Uncertain Supply Chain Management 2 (2014) 97–104

Contents lists available at GrowingScience

Uncertain Supply Chain Management

homepage: www.GrowingScience.com/uscm

An application of RFID in supply chain management to reduce inventory estimation error

Hamed Raki*

Department of Industrial Engineering, South Tehran Branch, Islamic Azad University, Tehran, Iran

CHRONICLE

Article history:
Received September 10, 2013
Received in revised format 10 December 2013
Accepted January 12 2014
Available online January 18 2014

Keywords:
SCM
RFID
Auto industry

ABSTRACT

Radio-frequency identification (RFID) is the wireless non-contact implementation of radio-frequency electromagnetic fields to transfer necessary data to identify and to track tags attached to objects, automatically. RFID has been successfully used for supply chain management (SCM) problems in order to reduce errors associated with inventory. This paper uses RFID technique in five different scenarios of labeling, errors in stolen parts, waste, wrong replacement and delivery. The study uses simulation technique based on Enterprise Dynamics to analyze three parts in an auto industry. The study considers different criteria including inventory error estimation, profitability, profitability, customer satisfaction and SCM performance. The preliminary results indicate that the proposed method is capable of optimizing most objectives, significantly.

1. Introduction

Radio-frequency identification (RFID) is the wireless non-contact implementation of radio-frequency electromagnetic fields to transfer necessary data to identify and to track tags attached to objects, automatically (Asif & Mandviwalla, 2005; Niederman et al., 2007). RFID has been successfully used for supply chain management (SCM) problems in order to reduce errors associated with inventory. RFID technologies hold the promise of closing some necessary information gaps in the supply chain, more specifically in retailing and logistics. As a mobile technology, RFID is able to enable "process freedoms" and real-time visibility into supply chains (Angeles, 2005). Gaukler et al. (2007) considered a supply chain with one manufacturer and one retailer and within the context of this retail supply chain, they presented analytic models of the advantages of item-level RFID to both supply chain partners. They examined both the case of a dominant manufacturer as well as the case of a dominant retailer, and investigated the results of an introduction of item-level RFID to such a supply chain based on market power characteristics. Under each scenario, they demonstrated how the expenses of item-level RFID could be allocated among supply chain partners such that supply chain profit would be optimized.

* Corresponding author. Tel.: +98 939 330 3130
E-mail addresses: saho84@rocketmail.com (H. Raki)

doi: 10.5267/j.uscm.2014.1.001

Cannon et al. (2008) aimed to point to established theory bases from other disciplines applied to show the advantages, complexities and risks accompanying the adoption of RFID technology. They presented different theoretical disciplines to describe tension between uncertainty that spurs RFID adoption and uncertainty that accompanies RFID adoption.

Prater et al. (2005) investigated market drivers that are leading to RFID application in the grocery industry and provided a theoretical framework for future applied research on RFID implementation. They also developed a research framework, which includes research using modeling techniques, RFID implementation and the effect of RFID on daily operational issues.

Veronneau and Roy (2009) explored the potential contribution of RFID and other technologies to the efficiency of a cruise corporation's service supply chain. They also investigated different processes required in that supply chain. They reported that RFID could not reach direct gains significant enough on a pallet-level-tagging deployment to meet the expenses. However, a case-level-tagging deployment might be possible under certain conditions. They also demonstrated that contrary to current beliefs in the literature, density of flow of goods and not the scale of operations, detects whether a good return on investment is achievable.

2. The proposed study

This paper uses RFID technique in five different scenarios of labeling, errors in stolen parts, waste, wrong replacement and delivery. The study uses simulation technique based on Enterprise Dynamics to analyze three parts in an auto industry. The study considers different criteria including inventory error estimation, profitability, profitability, customer satisfaction and SCM performance. The proposed study has been applied for the body of a vehicle produced in Iran called Pride and the production line is composed of 34 workstations. The work stations are located longitudinally in one direction. Three major parts with consistent order times are considered for the proposed case study. The order policy is as follows: At the end of each shift operators attempt to count the number of existing items from the shop and warehouse. Next, the production planning is accomplished based on throughput of the next shift, which are production of 150 items. Next, manager attempts to issue a draft order for the storage and transportation of the units into production facilities. The scheduling for shipping parts to a spare workstation is based on times for transportation performed by trucks, received orders, counting and issuing orders and delays in storage and in transportation. To determine the time required for each stage, the action was sampled in three shifts based on stop-watch system. Table 1 shows the summary of our computations.

