Critical Analysis of Implementation of Just-In-Time in an Industry

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Abstract

The purpose of this work is to check the status of implementation of Just-In-Time (JIT) inventory management technique in an Indian industry. And also investigate whether Just-In-Time (JIT) inventory management technique is a worthwhile approach or not to manage inventories. Some experts in the field maintain that the additional transportation costs derived from using JIT and its costs due to frequent transportation is more than offset by the reduction in inventory levels. In this study a simulation is developed using the cost structure of some parts of an automobile in an automobile company. This work results indicate that despite all the advantages of using JIT, JIT is not always the lowest cost technique.

Keywords: *JUST-IN-TIME, Transportation Cost, Holding Cost, Ordering Cost, Demand Break-even-point, EOQ (Economic order quantity), Inventory.*

1. Introduction

JIT is a tool of lean manufacturing, which seeks to eliminate the ultimate source of waste; Variability, in all of its forms throughout the producing processes, from purchasing through distribution. By eliminating waste, JIT targets production with the minimum lead-time and at the lowest total cost. The JIT philosophy has its roots after World War II when the Japanese were striving to compete with the U.S. manufacturing system (also known as Mass Production). Tai sachi Ohno was the founder of this philosophy in the 1940s when he began developing a system that would enable Toyota to compete with U.S. automakers. Note that the environment dominating U.S. manufacturing over the last five decades has been based on the Material Requirements Planning (MRP) formalized by Joseph Orlicky, Oliver Wight, and George Plossl. In an MRP environment, planning is performed based on the independent (customers') demand, in an almost JIT basis. However, shop floor control is performed based on a push philosophy in which manufacturing orders are introduced in the system and pushed through production. This is the fundamental difference between JIT and MRP. According to Ohno, JIT rests on two pillars:

1. Just-in-time as it is described in the following chapters and

2. Automation with human touch. This term refers to the installation of one-touch automation so an operator will be able to place a part in a machine, initiate the machine cycle, and move on and ii) "fool proofing" or "poke yoke" which is the incorporation of sensors in the machines to signal abnormal conditions and even automatically stop machines if necessary, so operators don't need to watch machines during their cycle. Ohno formulated the whole idea based on two concepts he encountered during visits in the U.S.: An American supermarket and the cable cars in San Francisco. First, he was impressed by the way American supermarkets supplied merchandise in a simple, productive and, timely manner and attempted to develop a similar concept in manufacturing. Each workstation would become the internal customer for the preceding workstation. The former would simply pick up the required parts from the latter, a supermarket shelf. The second concept was analogous to a simple cable car operation. Ohno observed that the cable car riders were pulling an overhead cord when they wanted to disembark. This cord produced a similar sound signaling the cable car to stop the car. Ohno applied a similar system using machine sensors. An operator will stop the operation of a machine using a cord whenever he/she found a problem (automation) (Black and Hunter, 2003).JIT manufacturing can be traced back to the late 1700's (Just in Time, Toyota). Eli Whitney contributed his concept of interchangeable parts to the idea of JIT manufacturing in 1799. This concept was developed when Whitney took a contract from the United States Army to manufacture 10,000 muskets at the low price of $13.40 each. Over the next several years manufactures overall focused on the development of individual technologies. Through these years few people were concerned with the processes that each product went through during production (Just in Time, Toyota).

