Asian Social Science; Vol. 11, No. 4; 2015
ISSN 1911-2017 E-ISSN 1911-2025
Published by Canadian Center of Science and Education

Challenges with Multi-Dimensional Inventory Classifications and Optimization

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Received: November 1, 2014 Accepted: December 4, 2014 Online Published: January 14, 2015

doi:10.5539/ass.v11n4p365 URL: http://dx.doi.org/10.5539/ass.v11n4p365

Abstract

The level of automation in Inventory Management is increasing day by day. In ERPs various parameters have to be defined to achieve even simple levels of automation like Reorder-Point, Minimum Order Quantity, Lot-Size, Lead-Time etc. Inventory Management with today's ERP systems can become simpler if the parameter settings of Materials Requirement Planning (MRP) and Master Production Schedule (MPS) are clearly understood and mapped. Various Inventory Classification methods are used like the ABC, XYZ, VED, FSN, HML, SDE etc. to group the products and maintain similar parameter settings for different group of products. Each parameter setting and product classifications have underlying assumptions. In our daily business the underlying assumptions may often be overlooked. The primary objective in this study is to highlight one of the assumptions taken for granted and to find an optimized solution for Inventory Classification for this assumption. This in turn can help enterprises be more flexible with better managed inventory.

Keywords: ABC-XYZ classification analysis, inventory management optimization

1. Introduction

Sustainability for today's Enterprise largely depends upon the variety of products they can offer to their customers. Therefore most companies today are increasing the range of products in the portfolio. Due to customer demands and competition, companies are forced to introduce new products and at the same time often reluctant to take decisions to discontinue obsolete items. This results in ever increasing range of product portfolio. As the size of the product portfolio increases, the challenges in terms of planning, procurement, storage, distribution and sales also increase. At the same time, companies have to ensure that their Supply Chains are more agile, robust and flexible. When materials pass through the entire Supply Chain, the automated parameter settings can have cascading effects. Complex algorithms, measures and checks are built in different functions of the Supply Chain. Because of these complexities companies are now forced to ensure inventories are quantitatively and qualitatively (Torabi, Hatefi, Saleck, & Pay 2012) classified and managed. On one side customers are expecting more and more varieties of products and on the other side there is pressure on maintaining optimum levels of inventory for Finished Goods, Semi-Finished Goods and Raw Materials.

1.1 Challenges in Efficient Planning

Manufacturing companies have to ensure a wide range of resources are brought together to efficiently create items that satisfy customer needs. If all the resources are not synchronized, companies may not make profits. If companies have to be successful, production and manufacturing processes have to be planned carefully which in simple terms is called 'PP'. Through 'PP' the entire production process can be tracked, right from product conceptualization, design, manufacturing, storage and distribution. Planning also includes evaluation of existing production, possibilities of improvements in existing systems and requirements of products that may be planned for future releases.

Like most business strategies, 'PP' is designed to generate higher profits. Most production planning methods, like lean manufacturing, are used to reduce error and increase efficiency. PP is done to efficiently use all the resource of the company like machines, infrastructure, man-hours etc. Seamless integration of these resources is an important virtue of a good 'PP' system. Also finding ways for all of them to work together as seamlessly as possible. Other virtues include flexibility, scalability and agility. Production planning strategies include managing and maintaining different metrics for operational control.

1.2 Unexpected Costs

Budgeting is done to keep the overall production costs under control. All production strategies revolve around these budgets. Therefore budgets have to include costs of labor, raw materials, working capital, machinery, depreciation, transportation, inventory-holding-costs, insurance etc. Cost estimating is essential to determine a production strategy that will be within budget. Some of these costs may be fixed like raw material, Infrastructure, etc. But the real challenge is to keep the variable costs under control. When projects and production gets delayed, these variable costs can become very significant. Also when raw material and finished goods inventories are not managed efficiently the variable costs can have significant effect on profits.

1.3 Scheduling

For estimating cost, duration of the production needs to be known. To optimize expenses, all resources have to be scheduled appropriately. Different work centers have capacity constraints which plays an important role in production planning. The requirements of different phases of production have to be considered.