Table 1
The summary of times required to accomplish different tasks

Part number	Maximum lift truck time in minutes	Maximum lead time	Issuing orders	Delay in storage	Delay in transportation	Total time
1	6	60	65	6	46.6	183.6
2	6	60	65	6	46.6	183.6
3	6	60	65	6	46.6	183.6

Let T be the shift time and N be the number of production, then the cycle time (C) is calculated as $C = T/N$. Therefore, rate of production (ROP) is calculated as follows,

ROP = daily demand × waiting time (days) + safety stock – order in process. In addition, economic order quantity (EOQ) is calculated as follows,

$$Q^*=EOQ=\sqrt{\frac{2aD}{Ch}}. \quad (1)$$

where a is the ordering cost, D represents demand and C_h states the holding cost. The case study of this paper produces 700 units per day in three shifts of 240, 240 and 220 and there are 30 workstations. In production planning, first, the body of the vehicle is entered into the production unit and then different parts are assembled on the body. Each car is assembled in 120 seconds in the first and the second shifts and 131 seconds in the third shift. We study the behavior of the system under three different circumstances, one for 4th hour, one for 6th hour and the last one for 8th hour. In addition, we consider three scenarios for the beginning inventory where the first one considers the level of inventory is less than demand, equal and more than demand. The other point is that for 4th hour we only consider the production for the same shift, while for 6th and 8th hours we consider the production for the same and the next shift. Therefore, there are 9 different scenarios associated with the proposed study of this paper.

The first scenario considers the circumstance where we are in 4th hour of shift, inventory exceeds demand in that shift, and we have 183.6 minutes to complete all productions. Table 1 demonstrates the summary of information for all nine different scenarios.

Table 1
The summary of the production and inventory in all nine scenarios

Scenario	Part	Initial inventory	Entry production rate	Parts in process	Remained inventory
	1	375	120	0	255
1	2	375	120	0	255
	3	375	120	1	256
	1	240	120	0	120
2	2	240	120	0	120
	3	240	120	1	121
	1	200	120	0	80
3	2	200	120	0	80
	3	200	120	1	81
	1	375	180	0	195
4	2	375	180	0	195
	3	375	180	1	195
	1	240	180	0	60
5	2	240	180	0	60
	3	240	180	1	61
	1	200	180	0	20
6	2	200	180	0	20
	3	200	180	1	21
	1	375	240	0	125
7	2	375	240	0	125
	3	375	240	1	126

In addition, Table 2 and Table 3 show the amount of consumption as well as the amount of inventory during the 6th hour and .

Table 2
The summary of ordering at 4th hour when production continues for 8 hours

Part number	Inventory at the beginning period	Inventory at 4th hour	Inventory level up to request time	Consumption at 8th hour	Inventory at 8th hour
1	240	120	28	240	240
2	240	120	28	240	240
3	240	120	29	239	240

Table 3

The summary of ordering at 6th hour when production continues for 8 hours

Part number	Inventory at the beginning period	Inventory at 6th hour	Inventory level up to request time	Consumption at 8th hour	Inventory at 8th hour
1	200	20	103	240	135
2	200	20	103	240	135
3	200	21	104	239	136

Now, we consider the production planning based on the following criteria,

1. Reviewing the number of parts in storage and workstation using RFID method,
2. Determining the period of supplying parts,
3. Entering all orders into ordering system and determining the optimal order quantity.

Based on the above assumption, we first consider the amount of order until the receipt of the next shipment at 4th hour when the amount of inventory exceeds demand and then we consider other conditions for the 4th hour and Table 4 shows details of our survey.