2. Literature Review

Guido Nassimbeni (1995) analyses the intensity and nature of the relationship between the principal operational Just-In-Time purchasing practices. Norio Watanabe and Shusaku Hiraki (1996) consider a multi-stage multi-product production, inventory and transportation system including lot production processes and develop a goal programming model for a pull type ordering system based on the concept of a Just-In-Time (JIT) production system. Knut Richter (1996) an EOQ model is studied in which the stationary demand can be satisfied by newly made products and repaired used products. A. Gunasekran and J. Lyu (1997) implement JIT in a small company in Taiwan that produces different kinds of lamps such as rear combination lamps and front turn signal lamps. Richard Ehrhardt (1998) formulated a variety of models for studying the trade -off between finished goods inventory costs and JIT manufacturing schedule stability. Mohamad Y. Jaber, Maurice Bonney (1999) surveys work that deals with the effect of learning on the lot-size problem. It also explores the possibility of incorporating some of the ideas adapted by JIT to such models. Yan Donga, Craig R. Carter, Martin E. Dresner (2000) they developed a model and tested to determine whether the use of JIT purchasing reduces logistics costs for both suppliers and buyers. The results indicate that JIT purchasing directly reduces costs only for buyers. Vikas Kumar, Dixit Garg and N.P Mehta (2004) examine the implementation of JIT based managerial philosophy of Indian industries. Specifically JIT elements, JIT benefits and reasons for slow implementation of JIT in Indian industries are investigated through a survey. Low Sui Pheng and Wu Min (2005) Implementing just-in-time (JIT) management in the ready mixed concrete (RMC) industry seems viable. Rajeev N (2008)provide a guideline for entrepreneurs in enhancing their IM performance, as it presents the results of a survey based study carried out for machine tool Small and Medium Enterprises (SMEs) in Bangalore. Yufang Chiu (2009) proposes an inventory model that considers the defect rate to conform the real production environment. Manoj P K (2011) JIT implementation in KAMCO, an agro machinery manufacturing company based in Kerala state of Indian union.

3. Inventories Costs

a. Ordering Costs

Ordering costs reflect the expenses associated with purchasing and receiving orders for the replenishment of inventories. These costs associated with the determination of requirements processing request, and subsequent contract action through receipt of the order into the inventory control point system that will vary significantly in relation to the number of orders processed. Consequently, to determine ordering costs, SPD department requires the services to analyze labor and computer-processing costs, which include generation of purchase request, solicitation evaluation, contract administration, material receipt, payment, communications, documentation, and indirect personnel.

b. Holding Costs

Holding costs are the costs of having inventories of material on hand to distribute to meet customer demand. SPD department expresses this expense as a percentage of the value of average on-hand inventory during annual operation. It is assumed that this cost is linear due to the constant holding cost rate applied over the average inventory figure. Holding Cost Rate = Time Value of Money 10%, Warehousing 2%, Obsolescence 10%, Theft and Shrinkage 3% Total = 25% of unit price per year

4. Economic Order Quantity Model

To help solve the problems of inventory, it is necessary to build mathematical models which describe the inventory situation. Since it is never possible to represent the real world with total accuracy, approximations and simplifications must be made during the model-building process. The two fundamental questions faced by any traditional inventory system are when should an order be placed and what quantity should be ordered. To answer the second question, the Inventory Management System use some form of the Economic Order Quantity (EOQ) to determine the size of the reorder quantity. Economic order quantity model was derived originally by Harris Wilson in 1915.This model is also known as deterministic model. EOQ applies only when demand for a product is constant over the year. EOQ is the quantity to order, so that ordering cost + holding cost finds its minimum.

Total Annual cost, (TAC) = Purchase cost + Ordering cost +holding cost

$$TAC(Q) = DP + \frac{DC}{Q} + \frac{QH}{2}$$

Where: D = Annual demand in units, P = Purchase cost of an item, C = Ordering cost per order, H = Holding cost per unit per year, Q = Lot size or order quantity in units,

$$\frac{DC}{Q} = \frac{QH}{2}$$

$$Q^2 = \frac{2DC}{H}$$

$$Q^* = \sqrt{\frac{2DC}{H}}$$

$$Q^* = \sqrt{\frac{2 \times Annual\ Demand \times Ordering\ Cost}{Carrying\ Cost}}$$

5. Analysis and Results

This study focuses on a set of ready-to-issue tractor parts. These items are consumable parts. Table 5.1 shows a sample of the items that are the focus of this study. The data are collected from Merchandiser of SPD (Spare part Division) of the company. We have select 21 parts of tractor for this study.

