OF DIFFICULTIES OF VMI COMPONENTS IN INDUSTRIES**

| S.N. | VMI COMPONENTS                                      | RESPONSE | Mean Score (0-240) |
|------|----------------------------------------------------|----------|--------------------|
| 1    | Implementation of 4Ps                              | 11 9 15 22 3 | 123                |
| 2    | Technical Skills and capability of Vendor and Workforce | 12 14 17 7 10 | 131                |
| 3    | Sole Sourcing                                      | 9 16 13 9 13 | 119                |
| 4    | Kanban                                             | 11 10 12 18 9 | 116                |
4. Data Analysis

From XY matrix plot shown in figure 2, we find those VMI components that are highly essential and easily executable. These components are Kanban, Data Communication and Calculation, Employee Feedback and Suggestion, Level of Inventory, Performance of Non-Participating Members, House Keeping, Top Management Commitment, Poka Yoke and Statistical Process Control.

|   | Highly Effective Computer Information System | 4 | 7 | 14 | 28 | 7 | 93 |
|---|-----------------------------------------------|---|---|----|----|---|----|
| 6 | Total Productive Maintenance                  | 7 | 15| 20 | 13 | 5 | 126|
| 7 | Trust and Partnership between supply chain stake holders | 10| 14| 13 | 14 | 9 | 122|
| 8 | Policies of the organization                  | 9 | 12| 11 | 18 | 10| 112|
| 9 | Data Communication and Calculation            | 6 | 7 | 19 | 22 | 6 | 105|
|10 | Monitoring and Reporting                      | 8 | 6 | 13 | 23 | 10| 99 |
|11 | Communication and Information Sharing         | 5 | 9 | 15 | 18 | 13| 95 |
|12 | Employee Feedback and Suggestion              | 11| 10| 14 | 13 | 12| 115|
|13 | Level of Inventory                            | 6 | 8 | 17 | 20 | 9 | 102|
|14 | Performance of Non-Participating Members      | 12| 11| 10 | 17 | 10| 118|
|15 | Infrastructure                                | 10| 12| 16 | 13 | 9 | 121|
|16 | House Keeping                                 | 7 | 11| 14 | 21 | 7 | 110|
|17 | Top Management Commitment                     | 4 | 9 | 12 | 25 | 10| 92 |
|18 | Implementation of 5S                          | 12| 10| 13 | 16 | 9 | 120|
|19 | Advance Product Quality Planning              | 14| 12| 15 | 4  | 15| 118|
|20 | Use of Brainstorming                          | 9 | 11| 16 | 20 | 4 | 121|
|21 | Poka Yoke                                     | 6 | 17| 14 | 13 | 10| 116|
|22 | Statistical Process Control                   | 8 | 9 | 14 | 20 | 9 | 107|
|23 | Location of Inventory/Vendors                 | 6 | 3 | 11 | 31 | 9 | 86 |
|24 | Defect Analysis and Preventive Action         | 9 | 13| 22 | 10 | 6 | 129|
|25 | Failure Mode and Effect Analysis              | 11| 12| 18 | 17 | 2 | 133|
Figure 2: Matrix Plot for VMI Elements

The most essential but problematic in execution components are shown in upper right quarter. These elements are Technical Skills and capability of Vendor and Workforce, Infrastructure, Defect Analysis and Use of Brainstorming, Preventive Action and Failure Mode and Effect Analysis.

The comparatively lesser essential and highly problematic in execution components are shown in upper left quarter. So called components are Total Productive Maintenance and Trust and Partnership between supply chain stakeholders, Implementation of 4Ps.

The comparatively lesser essential but easily executable components are shown in lower left quarter. These elements are Statistical Process Control, Sole Sourcing, Advance Product Quality Planning, Kanban, Performance of Non-Participating Members, Data Communication and Calculation, Employee Feedback and Suggestion, Level of Inventory, Top Management Commitment, House Keeping, Poka Yoke.