Table 4

The amount of order under various scenarios at 4th hour

The first scenario: The amount of order until the receipt of the next shipment at 4th hour when the amount of inventory exceeds demand								
Part	Minimum inventory	Order point	Production	Available parts	Demand	The order pallet	Order quantity	Need
1	60	92	92	245	184	0	0	No
2	60	92	92	245	184	0	0	NO
3	60	92	92	246	184	0	0	NO
The second scenario: The amount of order of a complete shift at 4th hour when the amount of inventory exceeds demand								
Part	Minimum inventory	Order point	Production	Available parts	Demand	The order pallet	Order quantity	Need
1	60	92	240	245	332	77	77	YES
2	60	92	240	245	332	77	77	YES
3	60	92	240	246	332	76	76	YES
The third scenario: The amount of order until the receipt of the next shipment at 4th hour when the amount of inventory is equal to								
Part	Minimum inventory	Order point	Production	Available parts	Demand	The order pallet	Order quantity	Need
1	60	92	92	120	184	64	64	YES
2	60	92	92	120	184	64	64	YES
3	60	92	92	121	184	63	63	YES
The fourth scenario: The amount of order of a complete shift at 4th hour when the amount of inventory is equal to demand								
Part	Minimum inventory	Order point	Production	Available parts	Demand	The order pallet	Order quantity	Need
1	60	92	240	120	332	212	212	YES
2	60	92	240	120	332	212	212	YES
3	60	92	240	121	332	211	211	YES
The fifth scenario: The amount of order until the receipt of the next shipment at 4th hour when the amount of inventory is less than								
Part	Minimum inventory	Order point	Production	Available parts	Demand	The order pallet	Order quantity	Need
1	60	92	240	80	332	252	252	YES
2	60	92	240	80	332	252	252	YES
3	60	92	240	81	332	251	251	YES
The sixth scenario: The amount of order of a complete shift at 4th hour when the amount of inventory is less than demand								
Part	Minimum inventory	Order point	Production	Available parts	Demand	The order pallet	Order quantity	Need
1	60	92	92	80	184	104	104	YES
2	60	92	92	80	184	104	104	YES
3	60	92	92	81	184	103	103	YES

Similarly, we have performed the computations for the 6th hour and Table 5 shows the results of our survey.

Table 5
The amount of order under various scenarios at 6th hour

Part	Minimum inventory	Order point	Production	Available parts	Demand	The order pallet	Order quantity	Need
The first scenario: The amount of order until the receipt of the next shipment at 6th hour when the amount of inventory exceeds demand								
1	60	92	240	195	332	137	137	YES
2	60	92	240	195	332	137	137	YES
3	60	92	240	196	332	136	136	YES
The second scenario: The amount of order of a complete shift at 6th hour when the amount of inventory exceeds demand								
1	60	92	92	195	184	0	0	NO
2	60	92	92	195	184	0	0	NO
3	60	92	92	196	184	0	0	NO
The third scenario: The amount of order until the receipt of the next shipment at 6th hour when the amount of inventory is equal to demand								
1	60	92	92	60	184	124	124	YES
2	60	92	92	60	184	124	124	YES
3	60	92	92	61	184	123	123	YES
The fourth scenario: The amount of order of a complete shift at 6th hour when the amount of inventory is equal to demand								
1	60	92	240	60	332	272	272	YES
2	60	92	240	60	332	272	272	YES
3	60	92	240	61	332	271	271	YES
The fifth scenario: The amount of order until the receipt of the next shipment at 6th hour when the amount of inventory is less than demand								
1	60	92	92	20	184	164	164	YES
2	60	92	92	20	184	164	164	YES
3	60	92	92	21	184	163	163	YES
The sixth scenario: The amount of order of a complete shift at 6th hour when the amount of inventory is less than demand								
1	60	92	240	20	332	312	312	YES
2	60	92	240	20	332	312	312	YES
3	60	92	240	21	332	311	311	YES

Similarly, we have performed the computations for the 8th hour and Table 6 shows the results of our survey.