Table 5.1 Selected Parts with Annual Demand and Unit Price

Sr. No.	Part No.	Part Description	Annual Demand (D)	Unit Price(Rs.)
1	99272001	FAN	2000	258.66
2	99991770	FUEL PIPE FILTER ASSY. TO F.I.P	3500	57.65
3	99272006	RECOVERY BOTTLE	2500	74.87
4	99991705	FILTER ELEMENT PRIMARY	12000	32.98
5	99991706	FILTER ELEMENT SECONDARY	12000	28.09
6	99272003	ENGINE V-BELT (AV15×1125)	1000	94.7
7	99272009	OIL PRESSURE SWITCH	4000	100.28
8	99359056	GEAR SHIFTER LEVER	600	259.23
9	99358024	FIXED GEAR Z-24	1200	476.37
10	99352516	SPACER 16.5mm	350	36.88
11	99359060	GEAR SHIFTER ROD (2nd)	500	101.92
12	99359063	GEAR SHIFTER FORK (2nd)	300	234.06
13	99352524	SPACER (GEAR Z-24)	450	77.36
14	99357024	SLIDING GEAR Z-24 (M)	550	562.69
15	99991707	HYDRAULIC FILTER (K-SERIES)	15000	154.98
16	99251075	FRONT WHEEL RIM ASSY. (5.50F)	120	1845.91
17	99251077	FRONT TYRE 7.50"×16"-GYT	90	6384.47
18	99251057	BUMPER ASSY.	150	2188.83
19	99252025	BONNET ASSY.	150	2662.5
20	99657015	FENDER RIGHT (13.6×28)-OLD	250	2471.74
21	99657025	FENDER LEFT (13.6×28)-OLD	250	2471.74

Table 5.2 shows that the traditional inventory management method would incur a total annual holding cost of Rs. 47421.04 for the 21 items examined. Table 5.3 shows that the transportation costs for the same group of items being managed under JIT would result in a total annual transportation cost of Rs. 79193.78. These figures indicate that a further analysis should be conducted in order to decide which technique is the more appropriate.

Table 5.2 Annual holding costs under Non JIT

Part No.	Annual Demand (D)	Ordering Cost (C) (Rs.)	Holding Cost/unit per year (H) (Rs.)	Transportation Cost (S) (Rs.)	EOQ (√2DC/H)	Annual Holding Cost (HQ/2)
99272001	2000	43.97	64.665	2.431404	53	1713.62
99991770	3500	8.65	14.41	0.54191	65	468.41
99272006	2500	10.31	18.72	0.703778	53	496.01
99991705	12000	5.17	8.25	0.310012	123	507.08
99991706	12000	4.15	7.02	0.264046	120	421.35
99272003	1000	15.19	23.68	0.89018	36	426.15
99272009	4000	17.05	25.07	0.942632	74	927.59
99359056	600	41.86	64.81	2.436762	28	907.31
99358024	1200	78.65	119.09	4.477878	40	2381.85
99352516	350	6.05	9.22	0.346672	22	101.42
99359060	500	14.65	25.48	0.958048	24	305.76
99359063	300	39.79	58.52	2.200164	21	614.41
99352524	450	10.47	19.34	0.727184	23	222.41
99357024	550	90.36	140.67	5.289286	27	1899.08
99991707	15000	23.41	38.75	1.456812	135	2615.29
99251075	120	313.81	461.48	17.35155	13	2999.60
99251077	90	1085.36	1596.12	60.01402	12	9576.71
99251057	150	372.1	547.21	20.575	15	4104.06
99252025	150	452.63	665.63	25.0275	15	4992.19
99657015	250	440.2	617.94	23.23436	19	5870.38
99657025	250	440.2	617.94	23.23436	19	5870.38
						47421.04

Table 5.4 shows that only 6 items were selected for JIT out of the initial sample of21 when comparing the major drivers of the JIT techniques. This 28.75% acceptance rate for JIT was the result of breaking down the entire group and analyzing the two major drivers for each of the individual items.

5.1 Graphical and Mathematical Analysis

The next step in this investigation will be a graphical and mathematical break-even point analysis of two items picked from the initial group. These items were selected randomly. They had different recommendations in Table 5.4 as far as the practice of JIT in managing those items. Table 5.5 reproduces the different annual holding and transportation costs for distinct levels of demand throughout the same year for item 99251075 **(**FRONT WHEEL RIM ASSY. (5.50F)**)**. This item was selected to be under the JIT umbrella.