1.4 Management of Surprises

Though budgeting addresses the challenges associated with variable cost, there may be some un-foreseen elements that can impact production and production costs. Murphy's Law defines these effects. Adding 20 percent to your best estimate is a good rule of thumb. Production tasks going exactly as planned are rare. To handle surprises, Managers today use Safety Stock parameters to ensure production lines are not interrupted. These Safety Stock parameters are so often miss-used and managers may not realize its impact on the inventory until major damage is already done.

2. Inventory Management

Demands on the Supply Chain are increasing day by day. Due to innovation in technology, product life cycles are reducing. As the processes and product ranges become complex, management of Inventory also becomes complex. Based on the maturity levels of the processes, companies have to keep improving and innovating Inventory Management techniques. Various methodologies and techniques can be implemented to optimize the use of resources. To simplify Inventory Management, managers apply the concept of Importance and Exception. Based on these concepts, inventory is classified into different groups based on value, quantity, demand, availability and sometimes even weight and volume. Some of the classification methods (Mohammaditabara, Ghodsypoura, & O'Brienb, 2012) are known as ABC, XYZ, VED, FSN, HML, SDE etc.

2.1 Assumptions in Inventory Classifications

Most Inventory classification methods apply 3 levels and more or less follow the Pareto Principle. As per this principle 80% of the Revenue is contributed by 20% of the Items. The focus shifts totally on the 20% of the items. The remaining 80% of the items are categorized based on convenience. Let’s say this 80% is further split into 2 more levels as given below.

Table 1. Percentage and distribution on ABC classification

Category	Percentage	Distribution
A	80%	20%
B	80-95%	30%
C	95-100%	50%

The approximate distribution is also mentioned in the table above. These percentages and distribution is often taken for granted. Typically in an automated process and ERP systems various parameters for planning and inventory management is based on these categorizations (Millstein, Yang, & Li, 2013). Typically the ‘C’ class items would not have any parameters defined for planning because of their financial impact. Therefore there is a need to classify items based on the consistency and predictability of the movement. Items can further be classified as XYZ. Most highly predictable items are classified as ‘X’, items with variations in movement are classified as ‘Y’ and items which are highly unpredictable are classified as ‘Z’. This consistency and predictability of the items is derived from Standard Deviation and Coefficient of Variation. These two categorizations can be merged in a 2-Dimensional format and we get this matrix given below.

Table 2. ABC-XYZ 2 dimensional matrix

2D		**Consistency of the stock movement**		
		X (High)	**Y(Med)**	**Z(Low)**
	A (High)	AX	AY	AZ
Value of stock movement for the period	**B(Med)**	BX	BY	BZ
	C(Low)	CX	CY	CZ

Typically to minimize inventories the following strategies are used.

1) Just-In-Time sourcing (Wagner & Silveira-Camargos, 2011) is done for AX, AY, CX and BX items on Time Based (Order Cycle Method).

2) 'BY' is done of individual sourcing based on Stock Levels.

3) Demand based sourcing is done for AZ, BZ, CY and CZ items with safety stocks.

Nearly 40% of the items would be defined with Safety Stocks. This can result in increase of inventory levels if it is not efficiently managed. The 'C' items will also include the non-moving items. Consider this example from a Plastics-Auto-Component manufacturing company with 330 items in their inventory. When the ABC and XYZ analysis in done for the period December 2012 to November 2013, the typical distribution would be as follows.

Table 3. STD ABC-XYZ distribution

Dec12-Nov13 **ABC/XYZ**	**No. of Items**	**Distribution**
A	66	20% of 330
B	99	30% of 330
C	165	50% of 330
X	66	20% of 330
Y	99	30% of 330
Z	165	50% of 330

In reality there are only 175 active items in the total number of 330 items in the item master. Most of the items would get identified as 'A' and 'B' or 'X' and 'Y'. The remaining 155 items (330-175) would be classified as 'C' and 'Z'. For these items if safety stocks are defined, it may lead to unnecessary inventory. Most literature and Inventory Policies define three levels of product classification. There is a need to add another level in these classifications which denotes as inactive or non-moving product. A typical 4X4 matrix is given below.