Table 6
The amount of order under various scenarios at 8th hour

Part	Minimum inventory	Order point	Production	Available parts	Demand	The order pallet	Order quantity	Need
The first scenario: The amount of order until the receipt of the next shipment at 8th hour when the amount of inventory exceeds demand								
1	60	92	92	125	184	59	59	YES
2	60	92	92	125	184	59	59	YES
3	60	92	92	126	184	58	58	YES
The second scenario: The amount of order of a complete shift at 8th hour when the amount of inventory exceeds demand								
1	60	92	240	125	332	207	207	YES
2	60	92	240	125	332	207	207	YES
3	60	92	240	126	332	206	206	YES
The third scenario: The amount of order until the receipt of the next shipment at 8th hour when the order is placed at 4th hour								
1	60	92	92	240	184	0	0	NO
2	60	92	92	240	184	0	0	NO
3	60	92	92	240	184	0	0	NO
The fourth scenario: The amount of order until the receipt of complete shift requirements at 8th hour when the order is placed at 4th hour								
1	60	92	240	240	332	92	92	YES
2	60	92	240	240	332	92	92	YES
3	60	92	240	240	332	92	92	YES
The fifth scenario: The amount of order until the receipt of an order at 8th hour when the order is placed at 6th hour								
1	60	92	92	135	184	49	49	YES
2	60	92	92	135	184	49	49	YES
3	60	92	92	136	184	48	48	YES
The sixth scenario: The amount of order until the receipt of complete shift requirements at 8th hour when the order is placed at 6th hour								
1	60	92	240	135	332	197	197	YES
2	60	92	240	135	332	197	197	YES
3	60	92	240	136	332	196	196	YES

3. The Simulation

We now present details of the simulation under five different scenarios. In the first scenario, the chair of the workstation makes the orders manually by visiting the plants. Any shortage in order quantity may create different chaos in planning. Fig. 1 demonstrates the summary of our simulation process.

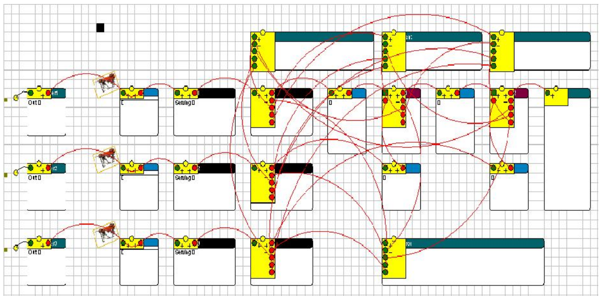

Fig. 1. The results of simulation for the first scenario

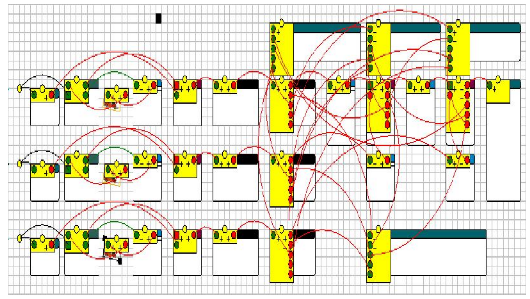

Fig. 2. The results of simulation for the second scenario

In the second scenario, we plan to assign a RFID to each pallet. Therefore, when the pallet becomes empty, the driver of lift trucks or an inspector could understand about the new circumstance and fill in the pallet. Note that when there is only one empty pallet in the system, there is a chance of facing shortage. In the third scenario, we consider a separate label for each part and we could keep track of the number of parts in each pallet (Fig. 3). In the fourth scenario, we save more information about the position of parts located in various pallets (Fig. 4).