Table 5.3 Annual Transportation Cost of managing inventory under JIT

Part No.	Annual Demand (D)	Transportation Cost (S) (Rs.)	Annual Transportation Cost (DS)
99272001	2000	2.431404	4862.808
99991770	3500	0.54191	1896.685
99272006	2500	0.703778	1759.445
99991705	12000	0.310012	3720.144
99991706	12000	0.264046	3168.552
99272003	1000	0.89018	890.18
99272009	4000	0.942632	3770.528
99359056	600	2.436762	1462.057
99358024	1200	4.477878	5373.454
99352516	350	0.346672	121.3352
99359060	500	0.958048	479.024
99359063	300	2.200164	660.0492
99352524	450	0.727184	327.2328
99357024	550	5.289286	2909.107
99991707	15000	1.456812	21852.18
99251075	120	17.35155	2082.186
99251077	90	60.01402	5401.262
99251057	150	20.575	3086.25
99252025	150	25.0275	3754.125
99657015	250	23.23436	5808.589
99657025	250	23.23436	5808.589
			79193.78

According to the Figure above, Demand break-even-point is approximately **250**. **Mathematically**

$$D = \frac{CH}{2S^2} = \frac{313.81 \times 461.4}{2 \times 17.35^2} = 240.54$$

The break-even point graphically and mathematically is not exactly the same due to the successive approximation built in the graphical approach.

Table 5.4 Test for JIT acceptability

Part No.	Annual Demand (D)	Unit Price(Rs.)	Ordering Cost (C) (Rs.)	Holding Cost/unit per year (H) (Rs.)	Transportation Cost (S) (Rs.)	EOQ (√2DC/H)	Annual Holding Cost (HQ/2)	Annual Transportation Cost (DS)	JIT should be used?
99272001	2000	258.66	43.97	64.665	2.431404	53	1713.623	4862.808	no
99991770	3500	57.65	8.65	14.4125	0.54191	65	468.4063	1896.685	no
99272006	2500	74.87	10.31	18.7175	0.703778	53	496.0138	1759.445	no
99991705	12000	32.98	5.17	8.245	0.310012	123	507.0675	3720.144	no
99991706	12000	28.09	4.15	7.0225	0.264046	120	421.35	3168.552	no
99272003	1000	94.7	15.19	23.675	0.89018	36	426.15	890.18	no
99272009	4000	100.28	17.05	25.07	0.942632	74	927.59	3770.528	no
99359056	600	259.23	41.86	64.8075	2.436762	28	907.305	1462.057	no
99358024	1200	476.37	78.65	119.0925	4.477878	40	2381.85	5373.454	no
99352516	350	36.88	6.05	9.22	0.346672	22	101.42	121.3352	no
99359060	500	101.92	14.65	25.48	0.958048	24	305.76	479.024	no
99359063	300	234.06	39.79	58.515	2.200164	21	614.4075	660.0492	no
99352524	450	77.36	10.47	19.34	0.727184	23	222.41	327.2328	no
99357024	550	562.69	90.36	140.6725	5.289286	27	1899.079	2909.107	no
99991707	15000	154.98	23.41	38.745	1.456812	135	2615.288	21852.18	no
99251075	120	1845.91	313.81	461.4775	17.35155	13	2999.604	2082.186	yes
99251077	90	6384.47	1085.36	1596.118	60.01402	12	9576.705	5401.262	yes
99251057	150	2188.83	372.1	547.2075	20.575	15	4104.056	3086.25	yes
99252025	150	2662.5	452.63	665.625	25.0275	15	4992.188	3754.125	yes
99657015	250	2471.74	440.2	617.935	23.23436	19	5870.383	5808.589	yes
99657025	250	2471.74	440.2	617.935	23.23436	19	5870.383	5808.589	yes

Table 5.5 Demand Break-even-point for the item which is under JIT 99251075 (Front Wheel Rim Assy. (5.50F))

Annual Demand = 120, Ordering cost = 313.81, Holding cost = 461.4775, transportation cost = 17.35155.