Table 4. ABC-XYZ 4X4 matrix

	A	**B**	**C**	**Inactive**
X	AX	AY	AZ	**--**
Y	BX	BY	BZ	**--**
Z	CX	CY	CB	**--**
Inactive	**--**	**--**	**--**	Inactive-Inactive

2.2 Challenging the 'Assumption': Period for Data Analysis

The period of analysis plays a vital role in inventory classification. If ABC and XYZ classifications are taken separately, the variations in each of the classification can be very significant. If you consider smaller periods of data, the number of active items would be less in comparison to larger periods of data. In a typical case study the variation of 'A' class items for different periods of data is given below.

Table 5. ABC classification

S No	Period (Months)	Feb 12	Mar 12	Apr 12	May 12	Jun 12	~	Apr 13	May 13	Jun 13	Jul 13
1	**1M**	10	9	9	12	15	~	13	8	7	10
2	**2M**	12	11	11	13	17	~	13	12	8	9
3	**3M**	15	12	12	14	17	~	15	13	10	9
4	**4M**	16	15	14	15	16	~	16	15	12	11
5	**5M**	16	16	17	16	17	~	17	16	14	13
6	**6M**	17	17	18	18	18	~	17	16	15	15
7	**7M**	18	18	18	19	20	~	17	16	15	15
8	**8M**	17	18	19	20	21	~	18	16	15	15
9	**9M**	18	17	19	20	21	~	19	17	15	15
10	**12M**	20	19	20	21	22	~	21	20	18	17

When we compare the 1-Month data in first line and 12-Month data in the last line the number for 'A' class item vary drastically. The difference is nearly two times. For planning and extrapolation identifying the most optimized period for data analysis becomes a big challenge because similar challenges are there for XYZ classification also as shown below.

Table 6. XYZ classification

S No	Period (Months)	Feb 12	Mar 12	Apr 12	May 12	Jun 12	~	Apr 13	May 13	Jun 13	Jul 13
1	**1M**	11	11	10	13	11	~	13	16	14	12
2	**2M**	14	15	15	16	17	~	21	21	22	19
3	**3M**	19	17	19	19	19	~	24	26	25	25
4	**4M**	21	21	20	22	21	~	25	29	29	27
5	**5M**	23	23	23	23	24	~	29	30	32	31
6	**6M**	25	26	25	27	25	~	29	33	33	33
7	**7M**	27	28	27	28	29	~	31	33	35	34
8	**8M**	29	29	29	30	30	~	34	35	36	36
9	**9M**	30	31	30	33	32	~	36	37	37	37
10	**12M**	34	34	35	36	36	~	41	41	43	42

When the XYZ classification is studied the difference between 1-Month and 12-Month data is more significant. If multi-dimensional approach is considered it becomes even more important that the optimized planning period is used for planning and extrapolation.

3. Optimization thru Measure of Dispersion

The suggested method for Optimization of 'Period' of Planning Data is through the measure of dispersion. For any specific period of planning, items jump from one classification to another. If this jump and be measured, quantified and compared then optimization can be achieved.

3.1 Quantum of Dispersion

Table 7. ABC-XYZ substitutions for quantification

A is replaced by	**1**	**X is replaced by**	**1**
B is replaced by	**2**	**Y is replaced by**	**2**
C is replaced by	**3**	**Z is replaced by**	**3**
BLANK is replaced by	**4**	**BLANK is replaced by**	**4**

Step 1. The classification of A, B, C, Blank and X, Y, Z, Blank are replaced by the alphabetic number 1, 2, 3, and 4.

Step 2. This numeric values of each period are compared (mathematically subtracted) with the previous period and this difference is Squared.

Step 3. For each type of classification the squared difference is added to compute the total variation

Quantified ABC and XYZ deviation is given below in separate tables.