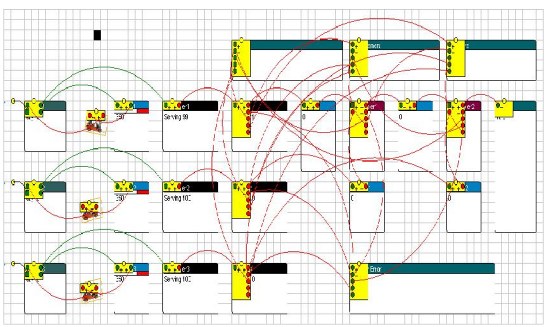

Fig. 3. The results of simulation for the third scenario

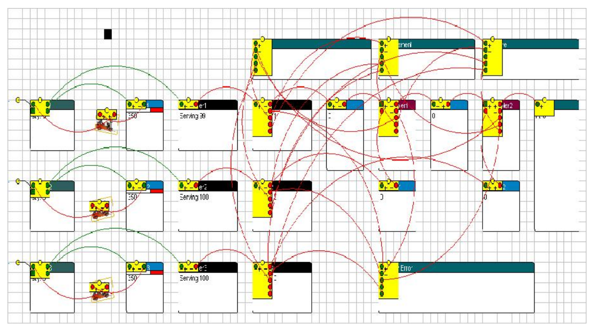

Fig. 4. The results of simulation for the fourth scenario

Table 7, Table 8 and Table 9 demonstrate the summary of our simulation for the first part for five scenarios.

Table 7
The summary of the simulation of the first product for five scenarios

	1	2	3	4	5
Output (%)	85.71	89.64	94.29	94.29	94.29
Stolen part (%)	0.57	0.40	0.29	0.29	0.29
Replaced by mistake (%)	4.57	1.99	0.86	0.86	0.86
Error in delivery (%)	3.71	3.19	1.43	1.43	1.43
Unavailable (%)	5.43	5.18	3.14	3.14	3.14

Table 8
The summary of the simulation of the second product for five scenarios

	1	2	3	4	5
Output (%)	87.14	90.44	94.86	94.86	94.86
Stolen part (%)	0.57	0.40	0.29	0.29	0.29
Replaced by mistake (%)	4.86	2.39	0.86	0.86	0.86
Error in delivery (%)	4.29	3.59	1.14	1.14	1.14
Unavailable (%)	3.14	3.19	2.86	2.86	2.86

Table 9
The summary of the simulation of the third product for five scenarios

	1	2	3	4	5
Output (%)	85.43	89.24	94.29	94.29	94.29
Stolen part (%)	0.57	0.40	0.29	0.29	0.29
Replaced by mistake (%)	5.14	2.79	1.14	1.14	1.14
Error in delivery (%)	4.57	3.98	1.14	1.14	1.14
Unavailable (%)	4.29	3.59	3.14	3.14	3.14

We have measured the performance of the proposed model under various scenarios and Fig. 5 shows customer satisfaction in five different scenarios.

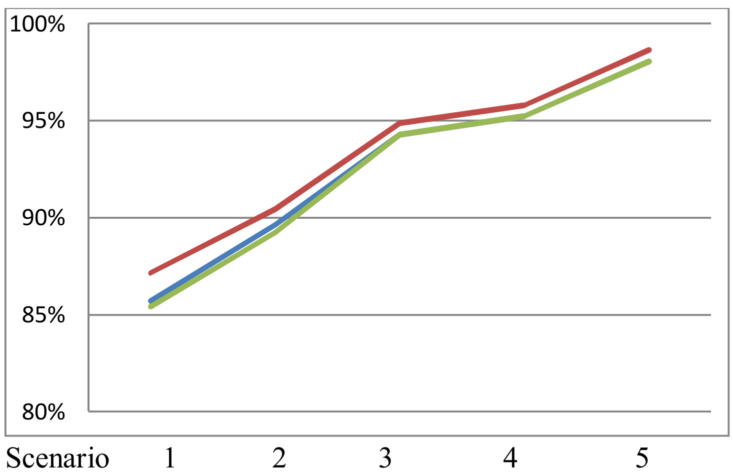

Fig. 5. The results of customer satisfaction in five scenarios

As we can observe from Fig. 5, customer satisfaction increases from the first scenario, present situation, to the fifth scenario. Fig. 6 demonstrates the error in measuring the inventory.