Annual Demand	EOQ= √2*D*C/H	EOQ Rounding off	Annual Holding Cost= HQ/2 (Rs.)	Annual Transportation Cost= DS (Rs.)
10	3.687839	4	922.96	173.5
20	5.215392	6	1384.44	347
30	6.387524	7	1615.18	520.5
40	7.375678	8	1845.92	694
50	8.246259	9	2076.66	867.5
60	9.033324	10	2307.4	1041
70	9.757105	10	2307.4	1214.5
80	10.43078	11	2538.14	1388
90	11.06352	12	2768.88	1561.5
100	11.66197	12	2768.88	1735
110	12.23118	13	2999.62	1908.5
120	12.77505	13	2999.62	2082
130	13.29669	14	3230.36	2255.5
140	13.79863	14	3230.36	2429
150	14.28294	15	3461.1	2602.5
160	14.75136	15	3461.1	2776
170	15.20535	16	3691.84	2949.5
180	15.64618	16	3691.84	3123
190	16.07492	17	3922.58	3296.5
200	16.49252	17	3922.58	3470
210	16.8998	17	3922.58	3643.5
220	17.2975	18	4153.32	3817
230	17.68625	18	4153.32	3990.5
240	18.06665	19	4384.06	4164
250	18.43919	19	4384.06	4337.5
260	18.80436	19	4384.06	4511
270	19.16257	20	4614.8	4684.5
280	19.51421	20	4614.8	4858
290	19.85962	20	4614.8	5031.5
300	20.19913	21	4845.54	5205
310	20.53302	21	4845.54	5378.5
320	20.86157	21	4845.54	5552
330	21.18502	22	5076.28	5725.5
340	21.50361	22	5076.28	5899
350	21.81755	22	5076.28	6072.5
360	22.12703	23	5307.02	6246

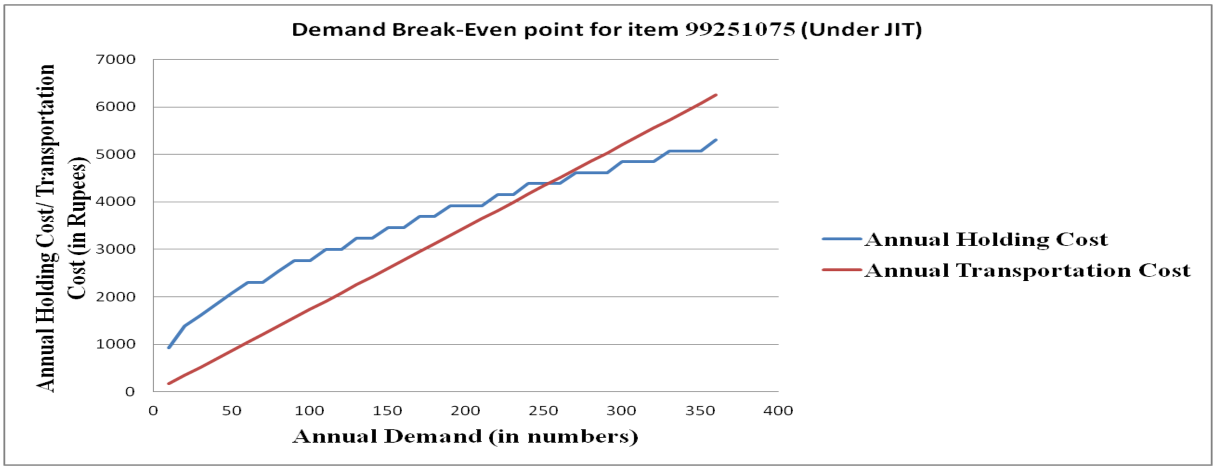

Fig. 5.1 Demand Break-even-point for the item which is under JIT

Table 5.6 Demand Break-even-point for the item which is under Non JIT 99352516SPACER 16.5mm

Annual Demand = 350, ordering cost = 6.05, holding cost = 9.22, transportation cost = 0.346

Annual Demand	EOQ=√2*D*C/H	EOQ Rounding off	Annual Holding Cost= HQ/2 (Rs.)	Annual Transportation Cost= DS (Rs.)
80	10.24642	11	50.71	28
90	10.86797	11	50.71	31.5
100	11.45585	12	55.32	35
110	12.01499	13	59.93	38.5
120	12.54925	13	59.93	42
130	13.06168	14	64.54	45.5
140	13.55474	14	64.54	49
150	14.03049	15	69.15	52.5
160	14.49063	15	69.15	56
170	14.9366	15	69.15	59.5
180	15.36963	16	73.76	63
190	15.7908	16	73.76	66.5
200	16.20101	17	78.37	70
210	16.6011	17	78.37	73.5
220	16.99177	17	78.37	77
230	17.37365	18	82.98	80.5
240	17.74732	18	82.98	84
250	18.11329	19	87.59	87.5
260	18.472	19	87.59	91
270	18.82388	19	87.59	94.5
280	19.1693	20	92.2	98
290	19.50861	20	92.2	101.5
300	19.84211	20	92.2	105
310	20.1701	21	96.81	108.5
320	20.49284	21	96.81	112
330	20.81058	21	96.81	115.5
340	21.12354	22	101.42	119
350	21.43193	22	101.42	122.5
360	21.73594	22	101.42	126