These components must be executed at initial stage in every organization, which are greatly essential and relatively less problematic to execute

4.1 ANOVA Technique

| TABLE 3. COMBINED TABLE FOR IMPORTANCE AND DIFFICULTY FOR THE NINE CRITICAL FACTORS |
|---------------------------------|----------------------------------|-------------------------------|-------------------------------|-----------------------------------|---------------------------------|---------------------------------|-------------------------------|
| Organization                    | Kanban                           | Data Communication and Calculaton | Employee Feedback and Suggestion | Level of Inventory | Performance of Non-Participating Members | House Keeping | Top Management Commitment | Poka Yoke | Statistical Process Control |
|---------------------------------|----------------------------------|-------------------------------|-------------------------------|-----------------------------------|---------------------------------|---------------------------------|-------------------------------|----------------|-----------------------------|
| Kanban                          | Data Communication and Calculaton | Employee Feedback and Suggestion | Level of Inventory | Performance of Non-Participating Members | House Keeping | Top Management Commitment | Poka Yoke | Statistical Process Control |
| Kanban                          | Data Communication and Calculaton | Employee Feedback and Suggestion | Level of Inventory | Performance of Non-Participating Members | House Keeping | Top Management Commitment | Poka Yoke | Statistical Process Control |
Following are the steps involved in the technique:

(i) Find mean for each sample i.e.

$$M_1, M_2, M_3, \ldots \ldots \ldots M_z$$

Where $z$ are the number of samples.

(ii) Mean of the sample means can be calculated as follows:

$$= \frac{M_1 + M_2 + M_3 + \ldots \ldots \ldots + M_z}{\text{No. of samples} (z)}$$

(1)
(iii) SS between or Sum of Squares between the sample, are calculated as given below:

\[
SS \text{ between } = n_1 \left( M_1 - \overline{M} \right)^2 + n_2 \left( M_2 - \overline{M} \right)^2 + \ldots + n_z \left( M_z - \overline{M} \right)^2
\]  
(2)

(iv) Mean Square between samples can be calculated as:

\[
MS \text{ between } = \frac{SS \text{ between}}{z-1}
\]  
(3)

(v) Calculate the Sum of Squares for variance within samples (or SS within) as given below:

\[SS \text{ within} = \sum (M_{1i} - \overline{M}_1)^2 + \sum (M_{2i} - \overline{M}_2)^2 + \ldots + \sum (M_{zi} - \overline{M}_z)^2 \]

\[i = 1, 2, 3\ldots\]

(vi) Now within sample Mean Square can be calculated as :

\[
MS \text{ within } = \frac{SS \text{ within}}{(n-z)}
\]  
(4)

where \((n-z)\) is DOF with in samples. And \(n\) represent total number of item in all samples

(vii) The next step comprises the calculation of SS for total variance as :

\[SS \text{ for total variance } = \sum (M_{ij} - \overline{M})^2 \]

\[i = 1, 2, 3\ldots \text{ and } j = 1, 2, 3\ldots\]

(viii) In the end, F-ratio can be found as:

\[
F-ratio = \frac{Mean \text{ Square between sample}}{Mean \text{ Square within sample}}
\]  
(6)

F ratio anticipate that whether the difference among several means is significant or not.

**TABLE 4. AVERAGES OF ELEMENTS FOR ANOVA**

| Groups                                | Count | Sum   | Averages       | Average of Averages |
|---------------------------------------|-------|-------|----------------|---------------------|
| Kanban                                | 30    | 206   | 6.866666667    |                     |
| Data Communication and Calculation    | 30    | 200   | 6.666666667    |                     |
| Employee Feedback and Suggestion      | 30    | 210   | 7              |                     |
| Level of Inventory                    | 30    | 196   | 6.533333333    | 6.918518519         |
| Performance of Non-Participating Members | 30    | 188   | 6.266666667    |                     |
| House Keeping                         | 30    | 204   | 6.8             |                     |
| Top Management Commitment             | 30    | 224   | 7.466666667    |                     |
| Poka Yoke                             | 30    | 202   | 6.733333333    |                     |
| Statistical Process Control           | 30    | 238   | 7.933333333    |                     |
TABLE 5. F-RATIO

| Sources of Variation | SS    | DOF | MS    | F-Ratio | 10% F-Limit |
|----------------------|-------|-----|-------|---------|-------------|
| Between Groups       | 69.74074 | 8   | 8.717 | 1.81    | 1.65        |
| Within Groups        | 1255.466 | 261 | 4.81  |         |             |
| Total                | 1416.207 | 269 |       |         |             |

As the F-calculated is greater than F-critical, the values of elements are significant.

5. CONCLUSIONS

Survey of 60 automobile professionals is carried out in this paper. Various components have been summarized, evaluated and schemed on a matrix plot to find out the less difficult and most important components, on the basis of mean determined for various components of VMI on 0-240 scale. The data has been verified with the help of ANOVA technique.

It is recommended that, firstly VMI components should be executed in a linear fashion and afterward the conformation of its success, it needs to be executed to the entire method. As an experimental work highly essential and less problematic & less essential and less problematic components need to be executed. Successful execution of experimental work, the highly essential and highly problematic components must be executed. This paper also identified the most beneficial elements for the automobile industries.

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