Table 8. Quantification of ABC deviation

	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13
1M	107	98	98	119	135	107	111	116
2M	70	37	90	63	60	89	47	56
3M	61	42	41	80	40	69	61	30
4M	45	44	52	44	59	50	39	43
5M	25	34	47	49	27	44	26	28
6M	27	14	45	54	31	29	34	18
7M	29	22	31	53	29	35	19	22
8M	14	26	27	33	37	31	23	10
9M	37	14	30	37	21	39	31	16
12M	37	12	30	33	14	27	26	18

Table 9. Quantification of XYZ deviation

	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13
1M	88	99	86	99	106	90	133	108
2M	83	40	67	50	62	94	72	78
3M	61	53	37	60	44	75	70	44
4M	41	49	53	35	50	58	44	54
5M	30	40	44	44	39	53	38	43
6M	24	23	43	51	41	55	47	19
7M	41	21	35	38	44	49	46	45
8M	36	34	31	26	45	38	39	32
9M	38	29	37	33	34	43	39	25
12M	18	52	26	28	23	23	32	41

3.2 A Inference from Quantification

Table 10. T-test statistics for ABC classification

	1M	2M	3M	4M	5M	6M	7M	8M	9M	12M
1M		0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2M	0.007		0.081	0.009	0.004	0.004	0.000	0.001	0.000	0.004
3M	0.000	0.081		0.244	0.025	0.011	0.012	0.004	0.001	0.007
4M	0.000	0.009	0.244		0.027	0.119	0.067	0.002	0.005	0.005
5M	0.000	0.004	0.025	0.027		0.556	0.541	0.070	0.029	0.124
6M	0.000	0.004	0.011	0.119	0.422		0.681	0.613	0.438	0.361
7M	0.000	0.000	0.012	0.067	0.682	0.681		0.161	0.123	0.180
8M	0.000	0.001	0.004	0.002	0.106	0.613	0.161		0.878	0.363
9M	0.000	0.000	0.001	0.005	0.053	0.438	0.123	0.878		0.459
12M	0.000	0.004	0.007	0.005	0.042	0.361	0.180	0.363	0.459	

As the period of analysis increases from 1 Month to 12 Months the quantum of deviation reduces but we do not get a conclusive result for optimization. The statistical t-test data are compared for all periods from 1 Month to 12 Months. The table below gives the t-test data for both ABC and XYZ.

Table 11. T-test statistics for XYZ classification

	1M	**2M**	**3M**	**4M**	**5M**	**6M**	**7M**	**8M**	**9M**	**12M**
1M		0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2M	0.001		0.207	0.023	0.001	0.001	0.001	0.001	0.000	0.000
3M	0.000	0.207		0.421	0.015	0.004	0.001	0.002	0.000	0.000
4M	0.000	0.023	0.421		0.018	0.015	0.004	0.000	0.003	0.001
5M	0.000	0.001	0.015	0.018		0.346	0.048	0.061	0.109	0.017
6M	0.000	0.001	0.004	0.015	0.368		0.640	0.171	0.383	0.102
7M	0.000	0.001	0.001	0.004	0.104	0.640		0.212	0.590	0.169
8M	0.000	0.001	0.002	0.000	0.024	0.171	0.212		0.510	0.922
9M	0.000	0.000	0.000	0.003	0.117	0.383	0.590	0.510		0.065
12M	0.000	0.000	0.000	0.001	0.034	0.102	0.169	0.922	0.065	

Based on the t-test data in the above tables, it is evident that there is no significant difference between quanta of deviation observed for 6-Months to 12 Months shown as shaded grey above tables as the values are greater than 0.05. Therefore we can conclude that at least six months data must be considered for extrapolation.

4. Conclusion

Proper application of the Pareto Principle has to be done when it is applied to product classification based on ABC and XYZ. The inactive items have to be clearly identified and not clubbed with slow moving and random moving items. If a 4X4 matrix seems inappropriate even a 3X3 matrix with A, B & Inactive or X, Y and Inactive may be considered. Most importantly before any data is extrapolated for long term planning, all the variables and assumptions need to be clearly understood and addressed. With the identification of Inactive items and optimized periods of data analysis, inventories can be more efficiently managed.

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