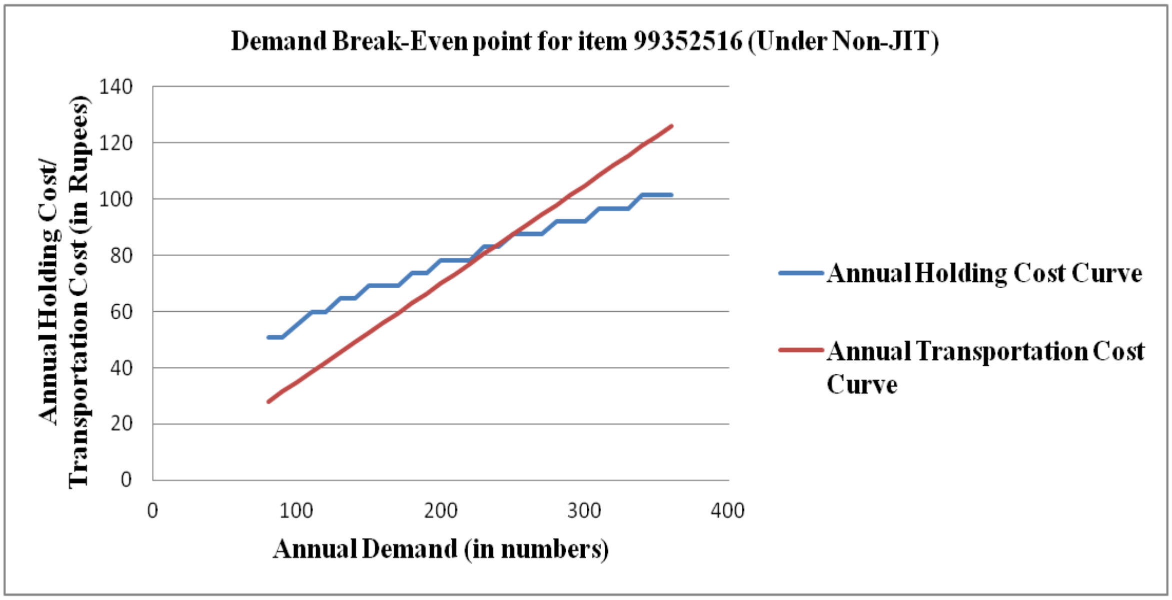

Fig. 5.2 Demand Break-even-point for the item under non JIT

From Figure 5.2 Demand break-even-point is approximately **230.**

Mathematically

$$D = \frac{CH}{2S^2} = \frac{6.05 \times 9.22}{2 \times 0.346^2} = 232.97$$

For the item 99251075 (FRONT WHEEL RIM ASSY. 5.50F) annual demands are 120. The graphical and mathematical analysis shows that the break-even point will occur when the annual demand is over 120 units. Graph 5.1, in particular, shows that the crossing point occurs all the way to the right of the normal annual demand which is 120 units.

This remarkable result indicates that JIT is the more appropriate technique to manage this particular item. This shows that the overwhelming majority of items with indications for JIT had the break-even point all the way to the far right of where the normal annual demand occurs. This reaffirms the indications for this kind of inventory guidance. In contrast, Table 5.6 and Figure 5.2 show that item 99352516 SPACER 16.5 mm, which was rejected for JIT management, has a demand break-even point all the way to the left of the normal annual demand. Annual demand is 350, signaling that JIT is not a wise approach. Table 5.7 highlights that all items rejected for JIT in this simulation had a break-even point far below the normal annual demand. This substantiates the rejection of JIT as a course of action.