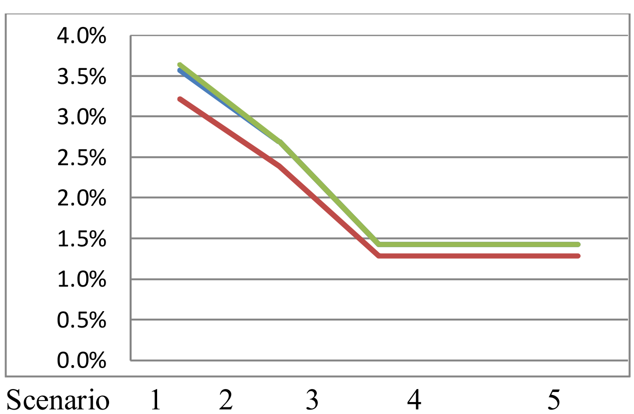

Fig. 6. Calculated error in inventory

According to the results of Fig. 6, scenarios 4 and 5 could significantly reduce the error in measuring the inventory. Our survey also indicates that the performance of supply chain increases in the fourth and fifth scenarios while the profitability will relatively higher for the third scenario, see Fig. 7.

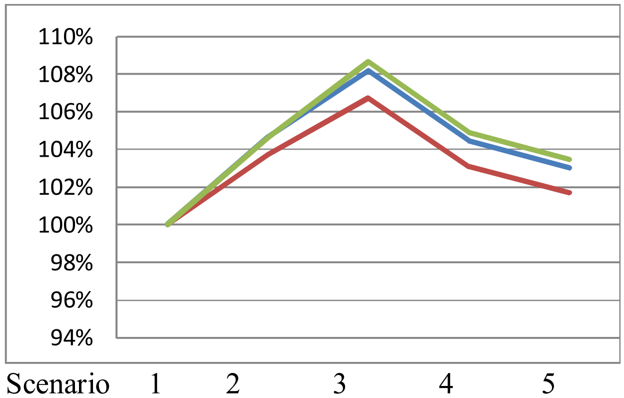

Fig. 7. The profitability

4. Conclusion

In this paper, we have presented an empirical investigation to study the behavior of a production planning by applying RFID system. The proposed study has considered the performance of the system under various types of RFID implementation and the behavior of the system has been examined using simulation technique. The results of our survey have indicated that we could increase the profitability of the system when we consider a separate label for each part and keep track of the number of parts in each pallet although other RFID implementation also improved the performance of the system, significantly.

References

Angeles, R. (2005). RFID technologies: supply-chain applications and implementation issues. *Information Systems Management*, *22*(1), 51-65.

Asif, Z., & Mandviwalla, M. (2005). Integrating the supply chain with RFID: a technical and business analysis. *Communications of the Association for Information Systems*, *15*(24), 393-426.

Cannon, A. R., Reyes, P. M., Frazier, G. V., & Prater, E. L. (2008). RFID in the contemporary supply chain: multiple perspectives on its benefits and risks. *International Journal of Operations & Production Management*, *28*(5), 433-454.

Gaukler, G. M., Seifert, R. W., & Hausman, W. H. (2007). Item-Level RFID in the retail supply chain. *Production and Operations Management*, *16*(1), 65-76.

Niederman, F., Mathieu, R. G., Morley, R., & Kwon, I. W. (2007). Examining RFID applications in supply chain management. *Communications of the ACM*, *50*(7), 92-101.

Prater, E., Frazier, G. V., & Reyes, P. M. (2005). Future impacts of RFID on e-supply chains in grocery retailing. *Supply Chain Management: An International Journal*, *10*(2), 134-142.

Veronneau, S., & Roy, J. (2009). RFID benefits, costs, and possibilities: the economical analysis of RFID deployment in a cruise corporation global service supply chain. *International Journal of Production Economics*, *122*(2), 692-702.