Table 5.7 Demand break-even-point for all items

Part No.	Unit Price(Rs.)	Annual Demand (D)	Ordering Cost (Rs.) (C)	Holding Cost/unit per year (Rs.) (H)	Transportation Cost (S) (Rs.)	EOQ (√2DC/H)	Annual Holding Cost (HQ/2)	Annual Transportation Cost (DS)	JIT should be used?	Demand Breakeven point (CH/2S²)
99272001	258.66	2000	43.97	64.665	2.431404	53	1713.623	4862.808	No	240.4814
99991770	57.65	3500	8.65	14.4125	0.54191	65	468.4063	1896.685	No	212.2614
99272006	74.87	2500	10.31	18.7175	0.703778	53	496.0138	1759.445	No	194.8073
99991705	32.98	12000	5.17	8.245	0.310012	123	507.0675	3720.144	No	221.7656
99991706	28.09	12000	4.15	7.0225	0.264046	120	421.35	3168.552	No	209.0021
99272003	94.7	1000	15.19	23.675	0.89018	36	426.15	890.18	No	226.9144
99272009	100.28	4000	17.05	25.07	0.942632	74	927.59	3770.528	No	240.5273
99359056	259.23	600	41.86	64.8075	2.436762	28	907.305	1462.057	No	228.438
99358024	476.37	1200	78.65	119.0925	4.477878	40	2381.85	5373.454	No	233.5655
99352516	36.88	350	6.05	9.22	0.346672	22	101.42	121.3352	No	232.0699
99359060	101.92	500	14.65	25.48	0.958048	24	305.76	479.024	No	203.3445
99359063	234.06	300	39.79	58.515	2.200164	21	614.4075	660.0492	No	240.4922
99352524	77.36	450	10.47	19.34	0.727184	23	222.41	327.2328	No	191.4629
99357024	562.69	550	90.36	140.6725	5.289286	27	1899.079	2909.107	No	227.1754
99991707	154.98	15000	23.41	38.745	1.456812	135	2615.288	21852.18	No	213.688
99251075	1845.91	120	313.81	461.4775	17.35155	13	2999.604	2082.186	Yes	240.4975
99251077	6384.47	90	1085.36	1596.118	60.01402	12	9576.705	5401.262	Yes	240.4934
99251057	2188.83	150	372.1	547.2075	20.575	15	4104.056	3086.25	Yes	240.4927
99252025	2662.5	150	452.63	665.625	25.0275	15	4992.188	3754.125	Yes	240.4961
99657015	2471.74	250	440.2	617.935	23.23436	19	5870.383	5808.589	Yes	251.9426
99657025	2471.74	250	440.2	617.935	23.23436	19	5870.383	5808.589	Yes	251.9426
							47421.04	79193.78		

The majority of items which have been proposed for JIT management are materials with low demands, and very low weight. These characteristics lead to high inventory carrying costs and low transportation costs. These factors endorse just-in-time methodology as the primary inventory management technique. On the other hand, items with high demand, and high weight should have inventory carrying cost figures much less than their transportation costs: therefore, the traditional methodology is more cost beneficial. Each item has different parameters that influence the holding cost and transportation cost calculations as noted throughout this research. For example, the majority of those items elected for JIT show the profile of:

- Low demand (less than 250 units per year)
- High unit price

In contrast, the items rejected for JIT:

- High transportation cost
- Low holding cost

6. Conclusions and Recommendations

1. JIT is the most appropriate technique for a particular set of items, after a thorough cost analysis, JIT inventory management techniques result in cost savings and add value to the final product. Hence, when the cost analysis indicates savings under a JIT environment, such techniques should be definitely adopted.

2. JIT is not always the minimum cost approach when considering a wide range of items. Hence, the cost elements under each technique should be delineated as the first step in the decision making process.

3. An item by item analysis may lead to a different diagnosis than an analysis performed for the entire group of items being managed. Therefore, a comparison between carrying costs and transportation costs should be performed on an individual item basis.

4. A graphical and mathematical break-even analysis is an excellent tool in assuring the appropriateness decision between the two techniques. Therefore, the trade-off analysis using the break-even point between the major cost drivers for each technique should be used as a filter to take advantage of the full benefits associated with JIT.

5. Inventory managers should develop the costs associated with each technique and develop a trade-off methodology, on an individual item basis. This should determine the approach that is the most suitable for each item. This is done in the context of the firm's operation, according to the company's cost structure and the demand level for each item.

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